Head-Driven Phrase Structure Grammar: The handbook

Edited by

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Basic properties and elements

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University of Essex

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1 Introduction

Phasellus maximus erat ligula, accumsan rutrum augue facilisis in. Proin sit amet pharetra nunc, sed maximus erat. Duis egestas mi eget purus venenatis vulputate vel quis nunc. Nullam volutpat facilisis tortor, vitae semper ligula dapibus sit amet. Suspendisse fringilla, quam sed laoreet maximus, ex ex placerat ipsum, porta ultrices mi risus et lectus. Maecenas vitae mauris condimentum justo fringilla sollicitudin. Fusce nec interdum ante. Curabitur tempus dui et orci convallis molestie (Chomsky 1957).

Meier (2017)

(1)   Latin (personal knowledge)

cogit-o   ergo   sum

think-1SG.PRES.IND hence exist.1SG.PRES.IND

'I think therefore I am'

Sed nisi urna, dignissim sit amet posuere ut, luctus ac lectus. Fusce vel ornare nibh. Nullam non sapien in tortor hendrerit suscipit. Etiam sollicitudin nibh ligula. Praesent dictum gravida est eget maximus. Integer in felis id diam sodales accumsan at at turpis. Maecenas dignissim purus non libero scelerisque porttitor. Integer porttitor mauris ac nisi iaculis molestie. Sed nec imperdiet orci. Suspendisse sed fringilla elit, non varius elit. Sed varius nisi magna, at efficitur orci consectetur a. Cras consequat mi dui, et cursus lacus vehicula vitae. Pellentesque sit amet justo sed lectus luctus vehicula. Suspendisse placerat augue eget felis sagittis placerat.

Table 1: Frequencies of word classes

	nouns	verbs	adjectives	adverbs
absolute	12	34	23	13
relative	3.1	8.9	5.7	3.2

Sed cursus [1] sapien pulvinar. Sed consequat, magna[2]. Nunc dignissim tristique massa ut gravida. Nullam auctor orci gravida tellus egestas, vitae pharetra nisl porttitor. Pellentesque turpis nulla, venenatis id porttitor non, volutpat ut leo. Etiam hendrerit scelerisque luctus. Nam sed egestas est. Suspendisse potenti. Nunc vestibulum nec odio non laoreet. Proin lacinia nulla lectus, eu vehicula erat vehicula sed.

Abbreviations

COP	copula	NEG	negation
FV	final vowel	SM	subject marker

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[1]eros condimentum mi consectetur, ac consectetur

[2]eu scelerisque laoreet, ante erat tristique justo, nec cursus eros diam eu nisl. Vestibulum non arcu tellus

Acknowledgements

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Chapter 2

The evolution of HPSG

Dan Flickinger
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HPSG was developed to express insights from theoretical linguistics in a precise formalism that was computationally tractable. It drew ideas from a wide variety of traditions in linguistics, logic, and computer science. Its chief architects were Carl Pollard and Ivan Sag, and its most direct precursors were Generalized Phrase Structure Grammar and Head Grammar. The theory has been applied in the construction of computational systems for the analysis of a variety of languages; a few of these systems have been used in practical applications. This chapter sketches the history of the development and application of the theory.

Introduction

From its inception in 1983, HPSG was intended to serve as a framework for the formulation and implementation of natural language grammars which are (i) linguistically motivated, (ii) formally explicit, and (iii) computationally tractable. These desiderata are reflective of HPSG's dual origins as an academic linguistic theory and as part of an industrial grammar implementation project with an eye toward potential practical applications. Here (i) means that the grammars are intended as scientific theories about the languages in question, and that the analyses the grammars give rise to are transparently relatable to the predictions

(empirical consequences) of those theories. Thus HPSG shares the general concerns of the theoretical linguistics literature, including distinguishing between well-formed and ill-formed expressions and capturing linguistically significant generalizations. (ii) means that the notation for the grammars and its interpretation have a precise grounding in logic, mathematics, and theoretical computer science, so that there is never any ambiguity about the intended meaning of a rule or principle of grammar, and so that grammars have determinate empirical consequences. (iii) means that the grammars can be translated into computer programs that can handle linguistic expressions embodying the full range of complex interacting phenomena that naturally occur in the target languages, and can do so with a tolerable cost in space and time resources.

The two principal architects of HPSG were Carl Pollard and Ivan Sag, but a great many other people made important contributions to its development. Many, but by no means all, are cited in the chronology presented in the following sections. There are today a number of groups of HPSG researchers around the world, in many cases involved in building HPSG-based computational systems. While the number of practitioners is relatively small, it is a very active community that holds annual meetings and publishes quite extensively. Hence, although Pollard no longer works on HPSG and Sag died in 2013, the theory is very much alive, and still evolving.

1 Precursors

HPSG arose between 1983 and 1985 from the complex interaction between two lines of research in theoretical linguistics: (i) work on context-free Generative Grammar (CFG) intitiated in the late 1970s by Gerald Gazdar and Geoffrey Pullum, soon joined by Ivan Sag, Ewan Klein, Tom Wasow, and others, resulting in the framework referred to as Generalized Phrase Structure Grammar (GPSG: Gazdar, Klein, Pullum & Sag (1985)); and (ii) Carl Pollard's Stanford dissertation research, under Sag and Wasow's supervision, on Generalized Context-Free Grammar, and more specifically Head Grammar (HG: Pollard (1984)).

1.1 Generalized Phrase Structure Grammar

In the earliest versions of Generative Grammar (Chomsky 1957), the focus was on motivating transformations to express generalizations about classes of sentences. In the 1960s, as generative linguists began to attend more explicitly to meaning, a division arose between those advocating using the machinery of transforma-

tions to capture semantic generalizations and those advocating the use of other types of formal devices. This division became quite heated, and was subsequently dubbed "the linguistic wars" (see Newmeyer (1980: Chapter 5)). Much of the work in theoretical syntax and semantics during the 1970s explored ways to constrain the power of transformations (see especially, Chomsky (1973) and Chomsky & Lasnik (1977)), and non-transformational approaches to the analysis of meaning (see especially Montague (1974) and Dowty (1979)).

These developments led a few linguists to begin questioning the central role transformations had played in the syntactic research of the preceding two decades (notably, Bresnan (1978)). This questioning of Transformational Grammar (TG) culminated in a series of papers by Gerald Gazdar, which (in those pre-internet days) were widely distributed as paper manuscripts. The project that they laid out was succinctly summarized in one of Gazdar's later publications (Gazdar 1981: 155) as follows:

> Consider eliminating the transformational component of a generative grammar. (Gazdar 1981: 155)

The framework that emerged became known as Generalized Phrase Structure Grammar; a good account of its development is Ted Briscoe's interview of Gazdar in November 2000.[1]

GPSG developed in response to several criticisms leveled against transformational grammar. First, TG was highly underformalized, to the extent that it was unclear what its claims—and the empirical consequences of those claims—amounted to; CFG, by comparison, was a simple and explicit mathematical formalism. Second, given the TG architecture of a context-free base together with a set of transformations, the claimed necessity of transformations was standardly justified on the basis of arguments that CFGs were insufficiently expressive to serve as a general foundation for NL grammar; but Pullum & Gazdar (1982) showed all such arguments presented up to that time to be logically flawed or else based on false empirical claims. And third, closely related to the previous point, they showed that transformational grammarians had been insufficiently resourceful in exploiting what expressive power CFGs *did* possess, especially through the use of complex categories bearing features whose values might themselves bear features of their own. For example, coordinate constructions and unbounded dependency constructions had long served as prime exemplars of the need for transformations, but Gazdar (1981) was able to show that both kinds of

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[1]https://nlp.fi.muni.cz/~xjakub/briscoe-gazdar/, 2018-08-21.

constructions, as well as interactions between them, did in fact yield straightforward analysis within the framework of a CFG.

Gazdar and Pullum's early work in this vein was quickly embraced by Sag and Wasow at Stanford University, both formally inclined former students of Chomsky's, who saw it as the logical conclusion of a trend in Chomskyan syntax toward constraining the tranformational component. That trend, in turn, was a response, at least in part, to (i) the demonstration by Peters & Ritchie (1973) that Chomsky's (1965) Standard Theory, when precisely formalized, was totally unconstrained, in the sense of generating all recursively enumerable languages; and (ii) the insight of Emonds (1976) that most of the transformations proposed up to that time were "structure-preserving" in the sense that the trees they produced were isomorphic to ones that were base-generated. Besides directly addressing these issues of excess power and structure preservation, the hypothesis that NLs were context-free also had the advantage that CFGs were well-known by computer scientists to have decidable recognition problems and efficient parsing algorithms, facts which seemed to have some promise of bearing on questions of the psychological plausibility and computational tractability of the grammars in question.

Aside from serving as a framework for theoretical linguistic research, GPSG also provided the theoretical underpinnings for a natural language processing (NLP) project established in 1981 by Egon Loebner at Hewlett-Packard Laboratories in Palo Alto. This project, which led in due course to the first computer implementation of HPSG, is described below.

1.2 Head Grammar

Pollard, with a background in pure mathematics, Chinese historical phonology, and 1930s–1950s-style American structural linguistics, arrived at Stanford in 1979 with the intention of getting a Ph.D. in Chinese linguistics, but was soon won over to theoretical syntax by Wasow and Sag. He had no exposure to Chomskyan linguistics, but was immediately attracted to the emerging nontransformational approaches, especially the early GPSG papers and the contemporaneous forms of CG in Bach (1979; 1980) and Dowty (1982a,b), in part because of their formal simplicity and rigor, but also because the formalism of CFG was (and is) easy to read as a more technically precise rendering of structualist ideas about syntax (as presented, e.g., in Bloomfield (1933) and Hockett (1958)).

Although Pullum & Gazdar (1982) successfully refuted all published arguments to date that CFGs were inadequate for analyzing NLs, by the following year, Stuart Shieber had developed an argument (published in Shieber (1985)), which was

(and remains) generally accepted as correct, that there could not be a CFG that accounted for the cross-serial dependencies in Swiss German; and Chris Culy showed, in his Stanford M.A. thesis (cf. Culy (1985)), that the presence of reduplicative compounding in Bambara precluded a CF analysis of that language. At the same time, Bach and Dowty (independently) had been experimenting with generalizations of traditional A-B (Ajdukiewicz-Bar Hillel) CG which allowed for modes of combining strings (such as reduplication, wrapping, insertion, cliticization, and the like) in addition to the usual concatenation. This latter development was closely related to a wider interest among nontransformational linguists of the time in the notion of discontinuous constituency, and also had an obvious affinity to Hockett's (1954) item-and-process conception of linguistic structure, albeit at the level of words and phrases rather than morphemes. One of the principal aims of Pollard's dissertation work was to provide a general framework for syntactic (and semantic) analysis that went beyond—but not too far beyond—the limits of CFG in a way that took such developments into account.

Among the generalizations of CFG that Pollard studied, special attention was given to HGs, which differ from CFGs in two respects: (i) the role of strings was taken over by headed strings, essentially strings with a designation of one of its words as its head; and (ii) besides concatenation, headed strings can also be combined by inserting one string directly to the left or right of another string's head. An appendix of his dissertation (Pollard 1984) provided an analysis of discontinuous constituency in Dutch, and that analysis also works for Swiss German. In another appendix, Pollard used a generalization of the CKY algorithm to prove that the head languages (HLs, the languages analyzed by HGs) shared with CFLs the property of deterministic polynomial time recognition complexity, but of order n^7, subsequently reduced by Kasami, Seki & Fujii (1989) to n^6, as compared with order n^3 for CFLs. For additional formal properties of HGs, see Roach (1987). Vijay-shanker & Weir (1994) proved that HGs had the same weak generative capacities as three other grammar formalisms (Combinatory Categorial Grammar (Steedman 1987; 1990), Lexicalized Tree-Adjoining Grammar (Shabes 1990), and Linear Indexed Grammar (Gazdar 1988)), and the corresponding class of languages became known as 'mildly context sensitive'.

Although the handling of linearization in HG seems not to have been pursued further within the HPSG framework, the ideas that (i) linearization had to involve data structures richer than strings of phoneme strings, and (ii) the way these structures were linearized had to involve operations other than mere concatenation, were implicit in subsequent HPSG work, starting with Pollard & Sag's (1987) Constituent Order Principle (which was really more of a promissory note than

an actual principle). These and related ideas would become more fully fleshed out a decade later within the linearization grammar avatar of HPSG developed by Reape (1996), Reape (1992), and Kathol (1995; 2000). On the other hand, two other innovations of HG, both related to the system of syntactic features, were incorporated into HPSG, and indeed should probably be considered the defining characteristics of that framework, namely the list-valued SUBCAT and SLASH features, discussed below.

2 The HP NLP project

Work on GPSG culminated in the 1985 book *Generalized Phrase Structure Grammar* by Gazdar, Klein, Pullum, and Sag. During the writing of that book, Sag taught a course on the theory, with participation of his co-authors. The course was attended not only by Stanford students and faculty, but also by linguists from throughout the area around Stanford, including the Berkeley and Santa Cruz campuses of the University of California, as well as people from nearby industrial labs. One of the attendees at this course was Anne Paulson, a programmer from Hewlett-Packard (HP) Laboratories in nearby Palo Alto, who had some background in linguistics from her undergraduate education at Brown University. Paulson told her supervisor at HP Labs, Egon Loebner, that she thought the theory could be implemented and might be turned into something useful. Loebner, a multi-lingual polymathic engineer, had no background in linguistics, but he was intrigued, and invited Sag to meet and discuss setting up a natural language processing project at HP. Sag brought along Gazdar, Pullum, and Wasow. This led to the creation of the project that eventually gave rise to HPSG. Gazdar, who would be returning to England relatively soon, declined the invitation to be part of the new project, but Pullum, who had taken a position at the University of California at Santa Cruz (about an hour's drive from Palo Alto), accepted. So the project began with Sag, Pullum, and Wasow hired on a part-time basis to work with Paulson and two other HP programmers, John Lamping and Jonathan King, to implement a GPSG of English at HP Labs. J. Mark Gawron, a linguistics graduate student from Berkeley who had attended Sag's course, was very soon added to the team.

The initial stages consisted of the linguists and programmers coming up with a notation that would serve the purposes of both. Once this was accomplished, the linguists set to work writing a grammar of English in Lisp to run on the DEC-20 mainframe computer that they all worked on. The first publication coming out of this project was a 1982 Association for Computational Linguistics paper

(Gawron et al. 1982). The paper's conclusion (p. 80) begins:

> What we have outlined is a natural language system that is a direct implementation of a linguistic theory. We have argued that in this case the linguistic theory has the special appeal of computational tractability (promoted by its context-freeness), and that the system as a whole offers the hope of a happy marriage of linguistic theory, mathematical logic, and advanced computer applications. (Gawron et al. 1982: 80)

This goal was carried over into HPSG.

It should be mentioned that the HP group was by no means alone in these concerns. The early 1980s was a period of rapid growth in computational linguistics (due at least in part to the rapid growth in the power and accessibility of computers). In the immediate vicinity of Stanford and HP Labs, there were at least two other groups working on developing natural language systems that were both computationally tractable and linguistically motivated. One such group was at the Xerox Palo Alto Research Center, where Ron Kaplan and Joan Bresnan (in collaboration with a number of other researchers, notably Martin Kay) were developing Lexical Functional Grammar; the other was at SRI International, where a large subset of SRI's artificial intelligence researchers (including Barbara Grosz, Jerry Hobbs, Bob Moore, Hans Uszkoreit, Fernando Pereira, and Stuart Shieber) worked on natural language. Thanks to the founding of the Center for the Study of Language and Information (CSLI) at Stanford in the early 1980s, there was a great deal of interaction among these three research groups. Although some aspects of the work being done at the three non-Stanford sites were proprietary, most of the research was basic enough that there was a fairly free flow of ideas among the three groups about building linguistically motivated natural language systems.

Other projects seeking to develop theories that combined computational tractability with linguistic motivation were also underway outside of the immediate vicinity of Stanford, notably at the Universities of Pennsylvania and Edinburgh. Aravind Joshi and his students were working on Tree Adjoining Grammars (Joshi et al. 1975; Joshi 1987), while Mark Steedman and others were developing Combinatory Categorial Grammar (Steedman 1987; 1990).

During the first few years of the HP NLP project, several Stanford students were hired as part-time help. One was Pollard, who was writing his doctoral dissertation under Sag's supervision. Ideas from his thesis work played a major role in the transition from GPSG to HPSG. Two other students who became very important to the project were Dan Flickinger, a doctoral student in linguistics,

and Derek Proudian, who was working on an individually-designed undergraduate major when he first began at HP and later became a master's student in computer science. Both Flickinger and Proudian became full-time HP employees after finishing their degrees. Over the years, a number of other HP employees also worked on the project and made substantial contributions. They included Susan Brennan, Lewis Creary, Marilyn Friedman (now Walker), Dave Goddeau, Brett Kessler, Joachim Laubsch, and John Nerbonne. Brennan, Walker, Kessler, and Nerbonne all later went on to academic careers at major universities, doing research dealing with natural language processing.

The HP NLP project lasted until the early 1990s. By then, a fairly large and robust grammar of English had been implemented. The period around 1990 combined an economic recession with what has sometimes been termed an "AI winter" – that is, a period in which enthusiasm and hence funding for artificial intelligence research was at a particularly low ebb. Since NLP was considered a branch of AI, support for it waned. Hence, it was not surprising that the leadership of HP Labs decided to terminate the project. Flickinger and Proudian came to an agreement with HP that allowed them to use the NLP technology developed by the project to launch a new start-up company, which they named Eloquent Software. They were, however, unable to secure the capital necessary to turn the existing system into a product, so the company never got off the ground.

3 The emergence of HPSG

A few important features of GPSG that were later carried over into HPSG are worth mentioning here. First, GPSG borrowed from Montague the idea that each phrase structure rule was to be paired with a semantic rule providing a recipe for computing the meaning of the mother from the meanings of its daughters (Gazdar 1981: 156); this design feature was shared with contemporaneous forms of Categorial Grammar (CG) being studied by such linguists as Emmon Bach (Bach 1979; 1980) and David Dowty (Dowty 1982a,b). Second, the specific inventory of features employed in GPSG for making fine-grained categorial distinctions (such as case, agreement, verb inflectional form, and the like), was largely preserved, though the technical implementation of morphosyntactic features in HPSG was somewhat different. And third, the SLASH feature, which originated in Gazdar's (1981) derived categories (e.g. S/NP), and which was used to keep track of unbounded dependencies, was generalized in HPSG to allow for multiple unbounded dependencies (as in the notorious violins-and-sonatas example in (1) below). As will be discussed, this SLASH feature bears a superficial—and

misleading—resemblance to the Categorial Grammar connectives written as '/' and '\'. On the other hand, a centrally important architectural feature of GPSG absent from HPSG (and from HG) was the device of metarules, higher-order rules used to generate the full set of context-free phrase structure rules (PSRs) from an initial inventory of basic PSRs. Among the metarules were ones used to introduce non-null SLASH values and propagate them upward through trees to a position where they were discharged by combination with a matching constituent called a filler (analogous to a *wh*-moved expression in TG).

A note is in order about the sometimes confusing use of the names *Head Grammar (HG)* and *HPSG*. Strictly speaking, HG was a specific subtype of generalized CFG developed in Pollard's dissertation work, but the term *HG* did not appear in academic linguistic publications with the exception of the Pollard & Sag (1983) WCCFL paper, which introduced the distinction between head features and binding features (the latter were incorporated into GPSG under the name *foot features*). In the summer of 1982, Pollard had started working part time on the HP NL project; and the term *HPSG* was first employed (by Pullum) in reference to an extensive reworking by Pollard and Paulson of the then-current HP GPSG implementation, incorporating some of the main features of Pollard's dissertation work in progress, carried out over the summer of 1983, while much of the HP NLP team (including Pullum and Sag) was away at the LSA Institute in Los Angeles. The implication of the name change was that whatever this new system was, it was no longer GPSG.

Once this first HPSG implementation was in place, the NLP work at HP was considered to be within the framework of HPSG, rather than GPSG. After Pollard completed his dissertation, he continued to refer to *HG* in invited talks as late as autumn 1984; but his talk at the (December 1984) LSA Binding Theory Symposium used *HPSG* instead, and after that, the term *HG* was supplanted by *HPSG* (except in publications by non-linguists about formal language theory). One additional complication is that until the Gazdar, Klein, Pullum & Sag (1985) volume appeared, GPSG and HPSG were developing side by side, with considerable interaction. Pollard, together with Flickinger, Wasow, Nerbonne, and others, did HPSG; Gazdar and Klein did GPSG; and Sag and Pullum worked both sides of the street.

HPSG papers, about both theory and implementation, began to appear in 1985, starting with Pollard's WCCFL paper *Phrase structure grammar without metarules* (Pollard 1985), and his paper at the Categorial Grammar conference in Tucson (Pollard 1988), comparing and contrasting HPSG with then-current versions of Categorial Grammar due to Bach, Dowty, and Steedman. These were followed

by a trio of ACL papers documenting the current state of the HPSG implementation at HP Labs: Creary & Pollard (1985), Flickinger, Pollard & Wasow (1985), and Proudian & Pollard (1985). Of those three, the most significant in terms of its influence on the subsequent development of the HPSG framework was the second, which showed how the lexicon could be (and in fact was) organized using multiple-inheritance knowledge representation; Flickinger's Stanford dissertation (Flickinger 1987) was an in-depth exploration of that idea.

4 Early HPSG

Setting aside implementation details, early HPSG can be characterized by the following architectural features:

Elimination of metarules   Although metarules were a central feature of GPSG, they were also problematic: Uszkoreit & Peters (1982) had shown that if metarules were allowed to apply to their own outputs, then the resulting grammars were no longer guaranteed to generate CFLs; indeed, such grammars could generate all recursively enumerable languages. And so, in GPSG, the closure of a set of base phrase structure rules (PSRs) under a set of metarules was defined in such a way that no metarule could apply to a PSR whose own derivation involved an application of that metarule. This definition was intended to ensure that the closure of a finite set of PSRs remained finite, and therefore still constituted a CFG.

So, for example, the metarule STM1 was used in GPSG to convert a PSR into another PSR one of whose daughters is [+NULL] (informally speaking, a 'trace'), and feature cooccurrence restrictions (FCRs) guaranteed that such daughters would bear a SLASH value, and that this SLASH value would also appear on the mother. Unfortunately, the finite closure definition described above does not preclude the possibility of derived PSRs whose mother carries multiple, in fact unboundedly many SLASH values (e.g. NP/NP, (NP/NP)/NP, etc.). And this in turn leads to an infinite set of PSRs, outside the realm of CF-ness (see Ristad (1986)). Of course, one could rein in this excess power by imposing another FCR that disallows categories of the form (X/Y)/Z; but then there is no way to analyze sentences containing a constituent with two undischarged unbounded dependencies, such as the VP complement of *easy* in the following example:

(1)   Violins this finely crafted, even the most challenging sonatas are easy to
      [play _ on _].

GPSG avoided this problem by not analyzing such examples. In HPSG (Pollard 1985), by contrast, such examples were analyzed straightforwardly by replacing GPSG's category-valued SLASH feature with one whose values were lists (or sets) of categories. This approach still gave rise to an infinite set of rules, but since maintaining context-freeness was no longer at stake, this was not seen as problematic. The infinitude of rules in HPSG arose not through a violation of finite closure (since there were no longer any metarules at all), but because each of the handful of schematic PSRs (see below) could be directly instantiated in an infinite number of ways, given that the presence of list-valued features gave rise to an infinite set of categories.

Lexical rules   GPSG, generalizing a suggestion of Flickinger (1983), constrained metarules to apply only to PSRs that introduced a lexical head. Pollard (1985) took this idea a step further, noting that many proposed metarules could be reformulated as lexical rules that (among other effects) operated on the subcategorization frames (encoded by the SUBCAT feature discussed below) of lexical entries. The idea of capturing some linguistic generalizations by means of rules internal to the lexicon had been explored by generative grammarians since Jackendoff (1975); and lexical rules of essentially the kind Pollard proposed were employed by Bach (1983), Dowty (1978), and others working in Categorial Grammar. Examples of constructions handled by metarules in GPSG but in HPSG by lexical rules included sentential extraposition, subject extraction, and passive. Flickinger, Pollard & Wasow (1985) argued for an architecture for the lexicon that combined lexical rules with multiple inheritance using a frame-based knowledge representation system, on the basis of both overall grammar simplicity and efficient, easily modifiable implementation.

CG-like treatment of subcategorization   In GPSG, subcategorization was treated by an integer-valued feature called SUBCAT that in effect indexed each lexical item with the rule that introduced and provided its subcategorization frame; e.g. *weep* was listed in the lexicon with SUBCAT value 1 while *devour* was listed with SUBCAT value 2, and then PSRs of roughly the form in (2)

(2)   VP → V[SUBCAT 1]
        VP → V[SUBCAT 2] NP

guaranteed that lexical heads would have the right kinds of complements. In HPSG, by contrast, the SUBCAT feature directly characterized the grammatical arguments selected by a head (not just the complements, but the subject too) as a

list of categories, so that e.g. *weep* was listed as V[SUBCAT <NP>] but *devour* as V[SUBCAT <NP,NP>] (where the first occurrence of NP refers to the object and the second to the subject). This treatment of argument selection was inspired by Categorial Grammar, where the same verbs would have been categorized as NP\S and (NP\S)/NP respectively;[2] the main differences are that (i) the CG treatment also encodes the directionality of the argument relative to the head, and (ii) in HPSG, all the arguments appear on one list, while in CG they are 'picked up' one at a time, with as many connectives (/ or \) as there are arguments. In particular, as in the CG of Dowty (1982c), the subject was defined as the last argument, except that in HPSG, 'last' now referred to the rightmost position on the SUBCAT list, not to the most deeply embedded connective. In HPSG, this ordering of the categories on the SUBCAT list was related not just to CG, but also to the traditional grammatical notion of obliqueness, and also to the accessibility hierarchy of Keenan & Comrie (1977).

Schematic rules   Unlike CFG, but like CG, HPSG had only a handful of schematic rules. For example, in Pollard (1985), a substantial chunk of English 'local' grammar (i.e. leaving aside unbounded dependencies) was handled by three rules: (i) a rule (used for subject-auxiliary inversion) that forms a sentence from an inverted (+INV) lexical head and all its arguments; (ii) a rule that forms a phrase from a head with SUBCAT list of length > 1 together with all its non-subject arguments; and (iii) a rule that forms a sentence from a head with a SUBCAT value of length one together with its single (subject) argument.

List- (or set-) valued SLASH feature   The list-valued SLASH was introduced in Pollard (1985) to handle multiple unbounded dependencies, instead of the GPSG category-valued SLASH (which in turn originated as the *derived categories* of Gazdar (1981), e.g. S/NP). In spite of the notational similarity, though, the PSG SLASH is not an analog of the CG slashes / and \ (though HPSG's SUBCAT is, as explained above). In fact, HPSG's SLASH has no analog in the kinds of CGs being developed by Montague semanticists such as Bach (1979; 1980) and Dowty (1982a) in the late 1970s and early 1980s, which followed the CGs of Bar-Hillel (1954) in having only rules for eliminating (or canceling) slashes as in (3):

(3) $\dfrac{\text{A A\textbackslash B}}{\text{B}}$ $\dfrac{\text{B/A A}}{\text{B}}$

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[2]We adhere to the Lambek convention for functor categories, so that expressions seeking to combine with an A on the left to form a B are written 'A\B' (not 'B\A').

To find an analog to HPSG's SLASH in CG, we have to turn to the kinds of CGs invented by Lambek (1958), which unfortunately were not yet well-known to linguists (though that would soon change starting with Lambek's appearance at the 1985 Categorial Grammar conference in Tucson). What sets apart grammars of this kind (and their elaborations by Moortgat (1989), Oehrle et al. (1988), Morrill (1994), and many others), is the existence of rules for hypothetical proof (not given here), which allow a hypothesized category occurrence introduced into a tree (thought of as a proof) to be discharged.

In the Gentzen style of natural deduction (see Pollard (2013)), hypothesized categories are written to the left of the symbol |- (turnstile), so that the two slash elimination rules above take the following form (where Γ and Δ are lists of categories, and comma represents list concatenation as in (4):

(4)
$$\frac{\Gamma \vdash A \quad \Delta \vdash A\backslash B}{\Gamma, \Delta \vdash B} \qquad \frac{\Gamma \vdash B/A \quad \Delta \vdash A}{\Gamma, \Delta \vdash B}$$

These rules propagate hypotheses (analogous to linguists' traces) downward through the proof tree (downward because logicians' trees are upside down with the conclusion ('root') at the bottom). In HPSG notation, these same rules can be written as one rule (since SUBCAT is nondirectional) in (5):

(5)
$$\frac{B[\text{SUBCAT} <..., A>, \text{SLASH} \ \Gamma] \quad A[\text{SLASH} \ \Delta]}{B[\text{SUBCAT} <...>][\text{SLASH} \ \Gamma, \Delta]}$$

This in turn is a special case of an HPSG principle first known as the Binding Inheritance Principle (BIP) and later as the Nonlocal Feature Principle (binding features included SLASH as well as the features QUE and REL used for tracking undischarged interrogative and relative pronouns). The original statement of the BIP (Pollard 1986) treated SLASH as set- rather than list-valued):

> The value of a binding feature on the mother is the union of the values of that feature on the daughters.

For example, the doubly-gapped VP in the violins-and-sonatas example in (1) is analyzed in HPSG roughly as is shown in Figure 1 and essentially the same way in Lambek-style CG:

(6)
$$\frac{\dfrac{\overset{\text{play}}{\vdash ((NP\backslash S)/PP)/NP} \quad \overset{t}{NP \vdash NP}}{NP \vdash (NP\backslash S)/PP} \quad \dfrac{\overset{\text{on}}{\vdash PP/NP} \quad \overset{t}{NP \vdash NP}}{NP \vdash PP}}{NP, NP \vdash NP\backslash S}$$

V[SUBCAT <NP>, SLASH <NP, NP>]

V[SUBCAT <PP, NP, NP>]   NP[SLASH <NP>]   PP[SLASH <NP>]

P[SUBCAT <NP>]   NP[SLASH <NP>]

play   t   on   t

Figure 1: *play on* as part of *Violins this finely crafted, even the most challenging sonatas are easy to play on.*

Aside from the binary branching of the Lambek analysis, the main difference is that HPSG traces of the form A[SLASH <A>] correspond to Lambek axioms of the form A |- A, which is the standard mechanism for introducing hypotheses in Gentzen-style natural deduction.

An overview and elaboration of early HPSG is provided by the two books Pollard & Sag (1987) and Pollard & Sag (1994). Confusingly, the former is called *Information-Based Syntax and Semantics, Volume 1: Fundamentals*, and the second simply *Head-Driven Phrase Structure Grammar* (not *Information-Based Syntax and Semantics, Volume 2*). The reason for the title change had to do with a change in the underlying mathematical theory of feature structures. In the first book, following work in theoretical computer science by Rounds & Kasper (1986) and Moshier & Rounds (1987), feature structures were treated as data structures that supplied partial information about the linguistic objects being theorized about; this perspective in turn was based on Scott's (1982) mathematical theory of computation in terms of what he called information systems. Subsequently, Paul King persuaded Pollard and Sag that it was more straightforward to distinguish between feature structures, thought of as formal models of the linguistic objects, and feature descriptions or formulas of feature logic, which provided partial information about them, as described in his Manchester dissertation (King 1989). Although the formal issues involved in distinguishing between the two approaches are of interest in their own right, they seem not to have had a lasting effect on how theoretical linguists used HPSG, or on how computational linguists implemented it. As for subject matter, Pollard & Sag (1987) was limited to the most basic notions, including syntactic features and categories (including the distinction between head features and binding features); subcategorization and the distinction between arguments and adjuncts (the latter of which necessi-

tated one more rule schema beyond the three proposed by Pollard (1985)); basic principles of grammar (especially the Head Feature Principle and the Subcategorization Principle); the obliqueness order and constituent ordering; and the organization of the lexicon by means of a multiple inheritance hierarchy and lexical rules. Pollard & Sag (1994) used HPSG to analyze a wide range of phenomena that had figured prominently in the syntactic literature of the 1960s–1980s, including agreement, expletive pronoun constructions, raising, control, filler-gap constructions (including island constraints and parasitic gaps); so-called binding theory (the distribution of reflexive pronouns, nonreflexive pronouns, and non-pronominal NPs), and scope of quantificational NPs.

5 Theoretical Developments

Three decades of vigorous work since Pollard & Sag (1987) developing the theoretical framework of HPSG receive detailed discussion throughout the present volume, but we highlight here two significant stages in that development. The first is in Chapter 9 of Pollard & Sag (1994), where a pair of major revisions to the framework presented in the first eight chapters are adopted, changing the analysis of valence and of unbounded dependencies. Following **Borsley87**; Borsley (1988; 1989; 1990), Pollard and Sag move to distinguish subjects from complements, and further to distinguish subjects from specifiers, thus replacing the single SUBCAT attribute with SUBJ, SPR, and COMPS. This formal distinction between subjects and complements enabled an improved analysis of unbounded dependencies, eliminating traces altogether by introducing three lexical rules for the extraction of subjects, complements, and adjuncts respectively. It is this revised analysis of valence constraints that came to be viewed as part of the standard HPSG framework, though issues of valence representation cross-linguistically remain a matter of robust debate.

The second notable stage of development was the introduction of a type hierarchy of *constructions* as descriptions of phrasal feature structures, employed first by Sag (1997) in a richly detailed analysis of a wide variety of relative clause phenomena in English. This extension from the lexicon of the use of descriptions of typed feature structures organized in hierarchies to syntactic rules preserved the ability to express general principles holding for rule schemata while also enabling expression of idiosyncratic properties of phrases. In Borsley & Abeillé (2018), Chapter 1 of this volume, the version of the framework with this extended use of types is termed *Construction-based HPSG*, including further elaboration by Ginzburg & Sag (2000) to a comprehensive analysis of interrogatives in English.

6 The LinGO Project

In the early 1990s, a consortium of research centers in Germany secured funding from the German government for a large project in spoken language machine translation, called Verb*mobil* (Wahlster 2000), which aimed to combine a variety of methods and frameworks in a single implemented state-of-the-art demonstrator system. Grammars of German and English were to be implemented in HPSG, to be used both for parsing and for generation in the translation of human-human dialogues, with a German grammar initially implemented by Pollard and Tibor Kiss at IBM in Heidelberg, later replaced by one developed at the German AI Research Center (DFKI), coordinator for the Verb*mobil* project. The DFKI contracted in 1993 with Sag at CSLI to design and implement the English grammar, with Flickinger brought over from HP Labs to help lead the effort, forming a new research group at CSLI initially called ERGO (for English Resource Grammar Online), later generalized to the name LinGO (Linguistic Grammars Online). Early LinGO members included Wasow and linguistics graduate student Rob Malouf, who authored the initial implementation of the English Resource Grammar (ERG), along with two other linguistics graduate students: Kathryn Campbell-Kibler, who contributed to the development of the lexicon, and Tony Davis, who helped in refining the lexical type hierarchy.

During the first of the two four-year phases of the Verb*mobil* project, the focus was on designing and implementing core syntactic and semantic analyses, initially using the DISCO/PAGE platform (Uszkoreit et al. 1994) developed at the DFKI, and largely informed by the framework presented in Pollard & Sag (1994). However, a more computationally useful semantic formalism emerged, called Minimal Recursion Semantics (MRS: Copestake, Flickinger, Pollard & Sag (2005)), which Ann Copestake, formerly of the European ACQUILEX project, helped to design. Copestake also expanded the LKB system (Copestake 2002) which had been used in ACQUILEX, to serve as the grammar development environment for the LinGO project, including both a parser and a generator for typed feature structure grammars.

The second four years of the Verb*mobil* project emphasized development of the generation capabilities of the ERG, along with steady expansion of linguistic coverage, and elaboration of the MRS framework. LinGO contributors in this phase, in addition to Sag, Wasow, Flickinger, Malouf, and Copestake, included Stanford Linguistics graduate students Emily Bender and Susanne Riehemann, along with a regular visitor and steady contributor from the DFKI, Stephan Oepen. Verb*mobil* had meanwhile added Japanese alongside German (Müller & Kasper 2000) and

English (Flickinger, Copestake & Sag 2000) for more translation pairs, giving rise to another relatively broad-coverage HPSG grammar, JaCY, authored by Melanie Siegel at the DFKI (Siegel 2000). Work continued at the DFKI, of course, on the German HPSG grammar, written by Stefan Müller, adapted from his earlier Babel grammars (Müller 1999), and with semantics contributed by Walter Kasper.

Before the end of Verbmobil funding in 2000, the LinGO project had already begun to diversify into other application and research areas using the ERG, including over the next several years work on augmented/adaptive communication, multiword expressions, and hybrid processing with statistical methods, variously funded by the National Science Foundation, the Scottish government, and industrial partners including IBM and NTT. At the turn of the millenium, Flickinger joined the software start-up boom, co-founding YY Software funded through substantial venture capital to use the ERG for automated response to customer emails for e-commerce companies. YY produced the first commercially viable software system using an HPSG implementation, processing email content in English with the ERG and the PET parser (Callmeier 2000) which had been developed by Ulrich Callmeier at the DFKI, as well as in Japanese with JaCY, further developed by Siegel and by Bender. While technically capable, the product was not commercially successful enough to enable YY to survive the bursting of the dot-com bubble, and it closed down in 2003. Flickinger returned to the LinGO project with a considerably more robust ERG, and soon picked up the translation application thread again, this time using the ERG for generation in the LOGON Norwegian-English machine translation project based in Oslo.

7 Research and Teaching Networks

The first international conference on HPSG was held in 1993 in Columbus, Ohio, in conjunction with the Linguistic Society of America's Summer Institute. The conference has been convened every year since then, with locations in Europe, Asia, and North America. Two of these annual meetings have been held jointly with the annual Lexical Functional Grammar conference, in 2000 in Berkeley and in 2016 in Warsaw. Proceedings of these conferences since 2000 are available on-line from CSLI Publications.[3] Since 2003, HPSG researchers in Europe have frequently held a regional workshop in Bremen, Berlin, Frankfurt, or Paris, to foster informal discussion of current work in HPSG. These follow in the footsteps of European HPSG workshops starting with one on German grammar, held in

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[3]http://csli-publications.stanford.edu/HPSG/, 2018-08-21.

Saarbrücken in 1991, and including others in Edinburgh and Copenhagen in 1994, and in Tübingen in 1995.

In 1994, the HPSG mailing list was initiated,[4] and from 1996 to 1998, the electronic newsletter, the HPSG Gazette,[5] was distributed through the list, with its function then taken over by the HPSG mailing list.

Courses introducing HPSG to students became part of the curriculum during the late 1980s and early 1990s at universities in Osaka, Paris, Saarbrücken, Seoul, and Tübingen, along with Stanford and OSU. Additional courses came to be offered in Bochum, Bremen, Carnegie-Mellon, Göttingen, Heidelberg, Jena, and Potsdam. Summer courses and workshops on HPSG have also been offered since the early 1990s at the LSA Summer Institute in the U.S., including a course by Sag and Pollard on binding and control in 1991 in Santa Cruz, and at the European Summer School in Logic, Language and Information (ESSLLI), including a course by Pollard in Saarbrücken in 1991 on HPSG, a workshop in Colchester in 1992 on HPSG, a workshop in Prague in 1996 on Romance (along with two HPSG-related student papers at the first-ever ESSLLI student session), and courses in 1998 in Saarbrücken on Germanic syntax, grammar engineering, and unification-based formalisms, in 2001 on HPSG syntax, in 2003 on linearization grammars, and more since. Also in 2001, a Scandinavian summer school on constraint-based grammar was held in Trondheim.

Several HPSG textbooks have been published, including at least Borsley (1991; 1996), Sag & Wasow (1999), Sag, Wasow & Bender (2003), Müller (2007a; 2013a)), Müller (2016), Kim (2016), and Levine (2017).

8 Implementations and Applications of HPSG

The first implementation of a grammar in the HPSG framework emerged in the Hewlett-Packard Labs natural language project, for English, with a lexical type hierarchy (Flickinger, Pollard & Wasow 1985), a set of grammar rules that provided coverage of core syntactic phenomena including unbounded dependencies and coordination, and a semantic component called Natural Language Logic (Laubsch & Nerbonne 1991). The corresponding parser for this grammar was implemented in Lisp (Proudian & Pollard 1985), as part of a system called HP-NL (Nerbonne & Proudian 1987) which provided a natural language interface for querying relational databases. The grammar and parser were shelved when HP Labs terminated their natural language project in 1991, leading Sag and Flickinger to begin

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[4]Its archives can be found at https://hpsg.hu-berlin.de/HPSG/MailingList.

[5]http://www.sfs.uni-tuebingen.de/~gazette, 2018-08-21.

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the LinGO project and development of the English Resource Grammar at Stanford.

By this time, grammars in HPSG were being implemented in university research groups for several other languages, using a variety of parsers and grammar engineering platforms for processing typed feature structure grammars. Early platforms included the DFKI's DISCO system (Uszkoreit et al. 1994) with a parser and graphical development tools, which evolved to the PAGE system; the ALE system (Franz 1990; Carpenter & Penn 1996), which evolved in Tübingen to TRALE (Meurers et al. 2002; Penn 2004); and Ann Copestake's LKB (Copestake 2002) which grew out of the ACQUILEX project. Other early systems included ALEP within the Eurotra project (Simpkins & Groenendijk 1994), ConTroll at Tübingen (Götz & Meurers 1997), CUF at IMS in Stuttgart (Dörre & Dorna 1993), CL-ONE at Edinburgh (Manandhar 1994), TFS also at IMS (Emele 1994), ProFIT at the University of Saarland (Erbach 1995), Babel at Humboldt University in Berlin (Müller 1996), and HDrug at Groningen (van Noord & Bouma 1997).

Relatively early broad-coverage grammar implementations in HPSG, in addition to the English Resource Grammar at Stanford (Flickinger 2000), included one for German at the DFKI (Müller & Kasper 2000) and one for Japanese (Jacy: Siegel (2000)), all used in the Verbmobil machine translation project; a separate German grammar (Müller 1996; 1999); a Dutch grammar in Groningen (Bouma, van Noord & Malouf 2001); and a separate Japanese grammar in Tokyo (Miyao et al. 2005). Moderately large HPSG grammars were also developed during this period for Korean (Kim & Yang 2003) and Polish (Mykowiecka, Marciniak, Przepiórkowski & Kupść 2003).

In 1999, research groups at the DFKI, Stanford, and Tokyo set up a consortium called DELPH-IN (Initiative for Deep Linguistic Processing in HPSG), to foster broader development of both grammars and platform components, described in Oepen, Flickinger, Tsujii & Uszkoreit (2002). Over the next two decades, substantial DELPH-IN grammars were developed for Norwegian, Portuguese, and Spanish, along with moderate-coverage grammars for Bulgarian, Greek, Hausa, Hebrew, Indonesian, Mandarin Chinese, Thai, and Wambaya, all described at http://delph-in.net. Several of these grammars are based on the Grammar Matrix (Bender, Flickinger & Oepen 2002), a starter kit generalized from the ERG and Jacy for rapid prototyping of HPSG grammars, along with a much larger set of coursework grammars.[6]

Broad-coverage grammars developed in the TRALE system (Meurers et al. 2002; Penn 2004) include German (Müller 2007a), Danish (Müller & Ørsnes 2013),

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[6]http://moin.delph-in.net/MatrixTop, 2018-08-21.

and Persian (Müller 2010). Other TRALE grammars include Mandarin Chinese (Müller & Lipenkova 2013), Georgian (Abzianidze 2011), Maltese (Müller 2009), Spanish (Machicao y Priemer 2015), and Yiddish (Müller & Ørsnes 2011). Development of grammars in TRALE is supported by the Grammix system (Müller 2007b); Müller (2015) provides a summary of this family of grammar implementations.

These grammars and systems have been used in a wide variety of applications, primarily as vehicles for research in computational linguistics, but also for some commercial software products. Research applications already mentioned include database query (HP Labs) and machine translation (Verb*mobil* and LOGON), with additional applications developed for use in anthology search (Schäfer, Kiefer, Spurk, Steffen & Wang 2011), grammar tutoring in Norwegian (Hellan, Bruland, Aamot & Sandøy 2013), ontology acquisition (Herbelot & Copestake 2006), virtual robot control (Packard 2014), visual question answering (Kuhnle & Copestake 2017), and logic instruction (Flickinger 2017), among many others. Commercial applications include e-commerce customer email response (for YY Software), and grammar correction in education (for Redbird Advanced Learning, now part of McGraw-Hill Education: Suppes, Flickinger, Macken, Cook & Liang (2012)).

For most practical applications, some approximate solution to the challenge of parse selection (disambiguation) must be provided, so several of the DELPH-IN grammars, including the ERG, follow the approach of Oepen, Flickinger, Toutanova & Manning (2004), which uses a manually-annotated treebank of sentences parsed by a grammar to train a statistical model which is applied at run-time to identify the most likely analysis for each parsed sentence. These treebanks can also serve as repositories of the analyses intended by the grammarian for the sentences of a corpus, and some resources, notably the Alpino Treebank (Bouma, van Noord & Malouf 2001), include analyses which the grammar may not yet be able to produce automatically.

9 Prospects

As we noted early in this chapter, HPSG's origins are rooted in the desire simultaneously to address the theoretical concerns of linguists and the practical issues involved in building a useful natural language processing system. In the decades since the birth of HPSG, the mainstream of work in both theoretical linguistics and NLP developed in ways that could not have been anticipated at the time. NLP is now dominated by statistical methods, with almost all practical applications making use of machine learning technologies. It is hard to see any influence

of research by linguists in most NLP systems. Mainstream grammatical theory, on the other hand, is now dominated by the Minimalist Program (MP), which is too vaguely formulated for a rigorous comparison with HPSG.[7] Concern with computational implementation plays virtually no role in MP research; see Müller (2016) for a discussion.

It might seem, therefore, that HPSG is further from the mainstream of both fields than it was at its inception, raising questions about how realistic the objectives of HPSG are. We believe, however, that there are grounds for optimism.

With regard to implementations, there is no incompatibility between the use of HPSG and the machine learning methods of mainstream NLP. Indeed, as noted above, HPSG-based systems that have been put to practical use have necessarily included components induced via statistical methods from annotated corpora. Without such components, the systems cannot deal with the full variety of forms encountered in usage data. On the other hand, existing NLP systems that rely solely on machine learning from corpora do not exhibit anything that can reasonably be called understanding of natural language. Current technologies for machine translation, automatic summarization, and various other linguistic tasks fall far short of what humans do on these tasks, and are useful primarily as tools to speed up the tasks for the humans carrying them out. Many NLP researchers are beginning to recognize that developing software that can plausibly be said to understand language will require representations of linguistic structure and meaning like those that are the stock in trade of linguists.

Evidence for a renewed interest in linguistics among NLP researchers is the fact that major technology companies with natural language groups have recently begun (or in some cases, resumed) hiring linguists, and increasing numbers of new linguistics PhDs have taken jobs in the software industry.

In the domain of theoretical linguistics, it is arguable that the distance between HPSG and the mainstream of grammatical research (that is, MP) has narrowed, given that both crucially incorporate ideas from Categorial Grammar (see Retoré & Stabler (2004), Berwick & Epstein (1995), and Müller (2013b) for comparisons between MP and CG). Rather than trying to make that argument, however, we will point to connections that HPSG has made with other work in theoretical linguistics. Perhaps the most obvious of these is the work of Peter Culicover and Ray Jackendoff on what they call *Simpler Syntax*. Their influential 2005 book with that title (Culicover & Jackendoff 2005) argues for a theory of grammar that

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[7]Most work in MP is presented without precise definitions of the technical apparatus, but Edward Stabler and his collaborators have written a number of papers aimed at formalizing MP. See in particular Collins & Stabler (2016).

differs little in its architecture and motivations from HPSG.

More interesting are the connections that have been forged between research in HPSG and work in Construction Grammar (CxG). Fillmore (1988: 36) characterizes the notion of *construction* as "any syntactic pattern which is assigned one or more conventional functions in a language, together with whatever is linguistically conventionalized about its contribution to the meaning or use of structures containing it." Among the examples that construction grammarians have described at length are *the Xer, the Yer* (as in *the older I get, the longer I sleep*), *X let alone Y* (as in *I barely got up in time to eat lunch, let alone cook breakfast*), and *What's X doing Y?* (as in *What's this scratch doing in the table?*). As noted above and in Müller (2018), Chapter 37 of this volume, HPSG has incorporated the notion of construction since at least the late 1990s.

Nevertheless, work that labels itself CxG tends to look very different from HPSG. This is in part because of the difference in their origins: many proponents of CxG come from the tradition of Cognitive Grammar or typological studies, whereas HPSG's roots are in computational concerns. Hence, most of the CxG literature is not precise enough to allow a straightforward comparison with HPSG, though the variants called Embodied Construction Grammar and Fluid Construction Grammar have more in common with HPSG; see Müller (2017) for a comparison. In the last years of his life, Ivan Sag sought to unify CxG and HPSG through collaboration with construction grammarians from the University of California at Berkeley, particularly Charles Fillmore, Paul Kay, and Laura Michaelis. They developed a theory called *Sign-Based Construction Grammar* (SBCG), which would combine the insights of CxG with the explicitness of HPSG. Sag (2012: 70) wrote, "To readers steeped in HPSG theory, SBCG will no doubt seem like a minor variant of constructional HPSG." Indeed, despite the name change, the main feature of SBCG that differs from HPSG is that it posits an inheritance hierarchy of constructs, which includes feature structure descriptions for such partially lexicalized multi-word expressions as *Ved X's way PP*, instantiated in such VPs as *ad-libbed his way through a largely secret meeting*. While this is a non-trivial extension to HPSG, there is no fundamental change to the technical machinery. In fact, it has been a part of the LinGO implementation for many years.

That said, there is one important theoretical issue that divides HPSG and SBCG from much other work in CxG. That issue is locality. To constrain the formal power of the theory, and to facilitate computational tractability, SBCG adopts what Sag (2012: 150) calls "Constructional Localism" and describes as follows: "Constructions license mother-daughter configurations without reference to embedding or embedded contexts." That is. like phrase structure rules, constructions

must be characterized in terms of a mother node and its immediate daughters. At first glance, this seems to rule out analyses of many of the examples of constructions provided in the CxG literature. But Sag (2012: 150) goes on to say, "Constructional Localism does not preclude an account of nonlocal dependencies in grammar, it simply requires that all such dependencies be locally encoded in signs in such a way that information about a distal element can be accessed locally at a higher level of structure."

Fillmore (1988: 35) wrote:

> Construction grammars differ from phrase-structure grammars which use *complex symbols* and allow the *transmission of information* between lower and higher structural units, in that we allow the direct representation of the required properties of subordinate constituents. (Should it turn out that there are completely general principles for predicting the kinds of information that get transmitted upwards or downwards, this may not be a real difference.) (Fillmore 1988: 35)

SBCG is committed to the position alluded to in the parenthetical sentence in this quote, namely, that general principles of information transmission within sentences makes it possible to insist on Constructional Localism. See Müller (2018), Chapter 37 of this volume for a much more detailed discussion.

Finally, another point of convergence between work in HPSG and other work in both theoretical linguistics and NLP is the increasing importance of corpus data. In the early years of the HP NLP project, the methodology was the same as that employed in almost all work in theoretical syntax and semantics: the grammar was based entirely on examples invented by the researchers. At one point during the decade of the HP NLP project, Flickinger, Pullum, and Wasow compiled a list of sentences intended to exemplify many of the sentence types that they hoped the system would eventually be able to analyze. That list, 1328 sentences long, continues to be useful as a test suite for the LinGO system and various other NLP groups. But it does not come close to covering the variety of sentence forms that are found in corpora of speech and various written genres. As the goals of the HPSG implementations have broadened from database query to dealing with "language in the wild", the use of corpora to test such systems and motivate extensions to them has increased. This parallels a development in other areas of linguistics, which have also increasingly made use of large on-line corpora as sources of data and tests of their theories. This is a trend that we expect will continue.

In short, there are signs of convergence between work on HPSG and work in

other areas, and it seems plausible to think that the market for HPSG research will grow in the future.

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Chapter 3

Formal Background

Frank Richter

Goethe-Universität Frankfurt

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1 Introduction

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rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 4

The nature and role of the lexicon in HPSG

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This chapter discusses the critical role the lexicon plays in HPSG and the approach to lexical knowledge that is specific to HPSG. We describe the tenets of lexicalism in general, and discuss the nature and content of lexical entries in HPSG. As a lexicalist theory, HPSG treat lexical entries as informationally rich, representing the combinatorial properties of words as well as their part of speech, phonology, and semantics. Thus many phenomena receive a lexically-based account, including some that go beyond what is typically regarded as lexical. We then turn to the global structure of the HPSG lexicon, the hierarchical lexicon and inheritance. We show how the extensive type hierarchy employed in HPSG accounts for lexical generalizations at various levels and discuss some of the advantages of default (nonmonotonic) inheritance over simple monotonic inheritance. We then describe lexical rules and their various proposed uses in HPSG, comparing them to alternative approaches to relate lexemes and words based on the same root or stem.

1 Introduction

The nature, structure, and role of the lexicon in the grammar of natural languages has been a subject of debate for at least the last 50 years. For some, the lexicon is a prison that "contains only the lawless" to borrow a memorable phrase from Di Sciullo & Williams (1987), and not much of interest resides there. In some recent views, the lexicon records merely phonological information and some world

knowledge about each lexical entry (see Marantz (1997)). All of the action is in the syntax, save the expression of complex syntactic objects as inflected words. In contrast, lexicalist theories of grammar, and HPSG in particular, posit a rich and complex lexicon embodying much of grammatical knowledge.

This chapter has two principal goals. One is to review the arguments for and against a lexicalist view of grammar within the generative tradition. The other is to survey the HPSG implementation of lexicalism. In regard to the first goal, we begin with the reaction to Generative Semantics, and note developments that led to lexicalist theories of grammar such as LFG and then HPSG. Central to these developments was the argument that lexical processes, rather than transformational ones, provided more perspicuous accounts of derivational morphological processes. The same kinds of arguments then naturally extended to phenomena like passivization, which had previously been treated as syntactic. Once on this path, lexical treatments of other prototypically syntactic phenomena — long distance extraction, *wh*-movement, word order, and anaphoric binding — were advanced as well, with HPSG playing a leading role.

But this does not mean that opposition to lexicalism melted away. Both Minimalism (cross-ref here), in particular Distributed Morphology, and Construction Grammar (cross-ref here) claim that lexicalist accounts fail in various ways. We discuss some of these current issues, including phrasal processes in the lexicon, word-internal ellipsis, and endoclitics, each of which poses challenges for those who advocate a strict separation between lexical and syntactic systems. While we maintain that the anti-lexicalist arguments are not especially strong, and the phenomena they are based somewhat marginal, we acknowledge that these questions are not yet settled. We then turn to the specifics of the lexicon as modeled within HPSG. Lexicalism demands, of course, that lexical entries be informationally rich, encoding not merely idiosyncratic properties of a single lexical item like its phonology and semantics, but also more general characteristics like its combinatorial possibilities. We outline what HPSG lexical entries must contain, and how that information is represented. This leads naturally to the next topic: with so much information in a lexical entry, and so much of that repeated in similar ones, how is massive redundancy avoided? The hierarchical lexicon, in which individual lexical entries are the leaves of a multiple inheritance hierarchy, is a core component of HPSG. Types throughout the hierarchy capture information common to classes of lexical entries, thereby allowing researchers to express generalizations at various levels. Just as all verbs share certain properties, all transitive verbs, all verbs of caused motion, and all transitive verbs of caused motion share additional properties, represented as constraints on types

within the hierarchy. We draw on examples from linking, gerunds, and passives as illustrations, but many others could be added.

Constraints specified on types in the hierarchy are deemed to be inherited by their subtypes, but monotonic inheritance of this kind runs into vexing issues. Most obviously, there are irregular morphological forms; any attempt to represent, say, the phonology of English plurals, as a constraint on a plural noun class in the hierarchical lexicon must then explain why the plural of *child* is *children* and not *childs. Beyond this simple example, there are ubiquitous cases of lexical generalizations that are true by default, but not always. Various mechanisms for modeling default inheritance have therefore been one focus within HPSG, and we furnish an example of their use in modeling the properties of gerunds cross-linguistically.

Finally, we discuss lexical rules and their alternatives. Along with the "vertical" relationships between classes of lexical entries modeled by types and their subtypes in the hierarchical lexicon, there is a perceived need for "horizontal" relationships between lexical entries that are based on a single root or stem, such as forms of inflectional paradigms. Yet formalizing lexical rules adequately within HPSG has proven tricky; specifying just what information is preserved and what is changed by a lexical rule is one prominent issue. We conclude this chapter by describing alternatives to lexical rules. One is implicational statements on partially specified feature structures; this might be thought of as a kind of "online lexical rule". The second augments the type hierarchy via online type construction, extending the predefined lexical types specified in the hierarchy to include "virtual types" that combine the information from multiple predefined types.

2 Lexicalism

2.1 Lexicalism and the origins of HPSG

Lexicalism began as a reaction to Generative Semantics, which treated any regularity in the structure of words (derivational patterns, broadly speaking) as only ephiphenomenally a matter of word structure and underlyingly as a matter of syntactic structure (see Lakoff (1970), among others). In the Generative Semantics view, all grammatical regularities are a matter of syntax (much of it, in fact, logical syntax). Chomsky (1970) presented many arguments that lexical knowledge differs qualitatively from syntactic knowledge and should be modeled differently. Jackendoff (1975) is an explicit model of lexical knowledge that follows Chomsky's insights, although it focuses exclusively on derivational morpholog-

ical processes. The main insight that Jackendoff formalizes is that relations between stems and words (say, between *destruct* and *destruction*) are to be modeled not via a generative device but through a redundancy mechanism that measures the relative complexity of a lexicon where these relations are present or not present (the idea is that a lexicon where *construct* and *construction* are related is simpler than one where they are not). Bochner (1993) is the most formalized and detailed version of this approach to lexical relations. Lexicalist approaches, including LFG and HPSG, took their lead from Jackendoff's work. LFG relied heavily on treating relations between stems and between words as lexical rules, rather than the kind of generative devices that one finds in syntax. But, as accounts of linguistic phenomena in LFG focused increasingly on the lexicon, the question of whether lexical rules retained the character of redundancy rules or turned into yet another kind of generative device arose. Consequently, the necessity of lexical rules has been questioned as well (see Koenig & Jurafsky (1994) and Koenig (1999) for potential issues that arise once lexical rules are assumed to be involved in the creation of new lexical entries).

Lexicalism, at least within HPSG, embodies two distinct ideas. First is the idea that parts of words are invisible to syntactic operations (*lexical integrity*, see Bresnan & Mchombo 1995), so that relations between stems and between word forms cannot be the result of or follow syntactic operations, as in distributed morphology, or other linguistic models that assign no special status to the notion of word. Relations between words are therefore not modeled via syntactic operations (hence the appeal to Jackendoff's lexical rules). Second is the idea that the occurrence of a lexical head in distinct syntactic contexts arises from distinct variants of words. For instance, the fact that the verb *expect* can occur both with a finite clause and an NP+VP sequence (see (1) vs. (2)) means that there are two variants of the verb *expect*, one that subcategorizes for a finite clause and one where it subcategorizes for an NP+VP sequence.[1] Not all lexicalist theories, though, cash out these two distinct ideas the same way. The net effect of lexicalism within HPSG is that words and phrases are put together via distinct sets of constructions and that words are syntactic atoms. These two assumptions justify positing two kinds of signs, *phrasal-sign* and *lexical-sign* and go hand in hand with the surface-oriented character of HPSG and what one might call a principle of surface combinatorics: If expression A consists of B⊕C, then all grammatical

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[1]As this chapter is an overview of the approach to lexical knowledge HPSG embodies rather than a description of particular HPSG analyses of phenomena, we will sample liberally from various illustrative examples and simplify whenever possible the analyses so that readers can see the forest and not get lost in the trees.

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constraints that make reference to B and C are circumscribed to A.

(1) I expected to leave yesterday

(2) I expected that I would leave yesterday.

An evident concern regarding this view of the lexicon is the potential proliferation of lexical entries, replete with redundant information. Will it be necessary to specify all the information in these two entries for *expect* without regard for the large amount of duplication between them? Will the same duplication be needed for the verb *hope*, which patterns similarly? How will somewhat similar verbs, such as *imagine* and *suppose*, which allow finite complements but not infinitive ones, be represented? We will describe HPSG's solutions to these questions below, in our discussion of the hierarchical lexicon. First, however, we turn to recent arguments against lexicalism, and then discuss in more detail just what kinds of information should be in HPSG lexical entries.

2.2 Recent challenges to lexicalism

As there are been several challenges to lexicalism (see Bruening (2018) and Haspelmath (2011) among others for some recent challenges), we now explore lexicalism and lexical integrity in HPSG in more detail. We first note that lexicalism does not imply that word and phrase formation are necessarily different "components" as is often claimed (see Marantz 1997, Bruening (2018)). Some lexicalist approaches *do* assume that word formation and phrase building belong to two different components of a language's grammar (this is certainly true of Jackendoff 1975), but they need not. Within HPSG, there are approaches that treat every sign-formation (be it word-internal or word-external) as resulting from typed mother-daughter configurations (this is the hypothesis pursued in Koenig (1999), and is also the approach frequently taken in implementations of large-scale grammars where lexical rules are modeled as unary-branching trees, see the English Resource Grammar at http://www.delph-in.net/erg/). Furthermore, recent approaches to inflectional morphology model realizational rules through the very same tools the rest of a language's grammar uses (see Crysmann & Bonami (2016) and the chapter on morphology in this volume). There are also approaches to phrases where the same analytical tools developed to model lexical knowledge (see Section 4) are employed to model phrase-structural constructions (see Sag's 1997 analysis of relative clauses, for example). So, both in terms of the formal devices and in terms of analytical tools used to model datasets, words and phrases can be treated the same way in HPSG (alhtough they need not be). Somewhat

ironically, and despite claims to the contrary, word formation in the syntactico-centric approach Marantz or Bruening advocate *does* make use of distinct formal machinery to model word formation, namely realizational rules to model inflectional morphology (see Halle & Marantz 1993).

With this red herring out of the way, we concentrate on the two most important challenges Bruening (2018) and Haspelmath (2011) present to lexicalist views. The first challenge are cases of phrasal syntax feeding the lexicon, purportedly exemplified by sentences such as (3).

(3)   I gave her a don't-you-dare! look. (example (1a) in Bruening 2018)

We can provisionally accept for the sake of argument Bruening's contention that *don't-you-dare!* is a word in (3), despite its reliance on the (unjustified) assumption that the secondary object in (3) involves N-N compounding rather than an AP N structure (we refer readers to Bresnan & Mchombo (1995) or Müller (2010) for counter-arguments to Bruening's claim). Crucially, though, examples such as (3) have no bearing on HPSG's model of lexical knowledge, as HPSG-style lexicalism does not preclude constructions that form words from phrases. Nothing, as far as we know, rules out constructions of the form *phrase → stem/word* in HPSG. The two assumptions underlying HPSG brand of lexicalism we mentioned above do not preclude a *lexical-sign* having a *phrasal-sign* as sole daughter (although we do not know of any HPSG work that exploits this possibility) and examples such as (3) are simply irrelevant to whether HPSG's lexicalist stance is empirically correct.

The second challenge to lexicalism presented in Bruening (2018) bears more directly on HPSG's assumption that words are syntactic atoms. Word-internal conjunction/ellipsis examples, illustrated in (4) (adapted from Bruening's (31a)), seem to violate the assumption that syntactic constraints cannot "see" the internal structure of words, as ellipsis in these kinds of examples seems to have access to the internal part of the word *over-application*. In fact, though, such examples do not violate lexical integrity if one enriches the representation of composite words (to borrow a term from Anderson 1992) to include a representation of their internal phonological parts as proposed in Chaves (2008; 2014).

(4)   Over- and under-application of stress rules plagues Jim's analysis.

Chaves' analysis assumes that the phonology of compound words and words that contain affixoids (to borrom a term from Booij 2005) is structured. The MorphoPhonology or MP attribute of words (and phrases) is a list of phonological

forms and morphs information. The MP of compound words and words that contain affixoids includes a separate member for each member of the compound, or for the affixoid and stem. Thus in (4), the MPs of *overapplication* and *underapplication* each contain two elements: one for *over*/*under*, and one for *application*. Given this enriched representation of the morphophonology of words like *under/overapplication*, a single ellipsis rule can apply both to phrases and to composite words, eliding the second member of the word *overapplication*'s MP. As Chaves makes clear (p.304) such an analysis is fully compatible with lexical integrity, as there is no access to the internal structure of composite words, only to the (enriched) morphophonology of the entire word.

Haspelmath (2011) similarly challenges the view that syntactic processes may not access the internal structure of words, although Haspelmath's point is merely that what is a word is cross-linguistically unclear. So-called suspended affixation in Turkish (see (5)) also shows that word parts can be elided. We cannot discuss here whether Chaves' analysis can be extended to cases like (5) where suffixes are seemingly elided or whether lexical sharing (where a single word can be the daughter of two c-structure nodes à la McCawley 1982), as proposed in Broadwell (2008) is needed. What is important for current purposes is that these putative challenges to lexical integrity such as (4) or (5) do not necessarily render a substantive version of it implausible. The same is true of another potential challenge to lexical integrity which neither Bruening nor Haspelmath discuss, endoclitics, which we discuss next.

(5) kedi ve   köpek-ler-im-e
     cat   and dog-PL-1SG-DAT
     'to my cat(s) and dogs'

Endoclitics are clitics that at least appear to be situated within a word, rather than immediately preceding or following it, as clitics often do. (cross-reference to Abeillé & Penn chapter on clitics) In many cases, endoclitics appear at morphological boundaries, as in the well-studied pronominal clitics of European Portuguese (Crysmann 2001a). An approach similar to what we have referenced above for composite words and elided morphology may well extend to these as well. But some trickier cases have also come to light, in which the clitic appears within a morpheme, not at a boundary. Two of the best documented cases from the Northeast Caucasian language Udi (Harris 2000) and from Pashto (Tegey 1977; Roberts 2000; Dost 2007). Here are examples from Udi (6) and Pashto (7), where the clitics appear in the middle of verbs.

(6) q'ačaɣ-ɣ-on bez tänginax   baš=**q'un**-q'-e
     thief-PL-ERG my money.DAT steal₁-3PL-steal₂-AORII
     'Thieves stole my money.' (root *bašq'*, 'steal')

(7) a. ʈəlwɑhə́=**me**
       push.IMPF.PST.3SG-cl.1SG
       'I was pushing it.' (from Tegey 1977; Dost 2007)

    b. ʈə́l=**me**-wɑhə
       push₁-cl.1SG-push₂.PF.PST.3SG
       'I pushed it.' (from Tegey 1977; Dost 2007)

In these cases. as with clitics in general, there is a clash between the phonological criteria for wordhood, under which the clitics would be regarded as incorporated within words, and the syntactic constituency and semantic compositionality. But what makes these particularly odd is that these clitics are situated word-internally, even morpheme-internally. Udi subject agreement clitics such as *q'un* in (6) typically attach to a focused constituent, which can be a noun, a questioned constituent, or a negation particle as well as a verb (Harris 2000). Under certain conditions, as in (6), none of these options is available or permitted, and the clitic is inserted before the final consonant of the verb root, dividing it in two pieces, neither of which has any independent morphological status. Its position in this instance is apparently phonologically determined; it cannot appear word-finally or word initially, and as there is no morphological boundary within the word it must therefore appear within the monomorphemic root. Pashto clitics seek "second position," whether at the phrasal, morphological, or phonological level; *me* in (7) appears to be situated after the first stressed syllable (or metrical foot), which, in the case of (7b), also divides the verb into two parts that lack any independent morphological status.

If clitics are viewed as a syntactic phenomenon ("phrasal affixes", as Anderson (2005) puts it), these endoclitics must have "visibility" into the internal structure of words (be it morphological, prosodic, or something else), thereby seemingly violating lexical integrity. Anderson's brief account invokes a reranking of optimality theoretic constraints from their typical ordering, whereby the clitic's positional requirements outrank lexical integrity requirements. Crysmann (2001b) proposes an analysis, paralleling in many respects his account of European Portuguese clitics in Crysmann (2001a), using Kathol's topological fields (Kathol 1999). The "morphosyntactic paradox in Udi" is effectively "resolved on the basis of discontinuous lexical items"; this account then "parallels HPSG's represen-

tation of syntactic discontinuity." (cross reference to Müller's chapter on word order here)

For Pashto, researchers generally agree that the notion of second position is crucial, but that it can be defined at various levels— phrasal, lexical, and phonological. In this last case clitics can appear within a word following the first metrical unit, as illustrated above. (cross reference to Tseng's chapter on phonology, and Crysmann's on morphology here). Dost (2007) invokes word order domains (Reape 1994) and topological fields (Kathol 1999) at these various levels to account for this distribution of clitics. In this analysis, some words contain more than one order domain at the prosodic level. Lexical integrity is preserved to the extent that, while domains at the prosodic level are "visible" to clitics in Pashto, syntatic processes do not reference the internal makeup of words.

Still, these accounts of endoclitics in Udi and Pashto appear to breach the wall of the strictest kind lexical integrity, requiring that they have access to some of the internal structure of lexical entries through a partial decomposition of their morphophonology into distinct order domains. Yet we would not wish to advocate models that permit unconstrained violations of lexical integrity, either. The troublesome cases we have noted here are relatively marginal or cross-linguistically rare, and limited in scope to prosodic or morphophonological information and seem to only pertain to phonological interactions (ellipsis, insertion). As Broadwell (2008) points out when comparing possible analyses of Turkish suspended affixation, rejecting lexicalism altogether may lead to an unconstrained theory of the interaction between words/stems and phrases and incorrect predictions (e.g., that all affixes in Turkish can be suspended). Likewise, we would not expect to find a language in which endoclitics positioning is utterly unconstrained, and thus we would not wish to see grammatical theories abandon lexical integrity altogether.

3 Lexical entries in HPSG

3.1 What are lexical entries?

A consequence of HPSG's lexicalist stance is that there will be many lexical entries where one might at first glance expect a single entry. We will see below how HPSG handles multiple entries and classes of entries while avoiding redundancy, but it is important at the outset to clarify what a lexical entry is in HPSG. One of the misunderstandings about lexical knowledge is that it confuses descriptions and entities being described, or the distinction between constructions

and constructs (lexical entry vs. fully instantiated lexeme). As the chapter on the formal foundations of HPSG discusses, grammars in HPSG consist of *descriptions* of structures, and the lexicon thus consists of descriptions of what are fully specified lexemes. What is stored in the lexicon is descriptions of fully instantiated lexemes. To see the importance of the distinction between descriptions (stored entries) and the fully instantiated entries that are being described, consider HPSG's model of subcategorization and consider the relevant portion of the tree for sentence (2). HPSG's model of the dependency between heads and complements involves identity between the syntactic and semantic information of each complement (the value of the SYNSEM attribute) and a member of the list of complements the head subcategorizes for. Since there are infinitely many SYNSEM values, on the assumption that there are infinitely many clausal meanings (a point Jackendoff (1990) emphasizes), there are, in principle, infinitely many fully instantiated entries for the verb *see* subcategorizing for a clausal complement (as in (2)). But each of these fully instantiated entries for *expect*, one for each clausal sentence that corresponds to the tree in (8) corresponds to a single abstract description, and it is this description that the lexicon contains.

(8)

$$\left[\text{COMPS } \langle \boxed{1} \rangle\right] \quad \left[\text{SYNSEM } \boxed{1}\right]$$

The formal status of lexical entries has engendered a fair amount of theoretical work and some debate, particularly over the question of whether lexical entries must be fully specified. We will touch on some aspects of this further below, in connection with online type construction. For further discussion of these kinds of issues, see the chapters on Basic Properties and Elements and on Formal Background.

3.2 What information is in lexical entries?

Because lexical items play a critical role in accounting for the syntax of natural languages, lexical entries are informationally rich in HPSG. Aside from the expected phonological and semantic information, specific to each lexeme, they include morphological and combinatorial potential information. Morphological information serves as input to inflectional rules, but is also used to select the appropriate types of phrases (via their projection through the Head-Feature Principle), as shown in (9). Some verbs, for instance, select for a PP headed by a particular preposition; others select for VPs whose verb is a gerund, or a bare

infinitive, and so forth. Lexical entries thus include as much morphological information as both (inflectional) morphology and syntactic selection require.

(9) a. John conceived *of/*about* the world's tastiest potato chip..

b. John regretted *going/*(to) go* to the party.

We illustrate the second leading idea behind HPSG or LFG's lexicalism (that there are different variants of lexical heads for different contexts in which heads occur) with the French examples in (10). The verb *aller* 'go' in (10a) combines with a PP headed by *à* that expresses its goal argument and a subject that expresses its theme argument. The same verb in (10b) combines with the so-called non-subject clitic *y* that expresses its goal argument. We follow Miller & Sag (1997) and assume here that French non-subject clitics are prefixes. Since the context of occurrence of the head of the sentence, *aller*, differs across these two sentences (NP____PP[*à*] and NP *y*____ , respectively and informally), there will be two distinct entries for *aller* for both sentences, shown in (11) and (12) (we simplify the entries' feature geometry for expository purposes).

(10) a. Muriel va   à Lourdes.
         Muriel go-PRES.3RD.SG at Lourdes.

b. Muriel y   va.
    Muriel there go-PRES.3RD.SG

(11)
$$
\begin{bmatrix}
\text{MORPH} \begin{bmatrix} \text{FORM} & \boxed{5} \\ \text{I-FORM} & \boxed{5}\ va \\ \text{STEM} & v\text{-} \end{bmatrix} \\
\text{CAT} \begin{bmatrix} \text{HEAD} \begin{bmatrix} verb \\ \text{VFORM} \begin{bmatrix} \text{MOOD} & indic \\ \text{TNS} & pres \\ \text{AGR} & 3rdsing \end{bmatrix} \end{bmatrix} \\ \text{VAL} \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix} \\ \text{ARG-ST} \ \langle \boxed{1}\text{NP}[3rdsg]_{\boxed{3}}, \boxed{2}\text{PP}[à]_{\boxed{4}} \rangle \end{bmatrix} \\
\text{CONT} \begin{bmatrix} go\text{-}rel \\ \text{THEME} & \boxed{3} \\ \text{GOAL} & \boxed{4} \end{bmatrix}
\end{bmatrix}
$$

$$
(12) \quad
\begin{bmatrix}
\text{MORPH} & \begin{bmatrix} \text{FORM} & \textit{y-va} \\ \text{I-FORM} & \textit{va} \\ \text{STEM} & \textit{v-} \end{bmatrix} \\[2em]
\text{CAT} & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix} \textit{verb} \\ \text{VFORM} & \begin{bmatrix} \text{MOOD} & \textit{indic} \\ \text{TNS} & \textit{pres} \\ \text{AGR} & \textit{3rdsing} \end{bmatrix} \end{bmatrix} \\[2em]
\text{VAL} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \rangle \end{bmatrix} \\[1em]
\text{ARG-ST} & \langle \boxed{1}\text{NP}[\textit{3rdsg}]_{\boxed{3}}, \ \text{PP}[\textit{p-aff,loc}]_{\boxed{4}} \rangle
\end{bmatrix} \\[3em]
\text{CONT} & \begin{bmatrix} \textit{go-rel} \\ \text{THEME} & \boxed{3} \\ \text{GOAL} & \boxed{4} \end{bmatrix}
\end{bmatrix}
$$

CATegory information in both entries include part of speech information (including morphologically relevant features of verb forms), ARGument-STructure information and VALence information. MORPH information includes both stem form information, inflected form information (I-FORM) and, in case so-called clitics are present, the combination of the clitic and inflected form information. Both entries illustrate how informationally rich lexical entries are in HPSG. But, postulating informationally rich entries does not mean stipulating all of the information within every entry. In fact, only the stem form and the relation denoted by the semantic content of the verb *aller* need be stipulated within either entry. All the other information can be inferred once it is known which classes of verbs these entries belong to. In other words, most of the information included in the entries in (11) and (12) is not specific to these individual entries, an issue we take up in Section 4. The entry-specific information in (11) and (12) is in black font while the shared information is in gray font; the informational difference between the two entries for *va* and *y va* is included in shadowed boxes in the respective entries. The first difference between the two variants of *va* 'goes' is in the list of complements: the entry for *y va* does not subcategorizes for a locative PP since the affix *y* satisfies the relevant argument structure requirement. This difference in the realization of syntactic arguments (via phrases and pronominal affixes) is recorded in the type of the PP members of ARG-ST, *p-aff* in (12) but not in (11). Finally, the two entries differ in the FORM of the verb, which is the same

as the inflected form of the verb in (11) (as indicated by the identically numbered ⑤), but not in (12) whose FORM includes the prefix *y*.

One other question arises with regard to the information in lexical entries. Are there attributes or values that occur solely within lexical signs, and not in phrasal ones? If so, they would provide a diagnostic for distinguishing lexical signs from others. Specific phonological information, for instance, is something we would expect to be introduced by lexical entries, and not elsewhere. Some information is claimed to be specific to lexical signs, such as phonological information (cross reference to Tseng here) and the ARG-ST list, on the premise that lexical items alone specify combinatorial requirements (but see Przepiórkowski (2001) for a contrary view, and see the chapter on Construction Grammar for other views questioning this assumption). But HPSG researchers have generally not typically explored this question in depth, and we will leave this issue here.

3.3 The role of the lexicon in HPSG

As we hope is evident by now, the lexicon plays a critical role in HPSG's explanatory mechanisms, as words encode their distributional potential, as well as their idiosyncratic phonological and semantic charateristics. Much of the information contained in lexical entries is geared to modeling the combinatorial potential of words. As detailed in the chapter on Argument Structure, their combinatorial potential is recorded using two kinds of information, a list of syntactic arguments or syntactic requirements to be satisfied, and distinct lists that indicate how these requirements are to be satisfied (as local dependents, as non-local dependents, as clitics/affixes). Not only are syntactic arguments recorded; so is their relative obliqueness (in terms of grammatical function), as per the partial hierarchy in (13) from Pollard and Sag 1992.

(13)   SUBJECT < PRIMARY OBJ < SECOND OBJ < OTHER COMPLEMENTS

We illustrate this explanatory role by alluding to the role of the lexicon in HPSG's approach to binding, as described in Pollard & Sag (1992) (see the chapter on Binding for details). As lexical entries of heads record both syntactic and semantic properties of their dependents, constraints between properties of heads and properties of dependents, e.g. subject-verb agreement, or between dependents, e.g. binding constraints illustrated in (15), can be stated as constraints on classes of lexical entries. The principle in (15) is such a constraint.

(14)   a. Mathilda$_i$ saw herself$_i$ in the mirror.
         b. *Mathilda$_i$ saw her$_i$ in the mirror.

(15)   An anaphor must be coindexed with a less oblique co-argument, if there is one.

Principle (15) is, formally, a constraint on lexical entries that makes use of the fact that an entry's argument structure records the syntactic and semantic properties of a word's dependents. The three argument structures in (16) illustrate permissible and ungrammatical entries. (16a) illustrates exempt anaphors as there is no less oblique syntactic argument than the anaphoric NP; (16b) illustrates a non-exempt anaphor properly bound by a less oblique, co-indexed non-anaphor; (16c) illustrates an ungrammatical lexical entry that selects for an anaphoric syntactic argument that is not co-indexed by a less oblique syntactic argument, despite not being an exempt anaphor (i.e., not being the least oblique syntactic argument).

(16)   a. $\left[\text{ARG-ST} \; \langle \text{NP}_{i,+ana}, ... \rangle \right]$

     b. $\left[\text{ARG-ST} \; \langle \text{NP}_{i,-ana}, ..., \text{NP}_{i,+ana}, ... \rangle \right]$

     c. $^{*}\left[\text{ARG-ST} \; \langle \text{XP}_{j}, ..., \text{NP}_{i,ana}, ... \rangle \right]$

Our purpose here is not to argue in favor of the specific approach to binding just outlined. Rather, we wish to illustrate that in a theory like HPSG where much of syntactic distribution is accounted for by properties of lexical entries, co-occurrence restrictions treated traditionally as constraints on trees (via some notion of command) are modeled as constraints on the argument structure of lexical entries. It is tempting to think of such a lexicalization of binding principles as a notational variant of tree-centric approaches. Interestingly, this is not the case, as argued in Wechsler (1999). Wechsler argues that the difference between argument structure and valence is critical to a proper model of binding in Balinese. Summarizing briefly, voice alternations in Balinese (e.g., objective or agentive voices) do not alter a verb's argument structure but do alter its valence, which is the subject and object it subcategorizes for. As binding is sensitive to relative obliqueness within ARG-ST, binding possibilities are not affected by voice alternations within the same clause, which are represented with different valence values. In the case of raising, on the other hand, the argument structure of the raising verb and the valence of the complement verb interact, as the subject of the complement verb is part of the argument structure of the raising verb. An HPSG approach to binding therefore predicts that voice alternations within the embedded clause will not affect binding of co-arguments of the embedded verb, but will affect binding of the raised NP and an argument of the embedded verb. This prediction seems to be borne out, as the examples in (17) show.

(17)   a.   Ia$_i$ nawang awakne$_i$/Ia$_{*i}$ lakar tangkep polisi.
            3rd AV.know self/3rd   FUT OV.arrest police
            'He$_i$ knew that the police would arrest self$_i$./him$_{*i}$.'

       b.   Cang ngaden ia$_i$ suba   ningalin awakne$_i$/ia$_{*i}$
            1sg AV.think 3rd already AV.see   self/3rd
            'I believe him$_i$ to have seen himself$_i$/ him$_{*i}$.'

       c.   Cang ngaden awakne$_i$ suba   tingalin=a$_i$.
            1sg AV.think self$_i$ already OV.see=3
            'I believe him to have seen himself.'

Sentence (17a) shows that the proto-agent (the first element of ARG-ST) of the subject-to-object raising verb *nawang* 'know' can bind the raised subject (which in this case corresponds to the proto-patient of the complement verb *tangkep* 'arrest' since that verb is in the objective voice). Sentence (17b) shows that the raised (proto-agent) subject of the complement verb can bind its proto-patient argument. Critically, sentence (17c) shows that the raised proto-patient (second) argument of the complement verb can be bound by the complement verb's proto-agent. The contrast between sentences (17b) and (17c) illustrates that while binding is insensitive to valence alternations (the same proto-agent binds the same proto-patient argument in both sentences), raising is not (the proto-agent argument is raised in (17b) and the proto-patient argument in (17c)). As Wechsler argues, this dissociation between valence subjects and less oblique argumentson the ARG-ST list is hard to model in a configurational approach to binding that equates the two notions in terms of c-command or the like. What is important for our purposes is that a 'lexicalization' of argument structure, valence, and binding has explanatory power beyond tree configurations, illustrating some of analytical possibilities informationally rich lexical entries create.

3.4 Lexical vs. constructional explanations

As we have noted above, HPSG posits that much of the combinatorics of natural language syntax is lexically determined; lexical entries contain information about their combinatorial potential and, if a word occurs in two distinct syntactic contexts, it must have two distinct combinatorial potentials. Under this view, phrase-structure rules are boring and few in number. They are just the various ways for words to realize their combinatorial potential. In the version of HPSG presented in Pollard & Sag (1994), for example, there are only a handful of general phrase-structural schemata, one for a head and its complements, one for a head

and its specifier, one for a head and a filler in an unbounded dependency and so forth and the structure of clauses is relatively flat in that relations between contexts of occurrence of words is done "at the lexical level" rather through operations on trees.

In a transformational approach, on the other hand, relations between contexts of occurrence of words are seen as relations between trees, and the information included in words can be thus rather meager. In fact, in some recent approaches, lexical entries contain nothing more than some semantic and phonological information, so that even part of speech information is something provided by the syntactic context (see Borer 2003; Marantz 1997). In some constructional approaches (Goldberg (1995), for example), part of the distinct contexts of occurrence of words comes from phrase structural templates that words fit into. So again, there can be a single entry for several contexts of occurrence.

HPSG's approach to lexical knowledge is quite similar to that of Categorial Grammar (to some degree this is due to HPSG's borrowing from Categorial Grammar important aspects of its view on subcategorization). As in HPSG, the combinatorial potential of words is recorded in lexical entries so that two distinct contexts of occurrence correspond to two distinct entries. The difference from HPSG lies in how lexical entries relate to each other. In Categorial Grammar (be it Combinatorial or Lambek-calculus style), relations between entries are the result of a few general rules (e.g., type raising, function composition, hypothetical reasoning …) and the assumption is that those rules are universally available (although those rules could be organized in a type hierarchy, as in Baldridge (2002)). Relations between entries in HPSG can be much more idiosyncratic and language-specific. We note, however, that nothing prevents lexical rules constituting a part of a Categorial Grammar (see Carpenter 1992a), so that this difference is not necessarily qualitative, but concerns how much of researchers' efforts are typically spent on extracting lexical regularities; HPSG has focused much more, it seems, on such efforts.

4 The hierarchical lexicon

We have seen that lexicalism demands that lexical entries be information rich, in order to encode what might otherwise be represented as syntactic rules. To avoid massive and redundant stipulation within each lexical entry, we need mechanisms to represent regularities within the lexicon. Two main mechanisms have been used in HPSG to represent these regularities. The first mechanism is the organization of information shared by lexical entries or parts of entries into a hi-

erarchy of types in a way quite similar to semantic networks within Knowledge Representation systems (see among others Brachman & Schmolze 1985). This hierarchy of types (present in HPSG since the beginning, Pollard & Sag (1987) and the seminal work of Flickinger (1987)) ensures that individual lexical entries only specify information that is unique to them. The second mechanism is lexical rules, which relates variants of entries, and more generally, members of a lexeme's morphological family (which consists of a root or stem as well as all stems derived from that root or stem). In this section, we discuss the hierarchical organization of the lexicon into cross-cutting classes of lexical entries at various levels of generality.

4.1 Inheritance

All grammatical frameworks classify lexical entries to some extent, of course. Basic part of speech information is one obvious case. This high-level classification is present in HPSG, too, as part of the hierarchy of types of heads. That information is recorded in the value of the HEAD feature. A simple hierarchy of types of heads is depicted in (18).

(18)
$$
\begin{array}{c}
\textit{head} \\
\diagup \quad | \quad \diagdown \\
\textit{noun} \quad \textit{verb} \quad \textit{...}
\end{array}
$$

Each of these types is a partial specification of a lexical entry's head properties. Typing of HEAD information allows the ascription of appropriate properties to different classes of lexical entries. For example, case information is only relevant to nouns, and whether a verb is an auxiliary or not is only relevant to verbs. Each type in (18) includes in its definition a specification of which features are appropriate for it, as shown in (19). (19) specifies what it means to be a noun or a verb in a particular language (of course, there will strong similarities in these properties across languages).

(19) a. *noun* $\Rightarrow$ $\begin{bmatrix} \text{CASE} & \textit{case} \end{bmatrix}$

b. *verb* $\Rightarrow$ $\begin{bmatrix} \text{AUX} & \textit{boolean} \\ \text{TENSE} & \textit{tns} \\ \text{ASPECT} & \textit{asp} \end{bmatrix}$

More technically, each type of head imposes some constraint on lexical entries of that type. Thus, (19a) requires all noun lexemes to be eligible for case information. Here, the constraint on each type specifies the value of SYNSEM|LOC|CAT|HEAD.

as the atomic value *noun*, *verb*, etc. Since these atomic values are disjoint, and since the HEAD value is unique for each lexical entry, the types in (18) are also disjoint. If there's a type corresponding to each possible HEAD value, then they constitute a partition of lexical entries as well. Lexical entries for particular lexemes make use of the definitions of types like (19) to abstract information that is shared across classes of entries. Thus, the pronoun *him* need only include the fact that its HEAD is of type *noun*; the fact that it might bear case can be inferred. Similarly, the entry for the verb *can* need only include information that its head information include the specification [AUX +] for us to be able to infer that it is a *verb*.

So far, this is merely an HPSG implementation of a part of speech taxonomy, but once we consider subtypes with additional constraints the utility of the hierarchical lexicon within a lexicalist framework becomes apparent. There are interesting generalizations to be made about more specific classes, such as transitive verbs, or past participles, or predicators denoting caused motion (regardless of their part of speech). In the hierarchical lexicon, we can represent these "interesting" classes as types. Which classes are worth instantiating in the grammar of a given language depends on its grammar; thus we expect lexical classes to specify a mix of cross-linguistically common (maybe, in some cases, universal) and language-particular constraints. Consider some of the subtypes of verbs shown in (20) adapted from Bouma et al. (2000):

(20)

Again, each subtype specifies additional information constraining the lexical entries belonging to it. The boxed labels have no independent formal status (although they play a role in the framework of online type construction, discussed below), indicating simply that the parent type, here *verb*, is partitioned by the subtypes under each box. Typically, this means that each subtype specifies an atomic value for a particular attribute, out of a set of mutually disjoint values, as in the part of speech types above. Thus *main-verb* and *aux-verb* are disjoint subtypes of *verb*, with the values + and − for the attribute SYNSEM|LOC|CAT|HEAD|AUX.

More specific verb subtypes can combine the constraints of the types depicted in (20), through multiple inheritance. Infinitive forms of transitive verbs, for example, inherit the constraints of both *infinitive-verb* and *transitive-verb*. Provided

that the constraints do not conflict (i.e., the descriptions of the two types unify), such a type can exist and have members. Whether it is useful to reify such a type is another matter; not all possible combinations of constraints yield linguistically interesting classes of lexical entries (this is another issue we address in the discussion of online type construction). It seems desirable, for instance, to avoid a proliferation of types for each form of a verb in a paradigm in an inflectionally complex language, as the number of forms, and thus types, would be extremely large (there are, for example, 2,494 combinations of inflectional prefixes in Oneida, a Northern Iroquoian language, Karin Michelson, p.c.). While an economical type-based description of regular morphological paradigms may prove descriptively adequate, it is implausible in assuming that each form of every fully regular verb is reified as a lexical entry. We will discuss mechanisms (lexical rules and online type construction) that offer better accounts of morphologically regular and productive word formation below.

In general, types are posited in the hierarchy when there is some additional constraint to state about them. We now briefly examine some of the lower levels of the lexical hierarchy; that is, some more specific lexical types that illustrate how types is one way to reduce the amount of information that needs to be stipulated in individual lexical entries and are one of the tools HPSG employs to represent lexical generalizations. We begin with the *transitive-verb* type (*trans-vb* for short). Apart from requiring its ARG-ST list to contain two NPs, *trans-vb* is further constrained, at least in English, to be a main verb rather than an auxiliary verb (see the value of HEAD *main* in (21) and the hierarchy of verbal head information in (20)): there are no transitive auxiliaries in English. So, *trans-vb* includes information constraining the feature values of transitive verbs that goes beyond simply specifying the nature of the ARG-ST list.

The partial representation of the type *transitive-verb* in (21).

$$
(21) \quad \begin{bmatrix} \textit{trans-vb} \\ \textsc{head} & \textit{main} \\ \textsc{arg-st} & \langle \text{NP, NP, ...} \rangle \end{bmatrix}
$$

A more specific subtype of *trans-vb* is *caused-motion-transitive-verb*, which states information about the semantics of verbs in the class as well as their subcategorization, as in (22). (↑ indicates that the type that follows it is a supertype of the type indicated in the feature structure; in this case that *caused-mot-trans-vb* is a subtype of *trans-vb*.)

$$(22) \quad \begin{bmatrix} \textit{caused-mot-trans-vb}(\uparrow \textit{trans-vb}) \\ \text{CONTENT} \quad \begin{bmatrix} \textit{caused-motion-rel} \\ \text{CAUSER} \quad \boxed{1} \\ \text{MOVED} \quad \boxed{2} \end{bmatrix} \\ \text{ARG-ST} \quad \left\langle \text{NP}_{\boxed{1}}, \text{NP}_{\boxed{2}} \right\rangle \end{bmatrix}$$

The information in each type constitutes constraints on objects of that type. With the types situated in a hierarchy, each type inherits all the constraints of its supertypes. Thus constraints will be inherited from supertypes. But additional constraints can be added at the level of that type as well; this is the principal fashion in which generalizations about classes of lexical entries can be stated. For example, following Davis & Koenig (2000) and Koenig & Davis (2003) we might state a contraint on argument realization on the type *caused-motion-transitive-verb*, to ensure that the causer is linked to the subject and the entity that is caused to move to the direct object, as in (23). (cross-reference to chapter on argument structure and linking here) Here, we make use of Richter's logic (Richter 1999) to encode constraints on information that is included in lexical entries. The constraint in (23) says that if a verb's semantic content is a cause relation, the causer arguments corresponds to the index of the first NP on the ARG-ST list and that if a verb's semantic content is a motion relation, the moved entity is realized as an NP. Implicational constraints such as (23) relieve some of the burden of encoding generalizations over lexical entries exclusively through the lexical type hierarchy, and can lead to a simpler model of lexical generalizations in some cases, as Koenig & Davis (2003) point out. When it is preferable to use a hierarchy of lexical types or conditional constraints on the information included in lexical types remains an open issue.

$$(23) \quad \begin{bmatrix} \text{CONTENT} \quad \textit{cause-rel} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{CONT} \quad \begin{bmatrix} \text{CAUSER} \quad \boxed{1} \end{bmatrix} \\ \text{ARG-ST} \quad \left\langle \text{NP}:\boxed{1}, ... \right\rangle \end{bmatrix}$$

$$\begin{bmatrix} \text{CONTENT} \quad \textit{move-rel} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{CONT} \quad \begin{bmatrix} \text{MOVED} \quad \boxed{1} \end{bmatrix} \\ \text{ARG-ST} \quad \left\langle ...\text{NP}:\boxed{1}, ... \right\rangle \end{bmatrix}$$

More specific classes of transitive caused-motion verbs, such as the *spray* verbs in English that exhibit locative alternations, inherit the additional constraints in (22) and further specify additional semantic constraints that characterize these alternating verbs. The hierarchical organization of lexical types allows us to state these additional restrictions, which are often language-particular, in the appropriate place without additional formal mechanisms. The range of ditransitive constructions, to take one such case, varies across languages, with some lacking

them entirely and others freely allowing them in, e.g., morphologicallly productive causatives of any transitive verb. For those languages, like English, in between these extremes, semantic (and possibly other) constraints can be placed on the type *ditransitive-verb*, limiting such verbs to those involving, e.g., transfer of possession.

We now illustrate how the organization of the lexicon in a hierarchy of lexical types minimizes the information that needs to be specified within individual entries, such as those for the forms of the French verb *va* we provided earlier (see (11)). We start with semantics and how it links to the argument structure. We can infer that the use of *va* illustrated in (10a) includes two arguments, a theme and a goal, from the hierarchy of semantic relations, which ensures that all types of directed motion events, of which *go-rel* is a subtype, includes these two arguments (see Davis (2001) for such an approach to semantic relations). The linking of these arguments to an NP and PP follows either from linking types, as in Davis & Koenig (2000) or Davis (2001), or from constraints similar to those we show above in (23) for English caused-motion verbs. The relation between the argument structure of *va* and its subcategorization requirements for a subject and PP complement follows from general constraints on words and a general type for intransitive verbs, analogous to (21) for transitive verbs. The inflectional features of this form are instantiations of possible combinations of values of mood, tense, and agreement information within French verbs. Finally, the expression of these inflectional features is the result of either general lexical rules (see Miller & Sag (1997) for some examples) or, as in more recent work in HPSG, a network of associations between morphosyntactic features and forms at various positions in the word (see Crysmann & Bonami 2016). In the end, nothing but the meaning of this use of *va* and the fact that the stem form is *v-* need be stipulated in the entry.

4.2 The lexicon as repository of generalizations at various levels

The hierarchical lexicon makes it possible to specify constraints on classes of lexical entries at any level, not just, e.g., all nouns, or a single word. An illustrative example, drawn from Ackerman & Webelhuth (1998), involves German passives, which come in several varieties, each with its own constraints. Each passive construction uses a different auxiliary: (*werden*, *sein*, or *bekommen*) and two of these constructions require a participial form of the verb, while the *sein* passive requires *zu* followed by an infinitive VP. Additionally, passives appear attributively, as NP modifiers, as well as predicatively. Here are two examples of the *zu* + infinitive passive, the first attributive, the second predicative:

(24) a. de dem Mann von Johann zu schenkenden Blumen
      the the man by Johann to give   flowers
      'the flowers that must be given to the man by Johann'

    b. weil   die Blumen den Mann von Johann zu schenken sind
      because the flowers the man   by Johann to give   are
      'because the flowers must be given to the man by Johann'

Ackerman & Webelhuth's account of German passives posits a multiple inheritance hierarchy of lexical types in German, a portion of which is shown in Figure 1.

Figure 1: A portion of the hierarchy of passive lexical types according to Ackermann and Webelhuth, p.244

While all passives share the constraint that a logical subject is demoted, as stipulated on a general *univ-pas-bas-lci* passive type, the other requirements for each kind of passive are stated on various subtypes. The *zu*+infinitive passive, for instance, requires not only that *sein* is the auxiliary and that the main verb is infinitive, but that the semantics involves necessity or obligation. This differs from the other passives, which simply maintain the semantics of their active counterparts. However, the types of the passive verb *schenken(den)* in (24) both

inherit from several passive verb supertypes. As mentioned, at a general level, there is information common to all German passives, or indeed to passives universally, namely that the "logical subject" (first element of the basic verb's ARG-ST list) is realized as an oblique complement of the passive verb, or not at all. A very common subtype, which Ackerman & Webelhuth also regard as universal, rather than specific to German, specifies that the base verb's direct object is realized as the subject of its passive counterpart; this defines personal passives. Once in the German-specific realm, an additional subtype specifies that the logical subject, if realized, is the object of a *von*-PP; this holds true of all three types of German personal passives. Among its subtypes is one that requires *zu* and the infinitive form of the verb; moreover, although Ackerman & Webelhuth do not spell this out in detail, this subtype specifies the modal force characteristic of this passive construction but not of the others. Finally, both the predicative and attributive forms are subtypes of all the preceding, but these inherit also from distinct supertypes for predicative and attributive passives of all kinds. The supertype for predicative passives constrains them to occur with an auxiliary; its subtype for *zu* + infinitive passives further specifies that the auxiliary is *sein*. The attributive passive type, on the other hand, inherits from modifier types generally, which do not allow auxiliaries, but do require agreement in person, number, and case with the modified noun. In summary, the hierarchical lexicon is deployed here to factor out the differing properties of the various German passive constructions, each of which obtains its particular combination of properties via multiple inheritance.

The most specific types of the lexical hierarchy, where individual lexical entries reside, is where constraints pertaining solely to a given word or root – its phonological form, inflectional class, specific semantics, register, and so forth – are stated. Specific information about a word needs to be spelled out somewhere in any grammatical framework. In a hierarchically organized lexicon we can view this as just the narrowest, most particular case of specifying information about a class of linguistic entities. But where information is shared across a broader set of lexical entries, it need not be stated separately for each one. Thus, the phonology of the word *spray* and the precise manner of motion of the particles or liquid caused to move in a spraying event are unique to this lexical entry. However, much of its syntactic and semantic behavior— it is a regular verb, participating in a locative alternation, involving caused ballistic motion of a liquid or other dispersable material— is shared with other English verbs such as *splash*, *splatter*, *inject*, *squirt*, and *drizzle*. To the extent that these "narrow conflation classes," as Pinker (1989) terms them, are founded on clear semantic criteria, we can readily

state syntactic and semantic constraints at the appropriate level in the hierarchical lexicon (some, however, such as Briscoe & Copestake (1999), cast doubt on the feasibility of formulating such constraints for dative and other alternations in English, suggesting that lexical rules might be a better alternative). Given this semantic similarity, it may be that much of the semantics of a verb like *spray* need not be specified at the level of that individual lexical entry. Apart from the broad semantics of caused motion, shared by numerous verbs, the verbs in the narrow conflation class containing *spray* share the selectional restriction, noted above, that their objects are set in motion by an initial impulse and that they are liquid or particulate material. We might therefore posit a subtype of the type *caused-motion-rel* to represent this shared semantics triggering the locative alternation, with further subtypes of that for the semantics of the individual verbs. Note that not all these constraints apply to precisely the same class (there are other verbs with somewhat different semantics, like *load* and *wrap*, exhibiting the locative alternation, for example), so a multitude of types in the hierarchy is crucial.

4.3 Default inheritance in the lexicon

So far, we have assumed rigid, monotonic inheritance of all information in supertypes to their subtypes; none of the inherited information can be overridden. This runs into difficulties when dealing with lexical entries that appear to be exceptional in some way, the obvious examples being morphological irregularities. How can productive regular forms such as **childs* be blocked, and only *children* allowed as a lexical entry?

While several approaches to exceptions have been proposed, we will focus here on *default unification*; that is, weakening monotonic inheritance in some circumstances. Then, although the plural of *child* might inherit the information from the pertinent lexical entry and from the *plural-noun* type, which would entail the phonology for **childs*, this regular plural form is overridden. Various complex issues arise in attempting to formulate a workable system of default unification and inheritance. See, e.g., Briscoe & Copestake (1999) for a brief overview of various ways that default unification might be defined. Lascarides & Copestake (1999) list several desirable criteria, including:

- Non-default information is always preserved

- Default unification behaves like monotonic unification whenever possible

- Default unification is order-independent

They explore the properties of their system, called YADU, in considerable detail. The intent is to preserve the behavior of non-default unification in cases where no default information is present, and for defeasible information at more specific level in the type hierarchy to override defeasible information at a more general level.

As another example of the use of default, nonmonotonic inheritance, outside of morphology, consider the account of the syntax of gerunds in various languages developed by Malouf (2000). Gerunds exhibit both verbal and nominal characteristics, and furnish a well-known example of seemingly graded category membership, which does not accord well with the categorical assumptions of mainstream syntactic frameworks. Roughly speaking, English gerunds, and their counterparts in other languages, act much like verbs in their "internal" syntax, allowing direct objects and adverbial modifiers, but function distributionally ("externally") as NPs. To take but a couple of pieces of evidence (see Malouf, op.cit. p.27 et seq. for more details), gerunds can be the complement of prepositions when finite clauses cannot (see (25)); conversely, adverbs, but not adjectives can modify gerunds, but adjectives must modify deverbal nouns (see (26)).

(25) a. Pat is concerned about Sandy('s) getting arrested.

      b. * Pat is concerned about (that) Sandy got arrested.

(26) a. Pat disapproved of (me/my) *quiet/quietly leaving before anyone noticed.

      b. Pat disapproved of my quiet/*quietly departure.

In contrast to accounts that attempt to model this dichotomy directly, via syntactic rules that allow an NP to be expanded as a constituent internally headed by a verb, Malouf posits a lexical rule, which converts the lexical category of a verb to *noun*, but otherwise preserves its verbal properties, such as subcategorization. This would pose problems with strictly monotonic inheritance, however, as it would force us to abandon generalizations about nouns other than gerunds (e.g., they do not take direct object complements, as many verbs and their gerunds do). Default inheritance provides one way to model the observed phenomena, without weakening the constraints on parts of speech to the point where no meaningful constraints distinguish them.

Malouf notes that some possible combinations of noun-like and verb-like attributes are frequently attested cross-linguistically in gerunds and their equivalents, while others are rare or unattested. Cross-linguistically, gerunds vary in their subcategorization possibilities: some allow subjects and complements,

while some allow only complements and no subjects. But there appear to be no cases of gerund-like lexical items that can take a subject but cannot take complements. Malouf invokes default inheritance (Lascarides & Copestake 1999) as a mechanism to represent these generalizations. In his account, there are both "hard" constraints – a verb lexical entry, for example, must have a HEAD value of type *relational* (encompassing verbs, adjectives, and adpositions) – and "soft", overridable constraints – a verb lexical entry by default has a HEAD value of type *verb*. In addition, following Bouma et al. (2001), he posits the types *ext-subj* and *ext-spr*. The former constrains the HEAD value to *relational* and the first element of the ARG-ST list to be the SUBJ (only adjective, adpositions, and verbs have subjects), while the latter constrains the HEAD value to *noun* and the first element of the ARG-ST list to be the SPR (only nouns have specifiers), as shown in (27).

$$(27) \quad \text{a.} \quad \begin{bmatrix} \textit{ext-subj} \\ \text{HEAD} \quad \textit{relational} \\ \text{VAL} \quad [\text{SUBJ} \; \boxed{1}] \\ \text{ARG-ST} \; \langle \boxed{1}, ... \rangle \end{bmatrix} \quad \text{b.} \quad \begin{bmatrix} \textit{ext-spr} \\ \text{HEAD} \quad \textit{noun} \\ \text{VAL} \quad [\text{SPR} \; \boxed{1}] \\ \text{ARG-ST} \; \langle \boxed{1}, ... \rangle \end{bmatrix}$$

Malouf then specifies default HEAD values for the lexical classes *n* and *v* (see (29) for the latter's definition). As gerunds have both properties of nominal and relational heads, they are subtypes of both, as shown in the multiple inheritance hierarchy in (28). The *v* type, which concerns us here, has a default HEAD value *verb*, as shown in (29) in addition to the non-default, more general type *relational* it also includes (default information follows /).

(28)

$$(29) \quad \begin{bmatrix} v \\ \text{HEAD} \quad \textit{relational /verb} \\ \text{CONT} \quad \textit{psoa} \end{bmatrix}$$

However, the default value *verb* is overridden in the subtype *vger*, in which the HEAD value is *gerund*, which is a subtype of both *noun* and *relational*, but not of *verb*. The type *vger* is shown in (30); where *f-ing* is a function the produces the *-ing* form of an English verb from its root.

$$(30) \quad \begin{bmatrix} vger \\ \text{MORPH} & \begin{bmatrix} \text{ROOT} & \boxed{1} \\ \text{I-FORM} & \textit{f-ing}(\boxed{1}) \end{bmatrix} \\ \text{HEAD} & \textit{gerund} \end{bmatrix}$$

The type *vger* is thus compatible with "verb-like" characteristics; in particular, it has an ARG-ST list. But, as its HEAD is also a subtype of *noun*, it lacks a SUBJ attribute and instead has a SPR attribute. Gerunds therefore allow complements (unlike ordinary nouns), but not subjects (unlike ordinary verbs). Malouf's hierarchy of types makes this prediction, in effect, because the *ext-spr* type requires that the "external argument" (the first on the ARG-ST list) is realized as the value of SPR.

While it would be possible to construct type hierarchies of lexical types, HEAD types, and so on that would allow for this kind of "reverse gerunds" – those that would act externally as nouns, allow subjects, but not permit complements – this would require reorganizing these type hierarchies to a considerable extent. Given that many nouns besides gerunds – nominalizations, for example – are relational (that is, have a CONTENT value of type *psoa*), it could be difficult to model a hypothetical language that permits only the reverse gerunds rather than the normal ones.

Malouf further notes a key difference between gerunds and exceptions like *childs/*children*: English gerunds are productive (and completely regular morphologically). If the same mechanisms of default unification are involved in both, what accounts for this difference? His answer is that productive and predictable processes involve online type construction (see Section 5.2 for details). The irregular form *children* must of course be learned and stored, not generated online. The default mechanisms described above, however, are employed at higher levels of the lexical hierarchy, and the individual gerunds forms *are* productively generated online. Note that, in contrast to the morphological and syntactic consistency among gerunds, English nominalizations display some idiosyncrasies that suggest at least some of them must be stored as distinct lexical items. Thus, as Malouf emphasizes, modeling prototypicality in the lexicon within HPSG can draw on both default inheritance and online type construction; together, they make "the connection between prototypicality, and productivity."

5 Lexical rules

In this section we describe the role lexical rules play in HPSG as well as their formal nature, i.e., how they model "horizontal" relations among elements of the

lexicon. These are relations between variants of a single entry (be they subcat-egorizational or inflectional variants) or between members of a morphological family, as opposed to the "vertical" relations modeled through inheritance. Thus they provide a means to represent the intuitive notion of "derivation" of one lexeme from another.

While lexical rules or similar devices have been invoked within HPSG since its inception, formalizing their nature and behavior was deferred until somewhat later. The intent, however, has always been, as Lahm (2016) stresses, to treat lexical rules (typically written $A \mapsto B$) to mean that for every lexeme or word described by A there is one described by B that has as much in common with A as possible.

Copestake & Briscoe (1991), Briscoe & Copestake (1999), Meurers (2001), and many others formalize the notion of lexical rule within HPSG by introducing a type, say *lex-rule*, with the attributes IN and OUT, whose values are respectively the rule's input and output lexical entries. As Briscoe & Copestake (1999) note, lexical rules of this form also bear a close relationship to default unification. The information in the input is intended to carry over to the output by default, except where the rule specifies otherwise and overrides this information. But, as Lahm (2016) points out, a sound basis for the formal details of how lexical rules work is not easy. Meurers' careful analysis of how to apply lexical rules to map a description of an entry A into the description B does not always work as intended in that what would expect to be licit inputs are actually not and no output description results as a consequence. Fortunately, it is not clear that this is a severe problem in practice, and Lahm notes that he has not found an example of practical import where Meurers's lexical rule formulation would encounter the problems he raises.

In a slight variant of the representation of lexical rules proposed by Copestake & Briscoe and Meurers, the OUT attribute can be dispensed with; the information in the lexical rule type not within the IN value then constitutes the output of the rule. In this variant, lexical rules could alternatively be viewed as be subtypes of a *derived-word* type, which could combine with other types in the lexical hierarchy, merely adding the derivational source via the IN value. Formulated in either fashion, lexical rules are essentially equivalent to unary syntactic rules, with the IN attribute corresponding to the daugther and the OUT attribute (or the rest of the information in the rule, if the OUT attribute is done away with) to the mother. This is the way lexical rules are implemented in the English Resource Grammar (see http://www.delph-in.net/erg/ for demos and details about this large-scale implemented grammar of English). (cross-reference to Bender &

Emerson's chapter on computational linguistics and language engineering here)

5.1 Phenomena accounted for by lexical rules

Lexical rules have been put to many uses, derivational and inflectional morphology (Copestake & Briscoe 1995; Emerson & Copestake 2015), complex predicate formation (Müller 2010), and diathesis alternations (Davis 2001). Moreover, proposals for lexical rules in HPSG have extended beyond what are traditionally or evidently viewed as lexical phenomena, to include treatments of extraction, unbounded dependencies, and adjuncts. In this section, we describe the use of lexical rules to model the realization of arguments as extracted dependents or affixes, rather than complements. We concentrate on these two cases, which we will contrast with alternative analyses not involving lexical rules presented by the same authors (see the next section). They thus provide a good illustration of some of the analytical choices available to model relations between variant lexical entries that are based on a single stem.

We begin with the Complement Extraction Lexical Rule (hereafter, CELR) proposed in Pollard & Sag (1994) shown in (31). The input to the rule is any lexeme that selects for a syntactic argument ([3]) that the lexeme requires be expressed as a complement (as indicated, this syntactic argument is also a member of the COMPS list). The ouput stipulates that this same syntactic argument is no longer a member of the COMPS list; however, the SLASH set now includes a new element, which is the local information of this syntactic argument ([1]). Informally stated, the input entry specifies that a syntactic argument must be realized as a complement, whereas the output entry specifies that the same syntactic argument must be realized by a non-local dependent (see Pollard & Sag (1994) for why only LOCAL information is shared between syntactic arguments and fillers that realize them).

$$
(31) \quad
\begin{bmatrix}
\text{ARG-ST} & \langle ..., \boxed{3}, ... \rangle \\
\text{COMPS} & \langle ...\boxed{3}[\text{LOC } \boxed{1}], ... \rangle \\
\text{SLASH} & \boxed{2}
\end{bmatrix}
\mapsto
\begin{bmatrix}
\text{ARG-ST} & \left\langle ..., \boxed{4}\begin{bmatrix}\text{LOC } \boxed{1} \\ \text{SLASH } \boxed{1}\end{bmatrix}, ... \right\rangle \\
\text{COMPS} & \langle ... \rangle \\
\text{SLASH} & \{\boxed{1}\} \cup \boxed{2}
\end{bmatrix}
$$

A similar use of lexical rules to model alternative realizations of arguments can be found in Monachesi (1993), who analyzes alternations between complements and so-called object clitics in Italian in a way that parallels the French examples in (10). In the output of her lexical rule, in (32), a subset of the list of complements in the input ([2]) corresponds to a list of clitic SYNSEMs, realized as prefixes through inflectional rules not shown here.

(32) $\begin{bmatrix} word \\ \text{HEAD} & verb \\ \text{VAL}|\text{COMPS} & \boxed{1} \bigcirc \boxed{2} \\ \text{CLTS} & elist \end{bmatrix} \mapsto \begin{bmatrix} word \\ \text{VAL}|\text{COMPS} & \boxed{1} \\ \text{CLTS} & \boxed{2}list(cl\text{-}ss) \end{bmatrix}$

Here as well, a lexical rule is employed in an analysis of what might well be considered a syntactic phenomenon. The possibility of treating phenomena like extraction and clitic placement at a lexical level, however, makes sense when they are considered fundamentally as matters of the combinatorial requirements of predicators, rather than effects of movement.

Before turning to the alternatives, we note in passing that lexical rules are inherently "directional", with an input and an output. This seems intuitively correct in the cases we've discussed, but might not always be so. Is there inherent directionality, for example between the causative and inchoative alternants of verbs such as *melt* or *slide*? In constrast, the alternatives to lexical rules described in the following section lack this notion of directionality.

5.2 Alternatives to lexical rules

In this section we briefly examine two alternatives to lexical rules, each involving underspecification. The types of members of the ARG-ST list might be underspecified so that a lexical entry accounts for more than one subcategorization. Or the type of the entry itself may be underspecified, so that it subsumes multiple inflectional or derivations forms. In both cases, the intent is that sufficiently underspecified information covers multiple entries that would otherwise have to be specified and related by lexical rules. We begin with alternatives to the complement extraction and clitic lexical rules in (31) and (32), proposed in Bouma et al. (2001) and Miller & Sag (1997).

In both cases, the idea is to distinguish between "canonical" and "non-canonical" realizations of syntactic arguments, as shown in the hierarchy of *synsem*s in (33). "Canonical" means local realization as a complement or subject/specifier, and "non-canonical" means realization as an affix or filler of an unbounded dependency. Linking constraints between semantic roles (values of argument positions) and syntactic arguments (members of ARG-ST) do not specify whether the realization is canonical or not; thus they retain their original form. Only canonical members of ARG-ST must be structured-shared with members of valence lists. The two constraints that determine the non-canonical realization of fillers are shown in (34). (34a) specifies what it means to be a *gap-ss*), namely that the argument is extracted (its local information is "slashed,") whereras (34b) prohibits any *gap-ss* member from being a member of the COMPS list. As these two constraints

are compatible with either a canonical or extracted object, there is no need for the lexical rule is (31).

(33)

$$
\begin{array}{c}
\textit{synsem} \\[4pt]
\textit{canon-ss} \quad \textit{non-canon-ss} \\[4pt]
\textit{gap-ss} \quad \textit{aff-ss}
\end{array}
$$

(34)   a. $\textit{gap-ss} \Longrightarrow \begin{bmatrix} \text{LOC} & \boxed{1} \\ \text{SLASH} & \boxed{1} \end{bmatrix}$

   b. $\textit{word} \Longrightarrow \begin{bmatrix} \text{SUBJ} & \boxed{1} \\ \text{COMPS} & \boxed{2} \ominus \textit{list(gap-ss)} \\ \text{DEPS} & \boxed{1} \oplus \boxed{2} \end{bmatrix}$

Miller & Sag (1997) make a similar use of non-canonical relations between the ARG-ST list and the valence lists, eschewing lexical rules to model French clitics and proposing instead the constraint in (35), where a subset of ARG-ST members, those that are realized as affixes (of type *aff*) are not also subcategorized for as complements.

(35)

$$
\begin{bmatrix}
\text{MORPH} & \begin{bmatrix} \text{FORM} & F_{PRAF}(\boxed{1}, \dots) \\ \text{I-FORM} & \boxed{1} \end{bmatrix} \\[12pt]
\text{SYNSEM} & \text{LOC|CAT} \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SUBJ} & \boxed{2} \\ \text{COMPS} & \boxed{3}\textit{list(non-aff)} \end{bmatrix} \\ \text{ARG-ST} & (\boxed{2} \oplus \boxed{3}) \bigcirc \textit{nelist(aff)} \end{bmatrix}
\end{bmatrix}
$$

The second alternative to lexical rules based on underspecification was presented in Koenig & Jurafsky (1994) and Koenig (1999). Typically in HPSG, all possible combinations of types are reified in the type hierarchy (in fact, they must be present, per the requirement that the hierarchy be sort-resolved, Carpenter 1992b,Pollard & Sag 1994). Thus, if one partitions verb lexemes into transitive and intransitive and, orthogonally, into, say, finite verbs and gerunds (limiting ourselves to two dimensions here for simplicity), the type hierarchy must also contain the combinations transitive+finite, transitive+gerund, intransitive+finite, and intransitive+gerund. Naturally, this kind of fully enumerated type system is unsatisfying. For one thing, there is no additional information that the combination subtype transitive+finite carries that is not present in its the two supertypes transitive and finite, and similarly for the other combinations. In contrast to

the "ordinary" types, posited to represent information shared by classes of lexemes, these combinations seem to have no other function than to satisfy a formal requirement of the mathematical structure of a type hierarchy (namely, that it forms a lattice under meet and join). Second, and related to the first point, this completely elaborated type hierarchy is redundant. Once you know that all verbs fall into two valence classes, transitive and intransitive, and simultaneously into two inflectional classes, finite and gerund, and that valence and inflection are two orthogonal dimensions of classification of verbs, you know all you need to know; the type of any verb can be completely predicted from these two orthogonal dimensions of classification and standard propositional calculus inferences.

In (36) is a simplified version of the hierarchy in (20), where the boxed labels in small caps VFORM and ARG-ST are mnemonic names of orthogonal dimensions of classification of subcategories of verbs (and are not themselves labels of subcategories). Inheritance links to the predictable subtypes are dashed and their names grayed out; this indicates that these types can be inferred, and need not be declared explicitly as part of the grammar. A grammar of English would include statements to the effect that head information about verbs includes a classification of verbs into finite or base forms (of course, there would be more types of verb forms in a realistic grammar of English) as well a classification into intransitive and transitive verbs (again, a realistic grammar would include many more types).

(36)

Crysmann & Bonami (2016) have shown how this *online type construction*, where predictable combinations of types of orthogonal dimensions of classification are not reified in the grammar, is useful when modeling productive inflectional morphology. Consider, for example, exponents of morphosyntactic features whose shape remains constant, but whose position within a word's template (to speak informally here) varies. One case like this is the subject and object markers of Swahili, which can occur in multiple slots in the Swahili verb template. For reasons of space we illustrate the usefulness of this dynamic ap-

proach to type creation, the Type Underspecified Hierarchical Lexicon (TUHL) with an example from Koenig (1999), the cross-cutting classification of syntactic/semantic information and stem form in the entry for the French verb *aller* (see Bonami & Boyé (2001) for a much more thorough discussion of French stem allomorphy along similar lines; Crysmann and Bonami's much more developed approach to stem allomorphy would model the same phenomena differently and we use Koenig's simplified presentation for expository purposes only). The forms of *aller* are based on four different suppletive stems: *all-* (1st and 2nd person plural of the indicative and imperative present, infinitive, past participle, and imperfective past), *i-* (future and conditional), *v-* (1st-3rd person singular and 3rd person plural of the indicative present), and *aill-* (subjunctive present). These four suppletive stems are shared by all entries (i.e., senses) of the lexeme *aller*: the one which means 'to fit' as well as the one which means 'to leave', as shown in (37) (see Koenig, op.cit, p.40-41). The cross-cutting generalizations over lexemes and stems are represented in Figure 2. Any *aller* stem combines one entry and one stem form. In a traditional HPSG type hierarchy, each combination of types (grayed out in Figure 2), would have to be stipulated. In a TUHL, these combinations can be dynamically created when an instance of *aller* needs to be produced or comprehended.

(37) a. Marc est   allé   à Paris.
         Marc be-PR.3RD.SG go-PPT to Paris
         'Marc went to Paris.'

      b. Marc s'en   ira.   'Marc will leave.'
         Marc 3.REFL-of.it go-FUT.3RD.SG

      c. Ce   costume te   va   bien.
         This suit   you go-PR.3.SG well
         'This suit becomes you.' (lit. goes well to you)

      d. Il faut   que j'y   aille.
         It must that I.to.there go-SUBJ.PR.1.SG
         'I must go there.'

Figure 2: A hierarchy of lexical entries and stem-forms for the French verb *aller*, from Koenig (1999)

Both *synsem* and type underspecification avoid conflict between the information specified in the variants of words based on a single lexeme (e.g., conflicts on how syntactic arguments are realized); they abstract over the relevant pieces of conflicting information. Underspecifying information included in lexical entries or lexical types allows a single entry or type to stand for the two distinct entries or types that would be related as input and output by lexical rules. The third alternative to lexical rules eschews informational conflict by adding internal structure to stems and words. This is the approach to derivational morphology taken by Riehemann (1998). Example (38) (Riehemann's (1)) illustrates *-bar* suffixation in German, a process by which an adjective that includes a modal component can be derived from verb stems (similar to English *-able* suffixation). A lexical rule approach would posit a verb stem input and derive an adjective output. As Riehemann stresses, though, there are many different subtypes of *-bar* suffixation, some productive, some unproductive, all sharing some information. This combination of productive and unproductive variants of a lexical process is exactly what the type hierarchy is meant to capture and what Riehemann's *Type-Based Derivational Morphology* capitalizes on. (39) presents the relevant information of Riehemann's type for regular *-bar* adjectives (see p.68 for more details). Critically, *-bar* adjectives include a singleton-list base (the value of MORPH-B) that records the information of the adjective's verbal base (what would be the lexical rule's input). Because of this extra layer, the local information in the base (*local*$_1$) and the *-bar* adjective (*local*$_2$) can differ without being in conflict.

(38) Sie   bemerken die Veränderung. Die Veränderung ist bemerkbar.
     They notice   the change.   The change   is noticeable.

(39) $\begin{bmatrix} \textit{reg-bar-adj} \\ \text{PHONOLOGY} \quad \boxed{1}\textit{+bar} \\ \\ \text{MORPH-B} \quad \left\langle \begin{bmatrix} \textit{trans-verb} \\ \text{PHON} \quad \boxed{1} \\ \text{LOCAL} \quad \textit{local}_1 \end{bmatrix} \right\rangle \\ \text{SYNSEM|LOCAL} \quad \textit{local}_2 \end{bmatrix}$

Lexical rules played a critical role in the rise of lexicalist approaches to syntax. But the three alternative analytical tools we discussed in this section (which, of course, can be combined in an analysis) have chipped away at their use in HPSG. Inflectional morphology is now dealt with through lexical types associating morphosyntactic features with forms/positions and constraints on words (ensuring that all morphosyntactic features are realized). (cross-reference the chapter on Morphology) Derivational morphology is handled via lexical types

too, but ones that add an extra internal layer (the MORPH-BASE in Riehemann's analysis and (39)). Non-canonical realization of syntactic arguments as affixes or fillers in unbounded dependencies is now modeled by distinguishing kinds of members of the ARG-ST list and constraints on words that relate valence, argument structure, and dependents lists. So, what remains of the case for lexical rules now? Müller (2006; 2010) argues that diathesis phenomena, broadly speaking, favor a lexical rules approach over a phrase-structural constructional approach à la Goldberg (1995) or an online type construction approach suggested in Kay (2002). The arguments are convincing, but it should be noted that some of the data involves derivational morphology (e.g., causatives) or passive morphemes, which, arguably, could be handled via a Type-Based Derivational Morphology of the kind Riehemann argues for (such an approach was suggested in Koenig (1999: Chapter 4)). It is unclear to us whether there are always motivated types for morphologically derived stems to dispense entirely with lexical rules of the kind Müller argues for. On the other hand, if one adopts the version of lexical rules in which the OUT attribute is eliminated and lexical rules are subtypes of *derived-lexeme*, little will be at stake formally, as lexical rules and derivational processes "look the same."

Abbreviations

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Chapter 5

Understudied languages

Doug Ball

Aron Broadwell

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1 Introduction

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Abbreviations

Acknowledgements

Part II

Syntactic phenomena

Chapter 6

Agreement

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Agreement is modeled in HPSG by assigning agreement features such as person, number, and gender ("phi features") to specified positions in the feature structures representing the agreement trigger and target. The locality conditions on agreement follow from the normal operation of the grammar in which those phi features are embedded. In anaphoric agreement phi features appear on referential indices; in verb agreement phi features appear on the verb's ARG-ST list items; and in modifier agreement phi features appear on the MOD value of the modifier. Selective underspecification of agreement features accounts for the alternation between formal and semantic agreement. Within the HPSG framework, long-distance agreement has been analyzed as anaphoric agreement in a special clausal construction, while superficial agreement has been modeled using linearization theory.

1 Introduction

Agreement is the systematic covariation between a semantic or formal property of one element (called the agreement *trigger*) and a formal property of another (called the agreement *target*). In the sentences *I am here* and *They are here*, the subjects (*I* and *they*, respectively) are the triggers; the target verb forms (*am* and *are*, respectively) covary with them. Research on agreement systems within HPSG has been devoted to describing and explaining a number of observed aspects of such systems. Regarding the grammatical relationship between the trigger and the target, we may first of all ask how local that relationship is, and in what grammatical terms it is defined. Having determined the prevailing locality conditions on agreement in a given language, we attempt to explain observed exceptions, that is, cases of apparent "long-distance agreement", as well as cases of superficial agreement defined on string adjacency. Agreement features across

languages include person, number, and gender (known as *phi* features), as well as deictic features and case, but various different subsets of those features are involved in particular agreement relations. How can we explain the distribution of features? How are locality and feature distribution related to the diachronic origin of agreement systems? Also, as indicated in the definition of agreement provided in the first sentence of this paper, the features of the target are sometimes determined by the trigger's form and sometimes by its meaning. What regulates this choice? In some cases a single trigger in a sentence determines different features on two different targets. Why does such "mixed agreement" exist, and what does its existence tell us about the grammatical representation of agreement? This chapter reviews HPSG approaches to these questions of locality, grammatical representation, feature distribution, diachrony, semantic versus formal agreement, and mixed agreement. Agreement with coordinate phrases is discussed by Abeillé & Chaves (2018), Chapter 17 of this volume.

HPSG offers an integrated account of these phenomena. In most cases the analysis of agreement phenomena does not involve any special formal devices dedicated for agreement, comparable to the *probe* and *goal*, or the AGREE relation, found in Minimalist accounts (Chomsky 2000). Instead the observed agreement phenomena arise as a side effect of other grammatical mechanisms responsible for valence saturation, the semantics of modification, and coreference.

2 Agreement as unification

Constraint-based formalisms such as HPSG are uniquely well-suited for modeling agreement. Within such formalisms agreement occurs when multiple feature sets arising from distinct elements of a sentence specify information about a single abstract object, so that the information must be mutually consistent (Kay 1984). The two forms are said to agree when the values imposed by the two constraints are compatible, while ungrammaticality results when they are incompatible. For example the English verb *is* in (1) specifies that its initial ARG-ST list item, which is identified with the SUBJ list item, has third person, singular features. In the mechanism of valence saturation, the NP list item in the value of SUBJ unifies with the feature description representing the SYNSEM value of the subject NP. The features specified by the verb for its subject and by the subject NP must be compatible; otherwise the representation for the resulting sentence is ill-formed, predicting ungrammaticality as in (3a).

(1) Simplified lexical sign for the verb *is*:

$$
\begin{bmatrix}
\text{PHON} & \langle \textit{is} \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix} \\
\text{ARG-ST} & \left\langle \boxed{1}\text{NP}\begin{bmatrix} \text{PERS} & \textit{3rd} \\ \text{NUM} & \textit{sg} \end{bmatrix}, \boxed{2}\text{XP} \right\rangle
\end{bmatrix}
$$

(2) Simplified lexical signs for *I* and *she*:

$$
\begin{bmatrix}
\text{PHON} & \langle \textit{I} \rangle \\
\text{HEAD} & \begin{bmatrix} \textit{noun} \\ \text{PERS} & \textit{1st} \\ \text{NUM} & \textit{sg} \end{bmatrix}
\end{bmatrix}
\qquad
\begin{bmatrix}
\text{PHON} & \langle \textit{she} \rangle \\
\text{HEAD} & \begin{bmatrix} \textit{noun} \\ \text{PERS} & \textit{3rd} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{fem} \end{bmatrix}
\end{bmatrix}
$$

(3)   a.   * I is sober.

       b.   She is sober.

The features supplied by the trigger and target must be consistent, but there is no general minimum requirement on how many features they specify. Both of them can be, and typically are, underspecified for some agreement features. For example, gender is not specified by the verb in (1) or the first pronoun in (2).

Since unification is commutative, the representation of an agreement construction is the same regardless of whether a feature originates from the trigger or the target. This immediately accounts for common agreement behavior observed when triggers are underspecified (Barlow 1988). For example, Serbo-Croatian is a grammatical gender language, where common nouns are assigned to the masculine, feminine, or neuter gender. The noun *knjiga* 'book' in (4) is feminine, so the modifying determiner and adjective appear in feminine form.

(4)   Ov-a   star-a   knjig-a   stalno   pad-a.

     this-NOM.F.SG old-NOM.F.SG book-NOM.SG always fall-3SG

     'This old book keeps falling.' (Wechsler & Zlatić 2003: 4, ex. (1))

However, some nouns are unspecified for gender, such as *sudija* 'judge'. Interestingly, the gender of an agreeing adjective actually adds semantic information, indicating the sex of the judge (Wechsler & Zlatić 2003: 42, ex. (23)).

(5)   a. Taj   stari sudija je   dobro sudio.

       that.M old.M judge AUX well   judged.M

       'That old (male) judge judged well.'

b. Ta   stara sudija je   dobro sudila.
that.F old.F judge AUX well   judged.F
'That old (female) judge judged well.'

Here the gender feature comes from the targets instead of the trigger. This illustrates an advantage of constraint-based theories like HPSG over transformational accounts in which a feature is copied from the trigger, where it originates, to the target, where it is then realized. The usual source of the feature (the noun) lacks it in (5), a problem for the feature-copying view.

The same problem occurs even more dramatically in *pro*-drop. Many languages allow subject pronouns to drop, and distinguish person, number, and/or gender on the verb. If those features originate from the null subject, then there would have to be distinct null pronouns, one for each verbal and predicate adjective inflection (Pollard & Sag 1994: 64). This would be more complex and stipulative, and moreover the paradigm of putative null pronouns would have to exactly match the set of distinctions drawn in the verb and adjective systems, rather than reflecting the pronoun paradigm. HPSG avoids this suspicious assumption. Null anaphora is modeled by allowing the *pro*-dropped argument to appear on the ARG-ST list but not a VALENCE list (see Wechsler, Koenig & Davis (2018), Chapter 9 of this volume). For example, in the context given in (6) a Serbo-Croatian speaker could omit the subject pronoun.

(6)   Context: Speaker comes home to find her bookcase mysteriously empty.
Gde   su (one)   nestale?
where did (they.F.PL) disappear.F.PL
'Where did they (i.e. the books) go?'

The sign for the inflected participle specifies feminine plural features on the initial item in its ARG-ST list. The SUBJlist item is optional:

(7)   Simplified lexical sign for the participle form *nestale*:

$$
\begin{bmatrix}
\text{PHON} & \langle \textit{nestale} \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle (\boxed{1}) \rangle \\ \text{COMPS} & \langle \ \rangle \end{bmatrix} \\
\text{ARG-ST} & \left\langle \boxed{1}\text{NP} \begin{bmatrix} \text{NUM} & pl \\ \text{GEN} & fem \end{bmatrix} \right\rangle
\end{bmatrix}
$$

The feminine plural features are specified regardless of whether the subject pronoun appears. When the pronoun is dropped we have the usual underspecifica-

tion, only in this case the trigger does not exist, so it is effectively fully under-specified, realizing no features at all.

3 Locality in agreement

3.1 Argument and modifier agreement

In HPSG, the grammatical agreement of a predicator with its subject or object, or an adjective, determiner, or other modifier with its head noun, piggy-backs on the mechanism of valence saturation and modification. Agreement is encoded in the grammar by adding features of person, number, gender, case and deixis to the existing feature descriptions involved in syntactic and semantic composition. This simple assumption is sufficient to explain the broad patterning of distribution of agreement, in contrast to the transformational approach where complex locality conditions must be stipulated.

In HPSG predicate-argument agreement arises directly from the valence saturation, as illustrated already in (1) above. Thus the locality conditions on the trigger-target relation follow from the conditions on the subject-head or complement-head relation. Similarly, attributive adjectives agree with nouns directly through the composition of the modifier with the head that it selects via the MOD feature. For example, the Serbo-Croatian feminine adjective form *stara* 'old.F' in (5b) specifies feminine singular features for the common noun phrase (N-bar) that it modifies.

(8) Simplified lexical sign for *stara*:

$$
\begin{bmatrix}
\text{PHON } \langle stara \rangle \\
\text{MOD } \begin{bmatrix}
\text{HEAD } \begin{bmatrix} noun \\ \text{NUM } sg \\ \text{GEND } fem \end{bmatrix} \\
\text{COMPS } \langle \ \rangle
\end{bmatrix}
\end{bmatrix}
$$

In head-adjunct phrases, the MOD value of the adjunct daughter is token-identical with the *synsem* value of the head daughter. So *stara*'s feminine singular features cannot conflict with the features of the noun it modifies.

The predicted locality conditions are also affected by the percolation of features from words to phrasal nodes, and this depends on the location of the features within the feature description. Agreement features of the *trigger* appear either within the HEAD value or the semantic CONTENT value (these give rise to CONCORD and INDEX agreement, respectively; see Section 4.2). In either case

these features percolate from the trigger's head word to its maximal phrasal projection, due to the Head Feature Principle in the former case and the Semantics Principle in the latter. For example the noun phrase *the books* inherits its [NUM *pl*] feature from the head word *books*. This determines plural agreement on a verb: *These books are/*is interesting.* Apparent exceptions, where a target seems to fail to agree with the head of the trigger, are discussed below.

However, agreement features of the *target* appear in neither the HEAD nor the CONTENT value of the target form, but rather appear embedded in an ARG-ST list item or MOD features. So agreement features of the target do not project to the target's phrasal projection such as VP, S, or AP. This is a welcome consequence. If the subject agreement features of the verb projected to the VP, for example, we would expect to find VP-modifying adverbs that consistently agree with them, but we do not.[1]

4 Varieties of agreement target

4.1 Anaphoric agreement

In anaphoric agreement, an anaphoric pronoun agrees in person, number, and gender with its antecedent. Since Pollard & Sag (1992; 1994), anaphoric agreement has been analyzed in HPSG by assuming that person, number, and gender are formal features of the referential index associated with an NP. Anaphoric binding in HPSG is modeled as coindexation, i.e. sharing of the INDEX value, between the binder and bindee. Thus any specifications for agreement features of the INDEX contributed by the binder and bindee must be mutually consistent. In (9) Principle A of the Binding Theory requires the reflexive pronoun to be coindexed with an o-commanding item, here the subject pronoun:

(9) a. She admires herself.

b. *admire*:

$$
\begin{bmatrix}
\text{ARG-ST} & \left\langle \text{NP:} \begin{bmatrix} ppro \\ \text{INDEX} & \boxed{1} \begin{bmatrix} \text{PERS} & 3rd \\ \text{NUM} & sg \\ \text{GEN} & fem \end{bmatrix} \end{bmatrix}, \text{NP:} \begin{bmatrix} ana \\ \text{INDEX} & \boxed{1} \begin{bmatrix} \text{PERS} & 3rd \\ \text{NUM} & sg \\ \text{GEN} & fem \end{bmatrix} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

The agreement features are formal features and not semantic ones, but the semantic correlates of person (speaker, addressee, other), number (cardinality), and

---

[1] VP-modifying secondary predicates sometimes agree with their own subjects. What we do not find are adjuncts that consistently agree with the subject agreement features of the VP even when the adjunct is not predicated of that subject.

gender (male, female, inanimate, etc.) are invoked under certain conditions (described in Section 5). Thus index agreement is distinct from *pragmatic agreement* whereby semantic features of two coreferential expressions must be semantically consistent in order for them to refer to a single entity. Index agreement is enforced only within the syntactic domain defined by binding theory, while pragmatic agreement applies everywhere. For example, feminine pronouns are sometimes used for ships, in addition to neuter pronouns. Whichever gender is chosen, it must be consistent in binding contexts (example based on Pollard & Sag (1994: 79, ex. (46a))):

(10)   a.   The ship lurched, and then it righted itself. She is a fine ship.

      b.   The ship lurched, and then she righted herself. It is a fine ship.

      c. * The ship lurched, and then she righted itself.

      d. * The ship lurched, and then it righted herself.

The bound reflexive must agree formally with its antecedent, while other coreferential pronouns need not agree, as they are not coarguments of the antecedent and not subject to the structural binding theory.

    In grammatical gender languages, where common nouns are conventionally assigned to a gender, an anaphoric pronoun appearing outside the binding domain of its antecedent can generally agree with that antecedent either formally or, if it is semantically appropriate (such as an animate, sexed entity), it can alternatively agree pragmatically. In most situations pronouns allow either pragmatic or INDEX agreement with their antecedents. For example, pronouns coreferential with the Serbian/Croatian grammatically neuter diminutive noun *devojče* 'girl' can appear in either neuter or feminine gender (from Wechsler & Zlatić (2003: p. 198)):

(11)   Ovo   malo   devojče$_i$ je   ušlo.NT.SG
      this.NT.SG little.NT.SG girl.NT.SG AUX.3SG entered.

    a.   Ono$_i$ je   htelo   da telefonira.
       it.NT.SG AUX.SG wanted.NT.SG that telephone

    b.   Ona$_i$ je   htela   da telefonira.
       she.F.SG AUX.SG wanted.F.SG that telephone

      'This little girl$_i$ came in. She$_i$ wanted to use the telephone.'

The neuter pronoun in (11a) reflects INDEX agreement with the antecedent while the feminine pronoun (11b) reflects its reference to a female (pragmatic agree-

ment). But when a reflexive pronoun is locally bound by a nominative subject, agreement in formal INDEX features is preferred:

(12) Devojče   je   volelo   samo/?*samu   sebe.
      girl.NOM.NT.SG AUX3.SG liked.NT.SG own.ACC.NT.SG/ACC.F.SG self.ACC
      'The girl liked herself.'

Again, this illustrates INDEX agreement in the domain defined by the structural binding theory.

4.2 Grammatical agreement: INDEX and CONCORD

As noted above, in HPSG agreement effectively piggy-backs on other independently justified grammatical processes. Anaphoric agreement is a side-effect of binding (Section 4.1) while grammatical agreement is a side-effect of valence saturation and modification (Section 3.1). The formal HPSG analysis of a particular agreement process mainly consists of positing agreement features somewhere in the feature structure; the observed properties follow from the location of those agreement features. With regard to the location of the features, grammatical agreement bifurcates into two types, INDEX and CONCORD.[2] (The attribute name CONCORD was introduced by Wechsler & Zlatić (2000: 799ff),Wechsler & Zlatić (2003: 14ff); precursors to the idea were treated as HEAD features in Pollard & Sag (1994), and called AGR by Kathol (1999).) The best way to understand this bifurcation of agreement, and indeed the operation of grammatical agreement systems generally, is by considering their diachronic origin. Although our primary goal is the description of synchronic grammar, a look at diachrony can help explain the forms that the grammar takes, and can also provide clues as to the best formalization of it.

Within the diachronic literature on agreement there are thought to be two different lexical sources for agreement inflections: (i) incorporated pronouns; and (ii) incorporated noun classifiers (Greenberg 1978). These two sources, ultimately traced to pronouns and common nouns, give rise to Index and Concord target inflections, respectively, as explained next.

---

[2]The INDEX / CONCORD theory is sketched in Pollard & Sag (1994: Chapter 2) and Kathol (1999), and developed in detail in Wechsler & Zlatić (2000; 2003), all in the HPSG framework. It has since been adopted into LFG (King & Dalrymple 2004: inter alia) and GB/Minimalism (Danon 2009).

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4.2.1 INDEX agreement

Taking pronouns first, many grammatical agreement systems evolve historically from the incorporation of pronominal arguments into the predicates selecting those arguments, such as verbs and nouns (Bopp 1842; Givón 1976; Wald 1979, inter alia). When a phrase serving as antecedent of the incorporated pronoun is reanalyzed as the true subject or object of the predicate, the pronominal affix effectively becomes an agreement marker. With this reanalysis the only change in the affix is that it loses its ability to refer: it no longer functions as a pronoun. The affix retains its agreement features, and what was formerly anaphoric agreement with the topic becomes grammatical agreement with the subject or object. This explains why the features of grammatical agreement match those of pronominal anaphora: typically person, number, and gender, with occasional deictic features (Bresnan & Mchombo 1987: 752).

As explained above, structural anaphoric binding involves identifying (structure sharing) the referential indices of the pronoun and its binder. Therefore grammatical agreement derived from it is also INDEX agreement. For example, the signs for English *is* and *I* in (1) and (2) above should be rewritten as follows:

(13)   Sign for *is*, illustrating INDEX agreement:

$$
\begin{bmatrix}
\text{PHON} & \langle is \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \left\langle \text{NP} \begin{bmatrix} \text{CONTENT|INDEX} & \begin{bmatrix} \text{PERS} & 3rd \\ \text{NUM} & sg \end{bmatrix} \end{bmatrix} \right\rangle \\ \text{COMPS} & \langle \text{XP} \rangle \end{bmatrix}
\end{bmatrix}
$$

(14)   Sign for *I*, illustrating INDEX features:

$$
\begin{bmatrix}
\text{PHON} & \langle I \rangle \\
\text{CONTENT|INDEX} & \boxed{1} \begin{bmatrix} \text{PERS} & 1st \\ \text{NUM} & sg \end{bmatrix} \\
\text{CONTEXT} & speaker(\boxed{1})
\end{bmatrix}
$$

This finite verb form specifies third person singular features of its subject's referential index.

One salient distinguishing characteristic of INDEX agreement is that it includes the PERSON feature. The only known diachronic source of the person feature is from pronouns. Therefore, the other type of agreement, CONCORD, lacks the person feature (as we will see below).

By modeling verb agreement in a way that reflects its historical origin, we are able to explain an array of facts concerning particular agreement systems. Some of these facts and explanations are presented in Section 6 below.

4.2.2 CONCORD

The agreement inflections on modifiers of nouns, such as adjectives and determiners, are thought to derive historically, not from pronouns, but from noun classifiers (Greenberg 1978; Reid 1997; Seifart 2009; Grinevald & Seifart 2004, Corbett 2006: 268–9). The classifier morphemes in turn derive historically from lexical common nouns denoting superordinate categories like animal, woman, man, etc. For example Reid (1997) posits the following historical development of Ngan'gityemerri (southern Daly; southwest of Darwin, Australia), a language where the historical stages continue to cooccur in the current synchronic grammar. Originally the language had general-specific pairings of nouns as a common syntactic construction, such as *gagu wamanggal* 'animal wallaby' in (15a) (from Reid (1997: 216) example 162–165). The specific noun can be omitted when reference to it is established in discourse, leaving the general noun and modifier, to form NPs like *gagu kerre*, literally 'animal big' but functioning roughly like nominal ellipsis 'big one'. Then, where the specific noun is also included, both noun and modifier attract the generic term (15b). The gender markers then reduce phonologically and incorporate, producing modifier gender agreement (15c).

(15)   a.   Stage I:
           Gagu   wamanggal kerre ngeben-da.
           animal wallaby   big   1SG.SB.AUX-shoot
           'I shot a big wallaby.'

       b.   Stage II:
           Gagu   wamanggal gagu   kerre ngeben-da.
           animal wallaby   animal big   1SG.SB.AUX-shoot
           'I shot a big wallaby.' (Reid 1997:216, example 164)

       c.   Stage III:
           wa=ngurmumba wa=ngayi   darany-fipal-nyine.
           male=youth   male=mine 3SG.AUX-return-FOC
           'My initiand son has just returned.'

If the same affix is retained on the modifiers and the noun they modify, then the result is symmetrical agreement (also known as alliterative agreement), like the feminine *-a* endings in Spanish *zona rosa* (Corbett 2006, 87-88). But often an asymmetry between the affixes on the noun and the modifiers develops: the noun affix becomes obligatory and is subject to morphophonological processes that do not affect the modifier affix (Reid 1997, 216). This process may further progress to "prefix absorption" into the common noun, as evidenced by "gender

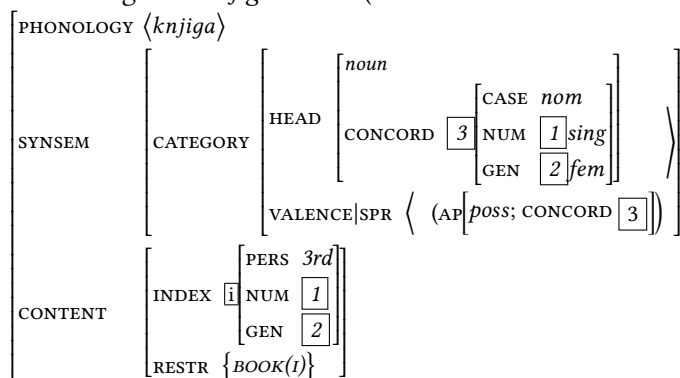prefixed nominal roots being interpreted as stems for further gender marking." (Reid 1997, 217)

Agreement marked with inflections from such nominal sources is called *concord*, which is described using the HPSG CONCORD feature. What is the proper HPSG formalization of this type of agreement, given its provenance? The last stages of the diachronic development, described in the previous paragraph, imply that the *form* of the trigger (the noun) is influenced by the agreement features. That is, noun declension classes tend to correlate with gender assignment (and more generally, phonological and morphological characteristics of nouns correlate with gender assignment); and number is marked on nouns as well. (This close relation between declension class and CONCORD is demonstrated in detail in Wechsler & Zlatić (2003: Chapter 2).) Thus the agreement features must appear both on the head noun (to inform its form and/or its gender selection and number value) and on the phrasal projection of that noun (to trigger agreement via the MOD feature of the agreement targets). Ergo CONCORD is a HEAD feature of the trigger.

Along with the number and gender features, the CONCORD value is assumed to include the case feature when case is a feature of NPs realized on both the head noun and its modifying adjectives or determiner. CONCORD lacks the person feature, since common nouns, from which the agreement inflections on the targets derive, lack the person feature (common nouns do not distinguish person values since they are all in the third person). Meanwhile, INDEX agreement preserves the pronominal features of person, number, and gender, reflecting its origins. In the usual case the number and gender values found in CONCORD match those found in INDEX. The Serbo-Croatian noun form *knjiga* triggers feminine singular nominative CONCORD on its adjectival possessive specifier and modifier, and third person singular INDEX agreement on the finite auxiliary. (The status of the participle is discussed below.)

(16) Moja   stara   knjiga   je   pala.
      my.F.NOM.SG old.F.NOM book.NOM.SG AUX.3.SG fall.PPRT.F.SG

      'My old book fell.' (from Wechsler & Zlatić (2003: 18))

The nominative singular noun form *knjiga* specifies its agreement features in both CONCORD (a HEAD feature) and INDEX, with the respective values for number and gender shared:

(17)   Lexical sign for *knjiga* 'book' (from Wechsler & Zlatić 2003: 18):

$$
\begin{bmatrix}
\text{PHONOLOGY } \langle \textit{knjiga} \rangle \\
\text{SYNSEM }
\begin{bmatrix}
\text{CATEGORY }
\begin{bmatrix}
\text{HEAD }
\begin{bmatrix}
\textit{noun} \\
\text{CONCORD } \boxed{3}
\begin{bmatrix}
\text{CASE } \textit{nom} \\
\text{NUM } \boxed{1}\textit{sing} \\
\text{GEN } \boxed{2}\textit{fem}
\end{bmatrix}
\end{bmatrix} \\
\text{VALENCE|SPR } \langle \ (\text{AP}\begin{bmatrix}\textit{poss}; \text{CONCORD } \boxed{3}\end{bmatrix}) \ \rangle
\end{bmatrix} \\
\text{CONTENT }
\begin{bmatrix}
\text{INDEX } \boxed{i}
\begin{bmatrix}
\text{PERS } \textit{3rd} \\
\text{NUM } \boxed{1} \\
\text{GEN } \boxed{2}
\end{bmatrix} \\
\text{RESTR } \{\textit{BOOK(I)}\}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

The specifier (SPR) is shown as AP because the possessive phrase is categorically an adjective phrase in Serbo-Croatian. The features in the overlap between CON-CORD and INDEX are normally shared as in this example. But with some special nouns features can be asymmetrically specified in only one of the two values (with no reentrancy linking them, of course). This leads to mismatches between CONCORD and INDEX targets, discussed in Section 6 below.

The phi features also appear within the HEAD value, as shown in (17), so that adjunct APs can agree with those features. For example, concord by the attributive adjective *stara* 'old' is guaranteed because its MOD feature is specified for feminine singular features, as shown in (8) in Section 3.1 above.

4.3 Conclusion

To summarize this section, we have seen the two main historical paths to agreement, and shown how HPSG formalizes these two types of agreement so as to capture the syntactic and semantic properties that follow directly from their origins. Agreement that descends from anaphoric agreement of pronouns with their antecedents, through the incorporation of personal pronouns into verbs and other predicators, inherits the INDEX matching process found in the anaphoric agreement from which it descends. Agreement that descends from the incorporation of noun classifiers involves features located in the HEAD value that connect a trigger noun form to its phrasal projection. The feature sets differ for the same reason; person is a feature only of the first type, and case only of the second. CONCORD correlates strongly with declension class, while INDEX agreement need not correlate as strongly (for evidence see Wechsler & Zlatić (2003: Chapter 2)). The differences in feature sets and morphology further correlate with systematic syntactic differences, described in the following section.

5 Syntactic, semantic, and default agreement

This chapter has so far focused mainly on formal agreement, as opposed to semantic agreement. But this is one of three different ways in which the form of an agreement target may be determined by a grammar:

(18)   Formal, semantic, and default determinants of target form.

      a. Formal agreement: The target form depends on the trigger's formal phi features.

      b. Semantic 'agreement': The target form depends on the trigger's meaning.

      c. Failure of agreement: The target fails to agree and hence takes its default form.

In formal agreement the trigger is grammatically specified for certain features as a consequence of the words making up the trigger phrase: for example a nominal may be marked for a gender as a consequence of the lexical gender of the head noun. In semantic agreement the target is sensitive to the meaning of the trigger instead of its formal features. English number agreement can be formal as in (19) or semantic as in (20):

(19)   a. His clothes are/*is dirty.

      b. His clothing is/*are dirty.
          (from Wechsler (2013: 92))

(20)   a. That the position will be funded and that Mary will be hired now seems/??seem likely.

      b. That the president will be reelected and that he will be impeached are/??is equally likely at this point.
          (from McCloskey (1991: 92))

Regarding (20) McCloskey (1991: 564–565) observes that singular is used for "a single complex state of affairs or situation-type", while plural is possible for "a plurality of distinct states of affairs or situation-types". The latter sort of interpretation is facilitated by the use of the adverb *equally*. Formal and semantic gender agreement are illustrated by the French examples in (21):

(21)   a. La   sentinelle à la barbe a   été { prise   / *pris   } en otage.
          the.F sentry   bearded   AUX been { taken.F.SG / taken.M } hostage

         'The bearded sentry was taken hostage.'

b. Dupont est { compétent   / compétente   }.
    Dupont is   { competent.M.SG / competent.F.SG }
    'Dupont { a man / a woman } is competent.'

The grammatically feminine noun *sentinelle* 'sentry' triggers feminine agreement regardless of the sex of the sentry; but in (21b) feminine agreement indicates that Dupont is female while masculine agreement indicates that Dupont is male.

How does the grammar negotiate between formal and semantic agreement? In HPSG syntactic and semantic representations are composed in tandem, making the framework well suited to address this question. It was addressed in early HPSG work, including Pollard & Sag (1994: Chapter 1). The specific approach due to Wechsler (2011) exploits the underspecification of agreement features (see Section 2). I posit the Agreement Marking Principle (AMP), which states that target agreement features are semantically interpreted whenever the trigger is underspecified for the formal grammatical features to which the target would normally be sensitive. The subject phrases in (19) are specified for number due to the formal features of the head nouns; but those in (20) are not, as a (coordinate) clause has no grammatical source for those features. Consequently, by the AMP the verb's number feature is semantically interpreted in (20). Similarly, *sentinelle* in (21a) gives its formal feminine gender feature to the subject, while *Dupont* lacks a gender specification, triggering the semantic interpretation of the target adjectives in (21b): feminine is interpreted as 'female'.

Agreement targets generally have a default form for use when there is no trigger or the normal agreement relation is blocked for some reason. Blocking of agreement comes about in various situations; here we consider a case where the trigger is interpreted metonymically, apparently resulting in a reassignment of the referential index. Swedish predicate adjectives normally agree with their subjects in number (either singular or plural) and grammatical gender, either neuter (NT) or 'common' gender (COM), the gender held in common between masculine and feminine:

(22) a. Hus-et   är gott.
          house-DEF.NT.SG is good.NT.SG
          'The house is good.'

      b. Pannkaka-n   är   god.
          pancake-DEF.COM.SG be.PRES good.COM.SG
          'The pancake is good.'

c. { Hus-en / Pannkak-orna } är god-a.
   { house-PL.DEF / pancake-PL.DEF } be.PRES good-PL
   'The houses / The pancakes are good.'

As shown in (22), a predicate adjective is inflected for number, and, in the singular, for gender, and agrees with its subject. But in sentences like (23), the adjective appears in the neuter singular form, regardless of the number and gender features of the subject. Note that *pannkakor* is the plural form of a common gender noun (Faarlund 1977; Enger 2004; Josefsson 2009):

(23) Pannkak-or är gott.
      pancake-PL be.PRES good.NT.SG
      'Situations involving pancakes are good.' (e.g. 'Eating pancakes is good.')

In general Swedish predicate adjectives appear in neuter singular when there is no triggering NP, such as with clausal subjects (see (25a) below). Wechsler & Zlatić (2003) posit the index type *unm* ('unmarked') for referential indices that lack phi features, such as those introduced by verbs. So *gott* has a SUBJlist item whose index is disjunctively specified for either neuter singular, or type *unm*.

The lack of agreement in (23) then arises because the subject phrase refers, not to the pancakes, but to a situation involving them; hence its referential index is distinct from the one lexically introduced by the noun *pannkakor*. A rule shifts the index and encodes the metonymic relation between the entity and the situation involving it. This is implemented with a non-branching phrasal construction in Wechsler (2013: 82, ex. 20):

(24) *metonymy-ctx:*

$$\begin{bmatrix} \text{MTR} & \begin{bmatrix} \text{SYN} & NP \\ \text{SEM} & \begin{bmatrix} \text{INDEX} & s_{unm} \\ \text{RESTR} & \{involve(s,i)\} \cup \boxed{1} \end{bmatrix} \end{bmatrix} \\ \text{DTRS} & \begin{bmatrix} \text{SYN} & NP \\ \text{SEM} & \begin{bmatrix} \text{INDEX} & i \\ \text{RESTR} & \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The noun *pannkakor* in (23) has an index marked with the features [PERSON *3rd*], [GENDER *com*], and [NUMBER *pl*], which, by the Semantics Principle, are therefore shared with the index of the daughter NP node in a structure licensed by rule (24). But the construction specifies the mother NP node's index is unmarked for those features, thus explaining the neuter singular adjective.

On the alternative ellipsis analysis, sentence (23) has an elliptical clausal or infinitival subject, with a structure like (25a) except that *att äta* is silent (Faarlund 1977; Enger 2004; Josefsson 2009):

(25)   a.   Att äta pannkakor är   gott.
            to eat pancakes be.PRES good.NT.SG

            'Eating pancakes is good.'

       b.   Det är   gott   att äta pannkakor.
            it   be.PRES good.NT.SG to eat pancakes

            'It is good to eat pancakes.'

       c. *Det är   gott   pannkakor.
            it   be.PRES good.NT.SG pancakes

            Intended: 'It is good to eat pancakes.'

But the metonymic subject behaves in all respects like an NP, and unlike a clause or infinitival phrase. For example, unlike an infinitival it resists extraposition, as shown in (25b,c). The metonymy analysis captures the fact that the subject has a clause-like meaning but not clause-like syntax.

6 Mixed agreement

The two-feature (INDEX/CONCORD) theory of agreement was originally motivated by *mixed agreement*, where a single phrase triggers different features on distinct targets (Pollard & Sag 1994: Chapter 2; Kathol 1999). For example, the French second person plural pronoun *vous* refers to multiple addressees, and also has an honorific or polite use for a single (or multiple) addressee. When used to refer politely to one addressee, *vous* triggers singular on a predicate adjective but plural on the verb, as in (26a):

(26)   a.   Vous êtes   loyal.
            you.PL be.2PL loyal.M.SG

            'You (singular, formal, male) are loyal.'

       b.   Vous êtes   loyaux.
            you.PL be.2PL loyal.PL

            'You (plural) are loyal.'

Wechsler (2011) analyzes this by adopting the following suppositions: (i) *vous* has a second person plural marked referential INDEX; (ii) *vous* lacks phi features for

CONCORD; (iii) finite verbs agree with their subjects in INDEX; and (iv) predicate adjectives agree with their subjects in CONCORD. Suppositions (i) and (iii) need not be stipulated, as they follow from the theory: the pronoun must have INDEX phi features since it shows anaphoric agreement (when it serves as binder or bindee); and the verb must agree in INDEX since it includes the PERSON feature. By the Agreement Marking Principle (see Section 5), the (CONCORD) number and gender features of the predicate adjective are interpreted semantically, which is what is shown by example (26).

"Polite plural pronouns" of this kind are found in many languages of the world (Head 1978). The cross-linguistic agreement patterns observed in typological studies (Comrie 1975; Wechsler 2011) confirm the predictions of the theory. Taken together, suppositions (i) and (iii) from the previous paragraph entail that any person agreement targets agreeing with polite pronouns should show formal, rather than semantic, agreement. Targets lacking person, meanwhile, can vary across languages. This pattern is confirmed for all languages with polite plurals that have been surveyed, including Romance languages, Modern Greek, Germanic (Icelandic), West, South and East Slavic, Hindi, Gbaya (Niger-Congo), Kobon and Usan (Papuan), and Sakha (Turkic) (see Comrie (1975) and Wechsler (2011)).

The INDEX/CONCORD distinction plays a crucial role in this account of mixed agreement. An earlier hypothesis, proposed by Kathol (1999), is that French predicate adjectives are grammatically specified for semantic agreement with their subjects, while finite verbs show formal agreement. But a plurale tantum noun such as *ciseaux* 'scissors' triggers syntactic agreement on the predicate adjective:

(27) Ces   ciseaux   sont géniaux!   (*génial!)
      these.PL scissors(M.PL) are.PL brilliant.M.PL (*brilliant.M.SG)
      'These scissors are cool!'

As far as the syntax is concerned, *ciseaux* 'scissors' is an ordinary common noun with masculine plural CONCORD features, so it triggers those features on the adjective. More generally, agreement target types cannot be split into "formal" and "semantic" agreement targets; both formal and semantic agreement are found across all target types. Which of the two is observed for a given agreement feature depends, according to the INDEX/CONCORD theory, on whether the trigger is specified for the grammatical feature, together with the INDEX versus CONCORD status of the target.

7 Agreement defined on other structures

So far our look at grammatical agreement has focused primarily on agreement defined on local grammatical relations like subject, object, and modifier. In this section we look at HPSG analyses of two other types of agreement, namely long-distance and superficial agreement.

7.1 Long-distance agreement

The simple picture of locality in the previous sections is challenged by the phenomenon of long-distance agreement, where the trigger appears within a clause subordinate to the one headed by the target verb. Long-distance agreement has been observed in a number of languages, including Tsez (Nakh-Dagestanian; Polinsky & Potsdam (2001), Hindi-Urdu (Bhatt 2005), and Passamaquoddy (Athabaskan; Bruening (2001); LeSourd (2018)).

Passamaquoddy long-distance agreement is illustrated by this sentence (LeSourd 2018: ex. (5)):

(28) N-kosicíy-a-*k*   [eli-   Píyel -litahási-t
      1-know-DIR-PROX.PL   thus- Peter -think-3AN
      [eli-kis-ankum-í-hti-t   *nìkt*   *ehpíc-ik*
        thus-PAST-sell-3/1-PROX.PL-3AN those.PROX woman-PROX.PL
      posonúti-yil]]
      basket-IN.PL

      'I know that Peter thinks that those women sold me the baskets.'

The *-k* suffix on the matrix verb *kosicíy* 'know' marks plural, deictically proximate agreement with the phrase *nìkt ehpícik* 'those women' in the doubly embedded subordinate clause. LeSourd (2018) analyzes Passamaquoddy long distance agreement in the HPSG framework. He notes that Passamaquoddy long distance agreement is parallelled by long-distance raising, in which an NP in the matrix clause is coreferential with an implicit argument of a subordinate clause (LeSourd 2018: ex. (4)):

(29) N-kosicíy-a-*k*   *nìkt*   *ehpíc-ik$_i$*   [eli-   Píyel
      1-know-DIR-PROX.PL those.PROX woman-PROX.PL   thus- Peter
      -litahási-t   [eli-kis-ankum-í-hti-t e_i posonúti-yil]]
      -think-3AN   thus-PAST-sell-3/1-PROX.PL-3AN   basket-IN.PL

      'I know about those women$_i$ that Peter thinks that they$_i$ sold me the baskets.'

Passamaquoddy speakers report that sentences (28) and (29) suggest the subject of 'know' (the speaker) is familiar with the women. This provides evidence that the phrase 'those women' in (29) is an argument of the matrix verb 'know', as implied by the translation. Similarly, the *-k* suffix in (28) is an incorporated object pronoun cataphoric to 'those women'.[3] What the long-distance agreement and raising constructions share is simply that the matrix object is coreferential with some argument contained in the subordinate clause. The following lexical entry for the verb root *kosicíy* 'know' captures that:

(30)   *kosicíy* 'know':

$$\begin{bmatrix} \text{PHON} & \langle kosicy \rangle \\ \text{ARG-ST} & \left\langle \text{NP}_i \, , \, \text{NP}_j \, , \, \text{S}{:}\left[\text{RESTR}\left\langle \ldots \left[\text{PRD}|\text{ARG} \quad j\right]\ldots\right\rangle\right]\right\rangle \end{bmatrix}$$

LeSourd adopts the version of HPSG described in the (Sag et al. 2003) textbook, which uses a simplified Minimal Recursion Semantics. The semantic restrictions feature (RESTR) takes as its value a list of elementary predications (PRD). The list for each node is a a concatenation of the restrictions of the daughter nodes. Thus every semantic argument contained within the S complement, whether overt or null, will correspond to some argument (ARG) of an elementary predication (PRD) in S's RESTR list. The lexical entry in (30) stipulates that the matrix object NP corefers with some such argument. In conclusion, Passamaquoddy long distance agreement is really the anaphoric agreement of a pronoun with an antecedent in a higher clause.

7.2 Superficial agreement

In some languages string adjacency of the trigger and target, rather than a grammatical relation such as subject or modifier, is a grammatical condition on agreement. This may arise because person agreement derives historically from pronoun incorporation, and a basic syntactic precondition for incorporation is string adjacency between the pronoun and the head into which it incorporates (Givón 1976; Ariel 1999; Wechsler et al. 2010; Fuss 2005). If the trigger occupies the syntactic position that the pronoun occupied prior to incorporation (for example because the trigger is itself a pronoun) then the result is that trigger and target are adjacent. For example, West Flemish complementizers agree with an immediately following subject, even though the complementizer and subject are not related by any grammatical relation (Haegeman 1992). To take another example,

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[3]LeSourd notes that Passamaquoddy lacks Principle C effects, so cataphora of this kind is permitted.

Borsley (2009) analyzes Welsh superficial agreement in the HPSG framework, citing examples like the following:

(31)   a.   Gwelon   nhw ddraig.
            see.PAST.3PL they dragon

            'They saw a dragon.'

       b.   arno   fo
            on.3SG.M he

            'on him'

       c.   Gweles   i a   Megan geffyl.
            see.PAST.1SG I and Megan horse

            'Megan and I saw a horse.'

The trigger is the subject in (31a), object in in (31b), first conjunct of a coordinate subject in in (31c). But in every case, "An agreeing element agrees with an immediately following noun phrase if and only if the latter is a pronoun" (Borsley 2009: ex. 48). (Borsley 2009: ex. 99) expresses this as an HPSG implicational constraint using the DOMAIN feature from linearization theory (Reape 1994; Müller 1995; 1999; Kathol 2000):

(32) $[\text{DOM} \langle [\text{AGR } \boxed{1}], \text{NP: } ppro_{\boxed{2}}, ... \rangle] \Rightarrow \boxed{1} = \boxed{2}$

The DOMAIN list encodes linear precedence between constituents that are not necessarily sisters. In (32) the AGR value is the set of phi features of the target; the colon following NP represents the semantic CONTENT attribute; and the subscripted tag $\boxed{2}$ is the INDEX value. The rule states that when a constituent bearing the AGR attribute is immediately followed by a personal pronoun (content of type *ppro*), then the AGR value is identified with the pronoun's index (shown here as $\boxed{2}$), that is, it agrees with a right-adjacent pronoun.

8 Conclusion

Agreement is analyzed in HPSG by assigning phi features to specific locations in the feature descriptions representing the grammar. Anaphoric agreement results from phi features appearing on the referential indices of the binder and bindee, together with the assumption that binding consists of the identification of those indices. Verbal agreement with subjects and objects results when phi features appear on the verb's ARG-ST list items that are identified with the the

SYNSEM values of the subject and object phrases. Modifier agreement with heads occurs when phi features appear within the MOD value of the modifier. According to the Index/Concord theory, when agreement is historically descended from anaphoric agreement of incorporated pronouns, then those features within the ARG-ST list or MOD items are located on the referential index; while otherwise they are collected in the CONCORD feature and placed within the value of the HEAD features. The locality conditions on agreement follow from the normal operation of the grammar in which those phi features are embedded. Some cases of agreement seem to exist outside those conditions. Long-distance agreement has been analyzed as a kind of anaphoric agreement within a prolepsis construction; and superficial agreement has been defined on string adjacency and precedence, within linearization theory.

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Chapter 7

Case

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Change the abstract in chapters/03.tex Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

HPSG is not widely known for its approach to grammatical case. For example, it is only mentioned in passing in the 2006 monograph *Theories of Case* (Butt 2006: 225) and in the 2009 *Oxford Handbook of Case* (Malchukov & Spencer 2009: 43), which features separate articles on GB/Minimalism, LFG, Optimality Theory, and other grammatical frameworks. As most of the HPSG work on case was carried out in 1990s and early 2000s, this perception is unlikely to have changed since the publication of these 2 volumes.

The aim of this chapter is to provide an overview of HPSG work on grammatical case and to show that it does offer novel solutions to some of the problems related to case. Two main research areas are presented in the two ensuing sections: structural case assignment is discussed in Section 1 and case neutralisation ('indeterminacy') and underspecification – in Section 2. Some of the other HPSG work on case, including implementational work, is outlined in Section 3.

1 Structural case assignment

Pollard & Sag (1994) did not envisage a separate theory of case:[1] "Nominative case assignment takes place directly within the lexical entry of the finite verb," while "the subject SUBCAT element of a nonfinite verb… does not have a case value specified" (30). However, they added in a footnote on the same page that "for languages with more complex case systems, some sort of distinction analogous to the one characterized in GB work as 'inherent' vs. 'structural' is required."

In the transformational Government and Binding theory of 1980s (GB; Chomsky 1981; 1986), *inherent* – or *lexical* – case is understood as rigidly assigned by the head and independent of syntactic environment, while 'structural' case varies with the structural context (e.g., Haider 1985: 70). This difference can be illustrated on the basis of the following examples from German (Przepiórkowski 1999a: 63, based on data from Heinz & Matiasek 1994):

(1) a. Der Mann   unterstützt *den Installateur.*
        the man.NOM supports   the plumber.ACC

        'The man is supporting the plumber.'

     b. *Der Installateur*   wird unterstützt.
        the plumber.NOM AUX supported

        'The plumber is supported.'

     c. das Unterstützen *des Installateurs*
        the supporting   the plumber.GEN

        'the support for/from the plumber'

(2) a. Der Mann   hilft   *dem Installateur.*
        the man.NOM helps the   plumber.DAT

        'The man is helping the plumber.'

     b. *Dem Installateur*   wird geholfen.
        the   plumber.DAT AUX helped

        'The plumber is helped.'

     c. das Helfen   *des Installateurs*
        the helping the plumber.GEN

        'the help from/*for the plumber'

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[1] This section is to some extent based on Przepiórkowski 1999a, Section 3.4 and Chapter 4; see also Müller 2013, Chapter 14.

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In (1), both arguments of the verb UNTERSTÜTZEN 'support' receive structural case: the patient argument occurs in the accusative in (1a), in the nominative in (1b), and in the genitive in (1c). Similarly, the agent argument is in the nominative in (1a), but it may only occur in the genitive in (1c); hence, the single argument marked as genitive in (1c) is ambiguous between the agent and the patient. In the case of (2), the agent argument of HELFEN 'help' is similarly assigned structural case, but the patient argument receives a rigid inherent case: it is always the dative, so, e.g., the genitive in (2c) may only be understood as marking the agent.

Examples such as above may still be handled without any general principles of case assignment. For example, lexical rules responsible for forming passive participles (as in the b. examples above) and gerunds (as in the c. examples) might be responsible for manipulating case values of arguments, e.g., for translating nominative and accusative – but not dative – to genitive in the case of gerunds. However, the interaction of the structural/inherent case dichotomy with raising (and – in some languages – with control) motivates a more comprehensive approach to case assignment.

Consider Icelandic raising verbs (all Icelandic data is taken from Sag et al. 1992: 304–305):

(3) a. *Hann* virðist elska   hana.
        he.NOM seems love.*inf* her.ACC

        'He seems to love her.'

     b. Þeir telja *Maríu*   hafa   skrifað ritgerðina.
        they believe Mary.ACC have.*inf* written the-thesis

        'They believe Mary to have written her thesis.'

As in other languages, the subject of the infinitival verb raised to the higher subject position, as in (3a), normally receives the nominative case there, while – in the case it is raised to the object position, as in (3b) – it normally receives the accusative case. This could be easily modelled in accordance with the suggestion of Pollard & Sag (1994: 30) that infinitival verbs do not assign case to their subjects, while finite verbs – in this case finite raising verbs – normally assign the nominative to their subjects and the accusative to their objects. But, as is well known (Andrews 1982; Zaenen & Maling 1983; Zaenen et al. 1985), some Icelandic verbs idiosyncratically assign specific "quirky" cases to their subjects, and when they do, the higher raising verbs must honour this assignment:

(4) a. *Hana* virðist vanta peninga.
         her.ACC seems lack.*inf* money
         'She seems to lack money.'

    b. Hann telur *mig* vanta peninga.
        he.NOM believes me.ACC lack.*inf* money
        'He believes that I lack money.'

(5) a. *Barninu* virðist hafa batnað veikin.
         the-child.DAT seems have.*inf* recovered-from the-disease
         'The child seems to have recovered from the disease.'

    b. Hann telur *barninu* hafa batnað veikin.
        he believes the-child.DAT have.*inf* recovered-from the-disease
        'He believes the child to have recovered from the disease.'

(6) a. *Verkjanna* virðist ekki gæta.
         the-pains.GEN seems not be-noticeable.*inf*
         'The pains don't seem to be noticeable.'

    b. Hann telur *verkjanna* ekki gæta.
        he believes the-pains.GEN not be-noticeable.*inf*
        'He believes the pains to be not noticeable.'

Thus, in (4), the understood subject of the infinitival VANTA 'lack' must be in the accusative, whether it is raised the object position, as in (4b), where the accusative would be expected anyway, or to the subject position, as in (4a), where normally the nominative case would be expected. Similarly in the case of verbs idiosyncratically assigning their subject the dative case, as in (5), or the genitive case, as in (6).

   The difficulty presented by such examples is this. If the finite raising verbs were assumed to assign case to the raised subjects – nominative in the case of raising to subject and accusative in the case of raising to object – than this would clash with 'quirky' cases assigned to their subjects by some verbs: (4a), (5) and (6) would be predicted to be ungrammatical. If, on the other hand, such raising verbs did not assign case to the raised arguments, instead relying on the lower verbs to assign appropriate cases to their subjects, then it is not clear what case should be assigned to their subjects by the usual – not 'quirky' – verbs: it cannot always be the nominative, as the accusative case is witnessed when the subject is raised to the object position, as in (3b); similarly, it cannot always be the accusative, as

the nominative case surfaces when the subject is raised to the subject position, as in (3a).

The intuition of the analysis proposed in Sag et al. 1992 relies on the distinction between structural and inherent case assignment, although these terms do not appear in this paper. Verbs such as those in (4)–(6) assign their subjects specific inherent cases (accusative in (4), dative in (5) and genitive in (6)), while the usual verbs, as in (3), only mark their subjects as structural, to be assigned case elsewhere. Finite raising verbs are, in a way, sensitive to this distinction, and only assign the nominative (in the case of raising to subject) or accusative (in the case of raising to object) to such structural arguments. While Sag et al. (1992) represent this distinction between structural and inherent case implicitly, via the interaction of two attributes, CASE (realised case) and DCASE (default case), later HPSG work assumes explicit representation of the two kinds of case as two subtypes of *case* in the type hierarchy: *str*(uctural) and *lex*(ical). Such a *case* type hierarchy is, apparently independently, alluded to in Pollard 1994 and introduced in detail in Heinz & Matiasek 1994, to which we turn presently.

On the basis of German examples such as (1)–(2), Heinz & Matiasek (1994) argue that out of 4 morphological cases in German – nominative, accusative, genitive and dative — the first three (i.e., without the dative) may be assigned structurally, by general case assignment principles. Similarly, they argue that the last three (i.e., without the nominative) may also be assigned lexically, in which case they are stable across various syntactic environments. These empirical observations are translated into the following *case* hierarchy:

(7)
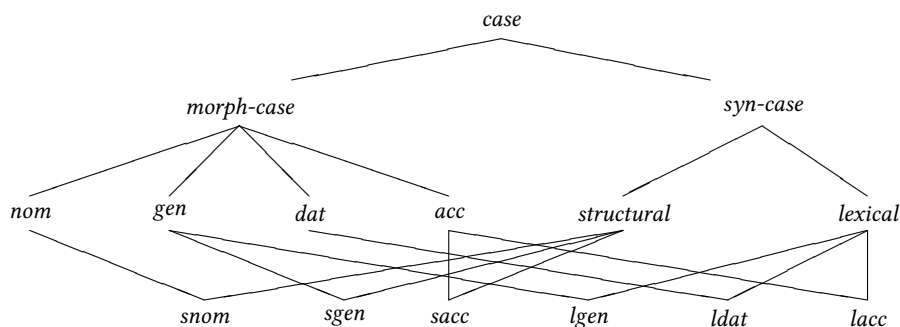
Particular verbs may assign specific lexical cases to their arguments, e.g., *ldat*.

They may also specify arguments as bearing structural case, in which case only the *str*(*uctural*) supertype is mentioned in the lexicon. For example, the lexical entries for UNTERSTÜTZEN 'support' and HELFEN 'help' contain the following subcategorisation requirements:

(8)   a. UNTERSTÜTZEN: [SUBCAT ⟨ NP[*str*], NP[*str*] ⟩]
      b. HELFEN: [SUBCAT ⟨ NP[*str*], NP[*ldat*] ⟩]

Assuming a similar *case* hierarchy for Icelandic, the difference between the usual verbs, such as ELSKA 'love' in (3a), and 'quirky' subject verbs, such as VANTA 'lack' in (4), could be represented as below (omitting non-initial arguments):

(9)   a. ELSKA: [SUBCAT ⟨ NP[*str*], …⟩]
      b. VANTA: [SUBCAT ⟨ NP[*lacc*], …⟩]

Since Pollard 1994 and Heinz & Matiasek 1994, such representations of case requirements are generally adopted in HPSG,[2] with the only difference that SUBCAT is currently replaced with ARG-ST. The point where different approaches diverge is how exactly structural case is resolved to a specific morphological case.

The simplest principle would resolve the case of the first *str* argument of a pure (non-gerundial) verb to nominative, i.e., to *snom*, the case of any subsequent *str* argument of a pure verb to accusative, i.e., to *sacc*, and the case of any *str* argument of a gerund to *sgen*. Unfortunately, this simple principle would not work in various cases of raising, e.g., in the case of the Icelandic data above. While the 'quirky' cases in (4)–(6) would be properly taken care of by this approach – once the subject is assigned a specific lexical case it is outside of the realm of a principle resolving structural cases – structural subjects raised to a higher verb would be assigned specific case twice (or more times, in the case of longer raising chains): on the SUBCAT (or ARG-ST) of the lower verb and on the SUBCAT (or ARG-ST) of the raising verb. This would not necessarily lead to problems in the case of raising to subject verbs, as in (3a), as the structural argument would be the subject in both subcategorisation frames, so it would be resolved to *snom* twice, but it would create a problem in the case of raising to object verbs, as in (3b), as the raised argument would be resolved to the nominative on the lower subcategorisation frame and to the accusative on the higher frame. So, the problem is not limited to Icelandic, but may be observed in any language with raising to object (also known as Exceptional Case Marking or Accusativus cum Infinitivo), including German (cf., e.g., Heinz & Matiasek 1994: 231). Obviously, even if a structural argument occurs on a number of SUBCAT or ARG-ST lists, it should be assigned

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[2]A very recent example being Machicao y Priemer & Fritz-Huechante 2018.

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specific morphological case according to its position on just one of them – the highest one.

Both Pollard 1994 and Heinz & Matiasek 1994 account for such facts via configurational case principles, e.g. (Heinz & Matiasek 1994: 209):

(10) CASE PRINCIPLE (for German):

In a *head-complement-structure* whose head has category
verb[*fin*]	the external argument has a CASE value of *snom*,
verb	the internal argument has a CASE value of *sacc*,
noun	the internal argument has a CASE value of *sgen*.

These are the only saturated or almost saturated *head-complement-structure*s with structural arguments.

(11) *Syntactically External Argument ('Subject')*:

If the first element of the SUBCAT list of a sign is an NP[*str*], it is called the *(syntactically) external argument* of that sign.

(12) *Syntactically Internal Argument ('Direct Object')*:

If the second element of the SUBCAT list of a sign is an NP[*str*], it is called the *(syntactically) internal argument* of that sign.

Heinz & Matiasek (1994: 209–210) formalize this CASE PRINCIPLE by giving the following constraints:

$$
(13) \quad
\begin{bmatrix}
phrase \\
\text{SYNSEM|LOC|CAT}
\begin{bmatrix}
\text{HEAD}
\begin{bmatrix}
verb \\
\text{VFORM } fin
\end{bmatrix} \\
\text{SUBCAT } \langle \rangle
\end{bmatrix} \\
\text{DTRS}
\begin{bmatrix}
h\text{-}c\text{-}str \\
\text{HEAD-DTR|…|SUBCAT } \langle \text{ NP}[str] \rangle
\end{bmatrix}
\end{bmatrix}
\Rightarrow
$$

$$
\begin{bmatrix}
\text{DTRS|HEAD-DTR|…|SUBCAT } \langle \text{ NP}[snom]\rangle, …
\end{bmatrix}
$$

$$(14) \quad \begin{bmatrix} phrase \\ \text{SYNSEM|LOC|CAT} \begin{bmatrix} \text{HEAD} & \begin{bmatrix} verb \\ \text{VFORM} & fin \end{bmatrix} \\ \text{SUBCAT} & \langle\rangle \vee \langle\ synsem\ \rangle \end{bmatrix} \\ \text{DTRS} \begin{bmatrix} h\text{-}c\text{-}str \\ \text{HEAD-DTR}|...|\text{SUBCAT} & \langle\ synsem,\ \text{NP}[str],\ ...\rangle \end{bmatrix} \end{bmatrix} \Rightarrow$$

$$\begin{bmatrix} \text{DTRS|HEAD-DTR}|...|\text{SUBCAT} & \langle\ synsem,\ \text{NP}[sacc]\rangle,\ ... \end{bmatrix}$$

$$(15) \quad \begin{bmatrix} phrase \\ \text{SYNSEM|LOC|CAT} \begin{bmatrix} \text{HEAD} & noun \\ \text{SUBCAT} & \langle\rangle \vee \langle\ synsem\ \rangle \end{bmatrix} \\ \text{DTRS} \begin{bmatrix} h\text{-}c\text{-}str \\ \text{HEAD-DTR}|...|\text{SUBCAT} & \langle\ synsem,\ \text{NP}[str],\ ...\rangle \end{bmatrix} \end{bmatrix} \Rightarrow$$

$$\begin{bmatrix} \text{DTRS|HEAD-DTR}|...|\text{SUBCAT} & \langle\ synsem,\ \text{NP}[sgen]\rangle,\ ... \end{bmatrix}$$

Note that the locus of this Case Principle is *phrase* and that it makes reference to *head-complement-structure* values of the DAUGHTERS (DTRS) attribute. In this sense, this principle is configurational. Similar principles were proposed for Korean (Yoo 1993; Bratt 1996), English (Grover 1995) and Polish (Przepiórkowski 1996a), *inter alia.*

This configurational approach to case assignment is criticised in Przepiórkowski 1996b; 1999b,a on the basis of conceptual and theory-internal problems. The conceptual problem is that a configurational analysis is employed to what is usually considered an essentially local phenomenon, one concerned with the relation between a head and its dependents (Blake 1994). The – more immediate – theory-internal problem is that such configurational case principles are restricted to locally realised arguments, and are not directly compatible with those – dominant since Pollard & Sag 1994: Chapter 9 – HPSG analyses of extraction which do not assume traces and with those HPSG approaches to cliticisation in which the clitic is realised as an affix rather than a tree-configurational constituent (cf., e.g., Miller & Sag 1997 on French and Monachesi 1999 on Italian).

The solution proposed in Przepiórkowski 1996b; 1999b,a is to resolve structural cases directly within ARG-ST, via local principles operating at the level of *category* of a word (where both head information and argument structure infor-

mation – but not constituent structure – is available) rather than at the level of *phrase*. This seems to bring back the problem, discussed in the connection of Icelandic data above, of raised arguments, which occur on a number of ARG-ST lists. The innovation of Przepiórkowski 1996b; 1999b,a is the proposal to mark, within ARG-ST, whether a given argument is realised locally (either tree-configurationally, or as a gap to be extracted higher on, or as an affix) or not. If it is realised locally, it may be assigned appropriate case; if it is not (because it is raised), its structural case must be resolved higher up. On this setup, the above constraints (13)–(14) responsible for the assignment of structural nominative and accusative are replaced with the following two constraints (and similarly for the structural genitive):

$$(16) \quad \begin{bmatrix} cat \\ \text{HEAD} \quad verb \\ \text{ARG-ST} \quad \left\langle \begin{bmatrix} \text{ARG NP}[str] \\ \text{REALIZED} + \end{bmatrix} \right\rangle \oplus \boxed{2} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{ARG-ST} \left\langle \begin{bmatrix} \text{ARG NP}[snom] \end{bmatrix} \right\rangle \oplus \boxed{2} \end{bmatrix}$$

$$(17) \quad \begin{bmatrix} cat \\ \text{HEAD} \quad verb \\ \text{ARG-ST} \quad \boxed{1} \; nelist \oplus \left\langle \begin{bmatrix} \text{ARG NP}[str] \\ \text{REALIZED} + \end{bmatrix} \right\rangle \oplus \boxed{2} \end{bmatrix} \Rightarrow$$
$$\begin{bmatrix} \text{ARG-ST} \; \boxed{1} \oplus \left\langle \begin{bmatrix} \text{ARG NP}[snom] \end{bmatrix} \right\rangle \oplus \boxed{2} \end{bmatrix}$$

Obviously, for such constraints to work, values of ARG-ST must be lists of slightly more complex objects than *synsem* (these are now values of ARG within such more complex objects), and additional principles must make sure that values of REALIZED are instantiated properly (see Przepiórkowski 1999a: 78–79 for details).

While this approach seems to be sufficient to account for almost all known structural case phenomena, German presents additional difficulties, as discussed in Müller 1997a; 2001 and Meurers 1999a,b. In brief, Müller (1997a; 2001) recalls arguments from Höhle 1983; 2018 that in German controlled (not: raised) structural subjects bear the nominative case. Since such subjects are never realised locally (as such), the above case principle stated in terms of REALIZED would not resolve their case. The problem with the particular approach of Przepiórkowski 1996b; 1999b,a is the assumption that an argument is locally realised – and hence may be assigned structural case – if and only if it is not raised to a higher argument

structure. The kind of data discussed in Höhle 1983; 2018 and Müller 1997a; 2001 shows that this equivalence does not always hold and suggests that structural case should be assigned to arguments on the basis of whether they are raised or not, and not whether they are locally realised or not.

The same conclusion may be reached on the basis of different data, discussed in Meurers 1999a,b on the basis of empirical observations in Haider 1990, Grewendorf 1994 and Müller 1997b:

(18)   a.   [*Ein   Außenseiter* gewinnen] wird hier nie.
            an.NOM outsider   win.*inf*   will   here never

            'An outsider will never win here.'

       b.   [*Einen   Außenseiter* gewinnen] läßt Gott hier nie.
            an.ACC outsider   win.*inf*   lets god   here never

            'God never lets an outsider win here.'

Assuming that fronted fragments, marked with square brackets, are single constituents,[3] the subject of *gewinnen* 'win' forms a constituent with this verb, i.e., it has the same configurational realisation in both examples. Hence, configurational case assignment principles should assign it the same case in both instances, contrary to facts: *ein Außenseiter* occurs in the nominative in (18a) and *einen Außenseiter* bears the accusative case in (18b). As argued by Meurers 1999a,b, the reason is that – although the subject is realised locally to its infinitival head – it is in some sense raised further to the subject position of the auxiliary *wird* in (18a) and to the object position of the AcI verb *läßt* in (18b); hence, the difference in cases. This, again, suggests that structural case should be assigned not where the argument is realised, but on the highest ARG-ST on which it occurs. A corresponding modification of the non-configurational case assignment approach of Przepiórkowski 1996b; 1999b,a – replacing the [REALIZED +] with [RAISED −] in constraints such as (16)–(17) and providing appropriate constraints on values of RAISED – is proposed in Przepiórkowski 1999a: 93–95; see also Müller 2013, Section 17.4 (and references therein), for further improvements.

While this non-configurational approach to syntactic case assignment was motivated largely by theory-internal technical considerations, it turns out to formalise sometimes apparently contradictory intuitions expressed in various approaches to case. First of all, it preserves the common intuition that case is a local phenomenon, an intimate relation between a head and its dependents.

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[3]This assumption is not completely uncontroversial; see Kiss (1994: 100–101) for potential counterexamples.

Second, it successfully formalises the distinction between structural and inherent/lexical case known from the transformational literature of 1980s, and nonconfigurationally encodes the apparently configurational principles of structural case assignment. Third, while most HPSG literature on case is concerned with syntactic phenomena in European languages, this approach has been extended to case stacking known, e.g., from languages of Australia and case attraction observed, e.g., in Classical Armenian and in Gothic (Malouf 2000). Fourth, by allowing antecedents of implicational constraints such as (16)–(17) to be *local* objects, not just syntactic *categories*, semantic factors influencing case assignment may also be taken into account, as in differential case marking, repeatedly considered in Lexical Functional Grammar (cf., e.g., Butt & King 2003 and references therein), but apparently not (so far) in HPSG. Fifth, as pointed out in Przepiórkowski 1999b,a, the above approach to case formalises the 'case tier' intuition of Zaenen et al. 1985, Yip et al. 1987 and Maling 1993 (see also Maling 2009).

Let us illustrate the last point with some Finnish data from Maling 1993:

(19) a. Liisa   muisti   matkan vuoden.
          Liisa.NOM remembered trip.ACC year.ACC

          'Liisa remembered the trip for a year.'

      b. Lapsen   täytyy lukea kirja   kolmannen kerran.
          child.GEN must   read book.NOM [third   time].ACC

          'The child must read the book for a 3rd time.'

      c. Kekkoseen   luotettiin   yksi kerta.
          Kekkonen.ILL trust.PASSP [one time].NOM

          'Kekkonen was trusted once.'

      d. Kekkoseen   luotettiin   yhden kerran   yksi vuosi.
          Kekkonen.ILL trust.PASSP [one   time].ACC [one year].NOM

          'Kekkonen was trusted for one year once.'

Maling (1993) argues at length that some adjuncts (adverbials of measure, duration and frequency) behave just like objects with respect to case assignment and, in particular, notes the following generalization about syntactic case assignment: only one NP dependent of the verb receives the nominative, namely the one which has the highest grammatical function; other dependents receive the accusative.[4] Thus, if none of the arguments bears inherent case, the subject is in

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[4]See also Zaenen & Maling 1983 and Zaenen et al. 1985 for a similar generalisation with respect to Icelandic.

the nominative and other dependents are in the accusative, cf. (19), but if the subject bears an idiosyncratic case, it is the object that gets the nominative, cf. (19b). Furthermore, if all arguments (if any) bear inherent case, the next 'available' grammatical function is that of an adjunct, thus one of the adjuncts receives the nominative, cf. (19c)–(19d).

Given such facts, Maling (1993) claims that syntactic case is assigned in Finnish on the basis of grammatical hierarchy and that (at least some) adjuncts belong to this hierarchy. Moreover, as evidenced by (19c)–(19d), adjuncts do not form a single class in this hierarchy: although the multiplicative adverbial *yksi kerta* is nominative in (19c), this case is won over by the duration adverbial in (19d). Taking into consideration also the partitive of negation facts (measure adverbials, but not duration or frequency adverbials, behave like direct objects in the sense that they take partitive case under sentential negation), Maling (1993) extends the grammatical function hierarchy for Finnish in the following way:

(20)   SUBJ > OBJ > MEASURE > DURATION > FREQUENCY

While these generalisations are developed in the context of Lexical Functional Grammar, it is not clear how they could be encoded in LFG: there are no formal mechanisms for stating such a hierarchy of grammatical functions and, additionally, all adjuncts are assumed to be elements of an unordered set. On the other hand, given the 'adjuncts as complements' approach of Bouma et al. 2001 and others, upon which at least some adjuncts are added to ARG-ST (perhaps renamed to DEPS), and assuming – as standard in HPSG – that ARG-ST elements satisfy the obliqueness hierarchy, formalisation of the 'case tier' approach is easy and consists of two implicational principles similar to (16)–(17). The first principle resolves the first structurally-cased element of extended ARG-ST to nominative, whether this element is the first element of ARG-ST or not (it is not in the case of (19b)–(19d)), and whether it corresponds to the subject, the direct object or an adjunct. The second principle resolves the structural case of all subsequent elements, if any, to accusative.

2 Case syncretism

Another important strand of HPSG work on case concerns situations in which a single syncretic form seems to simultaneously bear two (or more) case values, as in the following examples involving coordination, free relatives and parasitic gaps:

(21)   Polish coordination (Dyła 1984: 701–702):

a. Kogo Janek lubi a Jerzy
who.ACC/GEN Janek.NOM likes(OBJ.ACC) and Jerzy.NOM
nienawidzi?
hates(OBJ.GEN)
'Who does Janek (John) like and Jerzy (Jerry) hate?'

b. * Co   Janek lubi a Jerzy
what.NOM/ACC Janek.NOM likes(OBJ.ACC) and Jerzy.NOM
nienawidzi?
hates(OBJ.GEN)
'What does Janek (John) like and Jerzy (Jerry) hate?' (putative)

(22) German coordination (Pullum & Zwicky 1986: 764–765):

a. Er findet und hilft
he.NOM finds(OBJ.ACC) and helps(OBJ.DAT)
Frauen.
women.NOM/ACC/GEN/DAT
'He finds and helps women.'

b. * Sie findet und hilft Männer.
she.NOM finds(OBJ.ACC) and helps(OBJ.DAT) men.NOM/ACC/GEN
'She finds and helps men.' (putative)

c. * Sie findet und hilft Männern.
she.NOM finds(OBJ.ACC) and helps(OBJ.DAT) men.DAT
'She finds and helps men.' (putative)

(23) German free relatives (Groos & van Riemsdijk 1981: 212):

Was   du mir gegeben hast, ist
what.NOM/ACC you.NOM me.DAT given(OBJ.ACC) have is(SUBJ.NOM)
prächtig.
wonderful
'What you have given to me is wonderful.'

(24) English parasitic gaps (Hukari & Levine 1996: 482, Levine et al. 2001: 205):

Robin is someone who$_i$.NOM/ACC even good friends of e_i.ACC believe
e_i.NOM should be closely watched.

In (21a), the fronted syncretic accusative/genitive form *kogo* 'who' satisfies the requirements of the two coordinated verbal constituents: in one, *lubi* 'likes' requires an accusative object, and in the other, *nienawidzi* 'hates' expects a genitive

object. A form which is not syncretic between (at least) these two cases cannot occur in the place of *kogo*; this is illustrated in (21b), where the element putatively shared by the two verbal constituents is syncretic between accusative and nominative, rather than accusative and genitive. The well-known example (22) illustrates essentially the same phenomenon in German: the form *Frauen* 'women', which is fully syncretic with respect to case, simultaneously satisfies the accusative requirement of *findet* 'finds' and the dative requirement of *hilft* 'helps'. By contrast, this joint requirement is not satisfied either by *Männer*, which is accusative (among other cases) but not dative, or by *Männern*, which is dative but not accusative. The other two examples show that this phenomenon is not restricted to coordination. In (23), the syncretic form *was* 'what' simultaneously satisfies the constraint that the object of *gegeben* 'given' is accusative and that the subject of *ist* 'is' is nominative. Similarly, the extracted *who* in (24) seems to simultaneously bear the accusative case assigned by the preposition *of* and the nominative case of the subject of *should*.

Such examples were at one point considered as problematic not only for HPSG, but for unification-based theories in general (Ingria 1990). The reason is that, on the straightforward approach to case, they should all be ungrammatical. For example, in the case of (22a), the assignment of the accusative to the object of *findet* 'finds' should clash with the assignment of the dative to the object of *hilft* 'helps', as both objects are realised by the same noun *Frauen* 'women'. In other words, the attempt to unify accusative and dative should fail.

The solution first proposed by Levine et al. (2001: 207–208) is to enrich the *case* hierarchy in such a way that the unification of two different morphological cases does not necessarily result in failure. Specifically, assuming that nominative and accusative are structural cases in English, they propose the following part of the structural case hierarchy:[5]

(25)
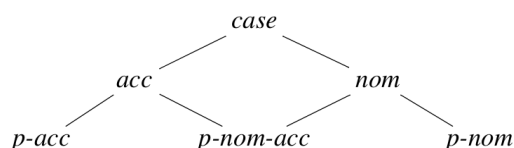
Particular nominal forms are specified in the lexicon as either pure accusative (*p-acc*), pure nominative (*p-nom*) or syncretic between the two (*p-nom-acc*):

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[5]Type names follow the convention in Daniels 2002, for increased uniformity with the remainder of this section.

(26)   *he*   [CASE *p-nom*]
        him   [CASE *p-acc*]
        whom [CASE *p-acc*]
        who   [CASE *p-nom-acc*]
        Robin [CASE *p-nom-acc*]

On the other hand, heads – or constraints of a case principle of the kind presented in the previous section – specify particular arguments as *nom* or *acc*. So, in the case of the parasitic gap example (24), the *acc* requirement associated with the preposition *of* and the *nom* requirement on the subject of *should* are not incompatible: their unification results in *p-nom-acc* and the shared dependent may be any form compatible with this case value, e.g., *who* (but not *whom*). Examples (21)–(23) can be handled in a similar way.

A situation often perceived as dual to such case neutrality, sometimes called 'case underspecification', occurs when a head specifies the case of its dependent disjunctively and may combine with a coordinate structure containing phrases in both cases, e.g.:

(27)   Polish (Przepiórkowski 1999a: 175):

    Dajcie wina   i   całą   świnię!
    give   wine.GEN and whole.ACC pig.ACC

    'Serve (some) wine and a whole pig!'

(28)   Russian (Levy 2001: 11):

    Včera   vec' den' on proždal svoju   podrugu   Irinu   i
    yesterday all   day he expected self's.ACC girlfriend.ACC Irina.ACC and
    zvonka ot   svoego brata   Grigorija.
    call.GEN from self's   brother Grigory

    'Yesterday he waited all day for his girlfriend Irina and for a call from his brother Grigory.'

In Polish, the object of the verb *dajcie* 'give' is normally in the accusative, but may also be realised as the genitive, when its meaning is partitive; in (27), the object is a coordination of such a genitive noun *wina* '(some) wine' and the accusative *całą świnię* 'whole pig'. Similarly, according to Levy 2001, the Russian verb *proždal* 'awaited' may combine with accusative or genitive, and in (28) it happily combines with a coordinate phrase containing both.

If such 'accusative and genitive' coordinate phrases bear case at all, the value of this grammatical category must be something like *acc+gen*. Note that this

situation differs from case neutrality discussed above: a neutral case such as *p-acc-gen* intuitively corresponds to intersection: a nominal bearing this case is accusative and genitive at the same time. On the other hand, the intuition behind *acc+gen* is that of union: a (coordinated) nominal with this case value has accusative elements (perhaps purely accusative) and genitive elements (perhaps purely genitive). In particular, *acc+gen* coordinate phrases cannot fill either purely accusative position, or purely genitive positions, or positions in which both the accusative and the genitive is expected, as in (21) above.[6]

This duality is a feature of the categorial grammar approach to case and coordination of Bayer 1996 (see also Bayer & Johnson 1995) and the corresponding HPSG analyses were presented in Levy 2001 and Levy & Pollard 2002, as well as in Daniels 2002. As noted in Levy & Pollard 2002: 233, the two approaches are isomorphic. The main technical difference is that the relevant case hierarchies are construed outside of the usual HPSG type hierarchy in the approach of Levy 2001 and Levy & Pollard 2002, but they are fully integrated in the approach of Daniels 2002. For this reason, and also because it is the basis of some further HPSG work (e.g., Crysmann 2005), this latter approach is presented below.

Intuitively, just as the common subtype of *acc* and *nom*, i.e., *p-nom-acc* in (25), represents forms which are simultaneously accusative and nominative, the common supertype, i.e., *case*, which should perhaps be renamed to *nom+acc*, should represent coordinate structures involving nominative and accusative conjuncts. However, given that all objects are assumed to be sort-resolved in standard HPSG, saying that the case of a coordinate structure is *case* (or *nom+acc*) is paramount to saying that it is either *p-acc* (pure accusative), or *p-nom-acc* (syncretic nominative/accusative), or *p-nom* (pure nominative). One solution is to "make a simple change to the framework's foundational assumptions" (Sag 2003: 268) and to allow linguistic objects to bear non-maximal types. This is proposed and illustrated in detail in Sag 2003. A more conservative solution, proposed in Daniels 2002, is to add dedicated maximal types to all such non-maximal types; for example, the above hierarchy (25) becomes (29):

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[6]To the extent that coordinate phrases may fill such a neutralised accusative/genitive position, all conjuncts – and, hence, also the whole coordinate structure – should bear the neutralised *p-acc-gen* case.

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(29)

```
                          nom+acc
                         ╱    │    ╲
               acc    p-nom+acc   nom
              ╱    ╲           ╲       ╲
          p-acc      p-nom-acc        p-nom
```
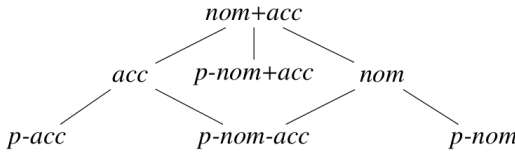
Apart from the trivial renaming of *case* to the more explicit *nom+acc*, a maximal type corresponding to this renamed non-maximal type is added here, namely, *p-nom+acc*.

Let us illustrate this approach with the two Polish examples (21a) and (27), repeated below as (30a) and (30b):

(30)   a. Kogo   Janek   lubi   a   Jerzy   nienawidzi?
          who.ACC/GEN Janek.NOM likes(OBJ.ACC) and Jerzy.NOM hates(OBJ.GEN)

          'Who does Janek like and Jerzy hate?'

      b. Dajcie wina   i   całą   świnię!
          give   wine.GEN and whole.ACC pig.ACC

          'Serve (some) wine and a whole pig!'

As these examples involve accusative and genitive, we will assume that the complete case hierarchy contains a subhierarchy such as (29) above, with all occurrences of *nom* replaced by *gen*.

First of all, heads subcategorise for (or relevant case principles specify) 'non-pure' cases, i.e., *acc*, *gen*, *gen+acc*, etc., but not *p-acc*, *p-gen*, *p-gen+acc*, etc. For example, *lubi* 'likes' and *nienawidzi* 'hates' in (30a) expect their objects to have the case values: *acc* and *gen*, respectively. Moreover, *dajcie* 'give' in (30b) specifies the case of its object as *gen+acc*. On the other hand, nominal dependents bear 'pure' cases. For example, *kogo* 'who' in (30a) is lexically specified as *p-gen-acc*. Similarly to the analysis of the English parasitic gap example above, this neutralised case is compatible with both specifications: *acc* and *gen*.

The analysis of (30b) is a little more complicated, as a new principle is needed to determine the case of a coordinate structure. The two conjuncts, *wina* 'wine' and *całą świnię* 'whole pig', have — by virtue of lexical specifications of their head nouns – the case values: *p-gen* and *p-acc*, respectively. Now, the case value of the coordination is determined as follows: take the 'non-pure' versions of the cases of all conjuncts (here: *gen* and *acc*), find their (lowest) common supertype (here: *gen+acc*), and assign to the coordinate structure the 'pure' type corresponding to this common supertype (here: *p-gen+acc*). This way the coordinate structure in (30b) ends up with the case value *p-gen+acc*, which is compatible with the

gen+acc requirement posited by the verb *dajcie* (or by an appropriate principle of structural case assignment). Obviously, a purely accusative, purely genitive or accusative/genitive neutralised object would also satisfy this requirement.

One often perceived – both within and outside of HPSG – problem with this approach is that it leads to very complex type hierarchies for *case* and rather inelegant constraints (Sag 2003: 272, Dalrymple et al. 2009: 63–66). Let us, following Daniels 2002, simplify the presentation of type hierarchies such as (29) in the following way, by removing all those 'pure' types which are only needed to represent some non-maximal types as maximal:

(31)
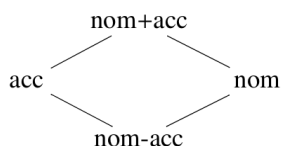
Hence, the above representation corresponds to 7 types shown explicitly in (29) (each non-maximal type in (31) has an additional *p-* type, while the maximal *nom-acc* in (31) is the same as *p-nom-acc* in (29)). What would a similar hierarchy for three morphological cases look like? Daniels 2002: 143 provides the following visualisation, involving 18 nodes, corresponding to 35 types in the full type hierarchy:

(32)
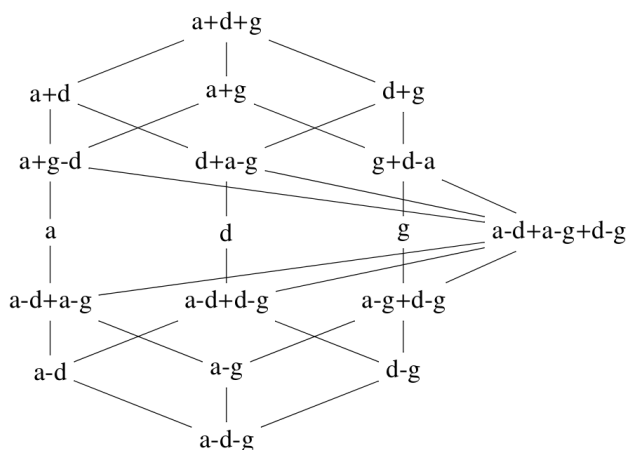
As mentioned in Levy & Pollard 2002: 225, the size of such a type hierarchy grows double exponentially with the number of grammatical cases, so it would

already be next to impossible to visualise such a hierarchy for German, with its four cases, not to mention Polish with its 7 cases or Finno-Ugric languages with around 15 cases. And matters are further complicated by the fact that sometimes form syncretism simultaneously involves a number of grammatical categories, so perhaps such type hierarchies should combine case information with person, gender and number (Daniels 2002: 145, Crysmann 2005), and by the fact that coordinated elements may be specified for different categories (e.g., an NP specified for case may be coordinated with a sentence), in which case it is not clear what categories should be borne by the coordinate structure as a whole (see, e.g., the inconclusive fn.10 in Sag 2003: 277).

After early 2000s, such complex *case* hierarchies seem to have been abandoned in HPSG. A possible reason for this is the increasing popularity of 'conjunction reduction', i.e., ellipsis-based, accounts of various coordinate constructions, including unlike category coordination cases, of which the 'case underspecification' examples (27)–(28) may be seen as special cases.[7] Such 'conjunction reduction' accounts are usually formulated within the linearisation approach of Reape 1992; 1994 and Kathol 1995, and they have been claimed to deal with some of the cases discussed in this section, e.g., by Crysmann 2008, Beavers & Sag 2004, and Chaves 2006; 2008. However, such linearisation-based approaches to coordination have more recently come under attack: see Levine 2011 and Kubota & Levine 2015, as well as Yatabe 2012; 2016 and, especially, Yatabe & Tam 2018 for a defence. Hence, it is difficult to predict at the moment whether 'conjunction reduction' analyses will permanently remove the need for complex type hierarchies modelling neutralisation and underspecification. But even if they do, some of the examples given at the beginning of this section, namely, (23)–(24), demonstrated that feature neutrality is not limited to coordinate structures, but also occurs at least in free relatives and multiple gapping, so case hierarchies of the kind illustrated in (25), with separate types representing syncretic cases, are still needed in contemporary HPSG, regardless of the analysis of coordination; an example of a more recent analysis which does assume such a case hierarchy (to account for gapping and resumptive pronouns in Modern Standard Arabic) is Alotaibi & Borsley 2013.[8]

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[7]Another HPSG approach to unlike category coordination which obviates the need for such complex hierarchies is that of Yatabe 2004, according to which the – perhaps disjunctive or underspecified – requirements of the head independently distribute to all conjuncts, in a manner similar to distributivity within coordinate structures assumed in LFG (Dalrymple & Kaplan 2000; Dalrymple et al. 2009; Przepiórkowski & Patejuk 2012).

[8]But see Crysmann 2017 for a reanalysis which does not need to refer to such a case hierarchy.

3 Other HPSG work on case

Apart from the two clearly identifiable strands of HPSG work described in the two preceding sections, there are also single papers concerned with various theoretical and implementational aspects of grammatical case. Of these, the report by Drellishak 2008 on modelling complex case phenomena in the Grammar Matrix (Bender et al. 2002) has the widest typological scope. It describes the treatment of various case systems in the multilingual platform for implementing HPSG grammars: not only the pure nominative-accusative, ergative-absolutive and tripartite systems, but also systems with various types of split ergativitity, systems – known from Austronesian languages, including Tagalog – in which case marking interact with focus marking, and so-called 'direct-inverse' systems, exemplified by Algonquian languages, in which case marking partially depends on the hierarchies – or scales – of nominal phrases, e.g., based on person and/or animacy. Similarly to the non-configurational case assignment principles discussed in Section (1) above, such systems are described – via constraints on specific lexical types – by specifying case values of elements on ARG-ST.

Two other works mentioned here are concerned with two very different aspects of case systems of particular languages. Ryu 2013 investigates the issue of case spreading from an argument of a verb to certain nominal dependents of this argument. He investigates the semantic relations that must hold between the two nominals for such 'case copying' to occur and proposes a repertoire of 16 semantic relations (collected in five coherent groups, further classified into two general classes) which make the spreading of the nominative possible, 10 of which (three of the five groups, one of the two classes) license the spreading of the accusative. On the syntactic side, the dependents of such nominal arguments are raised to become valency elements of the governing verbs. In particular, dependents of the subject are raised to the VAR|SUBJ list, resulting in multiple valency subjects. Configurational case assignment rules constrain the value of case of each valency subject to nominative, and of each valency complement – to accusative. The paper does not discuss the (im)possibility of formulating such case assignment rules non-configurationally, within local ARG-ST (or DEPS), but the challenge for the non-configurational case assignment seems to be the fact that multiple argument structure elements may correspond to valency subjects (and multiple – to valency complements), so – looking at the argument structure alone – it is not immediately clear how many initial elements of this list should be assigned the nominative case, and which final elements should get the accusative.

Finally, a very different aspect of Hungarian case is investigated in Thuilier 2011, namely, whether case affixes should be distinguished from postpositions and, if so, where to draw the line. In Hungarian, postpositions behave in some respect just like case affixes (e.g., they do not allow any intervening material between them and the nominal phrase) which led some researches to deny the existence of this distinction. Thuilier 2011 shows that, in this case, the traditional received wisdom is right, and that case affixes and postpositions differ in a number of morphological and syntactic ways. The proposed tests suggest that the essive element *két*, normally considered to be a case affix, should be reanalysed as a postposition, thus establishing the number of Hungarian cases as 16. The resulting analysis of Hungarian case affixes and postpositions is couched within Sign-based Construction Grammar (Boas & Sag 2012).

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Chapter 8

Nominal structures

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University of Leuven

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1 Introduction

Duis pulvinar lacus id gravida ornare. Phasellus eu mauris sed tortor maximus condimentum ultrices in leo. Donec non erat nec nulla ullamcorper ornare sed id ex. Integer risus mauris, aliquet vel aliquam sed, feugiat quis nisi. Suspendisse quis nunc a turpis porttitor mollis. In luctus nulla id nunc dapibus, id rhoncus lorem pretium. Nunc eget fringilla velit, semper commodo diam. Suspendisse odio odio, euismod ac ornare sed, tincidunt ac arcu. Pellentesque vitae fringilla orci. Donec faucibus metus dui, nec iaculis purus pellentesque sit amet. Sed fermentum lorem non augue cursus, eu accumsan risus ullamcorper. Suspendisse

rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 9

Argument structure and linking

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> What we cannot speak about, we must pass over in silence.

1 Introduction

When a verb or other predicator is composed with the phrases or pronominal affixes expressing its semantic arguments, the grammar must specify the mapping between the semantic participant roles and syntactic dependents of that verb. For example, the grammar of English indicates that the subject of *eat* fills the eater role and the object of *eat* fills the role of the thing eaten. In HPSG this mapping is usually broken down into two simpler mappings by positing an intermediate representation called ARG-ST ('argument structure'). The first mapping connects the participant roles within the semantic CONTENT with the elements of the ARG-ST feature; here we will call the theory of this mapping *linking theory* (see Section 4). The second mapping connects those ARG-ST list elements to the elements of the VALlists, namely COMPS ('complements') and SUBJ('subject'; or SPR, 'specifier'); we will refer to this second mapping as *argument realization* (see Section 2).[1] These two mappings are illustrated with the simplified lexical

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[1] Some linguists, such as Levin & Rappaport Hovav (2005), use the term 'argument realization' more broadly, to encompass linking as well.

sign for the verb *eat* in (1).

(1)　Lexical sign for the verb *eat*

$$
\begin{bmatrix}
\text{PHON} & \langle \text{eat} \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix} \\
\text{ARG-ST} & \langle \boxed{1}\text{NP}_i\,,\ \boxed{2}\text{NP}_j \rangle \\
\text{CONTENT} & \textbf{\textit{eat}}(i, j)
\end{bmatrix}
$$

In (1), 'NP' abbreviates a feature structure representing syntactic and semantic information about a nominal phrase. The variables i and j are the referential indices for the eater and eaten arguments, respectively, of the **eat** relation. The semantic information in NP_i semantically restricts the value or referent of i.

The ARG-ST feature plays an important role in HPSG grammatical theory. In addition to regulating the mapping from semantic arguments to grammatical relations, ARG-ST is the locus of the theories of anaphoric binding and other construal relations such as control and raising. (This chapter focuses on the function of ARG-ST in semantic mapping, with some discussion of binding and other construal relations only insofar as they interact with that mapping. A more detailed look at binding is presented in Chapter **??**.)

In HPSG, verb diathesis alternations, voice alternations, and derivational processes such as category conversions are all captured within the lexicon (see Section 5 and Chapter **??**). The different variants of a word are grammatically related either through lexical rules or by means of the lexical type hierarchy. HPSG grammars explicitly capture paradigmatic relations between word variants, making HPSG a *lexical approach to argument structure*, in the sense of Müller & Wechsler (2014a). This fundamental property of lexicalist theories contrasts with many transformational approaches, where such relationships are treated as syntagmatically related through operations on phrasal structures representing sentences and other syntactic constituents. Arguments for the lexical approach are reviewed in Section 8.

Within the HPSG framework presented here, we will formulate and address a number of empirical questions:

- We know that a verb's meaning influences its valence requirements, (via the ARG-ST list, on this theory). What are the principles governing the mapping from CONTENT to ARG-ST? Are some aspects of ARG-ST idiosyncratically stipulated for individual verbs? What aspects of the semantic CONTENT bear on the value of ARG-ST, and what aspects do not? (For example, what is the role of modality?)

- How are argument alternations defined with respect to our formal system? For each alternation we may ask which of the following it involves: a shuffling of the ARG-ST list; a change in the mapping from ARG-ST to VAL; or a change in the CONTENT, with a concomitant change in the ARG-ST?

These questions will be addressed below in the course of presenting the theory. We begin by considering ARG-ST itself (Section 2), followed by the mapping from ARG-ST to VAL(Section 3) and the mapping from CONTENT to ARG-ST (Section 4). The remaining sections address further issues relating to argument structure: the nature of argument alternations, extending the ARG-ST attribute to include additional elements, whether ARG-ST is a universal feature of languages, and a comparison of the lexicalist view of argument structure presented here with phrasal approaches.

2 The representation of argument structure in HPSG

In the earliest versions of HPSG, the selection of dependent phrases was specified in the SUBCAT feature of the head word (Pollard & Sag (1987), Pollard & Sag (1994: ch. 1–8)). The value of SUBCAT is a list of items, each of which corresponds to the SYNSEM value of a complement or subject. Following are SUBCAT features for an intransitive verb, a transitive verb, and a transitive verb with obligatory PP complement:

(2)   a.   *laugh*: [SUBCAT ⟨ NP ⟩]
       b.   *eat*: [SUBCAT ⟨ NP, NP ⟩]
       c.   *put*: [SUBCAT ⟨ NP, NP, PP ⟩]

Phrase structure rules in the form of immediate dominance schemata identify a certain daughter node as the head daughter (HEAD-DTR) and others as complement daughters (COMP-DTRS). In keeping with the *Subcategorization Principle*, here paraphrased from Pollard & Sag (1994: 34), list items are effectively 'cancelled' from the SUBCAT list as complement phrases are joined with the selecting head:

(3)   Subcategorization Principle: In a headed phrase, the SUBCAT value of the HEAD-DTR ('head daughter') is the concatenation of the phrase's SUBCAT list with the list of SYNSEM values of the COMPS-DTRS ('complement daughters').

Phrasal positions are distinguished by their saturation level: 'VP' is defined as a verbal projection whose SUBCAT list contains a single item, corresponding to the subject; and 'S' is defined as a verbal projection whose SUBCAT list is empty.

The 'subject' of a verb, a distinguished dependent with respect to construal processes such as binding, control, and raising, was then defined as the first item in the SUBCAT list, hence the last item with which the verb combines. However, defining 'subject' as the last item to combine with the head proved inadequate (Pollard & Sag 1994: Ch. 9). There are many cases where the dependent displaying subject properties need not be the last item added to the head projection. For example, in German the construal subject is a nominal in nominative case (Reis 1982), but the language allows subjectless clauses containing only a dative or genitive non-subject NP. If that oblique NP is the only NP dependent to combine with the verb then it is *ipso facto* the last NP to combine.

Consequently, the SUBCAT list was split into two valence lists, a SUBJ list of length zero or one for subjects, and a COMPS list for complements. Nonetheless, certain grammatical phenomena, such as binding and other construal processes, must still be defined on a single list comprising both subject and complements (Manning & Sag 1999). Additionally, some syntactic arguments are unexpressed or realized by affixal pronouns, rather than as subject or complement phrases. The new list containing all the syntactic arguments of a predicator was named ARG-ST ('argument structure').

In clauses without implicit or affixal arguments, the ARG-ST is the concatenation of SUBJ and COMPS respectively. For example, the SUBCAT list for *put* in (2c) is replaced with the following:

$$(4) \begin{bmatrix} \text{PHON} & \langle \text{put} \rangle \\ \text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2}, \boxed{3} \rangle \end{bmatrix} \\ \text{ARG-ST} & \langle \boxed{1}\text{NP}, \boxed{2}\text{NP}, \boxed{3}\text{PP} \rangle \end{bmatrix}$$

The idealization according to which ARG-ST is the concatenation of SUBJ and COMPS is canonized as the *Argument Realization Principle* (ARP) (Sag et al. 2003: PAGE). Exceptions to the ARP, that is, dissociations between VALENCE and ARG-ST, are discussed in Section 3.2 below.

A predicator's VALENCE lists indicate its requirements for syntactic concatenation with phrasal dependents (Section 3). ARG-ST, meanwhile, provides syntactic information about the expression of semantic roles and is related, via linking theory, to the lexical semantics of the word (Section 3.2). The ARG-ST list contains specifications for the union of the verb's syntactic local phrasal dependents (the

subject and complements, whether they are semantic arguments, raised phrases, or expletives) and its syntactic arguments that are not realized locally, whether they are unbounded dependents, affixal, or unexpressed.

Figure 1 provides a schematic representation of linking and argument realization in HPSG. Linking principles govern the mapping of of participant roles in a predicator's CONTENT to syntactic arguments on ARG-ST. Argument realization is shown in this figure only for mapping to VAL; affixal and null arguments are not depicted. Here, the semantic roles are just arbitrary labels, but we discuss in Section (4) how they can be systematically related to lexical entailments of predicators. The ARG-ST and VALlists in this figure contain only arguments linked to participant roles, but in Section **??** we note motivations for extending ARG-ST to include additional elements. And in Section (3), we examine cases where the relationship between ARG-ST and VALviolates the ARP.

Semantics (CONTENT)

$$\begin{bmatrix} sem\text{-}rel\text{-}1 \\ \text{SEM-ROLE-1} \quad \boxed{1} \\ \text{SEM-ROLE-2} \quad \boxed{2} \\ \text{SOA} \quad \begin{bmatrix} sem\text{-}rel\text{-}2 \\ \text{SEM-ROLE-3} \quad \boxed{3} \\ \text{SEM-ROLE-4} \quad \boxed{4} \end{bmatrix} \end{bmatrix}$$

Structured representation of semantic relations, their roles and the participants filling them

⇕ *Linking principles*

Argument structure (ARG-ST)

$$\begin{bmatrix} \text{ARG-ST} \langle \text{XP}_1, \text{XP}_2, ...\text{XP}_n \rangle \end{bmatrix}$$

List of syntactic arguments

⇕ *Argument Realization Principle*

Syntax (VALENCE)

$$\begin{bmatrix} \text{SPR} \quad \langle \, \rangle \\ \text{SUBJ} \quad \langle \text{XP}_1 \rangle \\ \text{COMPS} \langle \text{XP}_2, ...\text{XP}_n \rangle \end{bmatrix}$$

Lists of locally realized dependents

Figure 1: How linking works in HPSG

3 Argument realization: The mapping from ARG-ST to VALlists

3.1 Variation in the expression of arguments

The VALfeature is responsible for composing a verb with its phrasal dependents, but this is just one of the ways that semantic arguments of a verb are expressed in natural language. Semantic arguments can be expressed in various linguistic forms: as local syntactic dependents (SUBJand COMPS), as affixes, or displaced in unbounded dependency constructions (SLASH).

Affixal arguments can be illustrated with the first person singular Spanish verb *hablo* 'speak.1SG', as in 5.

(5) a. Habl-o   español.
        speak-1SG Spanish

        'I speak Spanish.'

     b. *hablo*'speak.1SG':

$$
\begin{bmatrix}
\text{PHON} & \langle \text{HABLO} \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle\ \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix} \\
\text{ARG-ST} & \left\langle \text{NP:} \begin{bmatrix} ppro \\ \text{INDEX} \begin{bmatrix} \text{PERS} & 1st \\ \text{NUM} & sg \end{bmatrix} \end{bmatrix}, \boxed{2}\text{NP} \right\rangle
\end{bmatrix}
$$

The *-o* suffix contributes the first person singular pronominal subject content to the verb form (the morphological process is not shown here; see Chapter MORPHOLOGY-CHAPTER). The pronominal subject appears on the ARG-ST list and hence is subject to the binding theory. But it does not appear in SUBJ, if no subject NP appears in construction with the verb.

A lexical sign whose ARG-ST list that is just the concatenation of its SUBJand COMPS lists conforms to the Argument Realization Principle (ARP); such signs are called *canonical signs* by Bouma et al. (2001). Non-canonical signs, which violate the ARP, have been approached in two ways. In one approach, a lexical rule takes as input a canonical entry and derives a non-canonical one by removing items from the VALlists, while adding an affix or designating an item as an unbounded dependent by placement on the SLASH list. In the other approach, a feature of each ARG-ST list item specifies whether the item is subject to the ARP (hence mapped to a VALlist), or ignored by it (hence expressed in some other way). See

the chapter on the lexicon for more detail and Miller & Sag (1997) for a treatment of French clitics as affixes.

A final case to consider is null anaphora, in which a semantic argument is simply left unexpressed and receives a definite pronoun-like interpretation. Japanese *mi-* 'see' is transitive but the object NP can be omitted as in (6).

(6) Naoki-ga   mi-ta.
    Naoki-NOM see-PAST
    'Naoki saw it/him/her/*himself.'

Null anaphors of this kind typically arise in discourse contexts similar to those that license ordinary weak pronouns, and the unexpressed object often has the (Principle B) obviation effects characteristic of overt pronouns, as shown in (6). But HPSG eschews the use of silent formatives like 'small *pro*' when there is no evidence for such items, such as local interactions with the phrase structure. Instead, null anaphors of this kind are present in ARG-ST but absent from VALlists. ARG-ST is directly linked to the semantic CONTENT and is the locus of binding theory, so the presence of a syntactic argument on the ARG-ST list but not a VALlist accounts for null anaphora. To account for obviation, the ARG-ST list item, when unexpressed, receives the binding feature of ordinary (non-reflexive) pronouns, usually *ppro*. This language-specific option can be captured in a general way by VALand ARG-ST defaults in the lexical hierarchy for verbs.

3.2 The syntax of ARG-ST and its relation to VALENCE

The ARG-ST ordering represents a preliminary syntactic structuring of the set of argument roles. In that sense it functions as an interface between the lexical semantics of the verb, and the expressions of dependents as described in Section 3. Its role thus bears some relation to the initial stratum in Relational Grammar, *argument structure* (including intrinsic classifications) in LFG Lexical Mapping Theory, D-structure in Government/Binding theory, and the Merge positions of arguments in Minimalism, assuming in the last two cases the Uniform Thematic Alignment Hypothesis (Baker 1988) or something similar. However, it also differs from all of those in important ways.

Semantic constraints on ARG-ST are explored in Section 4 below. But ARG-ST is not only structured by semantic distinctions between the arguments but also by syntactic ones. Specifically, the list ordering represents relative syntactic *obliqueness* of arguments. The least oblique argument is the subject (SUBJ), followed by

the complements (comps). Following Manning (1996) term arguments (direct arguments, i.e. objects) are assumed to be less oblique than 'oblique' arguments (adpositional and oblique case marked phrases), followed finally by predicate and clausal complements. The transitive ordering relation on the ARG-ST list is called *o-command* ('obliqueness command'): the subject list item o-commands those of the complements; an object list item o-commands those of any obliques; and so on.

Voice alternations like the passive, which are defined on the ARG-ST list, illustrate the ordering of terms before obliques on the ARG-ST list. Passivization alters the syntactic properties of ARG-ST list items: the initial item of the active, normally mapped to SUBJ of the active, is an oblique (*by* phrase) or unexpressed argument in the passive. Given that terms precede obliques in the list order, any term arguments must o-command the passive oblique, so passive effectively reorders the initial item in ARG-ST to a list position following any terms.

(7) a. Susan gave Mary a book.
b. Mary was given a book by Susan.

(8) a. *give* (active): [ARG-ST $< NP_i, NP_j, NP_k >$]
b. *given* (passive): [ARG-ST $< NP_j, NP_k, PP[by]_i >$]

Relative obliqueness conditions a number of syntactic processes and phenomena, including anaphoric binding. The o-command relation replaces the c-command in the Principles A, B, and C of Chomsky's (1981) configurational theory of binding. For example, HPSG's Principle B states that an ordinary pronoun cannot be o-commanded by its coargument antecedent, which accounts for the pronoun obviation observed in the English sentence *Naoki$_i$ saw him$_{*i/j}$*, and also accounts for obviation in the Japanese sentence (6) above.

Relative obliqueness also conditions the accessibility hierarchy of Keenan & Comrie (1977), according to which a language allowing relativization of some type of dependent also allows relativization of any less oblique than it. Hence if a language has relative clauses at all, it has subject relatives; if it allows obliques to relativize then it also allows subject and object relatives; and so on. Similar implicational universals apply to verb agreement with subjects, objects, and obliques Greenberg (1966).

Returning now to argument realization, we saw above that the rules for the selection of the subject from among the verb's arguments are also stated on the ARG-ST list. In a 'canonical' realization the subject is the first list item, o-commanding all of its coarguments.

3.3 Syntactic ergativity

The autonomy of ARG-ST from the VALlists is further illustrated by cross-linguistic
variation in the mapping between them. As just noted, in English and many other
languages the initial item in ARG-ST maps to the subject. However, languages
with so-called *syntactically ergative* clauses have been analyzed as following a
different mapping rule. Crucially, the ARG-ST ordering in those languages is still
supported by independent evidence from properties such as binding and NP ver-
sus PP categorial status of arguments. Balinese (Austronesian), as analyzed by
Wechsler & Arka (1998), is such a language. In the morphologically unmarked,
and most common voice, called 'Objective voice' (OV), the subject is any term
except the ARG-ST-initial one.

Balinese canonically has SVO order, regardless of the verb's voice form (Artawa
1994; Wechsler & Arka 1998). The preverbal NPs in (9) are the surface subjects and
the postverbal ones are complements. When the verb appears in the unmarked
OV verb, a non-initial term is the subject, as in (9a). But verbs in 'Agentive Voice'
(AV) select as their subject the ARG-ST-initial item, as in (9b).

(9) a. Bawi adol   ida.
         pig   OV.sell 3sg
         'He/She sold a pig.'
     b. Ida ng-adol bawi.
         3sg AV-sell pig
         'He/She sold a pig.'

A ditransitive verb such as the benefactive applied form of *beli* 'buy' in (10), has
three term arguments on its ARG-ST list. The subject can be either term that is
non-initial in ARG-ST:

(10)   a. Potlote   ento beli-ang=a   I   Wayan.
            pencil-DEF that OV.buy-APPL=3 Art Wayan
            '(s)he bought Wayan the pencil.'
        b. I   Wayan beli-ang=a   potlote   ento.
            Art Wayan OV.buy-APPL=3 pencil-DEF that
            '(s)he bought Wayan the pencil.'

Unlike the passive voice, which reorders the ARG-ST list, the Balinese OV does
not affect ARG-ST list order. Thus the agent argument can bind a coargument
reflexive pronoun (but not vice versa), regardless of whether the verb is in OV or
AV form:

(11) a. Ida ny-ingakin ragan idane.
          3sg AV-see   self
          '(s)he saw himself/herself'

  b. Ragan idane cingakin ida.
      self   OV.see 3sg
      '(s)he saw himself/herself'

The 'seer' argument o-commands the 'seen', with the AV versus OV voice forms regulating subject selection:

(12) Agentive Voice form of 'see':

$$
\begin{bmatrix}
\text{PHON} & \langle \textit{nyinkagin} \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix} \\
\text{ARG-ST} & \langle \boxed{1}\text{NP}_i , \boxed{2}\text{NP}_j \rangle \\
\text{CONTENT} & \begin{bmatrix} \textit{see-rel} \\ \text{SEER} & i \\ \text{SEEN} & j \end{bmatrix}
\end{bmatrix}
$$

(13) Objective Voice form of 'see':

$$
\begin{bmatrix}
\text{PHON} & \langle \textit{cinkagin} \rangle \\
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{2} \rangle \\ \text{COMPS} & \langle \boxed{1} \rangle \end{bmatrix} \\
\text{ARG-ST} & \langle \boxed{1}\text{NP}_i , \boxed{2}\text{NP}_j \rangle \\
\text{CONTENT} & \begin{bmatrix} \textit{see-rel} \\ \text{SEER} & i \\ \text{SEEN} & j \end{bmatrix}
\end{bmatrix}
$$

Languages like Balinese illustrate the autonomy of ARG-ST. Although the agent binds the patient in both (11)a and b, the binding conditions cannot be stated directly on the thematic hierarchy. For example, in HPSG a raised argument appears on the ARG-ST list of the raising verb even though that verb assigns no thematic role to that list item. But a raised subject can bind a coargument reflexive in Balinese (this is comparable to English *John seems to himself to be ugly*). Anaphoric binding in Balinese raising constructions thus behaves as predicted by the ARG-ST based theory (Wechsler 1999). In conclusion, neither VAL nor CONTENT provides the right representation for defining binding conditions, but ARG-ST fills the bill.

Syntactically ergative languages that have been analyzed as using an alternative mapping between ARG-ST and VALinclude Tagalog, Inuit, some Mayan languages, Chukchi, Toba Batak, Tsimshian languages, and Nadëb (Manning 1996; Manning & Sag 1999).

Interestingly, while the GB/Minimalist configurational binding theory may be defined on analogues of VALor CONTENT, those theories lack any analogue of ARG-ST. This leads to special problems for such theories in accounting for binding in many Austronesian languages like Balinese. In transformational theories since Chomsky (1981), anaphoric binding conditions are usually stated with respect to the A-positions ('argument positions'). A-positions are analogous to HPSG VALlist items, with relative c-command in the configurational structure corresponding to relative list ordering in HPSG, in the simplest cases. Meanwhile, to account for data similar to (11), where agents asymmetrically bind patients, Austronesian languages like Balinese were said to define binding on the 'thematic structure' encoded in d-structure or Merge positions, where agents asymmetrically c-command patients regardless of their surface positions (Guilfoyle et al. 1992). But the interaction with raising shows that neither of those levels is appropriate as the locus of binding theory (Wechsler 1999).[2]

3.4 Symmetrical objects

We have thus far tacitly assumed a total ordering of elements on the ARG-ST list, but Ackerman et al. (2018), Ackerman et al. (2017) propose a partial ordering for certain so-called 'symmetrical object' languages. In Moro (Kordofanian), the two term complements of a ditransitive verb have exactly the same object properties. Relative linear order of the theme and goal arguments is free, as shown by the two translations of (14) (from Ackerman et al. 2017: 9):

(14) é-g-a-natʃ-ó   óráŋ   ŋeɾá
      1SB.SM-CLg-MAIN-give-PFV CLg.man CLŋ.girl

      'I gave the girl to the man.' / 'I gave the man to the girl.'

More generally, the two objects have identical object properties with respect to occurrence in post-predicate position, case marking, realization by an object marker, and ability to undergo passivization (Ackerman et al. 2017: 9).

---

[2]To account for (11b) under the configurational binding theory, the subject position must be an A-bar position; but to account for binding by a raised subject, it must be an A-position. See Wechsler (1999).

Ackerman et al. (2017) propose that the two objects are unordered on the ARG-ST list. This allows for two different mappings to the COMPS list, as shown here:

(15) a. Goal argument as primary object:

$$
\begin{bmatrix}
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2}, \boxed{3} \rangle \end{bmatrix} \\
\text{ARG-ST} & \langle \boxed{1}\text{NP}_i, \{\boxed{2}\text{NP}_j, \boxed{3}\text{NP}_k\} \rangle \\
\text{CONTENT} & \begin{bmatrix} \textit{give-rel} \\ \text{AGENT} & i \\ \text{GOAL} & j \\ \text{THEME} & k \end{bmatrix}
\end{bmatrix}
$$

b. Theme argument as primary object:

$$
\begin{bmatrix}
\text{VALENCE} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{3}, \boxed{2} \rangle \end{bmatrix} \\
\text{ARG-ST} & \langle \boxed{1}\text{NP}_i, \{\boxed{2}\text{NP}_j, \boxed{3}\text{NP}_k\} \rangle \\
\text{CONTENT} & \begin{bmatrix} \textit{give-rel} \\ \text{AGENT} & i \\ \text{GOAL} & j \\ \text{THEME} & k \end{bmatrix}
\end{bmatrix}
$$

The primary object properties, which are associated with the initial term argument of COMPS, can go with either the goal or theme argument.

To summarize this section, while the relationship between ARG-ST, SUBJ, and COMPS lists was originally conceived as a straightforward one, enabling binding principles to maintain their simple form by defining ARG-ST as the concatenation of the other two, the relationship was soon loosened. Non-canonical relationships between ARG-ST and the VALlists are invoked in accounts of several core syntactic phenomena. Arguments not realized overtly in their canonical positions, due to extraction, cliticization, or pro-drop (null anaphora), appear on ARG-ST but not in any VALlist. Accounts of syntactic ergativity in HPSG involve variations in the mapping between ARG-ST and VALlists; in particular, the element of SUBJis not, in such languages, the first element of ARG-ST. Modifications of ARG-ST play a role in treatments of passivization, where its expected first element is suppressed, and in languages with multiple, symmetric objects, where a partial rather than total ordering of ARG-ST elements has been postulated. Thus ARG-ST has now acquired an autonomous status within HPSG, and is not merely a predictable rearrangement of information present elsewhere in lexical entries.

4 Linking: the mapping between semantics and ARG-ST

4.1 HPSG approaches to linking

The term *linking* refers to the mapping specified in a lexical entry between participant roles in the semantics and their syntactic representations on the ARG-ST list. Early HPSG grammars stipulated the linking of each verb: semantic CONTENT values with predicator-specific attributes like DEVOURER and DEVOURED were mapped to the subject and object, respectively, of the verb *devour*. But linking observes prevailing patterns, e.g. if one argument of a transitive verb in active voice has an agentive role, it will map to the subject, not the object. Thus these early accounts were unsatisfying, as they lead to purely stipulative accounts of linking, specified verb by verb. Beginning with Wechsler (1995b) and Davis (1996), researchers formulated linking principles stated on more general semantic properties holding across verbs.

Within the history of linguistics there have been three general approaches to modeling the lexico-semantic side of linking: thematic role types (Pāṇini ca 400 B.C., Fillmore 1968); lexical decomposition (Foley & Van Valin 1984; Rappaport Hovav & Levin 1998); and the proto-roles approach (Dowty 1991). In developing linking theories within the HPSG framework Wechsler (1995b) and Davis (1996) employed a kind of lexical decomposition that also incorporated some elements of the proto-roles approach. The reasons for preferring this over the alternatives are discussed in Section 4.4 below.

Wechsler's 1995b linking theory constrains the relative order of pairs arguments on the ARG-ST list according to semantic relations entailed between them. For example, his *notion rule* states that if one participant in an event is entailed to have a mental notion of another, then the first must precede the second on the ARG-ST list. The *conceive-pred* type is defined by the following type declaration (based on Wechsler (1995b: 127), with formal details adjusted for consistency with current usage):

(16) *conceive-pred:* $\begin{bmatrix} \text{ARG-ST} & \left\langle \text{NP}_i, \text{NP}_j \right\rangle \\ \\ \text{CONTENT} & \begin{bmatrix} \textit{conceive-rel} \\ \text{CONCEIVER} & i \\ \text{CONCEIVED} & j \end{bmatrix} \end{bmatrix}$

This accounts for a host of linking facts in verbs as varied as *like, enjoy, invent, claim,* and *murder,* assuming these verbs belong to the type *conceive-pred.* It explains the well known contrast between experiencer-subject *fear* and experiencer-object *frighten* verbs: *fear* entails that its subject has some notion of its object, so

The tourists feared the lumberjacks entails that the tourists are aware of the lumberjacks. But the object of *frighten* need not have a notion of its subject: in *The lumberjacks frightened the tourists (by cutting down a large tree that crashed right in front of them*, the tourists may not be aware of the lumberjacks' existence.

Two other linking rules appeared in Wechsler (1995). One stated that 'affected themes,' that is, participants that are entailed to undergo a change, map to the object, rather than subject, of a transitive verb. Another pertained to stative transitive verbs entailing a part-whole relation between the two participants, such as *include* and *contain*: the whole maps to the subject and the part to the object.

The linking constraints do not rely on a total ordering of thematic roles, nor on an exhaustive asssignment of thematic role types to every semantic role in a predicator. Instead, a small set of partial orderings of semantic roles, based on lexical entailments, suffices to account for the linking patterns of a wide range of verbs. This insight was adopted in a slightly different guise in work by Davis (1996; 2001) and Davis & Koenig (2000), who develop a more elaborated representation of lexical semantics, with which simple linking constraints can be stated. The essence of this approach is to posit a small number of dyadic semantic relations such as *act-und-rel* ('actor-undergoer relation') with attributes ACT(OR) and UND(ERGOER) that serve as intermediaries between semantic roles and syntactic arguments (akin to the notion of Generalized Semantic Roles discussed in Van Valin 1999).

What are the truth conditions of *act-und-rel*? Following Fillmore (1977), Dowty (1991), and Wechsler (1995b), Davis and Koenig note that many of the pertinent lexical entailments come in related pairs. For instance, one of Dowty's entailments is that one participant causally affects another, and of course the other is entailed to be causally affected. Another involves the entailments in Wechsler's notion rule (16); one participant is entailed to have a notion of another. These entailments of paired participant types characterize classes of verbs (or other predicators), and can then be naturally represented as dyadic relations in CONTENT. Collecting those entailments we arrive at a disjunctive statement of truth conditions:

(17)   **act-und-rel**(x, y) is true iff x causes a change in y, or x has a notion of y.

We can designate the *x* participant in the pair as the value of ACTOR (or ACT) and *y* as the value of UNDERGOER (or UND), in a relation of type *act-und-rel*. Semantic arguments that are ACTOR or UNDERGOER will then bear at least one of the entailments characteristic of ACTORS or UNDERGOERS (Davis & Koenig 2000: 72). This then simplifies the statement of linking constraints for all of these paired

participant types. Davis (1996) and Koenig & Davis (2001) argue that this obviates counting the relative number of proto-agent and proto-patient entailments, as advocated by Dowty (1991).

The linking constraints 18 and 19 state that a verb whose semantic CONTENT is of type *act-und-rel* will be constrained to link the ACT participant to the the first element of the verb's ARG-ST list (its subject), and the UND participant to the second element of the verb's ARG-ST list (this is analogous to Wechsler's constraints based on partial orderings).

These linking constraints can be viewed as parts of the definition of lexical types, as in Davis (2001), where (18) defines a particular class of lexemes (or words).[3]

(18) $\begin{bmatrix} \text{CONTENT|KEY} & \begin{bmatrix} \text{ACTOR} & \boxed{1} \end{bmatrix} \\ \text{ARG-ST} & \left\langle \text{NP}_{\boxed{1}}, ... \right\rangle \end{bmatrix}$

(19) $\begin{bmatrix} \text{CONTENT|KEY} & \begin{bmatrix} \text{UNDERGOER} & \boxed{2} \end{bmatrix} \\ \text{ARG-ST} & \left\langle ..., \text{NP}_{\boxed{2}}, ... \right\rangle \end{bmatrix}$

(20) $\begin{bmatrix} \text{CONTENT|KEY} & \begin{bmatrix} \textit{cause-possess-rel} \\ \text{SOA} & \begin{bmatrix} \text{ACTOR} & \boxed{3} \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST} & \left\langle \textit{synsem} \right\rangle \oplus \left\langle \text{NP}_{\boxed{3}}, ... \right\rangle \end{bmatrix}$

The first constraint, in (18), links the value of ACT (when not embedded within another attribute) to the first element of ARG-ST. The second, in (19), merely links the value of UND (again, when not embedded within another attribute) to some NP on ARG-ST. Given this understanding of how the values of ACTOR and UNDERGOER are determined, these constraints cover the linking patterns of a wide range of transitive verbs: *throw* (ACT causes motion of UND), *slice* (ACT causes change of state in UND), *frighten* (ACT causes emotion in UND), *imagine* (ACT has a notion of UND), *traverse* (ACT "measures out" UND as an incremetnal theme), and *outnumber* (ACT is superior to UND on a scale).

---

[3]Alternatively, (18) (and other linking constraints) can be recast as implicational constraints on lexemes or words (Koenig & Davis 2003). (i) is an implicational constraint indicating that a word whose semantic content includes an ACTOR role must map that role to the initial item in the ARG-ST list.

(i) $\begin{bmatrix} \text{CONTENT|KEY} & \begin{bmatrix} \text{ACTOR} & \boxed{1} \end{bmatrix} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{ARG-ST} & \left\langle \text{NP}_{\boxed{1}}, ... \right\rangle \end{bmatrix}$

The third constraint, in (20), links the value of an ACT attribute embedded within a SOA attribute to an NP that is second on ARG-ST. This constraint accounts for the linking of the (primary) object of ditransitives. In English, these verbs (*give*, *hand*, *send*, *earn*, *owe*, etc.) involve (prospective) causing of possession (Pinker 1989; Goldberg 1995), and the possessor is represented as the value of the embedded ACT in (20). There could be additional constraints of a similar form in langages with a wider range of ditransitive constructions; conversely, such a constraint might be absent in languages that lack ditransitives entirely. As mentioned earlier in this section, the range of subcategorization options varies somewhat from one language to another.

The KEY attribute in (18) – (20) also requires explanation. The formulation of linking constraints here employs the architecture used in Koenig & Davis (2006), in which the semantics represented in CONTENT values is expressed as a set of *elementary predications*, formalized within Minimal Recursion Semantics (Copestake et al. 2001; 2005). Each elementary predication is a simple relation, but the relationships among them may be left unspecified. For linking, one of the elementary predications is designated the KEY, and it serves as the locus of linking. This allows us to indicate the linking of participants that play multiple roles in the denoted situation. The KEY selects one relation as the "focal point," and the other elementary predications are then irrelevant as far as linking is concerned. The choice of KEY then becomes an issue demanding consideration; we will see in the discussion of argument alternations in Section 5 how this choice might account for some alternation phenomena.

Note too that these linking constraints are treated as constraints on classes in the lexical hierarchy (see Chapter **??**). One consequence of this fact merits brief mention. Constraint (19), which links the value of UND to some NP on ARG-ST, is a specification of one class of verbs. Not all verbs (and certainly not all other predicators, such as nominalizations) with a CONTENT value containing an UND value realize it as an NP. Verbs obeying this constraint include the transitive verbs noted above, and intransitive "unaccusative" verbs such as *fall* and *persist*. But some verbs with both ACT and UND attributes in their CONTENT are intransitive, such as *impinge (on)*, *prevail (on*, and *tinker (with)*. Interactions with other constraints, such as the requirement that verbs (in English, at least) have an NP subject, determine the range of observed linking patterns.

These linking constraints also assume that the proto-role attributes ACTOR, UNDERGOER, and SOA are appropriately matched to entailments, as described above. Other formulations are possible, such as that of Koenig & Davis (2003), where the participant roles pertinent to each lexical entailment are represented in CONTENT

by corresponding, distinct attributes.

In addition to the linking constraints, there may be some very general well-formedness conditions on linking. We rarely find verbs that obligatorily map one semantic role to two distinct members of the ARG-ST list that are both expressed overtly. A verb meaning 'eat', but with that disallowed property, could appear in a ditransitive sentence like (4.1), with the meaning that Pat ate dinner, and his dinner was a large steak.

(21)   *Pat ate dinner a large steak.

Typically semantic arguments map to at most one (overtly expressed) ARG-ST list item (Davis 2001: 262-268).

4.2 Linking oblique arguments

In this section we discuss linking of oblique arguments, that is, PP's and oblique case marked NP's. In some instances, a verb's selection of a particular preposition appears at least partly arbitrary; it is hard to explain why we *hanker after* and *yearn for*, but we don't **yearn after*. In these cases, the choice of preposition may be stipulated by the individual lexical entry. But as Gawron (1986) and Wechsler (1995a) have shown, many prepositions are semantically meaningful. *For* in the above-mentioned cases, and in *look for*, *wait for*, and *aim for* is surely not a lexical accident. And in the cases like *cut with*, *with* is used in an instrumental sense, denoting a *use-rel* relation, as with verbs that either allow (*eat*) or require (*cut*) an instrument. Davis (1996; 2001) adopts the position of Gawron and Wechsler in his treatment of linking to PPs As an example of this kind of account, the linking type in (22) characterizes a verb selecting a *with*-PP. The PP argument is linked from the RELS list rather the KEY.

(22)
$$
\begin{bmatrix}
\text{CONTENT} & \begin{bmatrix}
\text{KEY} & \boxed{1} \\
\text{RELATIONS} & \left\langle \boxed{1}, \boxed{2}\begin{bmatrix}
\textit{use-rel} \\
\text{ACT} & a \\
\text{UND} & u \\
\text{SOA} & s
\end{bmatrix}, ... \right\rangle
\end{bmatrix} \\
\text{ARG-ST} & \left\langle ..., \text{PP}_{with}{:}\boxed{2}\, ... \right\rangle
\end{bmatrix}
$$

Apart from the details of individual linking constraints, we have endeavored here to describe how linking can be modeled in HPSG using the same kinds of constraints used ubiquitously in the framework. Within the hierarchical lexicon, constraints between semantically defined classes and syntactically defined

ones, can furnish an account of linking patterns, and there is no resort to additional mechanisms such as a thematic hierarchy or numerical comparison of entailments.

4.3 To what extent does meaning predict linking?

The framework outlined above allows us to address the following question: how much of linking is strictly determined by semantic factors, and how much is left open to lexically arbitrary subcategorization specifications, or perhaps subject to other factors?

Subcategorization— the position and nature of ARG-ST elements, in HPSG terms— is evidently driven to a great extent by semantics, but debate continues about how much, and which components of semantics are involved. Views have ranged from the strict, highly constrained relationship in which lexical semantics essentially determines syntactic argument structure, to a looser one in which some elements of subcategorization may be stipulated. Among the first camp are those who espouse the Uniformity of Theta Assignment Hypothesis proposed in Baker (1988: 46) or Baker (1997), which maintains that "identical thematic relationships between items are represented by identical structural relationships" in the syntax. With regard to the source of diathesis alternations, Levin (1993: 12-13) notes that "studies of these properties suggest that argument structures might in turn be derivable to a large extent from the meaning of words", and accordingly "pursues the hypothesis of semantic determinism seriously to see just how far it can be taken."

Others, including Pollard & Sag (1987) (Section 5.3) and Davis (2001) (Section 5.1), have expressed caution, pointing out cases where subcategorization and diathesis alternations seem to be at least partly arbitrary. Pollard & Sag note contrasts like these:

(23) a. Sandy spared/*deprived Kim a second helping.
      b. Sandy *spared/deprived Kim of a second helping. (Pollard & Sag 1987: ex. 214–215)

And Davis provides these pairs of semantically similar verbs with differing subcategorization requirements:

(24) a. Few passengers waited for/awaited the train.
      b. Homer opted for/chose a chocolate frosted donut.
      c. The music grated on/irritated the critics. (Davis 2001: ex. 5.4)

Other cases where argument structure seems not to mirror semantics precisely include raising constructions, in which one of a verb's direct arguments bears no semantic role to it at all. Similarly, overt expletive arguments cannot be seen as deriving from some participant role in a predicator's semantics. Like the examples above, these phenomena suggest that some aspects of subcategorization are specified independently of semantics.

Another point against strict semantic determination of argument structure comes from cross-linguistic observations of subcategorization possibilities. It is evident, for example, that not all languages display the same range of direct argument mappings. Some lack ditransitive constructions entirely (Halkomelem), some allow them across a limited semantic range (English), some quite generally (Georgian), and a few permit tritransitives (Kinyarwanda and Moro). Gerdts (1992) surveys about twenty languages and describes consistent patterns like these. The range of phenomena such as causative and applicative formation in a language is constrained by what she terms its "relational profile;" this includes, in HPSG terms, the number of direct NP arguments permitted on its ARG-ST lists. Again, it is unclear that underlying semantic differences across languages in the semantics of verbs meaning 'give' or 'write' would be responsible for these general patterns.

Summarizing, there is much evidence tempting us to derive the contents of ARG-ST solely from lexical semantics. If this ultimately proves feasible, then ARG-ST serves more as a convenient interface notion with little possibility of independently expressing strictly syntactic aspects of subcategorization. This view, however satisfying it might be, does not accord with our current best understanding of the syntactic and semantic evidence. In the following sections we delve into some of the nuances that make linking more than a simple rendering of lexical semantics. We begin by noting a point on which HPSG accounts of linking differ from many others— the absence of traditional thematic roles.

4.4 HPSG and thematic roles

The ARG-ST list constitutes the syntactic side of the mapping between semantic roles and syntactic dependents. As ARG-ST is merely an ordered list of arguments, without any semantic "labels," it contains no counterparts to thematic roles, such as AGENT, PATIENT, THEME, or GOAL. Thematic roles like these, however, have been a mainstay of linking in generative grammar since Fillmore (1968) and have antecedents going back to (Pāṇini. Ranking them in a *thematic hierarchy*, and labeling each of a predicator's semantic roles with a unique thematic role, then yields an ordering of roles analogous to the ordering on the ARG-ST list. Indeed, it

would not be difficult to import this kind of system into HPSG, as a means of determining the order of elements on the ARG-ST list. However, HPSG researchers have generally avoided using a thematic hierarchy, for reasons we now briefly set out.

Fillmore (1968) and many others thereafter have posited a small set of disjoint, thematic roles, with each semantic role of a predicator assigned exactly one thematic role. Thematic hierarchies depend on these properties for a consistent linking theory. But they do not hold up well to formal scrutiny. Jackendoff (1987) and Dowty (1991) note (from somewhat different perspectives) that numerous verbs have arguments not easily assigned a thematic role from the typically posited inventory (e.g., the objects of *risk*, *blame*, and *avoid*), that more than one argument might sensibly be assigned the same role (e.g., the subjects and objects of *resemble*, *border*, and some alternants of commercial transaction verbs), and that multiple roles can be sensibly assigned to a single argument (the subjects of verbs of volitional motion are like both an AGENT and a THEME). In addition, consensus on the inventory of thematic roles has proven elusive, and some, notoriously THEME, have resisted clear definition. Work in formal semantics, including Ladusaw & Dowty (1988), Dowty (1989), Landman (2000), and Schein (2002), casts doubt on the prospects of assigning formally defined thematic roles to all of a predicator's arguments, at least in a manner that would allow them to play a crucial part in linking. Thematic role types seem to pose problems, and there are alternatives that avoids those problems. As Carlson (1998) notes about thematic roles, "It is easy to conceive of how to write a lexicon, a syntax, a morphology, a semantics, or a pragmatics without them."

4.5 CONTENT decomposition and ARG-ST

Instead of thematic role types, lexical decomposition is typically used in HPSG to model the semantic side of the linking relation. The word meaning represented by the CONTENT value is decomposed into a set of elementary predications that share arguments, as described in Section 4 above. Lexical decompositions cannot be directly observed, but the decompositions are justified indirectly by the roles they play in the grammar. Decompositions play a role in at least the following processes:

- *Linking.* As described in Section 4, linking constraints are stated on semantic relations like *act-und-rel* ('actor-undergoer relation'), so those relations must be called out in the CONTENT field.

- *Sublexical scope.* Certain modifiers can scope over a part of the situation denoted by a verb (Dowty 1979).

  (25)   John sold the car, and then he bought it again.

  In this sentence the adverb *again* either adds the presupposition that John bought it before, or, in the more probable interpretation, it adds the presupposition that *the result of buying the car* obtained previously. The result of buying a car is owning it, so this sentence presupposes that John previously owned the car. Thus the decomposition of the verb *buy* in (36) below includes the *possess-rel* ('possession relation') holding between the buyer and the goods. This is available for modification by adverbials like *again*.

- *Argument alternations.* Some argument alternations can be modeled as highlighting of different portions of a single lexical decomposition. See Section 5.

In general, sublexical decompositions are included in the CONTENT field only insofar as they are visible to the grammar for processes like these.

The ARG-ST feature lies at the syntax side of the linking relation. Much like the CONTENT field, the ARG-ST items are justified only insofar as they are visible to the syntax. Many ARG-ST list items are obviously justified by being explicitly expressed as subject and complement phrases or as affixal pronouns. Certain implicit arguments appear if they are subject to the binding theory as applied to the ARG-ST list (as discussed in Section 3.1 above).

Implicit arguments can also participate in the syntax, and therefore appear on the ARG-ST list, by acting as controllers of adjunct clauses. For example, English rationale clauses like the infinitival phrase in (26a) are controlled by the agent argument in the clause, *the hunter* in this example. The implicit agent of a short passive can likewise control the rationale clause as shown in(26b). But the middle in (26c) lacks an implicit agent that is capable of controlling, even though native speakers assume that some agent must have caused the gun to load. This contrast was observed by Keyser & Roeper (1984) and confirmed in experimental work by Mauner & Koenig (2000).

(26)   a. The shotgun was loaded quietly by the hunter to avoid the possibility of frightening off the deer.

   b. The shotgun was loaded quietly to avoid the possibility of frightening off the deer.

c. *The shotgun had loaded quietly to avoid the possibility of frightening off the deer.

If the syntax of control is specified such that the controller of the rationale clause is an (agent) argument on the ARG-ST list of the verb, then this contrast is captured by assuming that the agent appears on the ARG-ST list of the passive verb but not the middle.

4.6 Modal transparency

Another observation concerning lexical entailments and linking was developed by Koenig & Davis (2001), who point out that linking appears to ignore modal elements of lexical semantics, even when those elements invalidate entailments (expanding on an observation implicit in Goldberg 1995). For instance, there are various English verbs displaying linking patterns like the ditransitive verbs of possession transfer *give* and *hand*, but which denote situations in which the transfer need not, or does not, take place. Thus, *offer* describes a situation where the transferor is willing to effect the transfer, *owe* one in which the transferor should effect the transfer but has not yet, *promise* describes a situation where the transferor commits to effect the transfer, and *deny* one in which the transferor does not effect the contemplated transfer. Koenig and Davis argue that modal elements should be clearly separated in CONTENT values from the representations of predicators and their arguments. (27) exemplifies this factoring out of sublexical modal information from core situational information. This pattern of linking functioning independently of sublexical modal information applies not only to these ditransitive cases, but also to verbs involving possession (cf. *own* and *obtain*, vs. *lack*, *covet* and *lose*), perception (*see* vs. *ignore* and *overlook*), and carrying out an action (*manage* vs. *fail* and *try*). Whatever the role of lexical entailments in linking, then, the modal information should be factored out, since the entailments canonically driving, e.g., the ditransitive linking patterns of verbs like *give* and *hand*, do not hold of *offer*, *owe*, or *deny*. The constraints in (18)-(20) need only been minimally altered to target the value of SIT-CORE within the representation of relation.

(27) The lexical semantic representation of *promise* (Koenig & Davis 2001: 101)

$$
\begin{bmatrix}
\textit{promise-sem} \wedge \textit{cause-possess-sem} \\
\text{SIT-CORE} \quad \boxed{3}
\begin{bmatrix}
\textit{cause-possess-rel} \\
\text{ACTOR} \quad \boxed{1} \\
\text{UNDERGOER} \quad \boxed{2} \\
\text{SOA} \quad
\begin{bmatrix}
\text{sit-core} \ \boxed{5}
\begin{bmatrix}
\textit{have-rel} \\
\text{ACTOR} \quad \boxed{2} \\
\text{UNDERGOER} \quad \boxed{4}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix} \\
\text{MODAL-BASE} \ \left\langle
\begin{bmatrix}
\textit{deontic-mb} \wedge \textit{condit-satis-mb} \\
\text{SOA} \quad \boxed{3}
\end{bmatrix}
\right\rangle
\end{bmatrix}
$$

5 The semantics and linking of argument alternations

A verb can often occur in varied syntactic contexts, as *find* does in (28); these are termed *valence alternations* or *diathesis alternations*, in reference to their different argument structuress. Levin (1993) lists around 50 kinds of alternations in English, and there are still more, including the alternation illustrated in (28).

(28) a. I found that the chair was comfortable
      b. I found the chair to be comfortable
      c. I found the chair comfortable

Another well studied alternation, the locative alternation, is exemplified by the two uses of *spray* in (29).

(29) a. *spray$_{loc}$*: Joan sprayed the paint onto the statue.
      b. *spray$_{with}$*: Joan sprayed the statue with paint.

It is typically assumed that these two different uses of *spray* in (29) have slightly different meanings, with the statue being in some sense more affected in the *with* alternant. This exemplifies the "holistic" effect of direct objecthood, which we will return to. Here, we will examine how semantic differences between alternant relate to their linking patterns. The semantic side of linking has often been devised with an eye to syntax (e.g., Pinker (1989), and see Koenig & Davis (2006) for more examples). There is a risk of stipulation here, without independent evidence for these semantic differences. In the case of locative alternations, though, the meaning difference between (29a) and (29b) is easily stated (and Pinker had the right intuition), as (29b) entails (29a), bot not conversely. Informally, (29a) describes a particular kind of caused motion situation, while (29b) describes a situation in which this kind of caused motion additionally results in a caused change of state. The difference is depicted in the two structures in (30).

(30) a. CAUSE (JOAN, GO (PAINT, TO (STATUE)))

b. ACT-ON (JOAN, STATUE, BY (CAUSE (JOAN, GO (PAINT, TO (STATUE)))))

This description of the semantic difference between sentences (29a) and (29b) provides a strong basis for predicting their different argument structures. But we still need to explain how linking principles give rise to this difference. Pinker's account rests on semantic structures like (30), in which depth of embedding reflects sequence of causation, with ordering on ARG-ST stemming from depth of semantic embedding, a strategy adopted in Davis (1996; 2001). This is one reasonable alternative, although the resulting complexity of some of the semantic rpresentations raises valid questions about what independent evidence supports them. An alternative appears in Koenig & Davis (2006), who borrow from Minimal Recursion Semantics (see the chapter on Semantics for an introduction to MRS). MRS "flattens" semantic relationss, rather than embedding them in one another, so the arrangment of these *elementary predications*, as they are temed, is of less import. They posit a RELATIONS (or RELS) attribute that collects a set of elementary predications, each representing some part of the predicator's semantics. A KEY attribute specifies a particular member of RELS as the relevant one for linking (of direct syntactic arguments). In the case of (29b) the KEY is the caused change of state description. These MRS-style representations of the two alternants of *spray*, with different KEY values, are shown in (31) and (32).

(31)
$$
\begin{bmatrix}
\text{KEY} & \boxed{5} \\
\text{RELATIONS} & \left\langle \boxed{5}\begin{bmatrix} \textit{spray-ch-of-loc-rel} \\ \text{ACT} \;\; \boxed{1} \\ \text{UND} \;\; \boxed{4} \\ \text{SOA} \;\; \begin{bmatrix} \textit{ch-of-loc-rel} \\ \text{FIG} \;\; \boxed{4} \end{bmatrix} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

(32)
$$
\begin{bmatrix}
\text{KEY} & \boxed{3}\begin{bmatrix} \textit{spray-ch-of-st-rel} \\ \text{ACT} \;\; \boxed{1} \\ \text{UND} \;\; \boxed{2} \\ \text{SOA} \;\; \begin{bmatrix} \textit{ch-of-st-rel} \\ \text{UND} \;\; \boxed{2} \end{bmatrix} \end{bmatrix} \\
\text{RELATIONS} & \left\langle \boxed{3}, \begin{bmatrix} \textit{use-rel} \\ \text{ACT} \;\; \boxed{1} \\ \text{UND} \;\; \boxed{4} \\ \text{SOA} \;\; \boxed{3} \end{bmatrix}, \begin{bmatrix} \textit{spray-ch-of-loc-rel} \\ \text{ACT} \;\; \boxed{1} \\ \text{UND} \;\; \boxed{4} \\ \text{SOA} \;\; \begin{bmatrix} \textit{ch-of-loc-rel} \\ \text{FIG} \;\; \boxed{4} \end{bmatrix} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

Generalizing from this example, one possible characterization of valence al-

ternations, implicit in Koenig & Davis (2006), is as systematic relations between two sets of lexical entries in which the RELS of any pair of related entries are in a subset/subset relation (a weaker version of that definition would merely require an overlap between the RELS values of the two entries). Consider another case; (33) illustrates the causative-inchoative alternation, where the intransitive alternant describes only the change of state, while the transitive one ascribes a explicit causing agent.

(33) a. John broke the window.
      b. The window broke.

Under a MRS representation, the change of state relation is a separate member of RELS; it is also included in the RELS of the transitive alternant, which contains a cause relation as well. Again, the RELS value of one member of each pair of related entries is a subset of the RELS value of the other.

Many other alternations linvolve one argument shifting from direct to oblique. Some English examples include conative, locative preposition drop, and *with* preposition drop alternations, as shown in (34):

(34) a. Rover clawed (at) Spot.
      b. Bill hiked (along) the Appalachian Trail.
      c. Burns debated (with) Smithers.

It is well known that the direct objects in these alternations seem to be "affected" more than their oblique counterparts. So if Rover clawed Spot, we infer that Spot was subjected to direct contact with Rover's claws and may have been injured by them, while if Rover merely clawed *at* Spot, no such inference can be made. Similarly, to say the one has hiked the Appalachian Trail suggests that one has hiked its entire length, not merely hiked along some portion of it. This holistic effect is not so evident in cases like (34c), though the direct object variant suggests that a formally organized debate took place, while the *with* variant could just describe an informal discussion. How might these varying intuitions related to "affectedness" relate to lexical semantic representations like those in (31) and (32)? Beavers (2010) provides one analytical advance in this direction, similar to the subset relationship between RELS values described above. He generalizes from affectedness to strength of entailments, where one semantic role's entailments are stronger than another's if and only if the set of entailments characterizing the second role also hold of the first. That is, what is true for any particpant that bears the first role will be true for any particpant that bears the

second, but not necessarily the converse. His *Morphosyntactic Alignment Principle* then relates this to linking, as stated in (35), where an "L-thematic role" is a linguistically relevant semantic role:

(35)   When participant x may be realized as either a direct or oblique argument of verb V, it bears L-thematic role R as a direct argument and L-thematic role $Q \subseteq_M R$ as an oblique. (Beavers 2010: 848)

Here, $Q \subseteq_M R$ means that Q is a "minimally weaker" role than R; in other words, there is no role P in the predicator such that $Q \subset P \subset R$. Thus, the substantive claim is essentially that the MAP rules out "verbs where the alternating participant has MORE lexical entailments as an oblique than the corresponding object realization" (Beavers 2010: 849).

The entailments Beavers employs differ somewhat from those we have discussed here, involving quantized change, nonquantized change, potential for change (where change can refer to change in location, possession, state, or something more abstract), furnishing the clear ordering by strength that is central to his proposal. But they do resemble entailments of semantic relations we have represented as elementary predications, such as incremental theme, change of state, and possession, along with the modal effects described in Koenig & Davis (2001). Thus the notion of a stronger role in Beavers' analysis has a rough analog in terms of whether a particular elementary predication is present in the semantics of a particular alternant. And only if an elementary predication is present, can it be designated as the KEY, and its roles linked directly. For example, in (31), there is nothing representing affectedness of the location, while in (32), there is, and it is designated as the KEY. As noted earlier, the semantics in (32) represents this additional entailment borne by the location argument. However, we are not aware of any simple, general way to represent Beavers' MAP within the EP-based model of Koenig & Davis (2006). Indeed, there is an aspect of Beavers' view that seems more in accord with numerical comparison approaches such as those of Dowty (1991) and Ackerman & Moore (2001), in that role strength is determined by the number of entailments that hold of it relative to others.

Having outlined the semantic basis of the different linking patterns of alternating verbs, we briefly take up three other issues. First is the question of how the alternants are related to one another. Second is how KEY selection has been used to account not just for alternants of the same verb, but for (nearly) synonymous verbs whose semantics contain the same set of elementary predications. Third is whether passives, which arguably do not differ semantically from their active counterparts, should be assimilated with other alternations or treated distinctly,

as a kind of non-canonical lexical item.

The hypothesis pursued in Davis (1996; 2001) is that most alternations are the consequence of classes of lexical entries having two related meanings. This follows researchers such as Pinker (1989) and Levin (1993) in modeling subcategorization alternations as underlyingly meaning alternations. This change in meaning is crucial in Koenig & Davis (2006) KEY shifts as well. In some cases, the value of the RELS attribute of the two valence alternates differ (as in the two alternates of *spray* in *spray/load* alternation we discussed earlier). In some cases, the alternation might be different construals of the same event for some verbs, but not others, as Rappaport Hovav & Levin (2008) claim for the English ditransitive alternations, which adds the meaning of transfer for verbs like *send*, but not for verbs like *promise*; a KEY change would be involved (with the addition of a *cause-possess-rel*) for the first verb only. But KEY shifts and diathesis alternations do not always involve a change in meaning. The same elementary predications can be present in as the CONTENT values of two alternants, with each alternant designating a different elementary predication as the KEY.

Koenig & Davis propose this not only for cases in which there is no obvious meaning difference between two alternants of a verb, but also for different verbs that appear to be truth-conditionally equivalent, one famous example being the verbs of commercial exchange *buy* and *sell* (but see Van Valin (1999: 387-388), Levin & Rappaport Hovav (2005: 20), and Wechsler (2005a) for arguments that *buy* and *sell* are not equivalent). Koenig and Davis argue that a commercial event involves two reciprocal actions, an exchange of goods (which involves giving goods and obtaining goods) and an exchange of money (which involves giving money and obtaining money). Individual verbs might select one or the other these four relations, thus accounting for the differences in subject and object selection. As shown in (36) and (37), each of these verbs contains four elementary predications: one *exch-give-rel* and one *obtain-rel* for the transfer of goods, and one of each for the counter-transfer of money. *Buy* designates the *obtain-rel* representing the transfer of goods as the KEY, while *sell* designates the *exch-give-rel* representing the transfer of goods as the KEY. Other verbs, such as *pay* or *charge*, choose elementary predications representing the counter-transfer as the KEY. In all cases, the same linking constraints apply between the KEY and the ARG-ST list, yielding the different argument realizations of these verbs while preserving their underlying semantic commonality. The relevant portions of the entries for *buy* and *sell* in (36) and (37) below illustrate: critically, the KEY relation for *buy* is not the same as that for *sell*.

(36)   A representation of the relevant parts of the lexical entry for *buy*:

$$
\begin{bmatrix}
\text{CONTENT} &
\begin{bmatrix}
\text{KEY} & \boxed{7} \\
\text{RELATIONS} &
\left\langle
\boxed{7}
\begin{bmatrix}
\text{ACT} & \boxed{1}\ (buyer) \\
\text{UND} & \boxed{2} \\
\text{SOA} & \boxed{5}
\begin{bmatrix}
possess\text{-}rel \\
\text{ACT} & \boxed{1} \\
\text{UND} & \boxed{2}\ (goods)
\end{bmatrix}
\end{bmatrix},
\begin{bmatrix}
\text{ACT} & \boxed{1}\ (buyer) \\
\text{UND} & \boxed{4} \\
\text{SOA} & \boxed{6}
\begin{bmatrix}
possess\text{-}rel \\
\text{ACT} & \boxed{3}\ (seller) \\
\text{UND} & \boxed{4}\ (money)
\end{bmatrix}
\end{bmatrix},
\right. \\
\left.
\begin{bmatrix}
obtain\text{-}rel \\
\text{ACT} & \boxed{3}\ (seller) \\
\text{UND} & \boxed{4} \\
\text{SOA} & \boxed{6}
\begin{bmatrix}
possess\text{-}rel \\
\text{ACT} & \boxed{3}\ (seller) \\
\text{UND} & \boxed{4}\ (money)
\end{bmatrix}
\end{bmatrix},
\boxed{8}
\begin{bmatrix}
exch\text{-}give\text{-}rel \\
\text{ACT} & \boxed{3}\ (seller) \\
\text{UND} & \boxed{2} \\
\text{SOA} & \boxed{5}
\begin{bmatrix}
possess\text{-}rel \\
\text{ACT} & \boxed{1} \\
\text{UND} & \boxed{2}\ (goods)
\end{bmatrix}
\end{bmatrix}
\right\rangle
\end{bmatrix} \\
\text{ARG-ST} & \langle \text{NP:}\boxed{1},\ \text{NP:}\boxed{2},\ \text{PP(FROM):}\boxed{8} \rangle
\end{bmatrix}
$$

(37) A representation of the relevant parts of the lexical entry for *sell*:

$$
\begin{bmatrix}
\text{CONTENT} &
\begin{bmatrix}
\text{KEY} & \boxed{7} \\
\text{RELATIONS} &
\left\langle
\boxed{7}
\begin{bmatrix}
\text{ACT} & \boxed{1}\ (seller) \\
\text{UND} & \boxed{2} \\
\text{SOA} & \boxed{6}
\begin{bmatrix}
\text{POSSESS-REL} \\
\text{ACT} & \boxed{3}\ (buyer) \\
\text{UND} & \boxed{2}\ (goods)
\end{bmatrix}
\end{bmatrix},
\begin{bmatrix}
\text{ACT} & \boxed{1}\ (seller) \\
\text{UND} & \boxed{4} \\
\text{SOA} & \boxed{6}
\begin{bmatrix}
\text{POSSESS-REL} \\
\text{ACT} & \boxed{1} \\
\text{UND} & \boxed{4}\ (money)
\end{bmatrix}
\end{bmatrix}
\right\rangle
\end{bmatrix} \\
\text{ARG-ST} & \langle \text{NP:}\boxed{1},\ \text{NP:}\boxed{2},\ \text{PP(TO):}\boxed{7} \rangle
\end{bmatrix}
$$

As a final example of semantic alternations in the fine-grained meaning possibilities of verbs, we consider here the source-final product alternation exemplified in (38) where the direct object can be either the final product or the material source of the final product. Davis proposes that the (38a) sentences involve an alternation between the two meanings of entries represented in (39). We adapt Davis (2001) to make it consistent with Koenig & Davis (2006) and also treat the alternation as an alternation of meaning of *entries*. Note that in the meaning alternation described in (39), we use, informally, a double-headed arrow. One of the potential drawbacks of a lexical rule approach to valence alternations is that it requires selecting one or the other alternant as basic and the other as derived (e.g., is the inchoative or the causative basic?). This is not always an easy decision, as Goldberg (1995) or Levin & Rappaport Hovav (1994) have pointed out. Sometimes, morphology provides a clue, although in different languages the clues may point in different directions. French, and other Romance languages, use a "reflexive" clitic as a detransitivizing affix. In English, though, there is no obvious "basic" form or directionality. It is to avoid committing ourselves to a directionality in the meaning relation described in (39) that we eschews treating

it as a lexical rule.

(38)   a. Kim made/carved/sculpted/crafted a toy (out of the wood).

   b. Kim made/carved/sculpted/crafted the wood into a toy.

(39) $\begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \text{KEY} & \boxed{3} \begin{bmatrix} \textit{affect-incr-th-rel} \\ \text{ACT} & \boxed{1} \\ \text{SOA} & \boxed{2}\textit{(final product)} \end{bmatrix} \\ \text{RELS} & \langle \boxed{3}, \boxed{4} \rangle \end{bmatrix} \end{bmatrix}$

$\longleftrightarrow$

$\begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \text{KEY} & \boxed{4} \begin{bmatrix} \textit{affect-incr-th-rel} \\ \text{ACT} & \boxed{1} \\ \text{UND} & \textit{(source material)} \\ \text{SOA} & \begin{bmatrix} \textit{affect-incr-th-rel} \\ \text{ACT} & \boxed{1} \\ \text{SOA} & \boxed{2}\textit{(final product)} \end{bmatrix} \end{bmatrix} \\ \text{RELS} & \langle \boxed{3}, \boxed{4} \rangle \end{bmatrix} \end{bmatrix}$

Although most diathesis alternations can be modeled as alternations in meaning and as KEY shifts, some arguably cannot. We discuss the active/passive alternation here, but impersonals, as well as raising structures exemplified in (28) are good candidates too. The semantic relations of actives and long passives, as in (40), are practically identical and the difference between the two alternates is pragmatic in nature. Arguably, then, passives are a degenerate case of the subset relationship between RELS attributes, where the RELS values of the two entries are identical and so are the two entries' KEY. But this raises the question of whether linking in passives violates the constraints in (18)–(20), especially (18, which links the value of ACT to the first element of ARG-ST.

(40)   a. Fido dug a couple of holes.

   b. A couple of holes were dug by Fido.

One typical HPSG method for modeling valence alternations like passives is through lexical rules (see Chapter ??) with one alternant serving as input and the other as output; the main effect of the lexical rule in such an approach is to alter the ARG-ST of the input, going from the ARG-ST of *give* to that of *given* in (8). Critically, we must assume that the output cannot be subject to linking constraint (18), since the actor argument is not linked to the first member of the ARG-ST list. A simplified representation of what such a rule would look like is provided in (41) where we assume that the input to the rule must be transitive.

(41) $\begin{bmatrix} trans\text{-}vb \\ \text{HEAD} \quad verb \\ \text{ARG-ST} \quad \left\langle \text{NP}_{\boxed{1}}, \text{NP}_{\boxed{2}} \right\rangle \oplus \boxed{3} list \end{bmatrix} \mapsto \begin{bmatrix} \text{HEAD} \quad [\text{VFORM} \quad pass] \\ \text{ARG-ST} \quad \left\langle \text{NP}_{\boxed{2}} \right\rangle \oplus \boxed{3} \oplus \left\langle \text{PP}[_{by}]_{\boxed{1}} \right\rangle \end{bmatrix}$

To sum up, in contrast to most meaning-driven alternations, valence alternations like the active/passive are modeled through the use of lexical rules that alter the ARG-ST of "base" entries. Which alternations pattern with active/passive and require positing lexical rules that alter a "base" entry's ARG-ST list is, as of yet, not settled. We turn now to roles that are putatively present semantically, but not realized syntactically at all.

6 Extended ARG-ST

Most of this chapter focuses on cases where semantic roles linked to the ARG-ST list are arguments of the verb's core meaning. But in quite a few cases, complements (or even subjects) of a verb are not part of this basic meaning; consequently, the ARG-ST list must be extended to include elements beyond the basic meaning. We consider three cases here, illustrated in (42)–(44).

Resultatives, illustrated in (42), express an effect, which is caused by an action of the type denoted by the basic meaning of the verb. The verb *fischen* 'to fish' is a simple intransitive verb (42a) that does not entail that any fish were caught, or any other specific effect of the fishing.

(42) a. dass er fischt
     that he fishes
     'that he is fishing'

   b. dass er ihn leer   fischt
     that he it   empty fishes
     'that he is fishing it empty'

   c. wegen   der Leerfischung der   Nordsee
     because.of the empty.fishing of.the North.See.GEN
     'because of the North Sea being fished empty'

In (42b) we see a resultative construction, with an object NP and a secondary predicate AP. The meaning is that he is fishing, causing it (the body of water) to become empty of fish. Müller (2002) posits a German lexical rule applying to the verb that augments the ARG-ST list with an NP and AP, and adds the causal semantics to the CONTENT (see Wechsler (2005b) for a similar analysis of English

resultatives). The existence of deverbal nouns like *Leerfischung* 'fishing empty', which takes the body of water as an argument in genitive case (see 42c) confirms that the addition of the object is a lexical process, as noted by Müller (2002).

Romance clause-union structures as in (43) have long been analyzed as cases where the complements of the complements of a clause-union verb (*faire* in (43)) are complements of the clause-union verb itself (Aissen 1979).

(43)   Johanna a   fait   manger les enfants.
       Johanna have made eat   the children
       'Johanna had the children eat.'

Within HPSG, the "union" of the two verbs' dependents is modeled via the composition of ARG-ST lists of the clause union verb, following Hinrichs & Nakazawa (1994) (this is a slight simplification, see Chapter **??** for details).

Sentence (44) illustrates a slightly different point, namely that some semantic modifiers, such as *souvent* in (44), can be realized as complements, and thus should be added as members of ARG-ST (or members of the DEPS list if one countenances such an additional list).

(44)   Mes amis   m' ont   souvent aidé.
       My friends me have often   helped
       'My friends often helped me.'

Abeillé & Godard (1997) have argued that many adverbs including negative adverbs and negation in French are complements of the verb and Kim & Sag (2002) extended that view to some uses of negation in English. In contrast to resultatives, which affect the meaning of the verb, or to clause union, where one verb co-opts the argument structure of another verb, what is added to the ARG-ST list in these cases is typically considered a semantic adjunct and a modifier in HPSG (thus it selects the verb or VP via the MOD attribute).

Another case of an adjunct that behaves like a complement is found in (45). The clitic *en* expressing the cause of death is not normally an argument of the verb *mourir* 'die', but rather an adjunct (Koenig & Davis 2006):

(45)   Il en   est mort
       He of.it is   dead.PERF.PAST
       'He died of it' (Koenig & Davis 2006, ex. 12a)

On the widespread assumption (at least within HPSG) that pronominal clitics are verbal affixes (see Miller & Sag 1997), the adjunct cause of the verb *mourir* must be

represented within the entry for *mourir*, so as to trigger affixation by *en*. Bouma, Malouf & Sag (2001) discuss such cases and other cases where "adverbials" as they call them, can be part of a verb's lexical entry. To avoid mixing those adverbials with the argument structure list (and have to address their relative obliqueness with syntactic arguments of verbs), they introduce yet an additional list, the dependents list (abbreviated as DEPS) which includes the ARG-ST list but also a list of adverbials. Each adverbial selects for the verb on whose DEPS list it appears as argument, as shown in (46). But, of course, not all verb modifiers can be part of the DEPS list and Bouma, Malouf & Sag discuss at length some of the differences between the two kinds of "adverbials."

(46) $verb \Rightarrow$ $\begin{bmatrix} \text{CONT|KEY} & \boxed{2} \\ \text{HEAD} & \boxed{3} \\ \text{DEPS} & \boxed{1} \oplus list\left(\begin{bmatrix} \text{MOD} & \begin{bmatrix} \text{HEAD} & \boxed{3} \\ \text{key} & \boxed{2} \end{bmatrix} \end{bmatrix} \right) \\ \text{ARG-ST} & \boxed{1} \end{bmatrix}$

Although the three cases we have outlined result in an extended ARG-ST, the ways in which this extension arises differ. In the case of resultatives, the extension results partly or wholly from changing the meaning in a way similar to Rappaport Hovav & Levin (1998): by adding a causal relation, the effect argument of this causal relation is added to the membership in the base ARG-ST list (see Section 5 for a definition of the attributes KEY and RELS; suffice it to say for now that a *cause-rel* is added to the list of relations that are the input of the rule). The entries of the clause union verbs are simply stipulated to include on their ARG-ST lists the syntatic arguments of their (lexical) verbal arguments. Finally, (negative) adverbs that select for a verb (VP) are added to the ARG-ST of the verb they select. A simplified representation of all three processes is provided in (47)-(49).

(47) $\begin{bmatrix} \text{KEY} & \boxed{2} \\ \text{RELS} & \boxed{1}\langle ...\boxed{2}...\rangle \end{bmatrix} \mapsto \begin{bmatrix} \text{KEY} & \boxed{3}\textit{cause-rel} \\ \text{RELS} & \boxed{1} \oplus \boxed{3} \end{bmatrix}$

(48) $\begin{bmatrix} \text{ARG-ST} & \left\langle ...,\begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{ARG-ST} & \boxed{1} \end{bmatrix} \right\rangle \bigcirc \boxed{1} \end{bmatrix}$

(49) $\begin{bmatrix} \text{ARG-ST} & \boxed{1} \end{bmatrix} \mapsto \begin{bmatrix} \text{ARG-ST} & \boxed{1} \bigcirc \langle \text{ADV}_{neg} \rangle \end{bmatrix}$

7 Is ARG-ST universal?

In this section, we briefly consider the question of whether something akin to Figure 1 offers a satisfying account of the grammatical encoding of semantic ar-

guments across all languages. Because of its role in accounting for the syntax of basic clauses, the presence of an ARG-ST list on lexical entries comes with expectations about the syntactic realization of semantic roles. In recent work, Koenig & Michelson (2015) argue these expectations are not universally borne out, based on data from Oneida (Norther Iroquoian). The only grammatical reflex of semantic arguments in Oneida, they argue, is inflectional: the referencing of semantic arguments by so-called pronominal prefixes, which are better thought of as agreement markers à la Evans (2002). Koenig and Michelson distinguish between grammatical and syntactic arguments. Grammatical arguments include not only syntactic arguments (that is, those on ARG-ST) but also inflectional referencing of semantic roles. Some ordering analogous to linking in other languages is present in Oneida, because the semantic roles are not arbitrarily associated with agreement morphemes, but this can be captured in an ordered list of semantic indices , called INFL-STR in this proposal. INFL-STR is part of the morphological information relevant to word-internal inflectional processes, what Anderson (1992) calls 'Morphosyntactic Representation' in his treatment of Georgian agreement markers. The ordering of semantic indices on INFL-STR insures that the predicator is properly inflected. For example, the prefix *lak-* occurs if a third singular masculine proto-agent argument is acting on a first singular proto-patient argument as in *lak-hlo·lí-heʔ* 'he tells me' (habitual aspect), whereas the prefix *li-* occurs if a first singular proto-agent argument is acting on a third masculine singular argument, as in *li-hlo·lí-heʔ* 'I tell him' (habitual aspect).

In (50) and (51) we show the distinction between grammatical arguments realized as syntactic arguments (as in most languages) and those that are not (as in Oneida). Here, Koenig and Michelson follow the encoding of linking constraints as implicational constraints, as in Koenig & Davis (2003), although nothing critical hinges on that choice.

(50) $\begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \textit{cause-rel} \\ \text{CAUSER} & \boxed{1} \end{bmatrix} \\ \text{ARG-ST} & \langle \text{NP}, ... \rangle \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{ARG-ST} & \langle \text{NP:}\boxed{1}, ... \rangle \end{bmatrix}$

(51) $\begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \textit{cause-rel} \\ \text{CAUSER} & \boxed{1}\textit{anim} \end{bmatrix} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{INFL-STR} & \langle \boxed{1}, ... \rangle \end{bmatrix}$

(50) constrains the association between a cause and a *synsem* member of the ARG-ST list; (51) constrains the semantic *index* of the cause to be the first member of INFL-STR.

If a language like Oneida (Northern Iroquoian) only includes an ordering of semantic indices for inflectional purposes and constraints such as (51) and no

ARG-ST list, a number of predictions follow, which Koenig and Michelson claim are borne out. Briefly summarizing their evidence, the relation between semantic arguments and external phrases, when they occur, is not necessarily one of co-indexing, no binding constraints exist between external phrases (e.g., condition C violations can be found), there are no valence alternations, and no syntactic constraints on extraction. In other words, Oneida contains none of the evidence supporting the presence of an ARG-ST list and an ordering of syntactic arguments along an obliqueness hierarchy we have discussed in this chapter. The ARG-ST list may thus not a universal attribute of words, though present in the overwhelming majority of languages. Linking, understood as constraints between semantic roles and members of the ARG-ST list, is then but one possibility; constraints that relate semantic roles to an INFL-STR list of semantic indices is also an option. In languages that exclusively exploit that latter possibility, syntax is indeed simpler.

8 The lexical approach to argument structure

We end this chapter with a necessarily brief comparison between the approach to argument structure we describe in this chapter with other approaches to argument structure that have developed since the 1990's. This chapter describes a *lexical approach to argument structure*, which is typical of research in HPSG. The basic tenet of such approaches is that lexical items include argument structures, which represent essential information about potential argument selection and expression, but abstract away from the actual local phrasal structure. In contrast, *phrasal approaches*, which are common both in Construction Grammar and in transformational approaches such as Distributed Morphology, reject such lexical argument structures. Let us briefly review the reasons for preferring a lexical approach. (This section is drawn from Müller & Wechsler (2014b), which may be consulted for more detailed and extensive argumentation).

In phrasal approaches to argument structure, components of a verb's apparent meaning are actually 'constructional meaning' contributed directly by the phrasal structure. The linking constraints of the sort discussed above are then said to arise from the interaction of the verb meaning with the constructional meaning. For example, agentive arguments tend to be realized as subjects, not objects, of transitive verbs. On the theory presented above, that generalization is captured by the linking constraint (18), which states that the ACTOR argument of an *act-und-rel* ('actor-undergoer relation') is mapped to the initial item in the ARG-ST list. In a phrasal approach, the agentive semantics is directly associated with the subject position in the phrase structure. In transformational theories, a

silent 'light verb' (usually called 'little *v*') heads a projection in the phrase structure and assigns the agent role to its specifier (the subject). In constructional theories, the phrase structure itself assigns the agent role. In either type of phrasal approach, the agentive component of the verb meaning is actually expressed by the phrasal structure into which the verb is inserted.

The lexicalist's predicate argument structure provides essential information for a verb's potential combination with argument phrases. If a given lexical entry could only combine with the particular set of phrases specified in a single VALfeature, then the lexical and phrasal approaches would be difficult to distinguish: whatever information the lexicalist specifies for each VALlist item could, on the phrasal view, be specified instead for the phrases realizing those list items. But crucially, the verb need not immediately combine with its specified arguments. Alternatively it can meet other fates: it can serve as the input to a lexical rule; it can combine first with a modifier in an adjunction structure; it can be coordinated with another word with the same predicate argument structure; instead of being realized locally, one or more of its arguments can be effectively transferred to another head's valence feature (raising or argument transfer); or arguments can be saved for expression in some other syntactic position (partial fronting). Here we consider two of these, lexical rules and coordination.

The predicate argument structure is abstract: it does not directly encode the phrase structure or precedence relations between this verb and its arguments. This abstraction captures the commonality across different syntactic expressions of the arguments of a given root.

(52)   a. The rabbits were nibbling the carrots.

       b. The carrots were being nibbled (by the rabbits).

       c. a large, partly nibbled, orange carrot

       d. the quiet, nibbling, old rabbits

       e. the rabbit's nibbling of the carrots

       f. The rabbit gave the carrot a nibble.

       g. The rabbit wants a nibble (on the carrot).

       h. The rabbit nibbled the carrot smooth.

Verbs undergo morpholexical operations like passive (52d), as well as antipassive, causative, and applicative in other languages. They have cognates in other parts of speech such as adjectives (52c,d) and nouns (52e,f,g). Verbs have been argued to form complex predicates with resultative secondary predicates (52h), and with serial verbs in other languages.

The same root lexical entry *nibble*, with the same meaning, appears in all of these contexts. The effects of lexical rules together with the rules of syntax dictate the proper argument expression in each context. For example, if we call the first two arguments in an ARG-ST list (such as the one in (52) above) Arg1 and Arg2, respectively, then in an active transitive sentence Arg1 is the subject and Arg2 the object; in the passive, Arg2 is the subject and the referential index of Arg1 is optionally assigned to a *by*-phrase. The same rules of syntax dictate the position of the subject, whether the verb is active or passive. When adjectives are derived from verbal participles, whether active (*a nibbling rabbit*) or passive (*a nibbled carrot*), the rule is that whichever role would have been expressed as the subject of the verb is assigned by the participial adjective to the referent of the noun that it modifies, see Bresnan (1982) and Bresnan et al. (2015: Chapter 3). The phrasal approach, in which the agent role is assigned to the subject position, is too rigid.

Nor could this be solved by associating each syntactic environment with a different meaningful phrasal construction: an active construction with agent role in the subject position; a passive construction with agent in the *by*-phrase position; etc. The problem for that view is that that one lexical rule can feed another. In the example above, the output of the verbal passive rule (see (52d)) feeds the adjective formation rule (see (52e)).

A verb can also be coordinated with another verb with the same valence requirements. The two verbs then share their dependents. This causes problems for the phrasal view, especially when a given dependent receives different semantic roles from the two verbs. For example, in an influential phrasal analysis, Hale & Keyser (1993) derived denominal verbs like *to saddle* through noun incorporation out of a structure akin to [PUT a saddle ON x]. Verbs with this putative derivation routinely coordinate and share dependents with verbs of other types:

(53)   Realizing the dire results of such a capture and that he was the only one to prevent it, he quickly [saddled and mounted] his trusted horse and with a grim determination began a journey that would become legendary.[4]

Under the phrasal analysis the two verbs place contradictory demands on a single phrase structure. But on the lexical analysis, this is simple V^0 coordination.

To summarize, a lexical argument structure is an abstraction or generalization over various occurrences of the verb in syntactic contexts. To be sure, one key use of that argument structure is simply to indicate what sort of phrases the verb must (or can) combine with, and the result of semantic composition; if that were

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[4]http://www.jouetthouse.org/index.php?option=com_content&view=article&id=56&Itemid=
   63, 21.07.2012

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the whole story then the phrasal theory would be viable. But it is not. As it turns out, this lexical valence structure, once abstracted, can alternatively be used in other ways: among other possibilities, the verb (crucially including its valence structure) can be coordinated with other verbs that have a similar valence structure; or it can serve as the input to lexical rules specifying a new word bearing a systematic relation to the input word. The phrasal approach prematurely commits to a single phrasal position for the realization of a semantic argument. In contrast, a lexical argument structure gives a word the appropriate flexibility to account for the full range of expressions found in natural language.

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Chapter 10

Constituent order

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This chapter discusses local ordering variants and how they can be analyzed in HPSG. So-called scrambling, the local reordering of arguments of a head, can be accounted for by assuming flat rules or by binary branching rules with arbitrary order of saturation. The difference between SVO and SOV is explained by assuming different mappings between the argument structure list (a list containing all arguments of a head) and valence features for subjects and complements. The position of the finite verb in initial or final position in languages like German can be accounted for by flat rules and a separation between immediate dominance and linear precedence information or by something analogous to head-movement in transformational approaches. The chapter also addresses the analysis of languages allowing even more freedom than languages that just allow to scramble arguments. It is shown how one such langauge, namely Warlpiri, can be analyzed with so-called constituent order domains allowing for discontinuous constituents. I discuss problems of domain-based approaches and provide an alternative account of Warlpiri that does not rely on discontinuous constituents.

1 Introduction

This chapter deals with constituent order, with a focus on local order variants. English is the language that is treated most thoroughly in theoretical linguistics but is probably also a rather uninteresting language as far as the possibilities of reordering constituents is concerned: the order of subject, verb, and object is fixed in sentences like (1):

(1)   Kim likes bagels.

Of course, there is the possibility to front the object as in (2) but this is a special, non-local construction that is not the topic of this chapter but is treated in Borsley & Crysmann (2018), Chapter 14 of this volume.

(2) Bagels, Kim likes.

This chapter deals with scrambling (the local reordering of arguments) and with alternative placements of heads (called *head movement* in some theories). Examples of the former are the subordinate clauses in (3) and an example of the latter is given in (4):

(3) a. [weil] der Mann der Frau das Buch gibt (German)
         because the.NOM man the.DAT woman the.ACC book gives

     b. [weil] der Mann das Buch der Frau gibt
         because the.NOM man the.ACC book the.DAT woman gives

     c. [weil] das Buch der Mann der Frau gibt
         because the.ACC book the.NOM man the.DAT woman gives

     d. [weil] das Buch der Frau der Mann gibt
         because the.ACC book the.DAT woman the.NOM man gives

     e. [weil] der Frau der Mann das Buch gibt
         because the.DAT woman the.NOM man the.ACC book gives

     f. [weil] der Frau das Buch der Mann gibt
         because the.DAT woman the.ACC book the.NOM man gives

(4) Gibt der Mann der Frau das Buch?   (German)
     gives the.NOM man the.DAT woman the.ACC book

     'Does the man give the woman the book?'

(3) shows that in addition to the unmarked order in (3a) (see Höhle (1982) on the notion of unmarked order), five other argument orders are possible in sentences with three-place verbs. As with the examples just given, I will use German if a phenomenon does not exist in English. Section 6.2 discusses examples from Warlpiri, a language having even freer constituent order.

(4) shows that the verb is placed in initial position in questions in German. This contrasts with the verb final order in the subordinate clause in (3a), which has the same order as far as the arguments are concerned. This alternation of verb placement is usually treated as head movement in the transformational literature (Bach 1962; Bierwisch 1963: 34; Reis 1974; Thiersch 1978: Chapter 1). Declarative main clauses in German are V2 clauses and the respective fronting of the pre-verbal constituent is usually treated as a non-local dependency (see Borsley & Crysmann (2018), Chapter 14 of this volume). Hence, V2 sentences will not be handled here.

The following sections deal with the theoretical options within the HPSG framework for dealing with these phenomena. I first discuss the separation of grammar rules into an immediate dominance part and a linear precedence component in Section 2 and then flat vs. binary branching structures (Section 3). While flat structures allow verbs to be ordered clause-finally or clause-initially, this is not the case for binary branching structures, since only sisters can be ordered. So, for (3a) one would get the bracketing in (5a). If *das Buch* 'the book' and *gibt* 'gives' are ordered in a different order, (5b) results.

(5)   a.   [weil]   [der   Mann [der   Frau   [das   Buch gibt]]]
           because the.NOM man   the.DAT woman the.ACC book gives

    b.   * [weil]   [der   Mann [der   Frau   [gibt das   Buch]]]
           because the.NOM man   the.DAT woman gives the.ACC book

Hence, local reordering is not sufficient to get clause-initial verb order and therefore, proposals with binary branching structures are usually paired with HPSG's analogue of what is head-movement in transformational theories. These are explained in Section 5. Section 6 introduces an extension to standard HPSG developed by Reape (1994): constituent order domains. Such constituent order domains allow for discontinuous constituents and have been used to account for languages like Warlipri (Donohue & Sag 1999). Section 7 shows how such languages can be analyzed without admitting discontinuous constituents.

2 ID/LP format

HPSG was developed out of Generalized Phrase Structure Grammar (GPSG) and Categorial Grammar. The ideas concerning linearization of daughters in a local tree were taken over from GPSG (Gazdar, Klein, Pullum & Sag 1985). In GPSG a separation between immediate dominance and linear precedence is assumed. So, while in classical phrase structure grammar, a phrase structure rule like (6) states that the NP[nom], NP[dat] and NP[acc] have to appear in exactly this order, this is not the case in GPSG and HPSG:

(6)   S → NP[nom] NP[dat] NP[acc] V

The HPSG schemata corresponding to the phrase structure rule in (6) do not express information about ordering. Instead, there are separate linear precedence (LP) rules. A schema like (6) licenses 24 different orders: the six permutations of the three arguments that were shown in (3) and all possible placements of the verb (to the right of NP[acc], between NP[dat] and NP[acc], between NP[nom]

and NP[dat], to the left of NP[nom]). Orders like NP[nom], NP[dat], V, NP[acc] are not attested in German and hence these orderings have to be filtered out. This is done by linearization rules, which can refer to features or to the function of a daughter in a schema. (7) shows some examples of linearization rules:

(7)   a. X < V

      b. X < V[ɪɴɪ−]

      c. X < Head [ɪɴɪ−]

The first rule says that all constituents have to precede a V in the local tree. The second rule says that all constituents have to precede a V that has the ɪɴɪᴛɪᴀʟ value −. One option to analyze German would be the one that was suggested by Uszkoreit (1987) within the framework of GPSG: one could allow for two linearization variants of finite verbs. So in addition to the ɪɴɪ− variant of verbs there could be a ɪɴɪ+ variant and this variant would be linearized initially. The LP rule in (7c) is more general than (7b) in that it does not mention the part of speech but instead refers to the function of the constituent. The rule says that a head that has the ɪɴɪ value − has to be linearized to the right of all other elements in the local tree.

This treatment of constraints on linearization has an advantage that was already pointed out by researchers working in GPSG: it captures the generalizations regarding linearization. For instance the order of verbs and their arguments is the same in embedded sentences in German independent of the finiteness of the verb:

(8) a. dass er   dem   Mann das   Buch gab
       that he.ɴᴏᴍ the.ᴅᴀᴛ man   the.ᴀᴄᴄ book gave

       'that he gave the man the book'

     b. dass er   versucht, [dem   Mann das   Buch zu geben]
       that he.ɴᴏᴍ tried   the.ᴅᴀᴛ man   the.ᴀᴄᴄ book to give

       'that he tried to give the man the book'

This is also true for the relative order of dative and accusative object in (8). The constraints regarding linearization hold across rules. By factoring these constraints out, the generalizations can be captured.

Furthermore, generalizations about constituent structure can be captured. For example, the two phrase structure rules in (9) would be needed for head-initial and head-final languages, respectively:

(9)   a. VP → V NP NP

b. VP → NP NP V

In an ID/LP framework only one rule is needed. The linearization of the head is factored out of the rules. Similarly, HPSG has just one schema for Head-Adjunct structures although languages like English allow adjuncts to precede or follow the head they modify. The schema does not say anything about the order of the daughters. This is taken care of by two LP rules saying that adjuncts marked as pre-modifiers have to preceede their head while those that are marked as post-modifiers follow it.

3 Flat and binary branching structures

The previous section discussed LP rules and used flat phrase structure rules for illustration. The corresponding flat structures are also used in HPSG. Schema 1 shows a Head-Complement schema that combines a head with all the complements selected via the COMPS list.[1]

Schema 1 (Head-Complement Schema)

head-complement-phrase ⇒

$$
\begin{bmatrix}
\text{SYNSEM|LOC|CAT|COMPS } \langle\rangle \\
\text{HEAD-DTR } \begin{bmatrix} \text{SYNSEM|LOC|CAT|COMPS } \boxed{1} \end{bmatrix} \\
\text{NON-HEAD-DTRS synsem2signs(}\boxed{1}\text{)}
\end{bmatrix}
$$

synsem2signs is a relational constraint mapping a list of *synsem* objects as they are contained in the COMPS list onto a list of objects of type *sign* as they are contained in daughters (see Ginzburg & Sag 2000: 34 for a similar proposal).[2] How this schema can be used to analyze VPs like the one in (10) is shown in Figure 1.

(10)　Kim gave Sandy a book.

---

[1]Ginzburg & Sag (2000: 4) assume a list called DTRS for all daughters including the head daughter. It is useful to be able to refer to specific non-head daughters without having to know a position in a list. For example in head-adjunct structures the adjunct is the selector. So I keep DTRS for a list of ordered daughters and HEAD-DTR and NON-HEAD-DTRS for material that is not necessarily ordered.

[2]In Sign-Based Construction Grammar the objects in valence lists are of the same type as the daughters. A relational constraint would not be needed in this variant of the HPSG theory. Theories working with a binary branching Head-Complement Schema as Schema 2 on page 189 would not need the relational constraint either since the *synsem* object in the COMPS list can be shared with the SYNSEM value of the element in the list of non-head daughters directly.
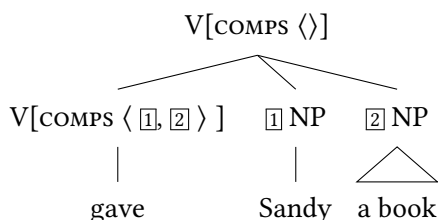
Figure 1: Analysis of the VP *gave Sandy a book* with a flat structure

Researchers working on English usually assume a flat structure (Pollard & Sag 1994: 39–40, 362; Sag 1997: 479; Ginzburg & Sag 2000: 34) but assuming binary branching structures would be possible as well, as is clear from analyses in Categorial Grammar, where binary combinatory rules are assumed (Ajdukiewicz 1935; Steedman 2000). For languages like German it is usually assumed that structures are binary branching (but see Reape 1994: 156 and Bouma & van Noord 1998: 51). The reason for this is that adverbials can be placed anywhere between the arguments as the following example from Uszkoreit (1987: 145) shows:

(11) *Gestern* hatte *in*   *der Mittagspause* der Vorarbeiter *in der*
      yesterday had   during the lunch.break   the foreman   in the
      Werkzeugkammer dem Lehrling   *aus Boshaftigkeit langsam* zehn
      tool.shop   the apprentice maliciously   slowly ten
      schmierige Gußeisenscheiben *unbemerkt* in die Hosentasche gesteckt.
      greasy   cast.iron.disks unnoticed in the pocket   put
      'Yesterday during lunch break, the foreman maliciously and unnoticed,
      put ten greasy cast iron disks slowly into the apprentice's pocket.'

A straightforward analysis of adjunct placement in German and Dutch is to assume that adjuncts can attach to any verbal projection. For example, Figure 2 shows the analysis of (12):

(12) weil   deshalb jemand   gestern der Frau   schnell das Buch gab
      because therefore somebody yesteray the woman quickly the book gave
      'because somebody quickly gave the woman the book yesterday'

The adverbials *deshalb* 'therefore', *gestern* 'yesterday' and *schnell* 'quickly' may attach to any verbal projection. For example, *gestern* could also be placed at the other adjunct positions in the clause.

Binary branching structures with attachment of adjuncts to any verbal projection also account for recursion and hence the fact that arbitrarily many adjuncts
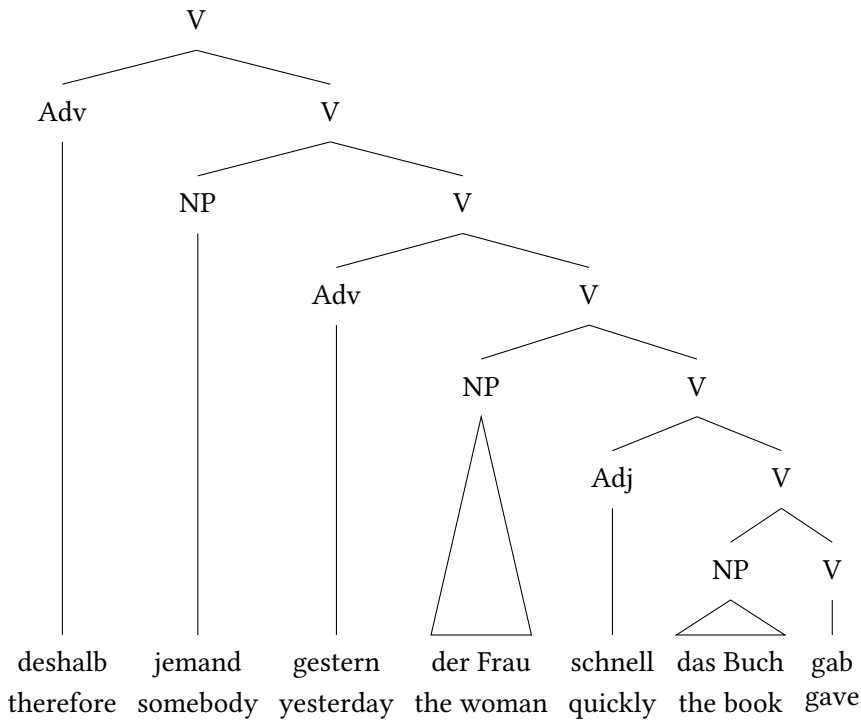
Figure 2: Analysis of [*weil*] *deshalb jemand gestern der Frau schnell das Buch gab* 'because somebody quickly gave the woman the book yesterday' with binary branching structures

can attach to a verbal projection. Of course it is possible to formulate analyses with flat structures that involve arbitrarily many adjuncts (Kasper 1994; van Noord & Bouma 1994; Bouma et al. 2001), but these analyses involve relational constraints in schemata or in lexical items. In Kasper's analysis the relational constraints walk through lists of daughters of unbounded length in order to compute the semantics. In the other two analyses adjuncts are treated as valents, which may be problematic because of scope issues. This cannot be dealt with in detail here but see Levine & Hukari (2006) and Chaves (2009) for discussion.

The following schema licenses binary branching head-complement phrases:

Schema 2 (Head-Complement Schema (binary branching))

head-complement-phrase ⇒

$$\begin{bmatrix} \text{SYNSEM}|\text{LOC}|\text{CAT}|\text{COMPS } \boxed{1} \oplus \boxed{2} \\ \text{HEAD-DTR} \qquad \begin{bmatrix} \text{SYNSEM}|\text{LOC}|\text{CAT}|\text{COMPS } \boxed{1} \oplus \langle\, \boxed{3}\, \rangle \oplus \boxed{2} \end{bmatrix} \\ \text{NON-HEAD-DTRS} \qquad \left\langle \begin{bmatrix} \text{SYNSEM } \boxed{3} \end{bmatrix} \right\rangle \end{bmatrix}$$

⊕ (append) is a relational constraint that concatenates two lists. The COMPS list of the head daughter is split into three lists: a beginning ($\boxed{1}$), a list containing $\boxed{3}$ and a rest ($\boxed{2}$). $\boxed{3}$ is identified with the SYNSEM value of the non-head daughter. All other elements of the COMPS list of the head daughter are concatenated and the result of this concatenation ($\boxed{1} \oplus \boxed{2}$) is the COMPS list of the mother node. This schema is very general. It works for languages that allow for scrambling since it allows an arbitrary element to be taken out of the COMPS list of the head daughter and realize it in a local tree. The schema can also be "parametrized" to account for languages with fixed word order. For head final languages with fixed order $\boxed{2}$ would be the empty list (= combination with the last element in the list) and for head-initial languages with fixed order (e.g., English) $\boxed{1}$ would be the empty list (= combination with the first element in the list). Since the elements in the COMPS list are ordered in the order of Obliqueness (Keenan & Comrie 1977; Pullum 1977) and since this order corresponds to the order in which the complements are serialized in English, the example in (10) can be analyzed as in Figure 3.[3] The second tree in the figure is the German counterpart of *gave Sandy a book*: the finite verb in final position with its two objects in normal order. Section 4 explains why SOV languages like German and Japanese contain their subject in the COMPS list while SVO languages like English and Romance languages do not.

The alternative to using relational constraints as in Schema 2 is to use sets rather than lists for the representation of valence information (Gunji 1986; Hinrichs & Nakazawa 1989; Pollard 1996; Engelkamp, Erbach & Uszkoreit 1992). The Head-Complement Schema would combine the head with one of its complements. Since the elements of a set are not ordered, any complement can be taken and hence all permutations of complements are accounted for.

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[3]This structure may seem strange to those working in Mainstream Generative Grammar (MGG, GB/Minimalism). In MGG different branchings are assumed since the form of the tree plays a role in Binding Theory. This is not the case in HPSG: Binding is done on the ARG-ST list. See Branco (2018), Chapter 21 of this volume for a discussion of HPSG's Binding Theory and Borsley & Müller (2018), Chapter 33 of this volume for a comparison between HPSG and Minimalism.

Draft of 29th November 2018, 11:59

V[COMPS ⟨⟩]

V[COMPS ⟨ 2 ⟩]   2 NP

V[COMPS ⟨ 1, 2 ⟩]   1 NP

gave   Sandy   a book

V[COMPS ⟨ 1 ⟩]

2 NP   V[COMPS ⟨ 1, 2 ⟩]

3 NP   V[COMPS ⟨ 1, 2, 3 ⟩]

Sandy   ein Buch   gab
Sandy   a book   gave
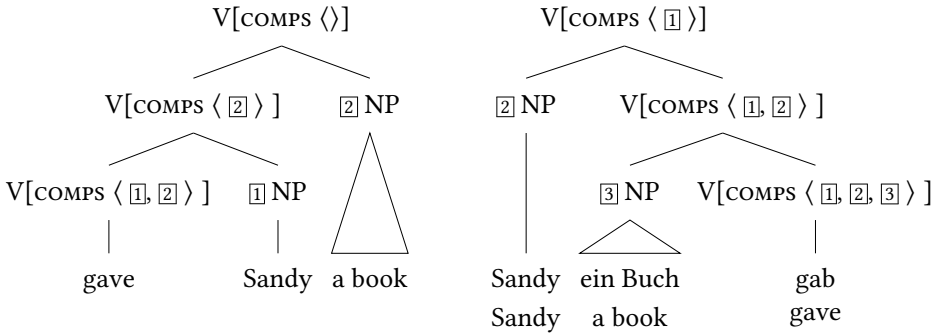
Figure 3: Analysis of the English VP *gave Sandy a book* and the corresponding German verbal projection *Sandy ein Buch gab* with binary branching structures

The disadvantage of set-based approaches is that sets do not impose an order on their members but an order is needed for various subtheories of HPSG (see Przepiórkowski (2018), Chapter 7 of this volume on case assignment, and Branco (2018), Chapter 21 of this volume on Binding Theory). In the approach proposed above and in Müller (2003b; 2015a,b), the valence lists are ordered but the schema allows for combination with any element of the list. For valence representation and the order of elements in valence lists see Wechsler, Koenig & Davis (2018), Chapter 9 of this volume.

4 SVO vs. SOV

The careful reader will have noticed that the COMPS list of *gave* in Figure 3 contains the two objects while it's German counterpart *gab* has three elements in the COMPS list. The rationale behind this is explained in this section.

In principle, one could assume a rule like (6) for SVO languages like English as well. The SVO order would then be accounted for by linearization rules stating that NP[*nom*] precede the finite verb while other arguments follow it. This would get the facts about simple sentences like (13a) right but leaves the analysis of (13c) open.

(13)   a. Peter reads books.
       b. Peter often read books.

The generalization about languages like English is that adverbials can attach to the left or to the right of verbs with their objects, that is, to the left or to the

right of the VP. Researchers like Borsley (1987) argued that subjects, specifiers, and complements differ in crucial ways and should be represented by special (valence) features. For example, the subject of the VP *to read more books* is not realized but is referred to in Control Theory (Abeillé 2018, Chapter 13 of this volume).

(14)   Peter tries to read more books.

The subject in English main clauses is similar to the determiner in nominal structures and hence one way of expressing this similarity is using the same valence features and the same schema for subject-VP combinations as for determiner-noun combinations.[4] The schema is given here as Schema 3:

Schema 3 (Specifier-Head Schema)
specifier-head-phrase ⇒

$$
\begin{bmatrix}
\text{SYNSEM|LOC|CAT|SPR } \boxed{1} \\[4pt]
\text{HEAD-DTR|SYNSEM|LOC|CAT } \begin{bmatrix} \text{SPR} & \boxed{1} \oplus \langle\, \boxed{2}\, \rangle \\ \text{COMPS} & \langle\,\rangle \end{bmatrix} \\[10pt]
\text{NON-HEAD-DTRS } \left\langle \begin{bmatrix} \text{SYNSEM } \boxed{2} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

The last element of the SPR list is realized as the non-head daughter. The remaining list is passed up to the mother node. Note that the non-head daughter is taken from the end of the SPR list. For heads that have exactly one specifier this difference is irrelevant, but in the analysis of object shift in Danish suggested by Müller & Ørsnes (2013), the authors assume multiple specifiers and hence the difference in order of combination is relevant. The head-daughter must have an empty COMPS list. This way it is ensured that verbs form a unit with their objects (the VP) and the subject is combined with the VP rather than the subject combining with a lexical verb and this combination combining with objects later.

The analysis of the sentence in (15) including the analysis of the NP is given in Figure 4.

(15)   Kim gave Sandy a book.

---

[4] This is non-standard in HPSG. Usually the SUBJECT feature is used for subjects and SPR for determiners. I follow the German HPSG tradition and use SUBJ for unexpressed subjects. See also Eynde (2018), Chapter 8 of this volume for alternative analyses of nominal structures that do not assume a selection of the determiner by the noun.

Draft of 29th November 2018, 11:59
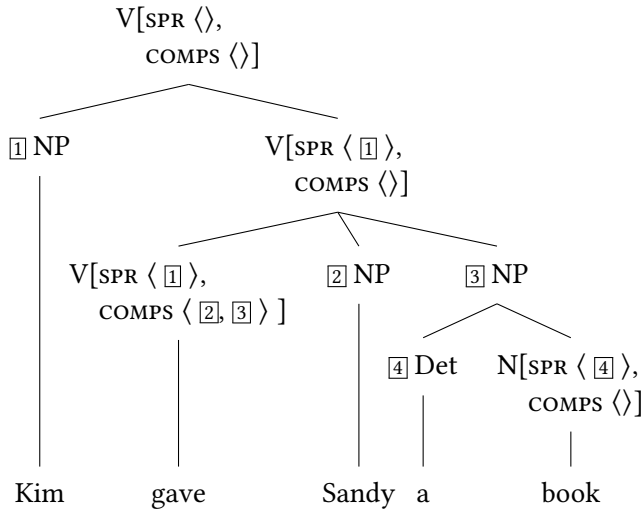
Figure 4: Analysis of *Kim gave Sandy a book* with SPR and COMPS feature and a flat VP structure

For German, it is standardly assumed that the subjects of finite verbs are treated like complements (Pollard 1996: 295–296, Kiss 1995: 80) and hence are represented at the COMPS list (as in Figure 3). The assumption that arguments of finite verbs are complements is also made by researchers working in different research traditions (e.g. Eisenberg 1994: 376). By assuming that the subject is listed among the complements of a verb it is explained why it can be placed in any position before, between, and after them. So, German differs from English in the way the arguments are distributed on the valence lists. However, HPSG ha a more basic representation in which the languages behave the same: the argument structure represented at the ARG-ST list. The ARG-ST list contains *synsem* objects and is used for linking (Wechsler, Koenig & Davis 2018, Chapter 9 of this volume), case assignment (Przepiórkowski 2018, Chapter 7 of this volume), and binding (Branco 2018, Chapter 21 of this volume). Ditransitive verbs in German and English have three NP arguments on their ARG-ST and they are linked in the same way to the semantic representation (Müller 2018a). (16) shows the mapping from ARG-ST to SPR and COMPS:

(16)   *gives* (English, SVO language):   *gibt* (German, SOV language):

$$\begin{bmatrix} \text{SPR} & \langle\, \boxed{1}\, \rangle \\ \text{COMPS} & \boxed{2} \\ \text{ARG-ST} & \langle\, \boxed{1}\,\text{NP}\rangle \oplus \boxed{2}\, \langle\, \text{NP, NP}\, \rangle \end{bmatrix} \qquad \begin{bmatrix} \text{SPR} & \langle\rangle \\ \text{COMPS} & \boxed{1} \\ \text{ARG-ST} & \boxed{1}\,\langle\, \text{NP, NP, NP}\, \rangle \end{bmatrix}$$

In SVO languages, the first element of the ARG-ST list is mapped to SPR and all others to COMPS and in languages without designated subject positions all ARG-ST elements are mapped to COMPS.

Having explained scrambling in HPSG and the order of subjects in SVO languages, I now turn to "head-movement".

5 Head movement vs. constructional approaches assuming flat structures

The Germanic languages signal the clause type by verb position. All Germanic languages with the exception of English are V2 languages: the finite verb is in second position in declarative main clauses. The same holds for questions with *wh* phrases. Yes/no questions are formed by putting the verb in initial position. English is a so-called *residual V2 language*, that is, there are some constructions that are parallel to what is known from V2 languages. For example, while declarative clauses are in base order (SVO), questions follow the pattern that is known from other Germanic languages.

(17)   What$_i$ will Kim read __$_i$?

Analyses assuming flat structures (or flat linearization domains, see Section 6) usually treat alternative orders of verbs in Germanic languages as linearization variants (Reape 1994; Kathol 2001; Müller 1995; 2003b; Bjerre 2006), but this is not necessarily so as Bouma and van Noord's analysis of Dutch clauses show (Bouma & van Noord 1998: 62, 71). The alternative to verb placement as linearization is something that is similar to verb movement in Government & Binding: an empty element takes the position of the verb in its canonical position and the verb is realized in initial or – in case something is realized before the finite verb – in second position. The following subsection deals with such approaches in more detail. Subsection 5.2 deals with a constructional approach.

5.1 Head movement approaches

Building on work by Jacobson (1987) in the framework of Categorial Grammar, Borsley (1989) showed that in addition to the analysis of auxiliary inversion in English that was suggested in GPSG (Gazdar et al. 1985) an analysis that is similar to the movement-based analysis in GB is possible in HPSG as well. The technique that is used in the analysis is basically the same that was developed by Gazdar (1981) for the treatment of nonlocal dependencies in GPSG. An empty category is assumed and the information about the missing element is passed up the tree until it is bound off at an appropriate place (that is by the fronted verb). Note that the heading of this section contains the term *head movement* and I talk about traces, but it is not the case that something is actually moved. There is no underlying structure with a verb that is transformed into one with the verb fronted and a remaining trace in the original position of the verb. Instead, the empty element is a normal element in the lexicon and can function as the verb in the respective position. The analysis of (18a) is shown in Figure 5.

(18)   a.   Will Kim get the job?
        b.   Kim will get the job.

A special variant of the auxiliary is licensed by a unary rule. The unary rule has as a daughter the auxiliary as it appears in canonical SVO order as in (18b). It licenses an auxiliary selecting a full clause in which the daughter auxiliary (with the LOCAL value ②) is missing. The fact that the auxiliary is missing is represented as the value of DOUBLE SLASH (DSL). The value of DSL is a *local* object, that is, something that contains syntactic and semantic information (② in Figure 5). DSL is a head feature and hence available everywhere along a projection path (see Borsley & Abeillé (2018), Chapter 1 of this volume for the Head Feature Principle). The empty element for head movement is rather simple:

check reference to Chapter 1.

(19)   empty element for head movement:

$$\begin{bmatrix} \textit{word} \\ \text{PHON} \quad \langle \rangle \\ \text{SYNSEM|LOC} \ ① \begin{bmatrix} \text{CAT|HEAD|DSL} \ ① \end{bmatrix} \end{bmatrix}$$

It states that there is an empty element that has the local requirements that correspond to its DSL value. For cases of verb movement it says: I am a verb that is missing itself.

Such head-movement analyses are assumed by most researchers working on German (Kiss & Wesche 1991: Section 4.7; Oliva 1992; Netter 1992; Kiss 1993;

Figure 5: Analysis of English auxiliary constructions as head-movement following (Borsley 1989)

Frank 1994; Kiss 1995; Feldhaus 1997, Meurers 2000; Müller 2005a; 2017) and also by (Bouma & van Noord 1998: 62, 71) in their work on Dutch, by Müller & Ørsnes (2015) in their grammar of Danish and by Müller (2018b) for Germanic in general.

5.2 Constructional approaches

The alternative to head-movement-based approaches is a flat analysis with an alternative serialization of the verb. This was already discussed with respect to German, but I want to discuss English auxiliary constructions here, since they have figured prominently in linguistic discussions. In the analysis of (20) shown in Figure 6, the auxiliary *did* selects for the subject *Kim* and a VP *get the job*.

(20) Did Kim get the job?

The tree in Figure 6 is licensed by a schema combining a head with its subject (⌶) and its VP complement (⌷) in one go.[5] As is common in HPSG since the

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[5]An alternative is to assume a separate valence feature for the subject (SUBJ) and assume a schema that combines the head with the element in the SUBJ list and the elements in the COMPS
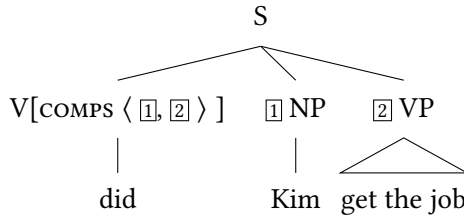
Figure 6: Analysis of English auxiliary constructions according to (Sag et al. 2018)

mid-1990s (Sag 1997) phrasal schemata are organized in type hierarchies and the general schema for auxiliary initial constructions has the type *aux-initial-cxt*. Fillmore (1999) and Sag et al. (2018) argue that there are various usages of auxiliary-initial constructions and assign the respective usages to subconstructions of the general auxiliary-initial construction. Technically this amounts to stating subtypes of *aux-initial-cxt*. For example, Sag et al. (2018) posit a subtype *polar-int-cl* for polar interrogatives like (21a) and another subtype *auxinitial-excl-cl* for exclamatives like (21b).

(21) a. Are they crazy?
      b. Are they crazy!

Chomsky (2010) compared the various clause types used in HPSG with the – according to him – much simpler Merge-based analysis in Minimalism. Minimalism assumes just one very general schema for combination (External Merge is basically equivalent to our Schema 2 above, see Müller (2013)), so this rule for combining linguistic objects is very simple, but this does not help in any way when considering the facts: there are at least five different meanings associated with auxiliary initial clauses (polar interrogative, blesses/curses, negative imperative, exclamatives, conditionals) and these have to be captured somewhere in a grammar. One way is to state them in a type hierarchy as is done in some HPSG analyses and in SBCG, another way is to use implicational constraints that assign meaning with respect to actual configurations (see Section 5.3) and a third way is to do everything lexically. The only option for Minimalism is the lexical one. This means that Minimalism has to either assume as many lexical items for auxiliaries as there are types in HPSG or to assume empty heads that contribute the meaning that is contributed by the phrasal schemata in HPSG (Borsley 2006: Section 5; Borsley & Müller 2018). The latter proposal is generally

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list (Ginzburg & Sag 2000: 36).

assumed in Cartographic approaches (Rizzi 1997). Since there is a fixed configuration of functional projections that contribute semantics, one could term these Rizzi-style analyses *Crypto-Constructional*.

Having discussed a lexical approach involving an empty element and a phrasal approach that can account for the various meanings of auxiliary inversion constructions, I turn now to a mixed approach in the next section and show how the various meanings associated with certain patterns can be integrated into accounts with rather abstract schemata for combinations like the one described in Section 5.1.

5.3 Mixed approaches

The situation with respect to clause types is similar in German. Verb first sentences can be yes/no questions (22a), imperatives (22b), conditional clauses (22c), and declarative sentences with topic drop (22d).

(22) a. Kommt Peter?   (German)
          comes   Peter

          'Does Peter come?'

      b. Komm!
          come

      c. Kommt Peter, komme ich nicht.
          comes   Peter come   I   not

          'If Peter comes, I won't come.'

      d. Kommt. (Was ist mit   Peter?)
          comes   what is with Peter

          'What about Peter?' 'He comes.'

Verb second sentences can be questions (23a), declarative sentences (23b), or imperatives (23c).

(23) a. Wer kommt?
          who comes

      b. Peter kommt.   (German)
          Peter comes

      c. Jetzt komm!
          now come

          'Come now!'

While one could try and capture this situation by assuming surface order-related clause types, such approaches are rarely assumed in HPSG (but see Kathol (2001) and Wetta (2011). See Section 6.4.2 on why such approaches are doomed to failure). Rather researchers assumed binary branching head-complement structures together with verb movement (for references see the end of Section 5.1).[6]

As was explained in Section 5.1, the head movement approaches are based on lexical rules or unary projections. These license new linguistic objects that could contribute the respective semantics. In analogy to what Borsley (2006) has discussed with respect to extraction structures, this would mean that one needs seven versions of fronted verbs to handle the seven cases in (22 and (23), which would correspond to the seven phrasal types that would have to be stipulated in phrasal approaches. But there is a way out of this: one can assume one lexical item with underspecified semantics. HPSG makes it possible to use implicational constraints referring to a structure in which an item occurs. Depending on the context the semantics contributed by a specific item can be further specified. Figure 7 shows the construction-based and the lexical rule-based analysis in the abstract for comparison. In the construction-based analysis the daughters

(a) Phrasal construction   (b) Unary construction and implication
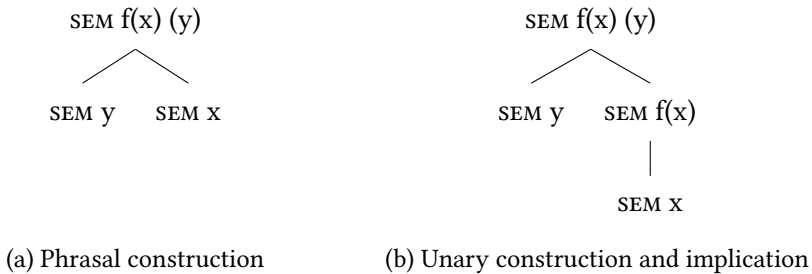
Figure 7: Construction-based, phrasal approach and approach with implicational constraint

contribute x and y as semantic values and the whole construction adds the construction meaning f. In the lexical rule- or unary projection-based analysis, the lexical rule/unary projection adds the f and the output of the rule is combined compositionally with the other daughter. Now, implicational constraints can be used to determine the exact contribution of the lexical item (Müller 2016). This is shown with the example of a question in Figure 8. The implication says: when the configuration has the form that there is a question pronoun in the left daughter, the output of the lexical rule gets question semantics. Since HPSG represents

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[6]I assumed linearization domains (see Section 6) for ten years and then switched to the head-movement approach (Müller 2005a,b; 2017).
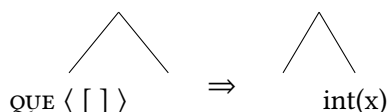
Figure 8: Implication for interrogative sentences

all linguistic information in the same attribute value matrix (AVM), such implicational constraints can refer to intonation as well and hence, implications for establishing the right semantics for V1 questions (22a) vs. V1 conditionals (22c) can be formulated.

6 Constituent order domains and linearization

There is an interesting extension to standard HPSG that opens up possibilities for analyses that are quite different from what is usually done in theoretical linguistics: Mike Reape (1991; 1992; 1994) working on German suggested formal tools that allow for the modeling of discontinuous constituents.[7] His original motivation was to account for scrambling of arguments in verbal complexes but this analysis was superseded by Hinrichs and Nakazawa's analysis (Hinrichs & Nakazawa 1989; 1994) since purely linearization-based approaches are unable to account for agreement and the so-called remote passive (Kathol 1998: Section 5.1, Section 5.2; Müller 1999: Chapter 21.1). Nevertheless, his work was taken up by others and was used for analyzing German (Kathol & Pollard 1995; Kathol 2000; Müller 1995; 1996; 2004; Wetta 2011; Wetta 2014). As will be discussed below in Section 6.4, there were reasons for abandoning linearization-based analyses of German assuming discontinuous constituents (Müller 2005b; 2017) but constituent order domains still play a major role in analyzing ellipsis (Nykiel & Kim 2018, Chapter 20 of this volume) and coordination (Abeillé & Chaves 2018, Chapter 17 of this volume).

6.1 A special representational layer for constituent order

The technique that is used to model discontinuous constituents in frameworks like HPSG goes back to Mike Reape's work on German (1991; 1992; 1994). Reape uses a list called DOMAIN to represent the daughters of a sign in the order in which

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[7]See also **Blevins94a**; Wells (1947); Dowty (1996) for proposals assuming discontinuous constituents in other frameworks.

they appear at the surface of an utterance. (24) shows an example in which the DOM value of a headed-phrase is computed from the DOM value of the head and the list of non-head daughters.

(24) *headed-phrase* $\Rightarrow$ $\begin{bmatrix} \text{HEAD-DTR|DOM} & \boxed{1} \\ \text{NON-HEAD-DTRS} & \boxed{2} \\ \text{DOM} & \boxed{1} \bigcirc \boxed{2} \end{bmatrix}$

The symbol '$\bigcirc$' stands for the *shuffle* relation. *shuffle* relates three lists A, B and C iff C contains all elements from A and B and the order of the elements in A and the order of the elements of B is preserved in C. (25) shows the combination of two sets with two elements each:

(25) $\langle\, a, b\,\rangle \bigcirc \langle\, c, d\,\rangle = \langle\, a, b, c, d\,\rangle \lor$
$\langle\, a, c, b, d\,\rangle \lor$
$\langle\, a, c, d, b\,\rangle \lor$
$\langle\, c, a, b, d\,\rangle \lor$
$\langle\, c, a, d, b\,\rangle \lor$
$\langle\, c, d, a, b\,\rangle$

The result is a disjunction of six lists. *a* is ordered before *b* and *c* before *d* in all of these lists, since this is also the case in the two lists $\langle\, a, b\,\rangle$ and $\langle\, c, d\,\rangle$ that have been combined. But apart from this, *b* can be placed before, between or after *c* and *d*.

On the linearization-based approach, every word comes with a domain value that is a list that contains the word itself:

(26) Domain contribution of single words, here *gibt* 'gives':
$\boxed{1}\begin{bmatrix} \text{PHON} & \langle\, gibt\,\rangle \\ \text{SYNSEM} & \dots \\ \text{DOM} & \langle\, \boxed{1}\,\rangle \end{bmatrix}$

The description in (26) may seem strange at first glance, since it is cyclic, but it can be understood as a statement saying that *gibt* contributes itself to the items that occur in linearization domains.

The constraint in (27) is responsible for the determination of the PHON values of phrases:

(27) *phrase* ⇒

$$
\begin{bmatrix}
\text{PHON } \boxed{1} \oplus \ldots \oplus \boxed{n} \\[2ex]
\text{DOM} \quad \left\langle \begin{bmatrix} sign \\ \text{PHON } \boxed{1} \end{bmatrix}, \ldots, \begin{bmatrix} sign \\ \text{PHON } \boxed{n} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

It states that the PHON value of a sign is the concatenation of the PHON values of its DOMAIN elements. Since the order of the DOMAIN elements corresponds to their surface order, this is the obvious way to determine the PHON value of the whole linguistic object.

Figure 9 shows how this machinery can be used to license binary branching structures with discontinuous constituents. Words or word sequences that are

V[DOM ⟨ *der Frau, ein Mann, das Buch, gibt* ⟩]

NP[*nom*, DOM ⟨ *ein, Mann* ⟩]   V[DOM ⟨ *der Frau, das Buch, gibt* ⟩]

NP[*dat*, DOM ⟨ *der, Frau* ⟩]   V[DOM ⟨ *das Buch, gibt* ⟩]

NP[*acc*, DOM ⟨ *das, Buch* ⟩]   V[DOM ⟨ *gibt* ⟩]

ein Mann	der Frau	das Buch	gibt
a man	the woman	the book	gives
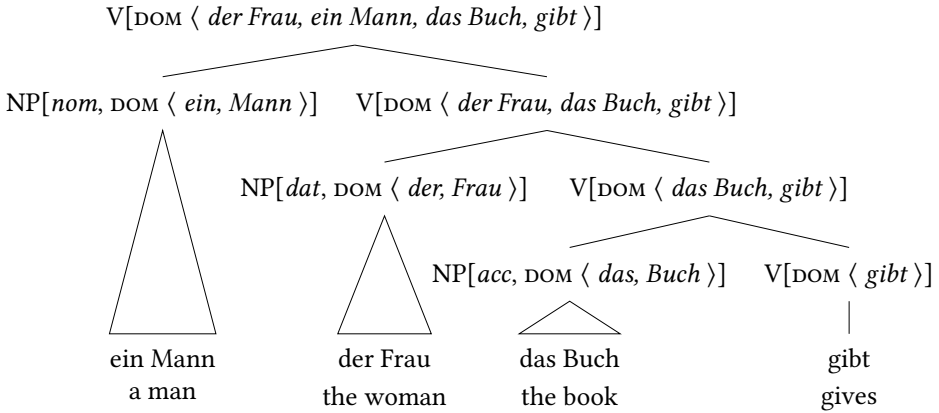
Figure 9: Analysis of *dass der Frau ein Mann das Buch gibt* 'that a man gives the woman the book' with binary branching structures and discontinuous constituents

separated by commas stand for separate domain objects, that is, ⟨ *das, Buch* ⟩ contains the two objects *das* and *Buch* and ⟨ *das Buch, gibt* ⟩ contains the two objects *das Buch* and *gibt*. The important point to note here is that the arguments are combined with the head in the order accusative, dative, nominative, although the elements in the constituent order domain are realized in the order dative, nominative, accusative rather than nominative, dative, accusative, as one would expect. This is possible since the formulation of the computation of the DOM value using the shuffle operator allows for discontinuous constituents. The node for *der Frau das Buch gibt* 'the woman the book gives' is discontinuous: *ein Mann* 'a man' is inserted into the domain between *der Frau* 'the woman' and *das Buch*

'the book'. This is more obvious in Figure 10, which has a serialization of NPs that corresponds to their order.
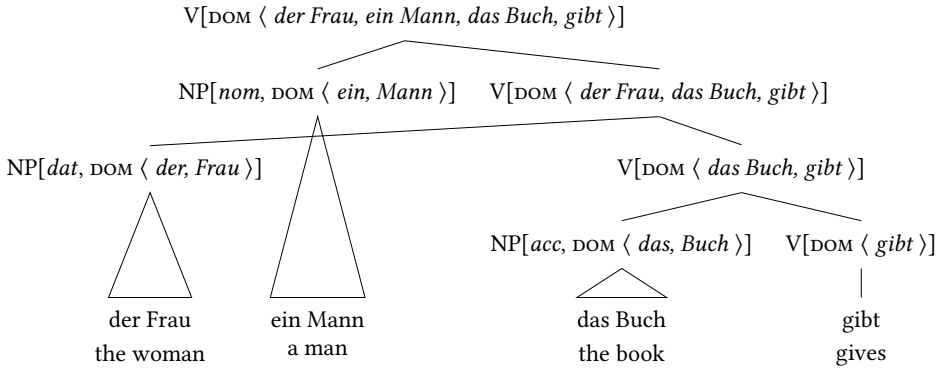
Figure 10: Analysis of *dass der Frau ein Mann das Buch gibt* 'that a man gives the woman the book' with binary branching structures and discontinuous constituents showing the discontinuity

6.2 Absolutely free

While German is more exciting than English in terms of constituent order it is still boring in comparison to languages like Warlpiri which have much freer constituent order. In Warlpiri the auxiliary has to be in first or in second position (Donohue & Sag 1999: 8) and apart from this even parts of what are noun phrases in German and English can appear separated from each other. For example, the two parts of the NP *Kurdujarrarlu witajarrarlu* 'child small' may appear discontinuously since they are marked with the same case:

(28) Kurdu-jarra-rlu ka-pala   maliki   wajili.pi-nyi wita-jarra-rlu.
      child-DU-ERG   PRES-3DU.SUBJ dog.ABS chase-NPAST small-DU-ERG

   'Two small children are chasing the dog.' or
   'Two children are chasing the dog and they are small.'

Donohue & Sag (1999) develop an analysis for this that simply liberates domain elements and inserts them into the next higher domain. (29) shows how this is formalized:

(29) *liberating-phrase* $\Rightarrow$

$$\begin{bmatrix} \text{DOM} & \delta_0 \bigcirc \delta_1 \bigcirc \ldots \bigcirc \delta_n \\ \text{HEAD-DTR} & \begin{bmatrix} \text{DOM} & \delta_0 \end{bmatrix} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{DOM} & \delta_1 \end{bmatrix}, \ldots, \begin{bmatrix} \text{DOM} & \delta_n \end{bmatrix} \right\rangle \end{bmatrix}$$

Rather than inserting the complete daughters into the domain of the mother as in (24), the DOM values of the daughters are shuffled into the domain of the mothers. So instead of having the NPs in the same domain as the verb as in the German example in the previous section one has all the parts of NPs in the next higher domain. Hence, a single nominal element being placed in front of the auxiliary in second position is explained without problems. Figure 11 shows the Donohue & Sag's (1999) analysis of a version of (28) with the VP constituents *maliki wajilipinyi* 'dog chase' serialized after *witajarrarlu* 'small'. Here *Kurdujarrarlu*

$$\begin{bmatrix} \text{PHON} & \left\langle \textit{kurdu-jarra-rlu, ka-pala, wita-jarra-rlu, ...} \right\rangle \\ \text{DOM} & \left\langle \boxed{1} \begin{bmatrix} \text{PHON} \left\langle \textit{kurdu-jarra-rlu} \right\rangle \end{bmatrix}, \boxed{2} \begin{bmatrix} \text{PHON} \left\langle \textit{ka-pala} \right\rangle \end{bmatrix}, \boxed{3} \begin{bmatrix} \text{PHON} \left\langle \textit{wita-jarra-rlu} \right\rangle \end{bmatrix}, ... \right\rangle \end{bmatrix}$$

IP

NP $\begin{bmatrix} \text{DOM} \left\langle \boxed{1}, \boxed{3} \right\rangle \end{bmatrix}$ Aux $\begin{bmatrix} \text{DOM} \left\langle \boxed{2} \right\rangle \end{bmatrix}$ VP $\begin{bmatrix} \text{DOM} \left\langle ... \right\rangle \end{bmatrix}$

kurdu-jarra-rlu wita-jarra-rlu   ka-pala   maliki wajili-pi-nyi
child-DU-ERG small-DU-ERG   PRS-3DU.SUBJ   dog.ABS chase-NPAST
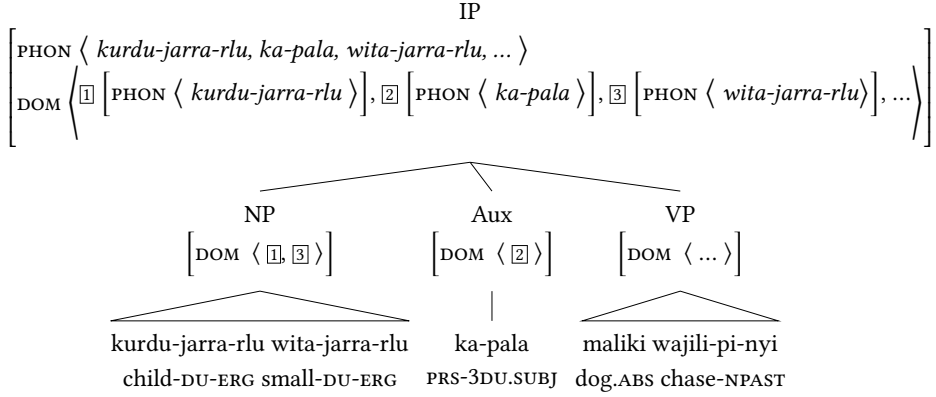
Figure 11: Analysis of free constituent order in Warlpiri according to Donohue & Sag (1999)

'child' and *witajarrarlu* 'small' form an NP. They contribute two independent domain objects ($\boxed{1}$ and $\boxed{3}$) to the domain of the mother. The second element in this domain has to be the auxiliary ($\boxed{2}$), $\boxed{1}$ is realized initially and $\boxed{3}$ follows the auxiliary.

We have seen so far an analysis that inserts complete objects into the domain of the mother (the analysis of German), an analysis that inserts all domain objects of objects into the domain of the mother (the analysis of Warlpiri) and in the next subsection I want to look at an intermediate case, so-called *partial compaction*.

6.3 Partial compaction (extraposition)

Kathol & Pollard (1995) develop an analysis of extraposition that is a mix of the strategies discussed in the two subsections: most of one NP object is inserted into the domain of the mother as a single object, only those parts that are extraposed are liberated and inserted as individual domain objects into the domain of the mother.[8] Kathol & Pollard's analysis of (30) is given in Figure 12.[9]

(30) einen Hund füttern, der Hunger hat   (German)
      a   dog feed   that hunger has
      'feed a dog that is hungry'

einen Hund, der Hunger hat 'a dog who is hungry' consists of three domain objects: *einen* 'a', *Hund* 'dog', and *der Hunger hat* 'who hungry is'. The two initial ones are inserted as one object (the NP *ein Hund* 'a dog') into the higher domain and the relative clause is liberated. While the formation of the new domain at the mother node is relatively straight-forward in the cases discussed so far, a complex relational constraint is needed to split the relative clause (3) from the other domain objects and construct a new domain object that has the determiner and the noun as constituents (2). Kathol and Pollard have a relational constraint called *compaction* that builds new domain objects for insertion into higher domains. *partial compaction* takes an initial part of a domain and forms a new domain object from this returning the remaining domain objects for separate insertion into the higher domain. Due to space limitations, this constraint will not be discussed here but see Müller (1999: 244) for a refined version of Kathol and Pollard's constraint. The effect of partial compaction in Figure 12 is that there is a new object 2 and a list containing the remaining objects, in the example ⟨ 3 ⟩. A list containing the new object ⟨ 2 ⟩, a list containing the remaining objects ⟨ 3 ⟩ are shuffled with the domain list of the head 4 . Since the relative clause is in the same domain as the verb, it can be serialized to the right of the verb.

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[8]This analysis of extraposition is not the only option available in HPSG. I explain it here since it shows the flexibility of the domain approach. The more common analysis of extraposition is one that is parallel to the SLASH-based approach to extraction that is explained in Borsley & Crysmann (2018), Chapter 14 of this volume. Since constraints regarding locality differ for fronting to the left and extraposition to the right a different feature is used (EXTRA). See Keller (1995) and Müller (1999: Section 13.2) for discussion. More recent approaches assume the projection of semantic indices (Kiss 2005) to be able to solve puzzles like Link's (1984) hydra sentences and even more recent proposals mix index projection and EXTRA projection (Crysmann 2013).

[9]The figure is taken over from Kathol & Pollard. Words in italics are the object language. Part of speech or category labels are provided at the top of AVMs.

$$
\begin{bmatrix} \text{VP} \\ \text{DOM } \boxed{5} \left\langle \boxed{2}\begin{bmatrix}\text{NP} \\ \textit{einen Hund}\end{bmatrix}, \begin{bmatrix}\text{V} \\ \textit{füttern}\end{bmatrix}, \boxed{3}\begin{bmatrix}\text{REL-S} \\ \text{EXTRA }+ \\ \textit{der Hunger hat}\end{bmatrix} \right\rangle \end{bmatrix}
$$

$$
\boxed{1}\begin{bmatrix} \text{NP} \\ \text{DOM } \left\langle \begin{bmatrix}\text{DET} \\ \textit{einen}\end{bmatrix}, \begin{bmatrix}\text{N} \\ \textit{Hund}\end{bmatrix}, \boxed{3}\begin{bmatrix}\text{REL-S} \\ \text{EXTRA }+ \\ \textit{der Hunger hat}\end{bmatrix} \right\rangle \end{bmatrix} \qquad \begin{bmatrix}\text{V} \\ \text{DOM } \boxed{4} \left\langle \begin{bmatrix}\text{V} \\ \textit{füttern}\end{bmatrix} \right\rangle \end{bmatrix}
$$

$$
\begin{bmatrix}\text{DET} \\ \textit{einen}\end{bmatrix} \qquad \begin{bmatrix} \overline{\text{N}} \\ \text{DOM } \left\langle \begin{bmatrix}\text{N} \\ \textit{Hund}\end{bmatrix}, \boxed{3}\begin{bmatrix}\text{REL-S} \\ \text{EXTRA }+ \\ \textit{der Hunger hat}\end{bmatrix} \right\rangle \end{bmatrix}
$$

$$
\begin{bmatrix}\text{N} \\ \textit{Hund}\end{bmatrix} \qquad \begin{bmatrix}\text{REL-S} \\ \text{EXTRA }+ \\ \textit{der Hunger hat}\end{bmatrix}
$$

p-compaction($\boxed{1}$, $\boxed{2}$, $\langle\,\boxed{3}\,\rangle$)

$\boxed{5} = \langle\,\boxed{2}\,\rangle \bigcirc \langle\,\boxed{3}\,\rangle \bigcirc \boxed{4}$

Figure 12: Analysis of extraposition via partial compaction of domain objects according to Kathol & Pollard (1995)

So, this subsection showed how examples like (30) can be analyzed by allowing for a discontinuous constituent consisting of an NP and a relative clause. Rather than liberating all daughters and inserting them into the domain of the mother node as in the Warlpiri example, determiner and noun form a new object, an NP, and the newly created NP and the relative clause are inserted into the domain of the mother node. This explains why determiner and noun have to stay together while the relative clause may be serialized further to the right.

6.4 Problems with order domains

Constituent order domains may seem rather straight-forward since linearization facts can be handled easily. I assumed constituent order domains and discontinuous constituents for German myself for over a decade (Müller 1995; 2004). However, there are some problems that seem to suggest that a traditional GB-like head-movement approach is the better alternative. In what follows I want to discuss just two problematic aspects of linearization approaches: spurious ambiguities and apparently multiple frontings.

6.4.1 Partial fronting and spurious ambiguities

Kathol (2000) suggests an analysis with binary branching structures in which all arguments are inserted into a linearization domain and can be serialized there in any order provided no LP rule is violated. Normally one would have the elements of the COMPS list in a fixed order, combine the head with one element from the COMPS list after another, and let the freedom in the DOM list be responsible for the various attested orders. So both sentences in (31) would have analyses in which the verb *erzählt* 'tells' is combined with *Geschichten* 'stories' first and then *Geschichten erzählt* 'stories tells' is combined with *den Wählern* 'the voters'. Since the verb and all its arguments are in the same linearization domain they can be ordered in any order including the two orders in (31):

(31) a. weil   er den Wählern Geschichten erzählt   (German)
          because he the voters   stories   tells
          'because he tells the voters stories'

      b. weil   er Geschichten den Wählern erzählt
          because he stories   the voters tells

The problem with this approach is that examples like (32) show that grammars have to account for fronted combinations of any of the verb and any of its objects to the exclusion of the other:

(32) a. Geschichten erzählen sollte   man den Wählern nicht.   (German)
          stories   tell   should one the voters   not
          'One should not tell the voters such stories.'

      b. Den Wählern erzählen sollte   man diese Geschichten nicht.
          the voters   tell   should one these stories   not

Kathol (2000: Section 8.9) accounts for examples like (32) by relaxing the order of the objects in the valence list. He uses the shuffle operator in the valence representation:

(33) $\langle$ NP[*nom*] $\rangle \oplus (\langle$ NP[*dat*] $\rangle \bigcirc \langle$ NP[*acc*] $\rangle)$

This solves the problem with examples like (32) but it introduces a new one: sentences like (31) now have two analyses each. One is the analysis we had before and another one is the one in which *den Wählern* 'the voters' is combined with *erzählt* 'tells' first and the result is then combined with *Geschichten* 'stories'. Since both objects are inserted into the same linearization domain, both orders can be derived. So we have too much freedom: freedom in linearization and freedom in the order of combination. The proposal that I suggested has just the freedom in the order of combination and hence can account for both (31) and (32) without spurious ambiguities.

6.4.2 Surface order, clause types, fields within fields, and empty elements

Kathol (2001) develops an analysis of German that uses constituent order domains and determines the clause types on the basis of the order of elements in such domains. He suggests the topological fields *1*, *2*, *3*, and *4*, which correspond to the traditional topological fields *Vorfeld* 'prefield', *linke Satzklammer* 'left sentence bracket', *Mittelfeld* 'middle field', *rechte Satzklammer* 'right sentence bracket'. Domain objects may assigned to these fields and they are then ordered by linearization constraints stating that objects assigned to *1* have to precede objects of type *2*, type *3*, and type *4*. Objects of type *2* have to precede type *3*, and type *4* and so on. For the *Vorfeld* and the left sentence bracket he stipulates uniqueness constraints saying that at most one constituent may be of this type. This can be stated in a nice way by using the linearization constraints in (34):

(34) a. *1 < 1*
      b. *2 < 2*

This trick was first suggested by Gazdar et al. (1985: 55, Fn. 3) in the framework of GPSG and it works since if there were two objects of type *1* than each one would be required to precede the other one resulting in a violation of the linearization constraint. So in order to avoid such constraint violation there must not be more than one *1*.

Kathol (2001) assumes the following definition for V2 clauses:

(35) *V2-clause* ⇒ $\begin{bmatrix} \text{S[\textit{fin}]} \\ \text{DOM} \quad \left\langle [1], \begin{bmatrix} 2 \\ \text{V[\textit{fin}]} \end{bmatrix}, \ldots \right\rangle \end{bmatrix}$

This says that the constituent order domain starts with one element assigned to field *1* followed by another domain object assigned to field *2*. While this is in accordance with general wisdom about German, which is a V2 language, there are problems for entirely surface-based theories: German allows for multiple constituents in front of the finite verb. (36) shows some examples:

(36)   a. [Zum zweiten Mal] [die Weltmeisterschaft]   errang Clark 1965 … [10]
            to.the second time   the world.championship won   Clark 1965

        'Clark won the world championship for the second time in 1965.'

       b. [Dem   Saft] [eine   kräftige Farbe] geben Blutorangen.[11]
            the.DAT juice a.ACC strong   color give blood.oranges

        'Blood oranges give the juice a strong color.'

Müller (2003a) extensively documents this phenomenon. The categories that can appear before the finite verb are almost unrestricted. Even subjects can be fronted together with other material (Bildhauer & Cook 2010: 72; Bildhauer 2011: 371). The empirical side of these apparent multiple frontings was further examined in the Collective Research Center 632, Project A6 and the claim that only constituents depending on the same verb can be fronted together (Fanselow 1993; Hoberg 1997: 1634) was confirmed (Müller 2017: Chapter 3). A further insight is that the linearization properties of the fronted material (NPs, PPs, adverbs, adjectives) correspond to the linearization properties they would have in the *Mittelfeld*. The example in (37) are even more interesting. It shows that there can be a right sentence bracket (the particle *los*) and an extraposed constituent (something following the particle: *damit*) before the finite verb (*geht* 'goes'):

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[10](Beneš 1971: 162)

[11]Bildhauer & Cook (2010) found this example in the *Deutsches Referenzkorpus* (DeReKo), hosted at Institut für Deutsche Sprache, Mannheim: http://www.ids-mannheim.de/kl/projekte/korpora, 2018-09-13.

(37) *Los* damit   *geht* es schon am 15. April.[12]   (German)
      off there.with goes it PRT   on 15. April
      4   5   2   3 3   3

      'The whole thing starts on the 15th April.'

As far as topology is concerned, this sentence corresponds to sentences with VP fronting and extraposition like the one in (38) discussed in Reis (1980: 82).

(38) [Gewußt, daß du kommst,] haben wir schon seit langem.   (German)
       known   that you come   have we PART since long

      'We have known for a while that you are coming.'

In (38) *gewußt, dass du kommst* 'known that you come' forms a VP in which *gewußt* is the right sentence bracket and *daß du kommst* 'that you come' is extraposed. We have the same situation in (37) with *los* 'off' and *damit* 'there.with', except that one would not want to claim that *damit* 'there.with' depends on *los* 'off'.

In Kathol's system, *los* would be of type *4* and *damit* would have to be of type *5* (an additional type for extraposed items). Without any modification of the general system, we would get a *4* and a *5* ordered before a *2* (a right sentence bracket and a postfield preceding the left sentence bracket), something that is ruled out by Kathol's linearization constraints.

Müller (2002), still working in a domain-based framework, developed an analysis assuming an empty verbal head to explain the fact that the fronted constituents have to depend on the same verb and that there is a separate topological area that is independent of the remaining clause. So, *los* and *damit* are domain objects within a larger domain object placed in the prefield. Wetta (2011) suggests an analysis in which two or more constituents are compacted into one domain object, so *los* and *damit* would form one object that is inserted into the domain containing the finite verb. However, this begs the question what kind of object it is that is formed. Section 6.3 dealt with partial compaction of NPs. Some of the elements from an NP domain were liberated and other elements were fused into a new object that had the same category as the object containing all material, namely NP. But the situation with examples like (36) and (38) is quite different. We have a particle and a pronominal adverb in (38) and various other combinations of categories in the examples collected by Müller (2003a) and Bildhauer (2011). It would not make sense to claim that the fronted object is a particle or a pronominal adverb. Note that it is not an option to leave the category of the

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[12]taz, 01.03.2002, p. 8.

fronted object unspecified since HPSG comes with the assumption that models of linguistic objects are total, that is, maximally specific (King 1999, see also Richter (2018), Chapter 3 of this volume). Leaving the category and valence properties of the item in the prefield unspecified would make such sentences infinitely many times ambiguous. Of course Wetta could state that the newly created object is a verbal projection but this would just be stating the effect of the empty verbal head within a relational constraint, which I consider less principled than stating the empty element.

However, the empty verbal head that I stated as part of a linearization grammar in 2002 comes as a stipulation since its only purpose in the grammar of German was to account for apparent multiple frontings. Müller (2005b; 2017) drops the linearization approach and assumes head-movement instead. The empty head that is used for accounting for the verb position in German can also be used to account for apparent multiple frontings. The analysis is sketched in (39):

(39)   a. [$_{VP}$ [Zum zweiten Mal] [die Weltmeisterschaft] _$_V$]$_i$ errang$_j$
              to.the second time the world.championship   won
          Clark 1965 _$_i$ _$_j$.
          Clark 1965

    b. [$_{VP}$ *Los* _$_V$ damit]$_i$ *geht*$_j$ es schon am 15. April _$_i$ _$_j$.
          off   there.with goes it PRT   on 15. April

       'The whole thing starts on the 15th April.'

Space precludes going into all the details here but the analysis treats apparent multiple frontings parallel to partial verb phrase frontings. A lexical rule is used for multiple frontings which is a special case of the head-movement rule that was discussed in Section 5.1. So apparent multiple frontings are analyzed with means that are available to the grammar anyway. This analysis allows us to keep the insight that German is a V2 language and it also gets the same-clause constraint and the linearization of elements right. As for (39b): *los damit* 'off there.with' forms a verbal constituent placed in the *Vorfeld* and within this verbal domain, we have the topological fields that are needed: the right sentence bracket for the verbal particle and the verbal trace and the *Nachfeld* for *damit* 'there.with'. See Müller (2005a,b; 2017) for details.

The paper so far discussed the tools that have been suggested in HPSG to account for constituent order: flat vs. binary branching structures, linearization domains, head-movement via DSL. I showed that analyses of German relying on discontinuous constituents and constituent order domains are not without problems and that head-movement approaches with binary branching and con-

tinuous constituents can account for the data. I also demonstrated in Section 6.2 that languages like Warlpiri that allow for much freer constituent order than German can be accounted for in models allowing for discontinuous constituents. The following section discusses a proposal by Bender (2008) showing that even languages like the Australian free constituent order languages can be handled without discontinuous constituents.

7 Free constituent order languages without order domains

Bender (2008) discusses the Australian language Wambaya and shows how phenomena parallel to those treated by Donohue & Sag (1999) can be handled without discontinuous constituents. Bender assumes that all arguments of a head are projected to higher nodes even when they are combined with the head, that is, arguments are not canceled off from valence lists. See also Meurers (1999); Przepiórkowski (1999) and Müller (2008) for earlier non-cancellation approaches.[13] The example (28) from Section 6.2 can be recast with continuous constituents as is shown in Figure 13. The figure shows that arguments are not removed from the
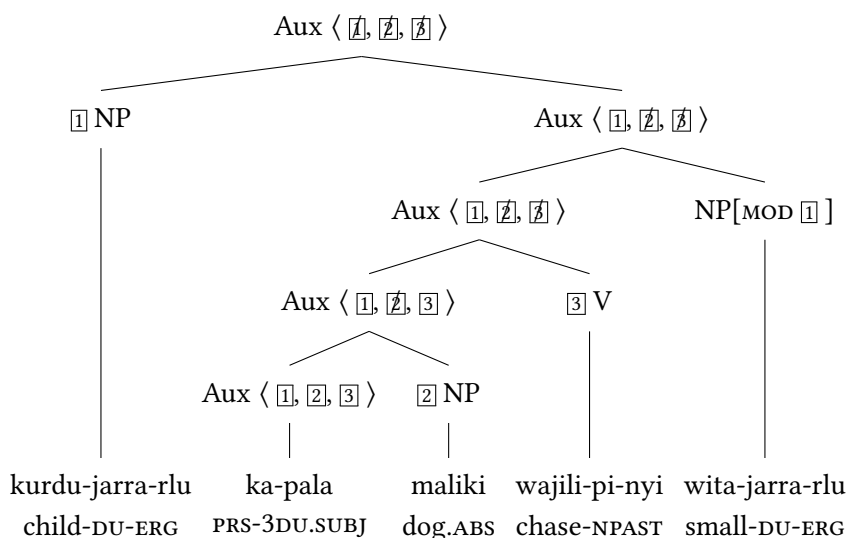
Figure 13: Analysis of free constituent order in Warlpiri using non-cancellation

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[13]Higginbotham (1985) and Winkler (1997) make similar suggestions with regard to the representation of theta roles.

valence representation after combination with the head. Rather they are marked as satisfied: ⊠. Since they are still in the representation, schemata may refer to them. Bender suggests a schema that identifies the MOD value of an element that could function as an adjunct in a normal head-adjunct structure with an element in the valence representation. In Figure 13 the MOD value of the second ergative nominal *wita-jarra-rlu* 'small' is identified with an argument of the auxiliary verb (⊡). The adjunct hence has access to the referential index of the argument and it is therefore guaranteed that both parts of the noun phrase refer to the same discourse referent. The NP for *kurdu-jarra-rlu* is combined with the projection of the auxiliary to yield a complete sentence. Since ⊡ not just contains the semantic index and hence information about number (the dual) but also case information, it is ensured that distributed noun phrases have to bear the same case. Since information about all arguments are projected along the head path, ⊠ would also be available for an adjunct referring to it. So in the place of *wita-jarra-rlu* 'small-DU-ERG' we could also have another adjunct referring to *maliki* 'dog.ABS'. This shows that even languages with constituent order as free as the Australian languages can be handled within HPSG without assuming discontinuous constituents.

8 Summary

This paper discussed general approaches to constituent order in HPSG. On the one hand there are approaches to constituent order assuming flat constituent structure allowing permutation of daughters as long as no LP constraints are violated and on the other hand, there are approaches assuming binary branching structures. Approaches that assume flat structures can serialize the head to the left or to the right or somewhere between other daughters in the structure. Approaches assuming binary branching have to use other means. One such means is "head movement", which is analyzed as a series of local dependencies by passing information about the missing head up along the head path. The alternative to head movement is linearization of elements in special linearization domains, allowing for discontinuous constituents. I showed that there are reasons for assuming head-movement for German and how even languages with extremely free constituent order can be analyzed without assuming discontinuous constituents.

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Chapter 11

Clitics

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lestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, sus-
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Abbreviations

Acknowledgements

Chapter 12

Complex predicates

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Chapter 13

Control and raising

Anne Abeillé

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Abbreviations

Acknowledgements

Chapter 14

Unbounded dependencies

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1 Introduction

finality

Abbreviations

Acknowledgements

Chapter 15

Relative clauses

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Abbreviations

Acknowledgements

Chapter 16

Island phenomena and related matters

Rui Chaves

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Extraction constraints on long-distance dependencies – so-called *islands* – have been the subject of intense linguistic and psycholinguistic research for the last half century. Despite of their importance in syntactic theory, the heterogeneity of island constraints has posed many difficult challenges to linguistic theory, across all frameworks. The HPSG perspective of island phenomena is that they are unlikely to be due to a unitary syntactic constraint given the fact that virtually all such island constraints have known exceptions. Rather, it is more plausible that island constraints result from a combination of independently motivated syntactic, semantic, pragmatic and processing phenomena. The present chapter is somewhat different from others in this volume in that its focus in not on HPSG analyses of some phenomena, but rather on the nature of the phenomena itself. This is because there is evidence that most of the phenomena are not purely grammatical, and to that extent independent from HPSG or indeed any theory of grammar. One may call this view of island phenomena 'minimalist' in the sense that much of it does not involve formal grammar.

1 Introduction

This chapter provides an overview of various island effects that have received attention from members of the HPSG community. I begin with the extraction constraints peculiar to coordinate structures, which not only have a special status in the history of HPSG but also because they illustrate well the non-unitary nature of island constraints. I then argue that, at a deeper level, some of these constraints are in fact present in many other island types, though not necessarily all. For example, I take it as relatively clear that *factive islands* are purely pragmatic in nature (Oshima 2007), as are *negative islands* (Kroch 1989; Szabolcsi & Zwarts

1993; Abrusán 2011; Fox & Hackl 2006; Abrusán & Spector 2011), although one can quibble about the particular technical details of how such accounts are best articulated. Similarly, the *NP Constraint* in the sense of Horn (1972) is likely to be semantic-pragmatic in nature (Kuno 1987; Godard 1988; Davies & Dubinsky 2009). Conversely, I take it as relatively uncontroversial that the *Clause Non-Final Incomplete Constituent Constraint* is due to processing difficulty (Hukari & Levine 1991; Fodor 1992). See also Kothari (2008) for evidence that 'bridge' verb effects in filler-gap dependencies are partly due to lack of contextualization.

In the present chapter I focus on islands that have garnered more attention from members of the HPSG community, and that have caused more controversy cross-theoretically. My goal is to provide an overview of the range of explanations that have been proposed to account for the complex array of facts surrounding islands, and to show that no single unified account is likely.

2 Background

As already detailed in Borsley & Crysmann (2018), Chapter 14 of this volume, HPSG encodes filler-gap dependencies in terms of a set-valued feature SLASH. Because the theory consists of a feature-based declarative system of constraints, virtually all that goes on in the grammar involves constraints stating which value a given feature takes. By allowing SLASH sets to be unioned, it follows that constructions in which multiple gaps are linked to the same filler are trivially obtained, as in (1).

(1) a. Which celebrity did [the article insult _ more than it praised _]?
     b. Which celebrity did you expect [[the pictures of _] to bother _ the most]?
     c. Which celebrity did you [inform _ [that the police was coming to arrest _]]?
     d. Which celebrity did you [compare [the memoir of _] [with a movie about _]?
     e. Which celebrity did you [hire _ [without auditioning _ first]]?
     f. Which celebrity did you [meet _ at a party] and [date _ for a few months]]?

But another advantage of encoding the presence of filler-gap dependencies as a feature is that certain lexical items and constructions can easily impose idiosyncratic constraints on SLASH values. For example, to account for languages that

do not allow preposition stranding, it suffices to state that prepositions are necessarily specified as [SLASH {}]. Thus, their complements cannot appear in SLASH instead of COMPS. The converse also occurs. Certain uses of the verb *assure*, for example, are lexically required to have on complement in SLASH rather than in COMPS. Thus, extraction is obligatory as (2) shows.

(2)   a.   * I can assure you him to be the most competent.

      b.   Who$_i$ can you assure me __ $_i$ to be the most competent?
         (Kayne 1980).

As we shall see, it would be rather trivial to impose the classic island constraints in the standard syntactic environments in which they arise.[1] The problem is that island effects are riddled with exceptions witch defy purely syntactic accounts of the phenomena. Hence, HPSG has generally refrained from assuming that islands are syntactic, in contrast to mainstream linguistic theory.

3 The Coordinate Structure Constraint

Ross (1967) first observed that coordinate structures impose various constraints on long-distance dependencies, shown in (3), collectively dubbed the *Coordinate Structure Constraint*. For perspicuity, I follow Grosu (1973a) in referring to (i) as the *Conjunct Constraint* and to (ii) as the *Element Constraint*.

(3)   COORDINATE STRUCTURE CONSTRAINT (CSC):
     In a coordinate structure, (i) no conjunct may be moved, (ii) nor may any element contained in a conjunct be moved out of that conjunct …unless each conjunct properly contains a gap paired with the same filler.

The *Conjunct Constraint* (CC) is illustrated by the unacceptability of the extractions in (4). No such constraint is active in other constructions like those in (5) and (6), for example.

(4)   a.   * Which celebrity did you see [Priscilla and __]?
         (cf. with 'Did you see Priscilla and Elvis?')

      b.   * Which celebrity did you see [__ and Priscilla]?
         (cf. with 'Did you see Elvis and Priscilla?')

---

[1] In such a view, island effects could perhaps result from gramaticized constraints, induced by parsing and performance considerations (Pritchett 1991; Fodor 1978; 1983a).

    c. * Which celebrity did you see [_ or/and a picture of _]?
       (cf. with 'Did you see Elvis or/and a picture of Elvis?')

(5)   a.   Which celebrity did you see Priscilla with _ ?
        (cf. with 'Did you see Priscilla with Elvis?')

      b.   Which celebrity did you see _ with Elvis?
        (cf. with 'Did you see Priscilla with Elvis?')

(6)   a.   Which celebrity is Kim as tall as _ ?
      b.   Which celebrity you say Robin arrived earlier than _ ?

HPSG accounts of extraction that assume the existence of traces (Pollard & Sag 1994; Levine & Hukari 2006) the CC must be stipulated at the level of the coordination construction, by stating that conjuncts cannot be empty elements.[2] On the other hand, the CC follows immediately in a traceless account of filler-gap dependencies (Sag & Fodor 1994; Bouma et al. 2001; Ginzburg & Sag 2000; Sag 2010) since there is simply nothing to conjoin in (4), and thus nothing else needs to be said about conjunct extraction; see Sag (2000) for more criticism of traces.

HPSG's traceless account of the CC is semantic in nature, in a sense. Coordinators like *and*, *or*, *but* and so on are not regarded as heads that select arguments, and therefore have empty ARG-ST and valence specifications. And given that HPSG assumes that the signs that can appear in a given lexical head SLASH values are valents, then it follows that the signs that coordinators combine with cannot instead be registered in the coordinator's SLASH feature. Hence, words like *and* have no valents, no arguments and therefore no conjunct extraction. Incidentally, adnominal adjectives cannot be extracted either, for exactly the same reason, as they are not selected by any head, and therefore are not listed in any ARG-ST list.

In order to allow certain adverbials to be extractable, Ginzburg & Sag (2000) assume that they are members of ARG-ST. See Levine & Hukari (2006) for more on adverbial extraction, and see Borsley & Crysmann (2018), Chapter 14 of this volume for further discussion.[3]

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[2]See however Levine (n.d.: 317–318) for the claim that each conjunct must contain at least one stressed syllable. Given that traces are phonologically silent, noting is there to bear stress and the CC is obtained. This raises the question of why no such stress constraint exists in P-stranding, for example, or indeed in any kind of extraction.

[3]The empirical facts are less clear when it comes to adnominal PPs, however. Even PPs that are usually regarded as modifiers can sometimes extract, as in *From which shelf am I not supposed*

Let us now turn to the *Element Constraint*, illustrated in (7). As before, the constraint appears to be restricted to coordination structures, as no oddness arises in the comitative counterparts like (8), or in comparatives like (9).[4]

(7)   a.   * Which celebrity did you see [Priscilla and a picture of _]?
           (cf. with 'Did you see Priscilla and a picture of Elvis?')
     b.   * Which celebrity did you see [a picture of _ and Priscilla]?
           (cf. with 'Did you see a picture of Elvis and Priscilla?')

(8)   a.   Which celebrity did you see [the brother of _ with Priscilla]?
     b.   Which celebrity did you see [Priscilla with the brother of _]?

(9)   a.   Which celebrity did [[you enjoy the memoir of _ more] than [any other non-fiction book]]?
     b.   Which celebrity did you say that [[the sooner we take a picture of _], [the quicker we can go home]]?

The ATB exception to the CSC is illustrated by the acceptability of (??), where each conjunct hosts a gap, linked to the same filler. As already noted above in (1), the fact that multiple gaps can be linked to the same filler is not unique to coordination.

Gazdar (1981) and Gazdar et al. (1985) assumed that the coordination rule requires SLASH values to be structure-shared across conjuncts and the mother node, thus predicting both the Element Constraint and the ATB exceptions. The failure of movement-based grammar to predict multiple gap extraction facts was also

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to read any books? In many such extractions the PP can alternatively be parsed as VP modifier, which complicates judgements.

[4] Although Winter (2001: 83) and others claim that coordination imposes semantic scope islands, Chaves (2007: 3.6) shows that this is not the case, as illustrated in examples like those below.

     (i)   a.   The White House is very careful about this. An official representative [[will personally read each document] and [reply to every letter]].
             (∀ doc-letter >∃ representative / ∃ representative >∀ doc-letter)
         b.   We had to do this ourselves. By the end of the year, some student [[had proof-read every document] and [corrected each theorem]].
             (∀ doc-theorem >∃ student / ∃ student >∀ doc-theorem)
         c.   Your task is to document the social interaction between [[each female] and [an adult male]].
             (∀ female >∃ adult male / ∃ adult male >∀ female)

seen as a major empirical advantage of GPSG/HPSG. A similar constraint is assumed in Pollard & Sag (1994: 202) and Beavers & Sag (2004: 60), among others, illustrated in (10). See Abeillé & Chaves (2018), Chapter 17 of this volume for more discussion about coordination.

(10)   Coordination Construction (abbreviated)

$$
coordinate\text{-}phr \rightarrow \left[
\begin{array}{l}
\text{SYNSEM} \mid \text{NONLOCAL} \mid \text{SLASH } \boxed{1} \\
\text{DTRS} \left\langle
\begin{array}{l}
[\text{SYNSEM} \mid \text{NONLOCAL} \mid \text{SLASH } \boxed{1}], \\
[\text{SYNSEM} \mid \text{NONLOCAL} \mid \text{SLASH } \boxed{1}]
\end{array}
\right\rangle
\end{array}
\right]
$$

Because the SLASH value $\boxed{1}$ is structure-shared between the mother and the daughters in (10), then all three nodes must bear the same SLASH value. This predicts the CSC and the ATB exceptions straightforwardly. The failure of mainstream Chomskyan grammar to predict these and related multiple gap extraction facts in a precise way is regarded as one of the major empirical advantages of HPSG over movement-based accounts.

But the facts about extraction in coordination structures are more complex than originally assumed, and than (10) allows for. A crucial difference between the Conjunct Constraint and the Element Constraint is that the latter is only in effect if the coordination has a symmetric interpretation (Ross 1967; Goldsmith 1985; Lakoff 1986; Levin & Prince 1986), as in (11).[5]

(11)   a.   Here's the whiskey which I [[went to the store] and [bought _]].
       b.   Who did Lizzie Borden [[take an ax] and [whack _ to death]]?
       c.   How much can you [[drink _] and [still stay sober]]?

The coordinate status of (11) has been questioned since Ross (1967). After all, if these are subordinate structures rather than coordinate structures then the possibility for non-ATB long-distance dependencies ceases to be exceptional. But as Schmerling (1972), Lakoff (1986), Levine (2001) and Kehler (2002: cf.) point out, there is no empirical reason to assume that (11) are anything other than coordination structures.

Another reason to reject the idea that the SLASH values of the daughters and the mother node are are simply equated in ATB extraction is the fact that sometimes

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[5]In symmetric coordination the order of the conjunct has a reflection on the interpretation. Thus, *Robin jumped on a horse and rode into the sunset* does not mean the same as *Robin rode into the sunset and jumped on a horse*. Conversely, in symmetric coordination the order of the conjuncts has no interpretational differences, as illustrated by the paraphrases *Robin drank a beer and Sue ate a burger* and *Sue ate a burger and Robin drank a beer*.

multiple gaps are 'cumulatively' combined into a 'pluralic gap'.[6] As an example, consider the extractions in (12). There are two possible interpretations for such extractions: one in which the *ex situ* signs (i.e. the gap signs) and the filler phrase are co-indexed, and therefore co-referential, and a second reading in which the two *ex situ* phrases are not co-indexed even though they are linked to the same filler phrase. Rather, the filler phrase refers to a plural referent composed by the referents of the *ex situ* signs, as indicated by the subscripts in (12). For different speakers, the preferred reading is the former, and in other cases, the latter, often depending on the example.

(12) a. [What]$_{\{i,j\}}$ did Kim eat $\_{i}$ and drink $\_{j}$ at the party?
       (answer: 'Kim at pizza and drank beer')

   b. [Which city]$_{\{i,j\}}$ did Jack travel to $\_{i}$ and Sally decide to live in $\_{j}$?
       (answer: 'Jack traveled to London and Sally decided to live in Rome')

   c. [Who]$_{\{i,j\}}$ did the pictures of $\_{i}$ impress $\_{j}$ the most?
       (answer: 'Robin's pictures impressed Sam the most')

   d. [Who]$_{\{i,j\}}$ did the rivals of $\_{i}$ shoot $\_{j}$?
       (answer: 'Robin's rivals shot Sam')

   e. [Who]$_{\{i,j\}}$ did you send nude photos of $\_{i}$ to $\_{j}$?
       (answer: 'I sent photos of Sam to Robin')

In conclusion, the non-ATB exceptions in (11) suggest that the coordination rule should not constrain slash at all, as argued for in Chaves (2003). Rather, the Element Constraint, its ATB exceptions in (??a,b), and the asymmetric non-ATB exceptions in (11) are more likely to be the consequence of a independent semantic-pragmatic constraint that requires the filler phrase to be 'topical' relative to the clause (Lakoff 1986; Kuno 1987; Kehler 2002; Kubota & Lee 2015). Thus, if the coordination is symmetric, then the topicality requirement distributes over each conjunct, to require that the filler phrase be topical in each conjunct. Consequently, extraction must be ATB in symmetric coordination. No distribution is need take place in asymmetric coordination, and thus both ATB and non-ATB extraction is licit in asymmetric coordination. For an attempt to transfer some of Kuno's and Kehlers' insights in to HPSG see Chaves (2003). In the latter proposal, the coordination rule is like most other rules in the grammar in that it says nothing about the slash values of the mother and the daughters, along the lines of

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[6]See for example Munn (1998; 1999), Postal (1998: 136,160), Kehler (2002: 125), Gawron & Kehler (2003), Zhang (2007), Chaves (2012a), and Vicente (2016).

Levine & Hukari (2006: 354). In other words, the constraints on SLASH in (10) are unnecessary. Rather, pragmatics is the driving force behind how long-distance dependencies propagate one or more conjuncts, depending on the coordination being interpreted symmetrically or not. See Abeillé & Chaves (2018), Chapter 17 of this volume for more discussion.

Let us take stock. The CSC does not receive a unitary account in modern HPSG, given that the Conjunct Constraint and the Element Constraint are of a very different nature. Whereas the former does not admit ATB extraction, and is predicted by a traceless analysis, the latter allows ATB extraction as seen by the contrast between (4c) and (??a,b). Upon closer inspection, the Element Constraint and the ATB exceptions are semantic-pragmatic in nature. As we shall see, a similar conclusion is plausible for various other island phenomena.

4 Complex NP Constraint

The Complex NP Constraint concerns the difficulty in extracting out of complex NPs formed with either relative clauses (13) or complement phrases (14).

(13) a. * [What]$_i$ does Robin know [someone who has _ $_i$]?
           (cf. with 'Does Robin know someone who has a drum kit?')

      b. * [Which language]$_i$ did they hire [someone [who speaks _ $_i$]]?
           (cf. with 'Did they hire someone who speaks Arabic?')

(14) a. * [Which book]$_i$ do you believe the claim [that Robin plagiarized _ $_i$]?
           (cf. with 'Do you believe the claim that Robin plagiarized *this book*?')

      b. * What$_i$ did you believe [the rumor [that Ed disclosed _ $_i$]]?
           (cf. with 'Did you believe [the rumor [that Ed disclosed *that*]]?')

It is tempting to prevent extractions out of adnominal clauses by simply stipulating that the SLASH value of the modifier must be empty, as (4) illustrates. Perhaps, along the lines of Fodor (1978; 1983b), Berwick & Weinberg (1984), and Hawkins (1999; 2004), processing difficulties lead to the grammaticization of such a constraint, effectively blocking any modified head from hosting any gaps.

(15)   HEAD-MODIFIER CONSTRUCTION (abbreviated)

$$\textit{head-mod-phr} \rightarrow \begin{bmatrix} \text{HEAD-DTR} \; \boxed{1} \\ \text{DTRS} \left\langle \boxed{1}, \begin{bmatrix} \text{SYNSEM} \begin{bmatrix} \text{LOC} \mid \text{MOD} \; \boxed{1} \\ \text{NONLOC} \mid \text{SLASH} \; \{\} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

However, the robustness of the CNPC has been challenged by various coun-
terexamples over the years (Ross 1967; Pollard & Sag 1994; Kluender 1998; Postal
1998; Sag et al. 2007). The sample in (16) involves acceptable extractions from NP-
embedded complement CPs (some of which definite), and (17) involves acceptable
extractions from NP-embedded relative clauses.[7]

(16)   a. The money which I am making [the claim [that the company
squandered _]] amounts to $400,000.
(Pollard & Sag 1994: 206, 207)

      b. Which rebel leader did you hear [rumors [that the CIA assassinated
_]]?

      c. Which company did Simon spread [the rumor [that he had started
_]]?

      d. What did your get [the impression [that the problem really was _]]?
(Kluender 1998)

(17)   a. This is the kind of weather$_i$ that there are [many people [who like
_ $_i$]].
(Erteschik-Shir & Lappin 1979)

      b. Violence is something$_i$ that there are [many Americans [who
condone _ $_i$]].
(McCawley 1981: 108)

      c. There were several old rock songs$_i$ that she and I were [the only two
[who knew _ $_i$]].
(Chung & McCloskey 1983)

      d. This is the chapter$_i$ that we really need to find [someone [who
understands _ $_i$]].
(Kluender 1992: 238)

      e. Which diamond ring did you say there was [nobody in the world
[who could buy _ $_i$]]?
(Pollard & Sag 1994: 206)

      f. John is the sort of guy that I don't know [a lot of people [who think
well of _ $_i$]].

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[7]Counterexamples to the CNPC can be found in a number of languages, including Japanese and
Korean (Kuno 1973; Nishigauchi 1999), Ahan (Saah & Goodluck 1995), Danish (Erteschik-Shir
1973: ch.2), Swedish (Allwood 1976; Engdahl 1982) Norwegian Engdahl 1980 (Taraldsen 1982)
and Romance languages (Cinque 2010). In some languages that support verb constructions the
CNPC is not active, which goes with the analysis as complex predicates Abeillé & Vivès (2019).

(Culicover 1999: 230)

In the above counterexamples the relative clauses contribute to the main assertion of the utterance, rather than expressing background information. For example, (17a) asserts 'There are many people who like this kind of weather' rather than 'This the kind of weather', and so on. Some authors have argued that it is precisely because such relatives express new information that the extraction can escape the embedded clause (Erteschik-Shir & Lappin 1979; Kuno 1987; Deane 1992; Goldberg 2013). If this is correct, then the proper account of CNPC effects is not unlike that of the CSC. In both cases, the information structural status of the clause that contains the gap is crucial to the acceptability of the overall long-distance dependencies.[8]

In addition to pragmatic constraints, Kluender (1992; 1998) also proposed that processing factors also influence the acceptability of CNPC violations. Consider for example the acceptability hierarchy in (18), more specific filler phrases increase acceptability whereas the presence of more specific phrases between the filler and the gap seem to cause increased processing difficulty, and therefore lower the acceptability of the sentence. The symbol '<' reads as 'is less acceptable than'.

(18) a. What do you need to find the expert who can translate _ ? <
      b. What do you need to find an expert who can translate _ ? <
      c. What do you need to find someone who can translate _ ? <
      d. Which document do you need to find an expert who can translate _ ?

There is on-line sentence processing evidence that CNPC violations with more informative fillers are more acceptable and are processed faster at the gap site than violations with less informative fillers (Hofmeister & Sag 2010), as in (19).

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[8] Although it is sometimes claimed that such island effects are also active in logical form and semantic scope (May 1985; Ruys 1993; Fox 2000; Sabbagh 2007; Bachrach & Katzir 2008), there much reason to be skeptical. For example, the universally quantified noun phrase in (i) is embedded in a relative clause can have wide scope over the indefinite *someone*, constituting a semantic CNPC violation. Note that these relatives are not presentational, and therefore are not specially permeable to extraction.

  (i) a. We were able to find someone who was an expert on each of the castles we planned to visit. (Copestake et al. 2005: 304)
       b. John was able to find someone who is willing to learn every language that we intend to study. (Chaves 2014)

(19) a. ? Who did you say that nobody in the world could ever depose _ ?

b. Which military dictator did you say that nobody in the world could ever depose _ ?

The same difference in reading times is found in sentences without CPNP violations, in fact. For example, (20b) was found to be read faster at *encouraged* than (20a). Crucially, that critical region of the sentence is not in the path of any filler-gap dependency.

(20) a. The diplomat contacted the dictator who the activist looking for more contributions encouraged to preserve natural habitats and resources.

b. The diplomat contacted the ruthless military dictator who the activist looking for more contributions encouraged to preserve natural habitats and resources.

Given that finite tensed verbs can be regarded as definite, and infinitival verbs as indefinite Partee (1984), and given that finiteness can create processing difficulty (Kluender 1992; Gibson 2000), then acceptability clines like (21) are to be expected. See Levine & Hukari (2006: ch.5) and Levine (n.d.: 308) for more discussion.

(21) a. Who did you wonder what Mary said to _ ? <

b. Who did you wonder what to say to _ ? <

c. Which of the people at the party did you wonder what to say to _ ?

4.1 On D-Linking

The amelioration caused by more specific (definite) *wh*-phrases as in (18d), (19b) and (21c) has been called a 'D-Linking' effect (Pesetsky 1987; 2000). It purportedly arises if the set of possible answers is pre-established or otherwise salient. But there are several problems with the D-Linking story. First, there is currently no non-circular definition of D-Linking; see Pesetsky (2000: 16), Ginzburg & Sag (2000: 247–250), Chung (1994: 33, 39), Levine & Hukari (2006: 242, 268–271). Second, the counterexamples above are given out-of-the-blue, and therefore cannot evoke any preexisting set of referents, as D-Linking requires. Furthermore, nothing should prevent D-Linking with a bare *wh*-item, as Pesetsky himself acknowledges, but on the other hand there is no experimental evidence that context can lead to D-linking of a bare *wh*-phrase (Sprouse 2007; Villata et al. 2016).[9]

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[9]For more detailed criticism of D-Linking see Hofmeister et al. (2007).

Kluender & Kutas (1993), Sag et al. (2007), Hofmeister (2007b), Hofmeister (2007a) and Hofmeister & Sag (2010) argue that more definite *wh*-phrases improve the acceptability of extractions because they resist memory decay better than indefinites, and are compatible with fewer potential gap sites. In addition, Kroch (1989) and Levine & Hukari (2006: 270) point out that D-Linking amelioration effects may simply result from the plausibility of background assumptions associated with the proposition.

4.2 On memory limitations

Sprouse et al. (2012a) use *n*-back and serial recall tasks to argue that there is no evidence that working memory limitations correlate with island acceptability, and therefore that the 'processing-based' account of islands put forth by Kluender (1992; 1998), Kluender & Kutas (1993), (Hofmeister & Sag 2010) and others is unfounded. To be sure, it cannot be stressed enough that the accounts in Kluender (1992) and (Hofmeister & Sag 2010) are not strictly based on performance, and involve other factors as well, most notably plausibility and pragmatic factors. See in particular Hofmeister et al. (2013: 49), where it is argued that at least some extraction constraints may be due to a combination of syntactic, semantic, pragmatic, and performance factors. Basically, if the correct location of a gap is syntactically, semantically, or pragmatically highly unlikely in that particular utterance, then it is less likely for the sentence to be acceptable. Indeed, there is independent experimental evidence that speakers attend to probabilistic information about the syntactic distribution of filler-gap dependencies (van Schijndel et al. 2014), and that gap predictability is crucial for on-line processing of islands (Michel 2014).[10] But as Sprouse et al. (2012b) point out, there is no reason to believe that *n*-back and serial recall tasks are strongly correlated to working memory capacity to begin with. Second, one of the main points of (Hofmeister & Sag 2010) is that the literature on experimental island research has not systematically controlled for multiple factors that can impact the processing and comprehension of complex sentences. If the experimental items are excessively complex, then readers are more likely to give up understanding the utterances

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[10]More broadly, there is good evidence that speakers deploy probabilistic information when processing a variety of linguistic input, including words (Altmann & Kamide 1999; Arai & Keller 2013; Creel et al. 2008; DeLong et al. 2005; Kutas & Hillyard 1984), lexical categories (Gibson 2006; Levy & Keller 2013; Tabor et al. 1997), syntactic structures (Levy et al. 2012; Lau et al. 2006; Levy 2008; Staub & Clifton 2006), semantics (Altmann & Kamide 1999; Federmeier & Kutas 1999; Kamide et al. 2003), and pragmatics (Ni et al. 1996; Mak et al. 2008; Roland et al. 2012).

and subtler effects will not be measurable. Phillips (2013b), however, regard such concerns as irrelevant. Although it is unclear to what extent expectations and processing constraints contribute to island effects, it is likely that they play some role in CNPC effects, as well as other island types discussed below.

5 Right Roof Constraint

Rightward movement is traditionally regarded as being clause bounded. Such *Right Roof Constraint* (Ross 1967) effects are illustrated in (22), in which a phrase appears *ex situ* in a position to the right of its *in situ* counterpart; see Akmajian (1975), Baltin (1978), and Stowell (1981), among others.

(22) a. *I [met a man [who knows _ $_i$] yesterday] [all of your songs]$_i$.

  b. *[[That a review _ $_i$ came out yesterday] is catastrophic] [of this article]$_i$.

  c. *It was believed _ $_x$ that [there walked into the room] _ $_y$ [by everyone]$_x$ [a man with long blond hair]$_y$.
  (Rochemont 1992)

When treated as a form of extraction, rightward movement has been predominantly accounted for via a feature EXTRA(POSED) (Keller 1995; van Noord & Bouma 1996; Van Eynde 1996; Keller 1994; Müller 1999; Kim & Sag 2005), rather than by SLASH. Thus, RRC island effects can be easily modeled by stipulating that the EXTRA value of an S node must be empty. One way to do so is to state that any S dependent (valent or adjunct) must be [EXTRA {}]. Thus, no extraposed element may escape its clause. However, the oddness of (22) may not be due any such syntactic stipulation, given the acceptability of counterexamples like (23). Note that the adverbial interveners in such examples do not require parenthetical prosody. Conversely, even strong parenthetical prosody on the adverbs in (22) fails to improve those data.

(23) a. I've [been requesting [that you pay back _] [ever since May]] [the money I lent to you a year ago].
  (Kayne 2000: 251)

  b. I've [been wanting to [meet someone who KNOWS _] [ever since I was little]] [exactly what happened to Amelia Earhart].

  c. I've been wondering if it is possible _] [for many years now] [for anyone to memorize the Bible word for word].
  (Chaves 2014: 861)

The durative semantics of *I've been wanting/requesting/wondering* raises an expectation about the realization of a durative adverbial expression like *ever since* or *for many years* that provides information about the durative semantics of the main predicate. Hence, the adverb is cued by the main predication, in some sense, and coheres much better in a high attachment than with a lower one.

The fact that the RRC is prone to exceptions has been noted by multiple authors as the sample in (24) illustrates. In all such cases, a phrase is right-extracted from an embedded clause, which should be flat out impossible if extraposition is clause-bounded. Again, the adverbial interveners in (24) do not require any special prosody, which means that these data cannot be easily discarded as parenthetical insertions.

(24) a. I have [wanted [to know _] for many years] [exactly what happened to Rosa Luxemburg].
(attributed to Witten (1972) in Postal (1974: 92n))

   b. I have [wanted [to meet _] for many years] [the man who spent so much money planning the assassination of Kennedy].
(attributed to Janet Fodor (p.c.) in Gazdar (1981: 177))

   c. Sue [kept [regretting _] for years] [that she had not turned him down].
(Van Eynde 1996)

   d. She has been [requesting that he [return _] [ever since last Tuesday]] [the book that John borrowed from her last year].
(Kayne 2000: 251)

   e. Mary [wanted [to go _] until yesterday] [to the public lecture].
(Howard Lasnik 2007 course handout[11])

Further evidence against a syntactic account of RRC comes from corpora (Müller 2004; 2007) and experimental findings (Strunk & Snider 2008; 2013), which confirm that extraposition does not always obey island constraints. The counterexamples in (25a–c) are adapted from Strunk & Snider (2008) and Strunk & Snider (2013), and those in (25d–f) are from Chaves (2014: 863).

(25) a. [In [what noble capacity _]] can I serve him [that would glorify him and magnify his name]?

   b. We drafted [a list of basic demands _] last night [that have to be unconditionally met or we will go on strike].

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[11]http://ling.umd.edu/~lasnik/LING819%202007/Multiple%20Sluicing%20819%20.pdf; Retr. 2009.

c. For example, we understand that Ariva buses have won [a number of contracts for routes in London _] recently, [which will not be run by low floor accessible buses].

d. Robin bought [a copy of a book _] yesterday [about ancient Egyptian culture].

e. I'm reading [a book written by a famous physicist _] right now, [who was involved in the Manhattan Project].

f. I saw [your ad in a magazine _] yesterday [on the table at the dentist office].

Grosu (1973b), Gazdar (1981) and Stucky (1987) argued that the RRC is the result of performance factors such as syntactic and semantic parsing expectations and memory resource limitations, not grammar proper. Indeed, we now know that there is a general well-known tendency for the language processor to prefer attaching new material to the more recent constituents (Frazier & Clifton 1996; Gibson et al. 1996; Traxler et al. 1998; Fodor 2002; Fernández 2003). Indeed, eye-tracking studies like Staub et al. (2006) indicate that the parser is reluctant to adopt extraposition parses. This explains why extraposition in written texts is less common in proportion to length of the intervening material (Uszkoreit et al. 1998): the longer the structure, the bigger the processing burden. Crucially, however, the preference for the closest attachment can be weakened by many factors (Fernández 2003; Desmet et al. 2006; De Vicenzi & Job 1993; Carreiras 1992). For example, Levy et al. (2012) show that relative clause extraposition creates significant processing difficulty when compared with non-extraposed counterparts of the same sentences, but that a preceding context that sets up a strong expectation for a relative clause modifying a given noun can facilitate comprehension of an extraposed relative clause modifying that noun. In other words, in spite of a larger processing burden, some extrapositions can be made easier to process by parsing expectations.

A detailed account of extraposition island phenomena does not exist in any framework, as far as I am aware. But the line of inquiry first proposed by Grosu (1973b), Gazdar (1981) and Stucky (1987), and later experimentally supported by Levy et al. (2012), Strunk & Snider (2008), and Strunk & Snider (2013) seems to be in the right track. If so, then there is no syntactic constraint on EXTRA. Rather, RCC effects are to a large extent the result of difficulty in integrating the extraposed phrase in its *in situ* position.

5.1 Freezing

A related island phenomenon also involving rightward displacement, first noted in Ross (1967: 305), is *Freezing*: leftward extraction (26a) and extraposition (26b) cause low acceptability when they interact, as seen in (27). In (27a) there is extraction from an extraposed PP, in (27b) there is extraction from an extraposed NP, and in (27c) an extraction from a PP crossed with direct object extraposition.

(26) a. Who$_j$ did you [give [a picture of _ $_j$] [to Robin]]?
      b. Did you [give _ $_i$ [to Robin] [a picture of my brother]$_i$]?

(27) a. * Who$_j$ did you [give a picture _ $_i$] [to Robin] [of _ $_j$]$_i$?
      b. * Who$_j$ did you [give _ $_i$ [to Robin] [a picture of _ $_j$]$_i$]?
      c. * Who$_j$ did you [give _ $_i$ [to _ $_j$] [a picture of my brother]$_i$]?

Fodor (1978: 457) notes that (27c) has a syntactically highly probable temporary alternative parse in which *to* combines with the NP *a picture of my brother*. The existence of this local ambiguity likely disrupts parsing, especially as it occurs in a portion of the sentence that contains two gaps in close succession. Indeed, constructions with two independent gaps in close proximity are licit, but not trivial to process, as seen in (28), specially if the extraction paths cross (Fodor 1978), as in (28b).

(28) a. * This is a problem which$_i$ John$_j$ is difficult to talk to _ $_j$ about _ $_i$.
      b. * Who$_j$ can't you remember which papers$_i$ you sent copies of _ $_i$ to
          _ $_j$?

A similar analysis is offered by Hofmeister et al. (2015: 477), who note that constructions like (27c) must cause increased processing effort since the point of retrieval and integration coincides with the point of reanalysis. The existence of a preferential alternative parse that is locally licit but globally illicit can in turn lead to a 'digging-in' effect (Ferreira & Henderson 1991; 1993; Tabor & Hutchins 2004), in which the more committed the parser becomes to a syntactic parse, the harder it is to backtrack and reanalyze the input. The net effect of these factors is that the correct parse of (27c) is less probable and therefore harder to identify than that of (27b), which suffers from none of these problems, and is regarded to be more acceptable than (27c) by Fodor (1978: 453) and others. See Chaves (2018) for experimental evidence that speakers can adapt and to some extent overcome some of these parsing biases.

Finally, prosodic and pragmatic factors are likely also at play in (27), as in the RRC. Huck & Na (1990) show that when an unstressed stranded preposition is separated from its selecting head by another phrase, oddness ensues for prosodic reasons. Finally, Huck & Na (1990) and Bolinger (1992) also argue that freezing effects are also in part due to a pragmatic conflict created by extraposition and extraction: *wh*-movement has extracted a phrase leftward, focusing interest on that expression, while at the same time extraposition has moved a constituent rightward, focusing interest on that constituent as well. Objects tend to be extraposed when they are discourse new, and even more so when they are heavy (Wasow 2002: 71). Therefore, the theme phrase *a picture of John* in (27c) is strongly biased to be discourse new, but this clashes with the fact that an entirely different entity, the recipient, is leftward extracted, and therefore is the *de facto* new information that the open proposition is about. No such mismatch exists in (27a) or (27b), in contrast, where the extraposed theme is more directly linked to the entity targeted by leftward extraction.

6 Subject islands

Extraction out of subject phrases like (29) is broadly regarded to be impossible in several languages, including English Ross (1967); Chomsky (1973), an effect referred to as a *Subject Island* (SI). This constraint is much less severe in languages like Japanese , German, and Spanish, among others (Stepanov 2007; Jurka et al. 2011; Goodall 2011; Sprouse et al. 2015; Fukuda et al. 2018; Polinsky et al. 2013).

(29)   a.   * Who did stories about terrify John?
             (Chomsky 1977: 106)

       b.   * Who was a picture of laying there?
             (Kayne 1981: 114)

       c.   * Who do you think pictures of would please John?
             (Huang 1982: 497)

       d.   * Who does the claim that Mary likes upset Bill?
             (Lasnik & Saito 1992: 42)

       e.   * Which candidate were posters of all over the town?
             (Lasnik & Park 2003)

However, English exceptions were noticed early on, and have since accumulated in the literature. In fact, for Ross (1967), English extractions like (30a) are not

illicit, and more recently Chomsky (2008: 147) has added more such counterexamples. Other authors noted that certain extractions from subject phrases are naturally attested, as in (30b,c). Indeed, Abeillé et al. (2018) shows that extractions like those in (30c) are in fact acceptable to native speakers, and that no such island effect exists in French either.[12]

(30) a. [Of which cars]$_i$ were [the hoods _ $_i$] damaged by the explosion?
(Ross 1967: 4.252)

b. They have eight children [of whom]$_i$ [five _ $_i$] are still living at home.
(Huddleston et al. 2002: 1093)

c. Already Agassiz had become interested in the rich stores of the extinct fishes of Europe, especially those of Glarus in Switzerland and of Monte Bolca near Verona, [of which]$_i$, at that time, [only a few _ $_i$] had been critically studied.
(Santorini 2007)

English exceptions to the SI constraint are not restricted to PP extractions, however. Although Ross (1967) claimed NP extractions from NP subjects like (31) are illicit, it was arguably premature to generalize from such a small sample.

(31) a. The hoods of these cars were damaged by the explosion.
b. *Which cars were the hoods of damaged by the explosion?
(Ross 1967)

Indeed, a number of authors have noted that some NP extractions from subject NPs are either passable or fairly acceptable, as illustrated in (32). See also Pollard & Sag (1994: 195,ft.32), Postal (1998), Sauerland & Elbourne (2002: 304), Culicover (1999: 230), Levine & Hukari (2006: 265), Chaves (2012b: 470,471), and Chaves & Dery (2014).

(32) a. [What]$_i$ were [pictures of _ $_i$] seen around the globe?
(Kluender 1998: 268)

b. It's [the kind of policy statement]$_i$ that [jokes about _ $_i$] are a dime a dozen.
(Levine et al. 2001: 204)

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[12]For completeness, other authors argue that PP extractions from NP subjects are illicit, such as Lasnik & Park (2003: 653), among many others.

    c.   There are [certain topics]$_i$ that [jokes about $\_\,_i$] are completely unacceptable.
          (Levine & Sag 2003: 252, ft.6)

    d.   [Which car]$_i$ did [some pictures of $\_\,_i$] cause a scandal?
          (Jiménez–Fernández 2009: 111)

    e.   [What]$_i$ did [the attempt to find $\_\,_i$] end in failure?
          (Hofmeister & Sag 2010: 370)

    f.   [Which president]$_i$ would [the impeachment of $\_\,_i$] cause outrage?
          (Chaves 2012b)

    g.   I have a question$_i$ that [the probability of you knowing the *answer to* $\_\,_i$] is zero.
          (Chaves 2013)

Whereas SI violations involving subject CPs are not attested, those involving infinitival VP subjects like (33) are. See Chaves (2012b: 471) for more natural occurrences.

(33)   a.   The eight dancers and their caller, Laurie Schmidt, make up the Farmall Promenade of nearby Nemaha, a town$_i$ that [[to describe $\_\,_i$ as tiny] would be to overstate its size].
           (Huddleston et al. 2002: 1094, ft.27)

      b.   In his bedroom, [which]$_i$ [to describe $\_\,_i$ as small] would be a gross understatement, he has an audio studio setup.

      c.   They amounted to near twenty thousand pounds, [which]$_i$ [to pay $\_\,_i$] would have ruined me. (Benjamin Franklin, William Temple Franklin and William Duane. 1834. Memoirs of Benjamin Franklin, vol 1. p.58)

Incidentally, Subject phrases are not extraposition islands either, as in (34). See also Guéron & May (1984). Odd examples like *[*Pictures* $\_$] *frighten people* [*of John*] from Drummond (2009), are more likely due to a digging-in effect, caused by speakers assuming that the subject is syntactically and semantically complete by the end of the verb phrase.

(34)   a.   [The circulation of a rumor $\_\,_i$] has started [that Obama will not seek re-election]$_i$.

      b.   [A copy of a new book $\_\,_i$] arrived yesterday [about ancient Egyptian culture]$_i$.

    c. [Concerns about the deaths _ ᵢ] were raised [of two diplomatic envoys recently abducted in Somalia]ᵢ.

6.1 Clausal Subject Constraint

Let us consider now SI effects involving more complex subjects. Infinitival subject clauses seem to impose no SI constraint, an observation going back to Kuno & Takami (1993), but noted elsewhere a few times:

(35) a. This is something [which]ᵢ – for you to try to understand _ ᵢ – would be futile.
        (Kuno & Takami 1993: 49)

      b. I just met Terry's eager-beaver research assistant [who]ᵢ – for us to talk to _ ᵢ about any subject other than linguistics – would be absolutely pointless.
        (Levine & Hukari 2006: 265)

      c. There are [people in this world]ᵢ that – for me to describe _ ᵢ as despicable – would be an understatement.
        (Chaves 2012b: 471).

Infinitival subjects contrast dramatically with finite subjects. The latter are renowned for being particularly hard to extract from, as in (36). Ross (1967) dubbed this extreme kind of SI the *Sentential Subject Constraint* (SSC). See also Chomsky (1973), Huang (1982), Chomsky (1986), Freidin (1992).[13]

(36) a. * [Who]ᵢ did [that Maria Sharapova beat _ ᵢ] surprise everyone?
        (cf. with 'That Maria Sharapova beat Serena Williams surprised everyone')

      b. * [Who]ᵢ did [that Robin married _ ᵢ] surprise you?
        (cf. with 'Did that Robin married Sam surprise you?')

There are some functional reasons for why clausal SI violations may be so strong. First, subject clauses are notorious for being particularly difficult to process, independent of extraction. Clausal subjects are often stylistically marked

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[13]That said, Chaves (2013) reports that some native speakers find SSC violations like (i) to be fairly acceptable, again raising some doubt about the robustness of English SI effects:

    (i) [Which actress]ᵢ does [whether Tom Cruise marries _ ᵢ] make any difference to you?

and difficult to process, as (37a) illustrates. Thus, it is extremely hard to embed a clausal subject within another clausal subject, even though such constructions ought to be perfectly grammatical, like (37b,c). In addition, it is known that tense can induce greater processing costs (Kluender 1992; Gibson 2000).

(37) a. That the food that John ordered tasted good pleased him.
          (Cowper 1976; Gibson 1991)
      b. * That that Jill left bothered Sarah surprised Max.
          (Kimball 1973)
      c. * That that the world is round is obvious is dubious.
          (Kuno 1974)

Interestingly, clausal subjects become more acceptable if extraposed as shown in (38). The explanation offered by Fodor et al. (1974: 356–357) is that speakers tend to take the initial clause in the sentence to be the main clause. Thus, *that* is taken to be the subject, but the remainder of the structure does not fit this pattern. Thus, a sentence like (38a) causes increased processing load because it has a different structure than the parser expects. This processing problem does not arise in the counterpart in (38b).[14]

(38) a. ? That [it is obvious that [the world is round]] is dubious.
      b. It is dubious that [it is obvious that [the world is round]].
          (Kuno 1974)

Indeed, Fodor & Garrett (1967), Bever (1970), Frazier & Rayner (1988) also show that extraposed clausal subject sentences like (39a) are easier to process than their in-situ counterparts like (39b). Not surprisingly, the former are much more frequent than the latter, which explains why the parser would expect the former more than the latter.

(39) a. It surprised Max that Mary was happy.
      b. That Mary was happy surprised Max.

---

[14]See Gibson (2006) for online evidence that the word *that* is preferentially interpreted as a determiner even in syntactic contexts where it cannot be a determiner. The use of 'determiner' corresponds to the traditional term, referring to a certain category of prenominal constituent rather than to the whole nominal phrase including the noun and all its dependents. Gibson's evidence suggests that both top-down (syntactic) expectations are independent from bottom-up (lexical) frequency-based expectations in sentence processing. Thus, clausal subject phrase starting with the complementizer *that* is likely to be misparsed as a matrix clause with sentence-initial pronominal or determiner *that*.

Note that embedded conditionals like (6.1a) are also exceedingly difficult to parse, although perfectly syntactically well-formed. However, such structures can become more acceptable with fewer embeddings to strain working memory, and with judicious use of prosodic cues that indicate the relevant structure, as illustrated by the acceptability of (6.1b). This is evidence that the oddness of (6.1) is at least in part due to performance.

(40)   If – if every time it snowed there was no school – then there wouldn't be classes all winter.

If we add a filler-gap dependency to a sentence that already is complex by virtue of having a clausal subject, the resulting structure may be too difficult to parse. This point is illustrated by the contrast in (41).

(41)   a.   ?* What does that he will come prove?
        b.   What does his coming prove?
                (Lewis 1993)

As argued by Davies & Dubinsky (2009), the low acceptability of extraction in subject-auxiliary inversion sentences with clausal subjects is more likely to be the result of extragrammatical factors than of grammatical conditions. For example, not all extractions like (42b) are unacceptable, as Delahunty (1983: 382–387) and Davies & Dubinsky (2009: 115) point out.

(42)   a.   That the food that John ordered tasted good pleased me.
        b.   * Who did that the food that John ordered tasted good please _ ?

The evidence discussed so far suggests that sentences involving extraction and clausal subjects are odd is at least in part due to the likely cumulative effect of various sources of processing complexity. Sentences with sentential subjects are unusual structures, which can mislead the parser into the wrong analysis. A breakdown in comprehension can occur because the parser must hold complex incomplete phrases in memory while processing the remainder of the sentence. The presence of a filler-gap dependency will likely only make the sentence harder to process. It is independently known that the more committed the parser becomes to a syntactic parse, the harder it is to reanalyze the string (Ferreira & Henderson 1991; 1993; Tabor & Hutchins 2004). This is usually referred to as a "digging-in" effect. For example, unless prosodic or contextual cues are employed to boost the activation of the correct parse, (6.1) will be preferentially misanalysed as having the structure [NP [V [NP]]].

(43)   Fat people eat accumulates.

The garden-path effect that the digging-in causes in example (6.1) serves as an analogy for what may be happening in particularly difficult subject island violations. In both cases, the sentences have exactly one grammatical analysis, but that parse is preempted by a highly preferential alternative which ultimately cannot yield a complete analysis of the sentence. Thus, without prosodic cues indicating the extraction site, sentences like (44) induce a significant digging-in effect as well.

(44)   a. * Which problem will a solution to be found by you?
       b. * Which disease will a cure for be found by you?

   This also explains why SI violations like (45) are relatively acceptable: the processing cost of an NP-embedded causal is smaller than the processing cost incurred by processing a clausal subject.[15] Clausal subjects are unusual structures, inconsistent with the parser expectations (Fodor et al. 1974), and the presence of filler-gap dependency in an NP-embedded clausal subject is less likely to cause difficulty for the parse to go awry than a filler-gap dependency in a clausal subject.[16]

(45)   a. [Which puzzle]$_i$ did the fact that nobody could solve _$_i$ astonish you the most?

       b. [Which crime]$_i$ did the fact that nobody was accused of _$_i$ astonish you the most?

       c. [Which question]$_i$ did the fact that none of us could answer _$_i$ surprise you the most?

---

[15]For claims that NP-embedded clausal SI violations are illicit see Lasnik & Saito (1992: 42), Phillips (2006: 796), and Phillips (2013a: 67).

[16]Clausen (2010; 2011) provide experimental evidence that complex subjects cause a measurable increase in processing load, with and without extraction. Moreover, it is known that elderly adults have far more difficulty repeating sentences with complex subjects than sentences with complex objects (Kemper 1986). Similar difficulty is found in timed reading comprehension tasks (Kynette & Kemper 1986), and in disfluencies in non-elderly adults (Clark & Wasow 1998). Speech initiation times for sentences with complex subjects are also known to be longer than for sentences with simple subjects (Ferreira 1991; Tsiamtsiouris & Cairns 2009), and sentences with center-embedding in subjects are harder to process than sentences with center-embedding in objects (Amy & Noziet 1978; Eady & Fodor 1981). Finally, Garnsey (1985), Kutas et al. (1988), and Petten & Kutas (1991) show that the processing of open-class words, particularly at the beginning of sentences, require greater processing effort than closed-class words.

d. [Which joke]$_i$ did the fact that nobody laughed at _ $_i$ surprise you the most?

6.2 Accounts of SI effects

This complex array of effects suggests that the SI constraint is not due to a single factor (Chomsky 2008; Chaves 2013; Jiménez–Fernández 2009), be it grammatical or otherwise. One possibility is that SIs are partly due to pragmatic and processing constraints, perhaps not too different from those that appear to be active in the island effects discussed so far. As Kluender (2004: 495) notes: 'Subject Island effects seem to be weaker when the *wh*-phrase maintains a pragmatic association not only with the gap, but also with the main clause predicate, such that the filler-gap dependency into the subject position is construed as of some relevance to the main assertion of the sentence'. Indeed, many authors (Erteschik-Shir 1981; Van Valin 1986; Kuno 1987; Takami 1992; Deane 1992; Goldberg 2013) have argued that extraction is in general restricted to the informational focus of the proposition, and that Subject Islands (among others) are predicted as a consequence. In a nutshell, since subjects are typically reserved for topic continuity, subject-embedded referents are unlikely to be the informational focus of the utterance. Although it is not easy to construct sentences where a dependent of the subject can be easily deemed as the informational focus, it is by no means impossible. For instance, (46a) is particularly acceptable because whether or not an impeachment causes outrage crucially depends on who is impeached (cf. with *Would the impeachment of Donald Trump cause outrage?*). Similarly, in (46b) whether or not an attempt failed or succeeded crucially depends on what was attempted (cf. with *The attempt to find the culprit ended in failure*).

(46) a. Which President would [the impeachment of _] cause outrage?
(Chaves 2012b)

b. What did [the attempt to find _] end in failure?
(Hofmeister & Sag 2010: 370)

Although experimental research has confirmed that sentences with SI violations tend to be less acceptable than grammatical controls (Sprouse 2009; Goodall 2011; Crawford 2011; Clausen 2011; Sprouse et al. 2015), and that their acceptability remains consistently low during repeated exposition (Sprouse 2009; Crawford 2011), other research has found that the acceptability of SI violations is not consistently low, and can be made to increase significantly (Hiramatsu 2000; Clausen 2011; Chaves & Dery 2014; Chaves 2012a). This mixed evidence is consistent

with the idea that SI effects are very sensitive to the particular syntax, semantics, and pragmatics of the utterance in which they occur. If the items are too complex, or stylistically awkward, or presuppose unusual contexts, then SI effects are strong. For example, if the extraction is difficult to process because the sentence gives rise to local garden-path and digging-in effects, and is pragmatically infelicitous in the sense that the extracted element is not particularly relevant for the proposition (i.e. unlikely to be what the proposition is about) or comes from the presupposition rather than the assertion, then we obtain a very strong SI effect. Otherwise, the SI effect is weaker, and in some cases nearly non-existent like (46), (33), or the pied-piping examples studied by Abeillé et al. (2018). The latter involve relative clauses, in which subjects are not strongly required to be topics, in contrast to the subjects or main clauses.

This approach also explains why subject-embedded gaps often become more acceptable in the presence of a second non-island gap: since the two gaps are co-indexed, then the fronted referent is trivially relevant for the main assertion, as it is predicated by the main verb. For example, the low acceptability of (47a) is arguably caused by the lack of plausibility of the described proposition: without further contextual information, it is unclear how the attempt to repair an unspecified thing x is connected to the attempt causing damage to a car.

(47)   a.   * What did [the attempt to repair _] ultimately damage the car?
       b.   What did [the attempt to repair _] ultimately damage _ ?
            (Phillips 2006)

The example in (47a) becomes more acceptable if it is contextually established that x is a component of the car. In contrast, (47b) is felicitous even out-of-the-blue because it conveys a proposition that is readily recognized as being plausible according to world knowledge: attempting to fix x can cause damage to x. If Subject Island effects are indeed contingent on how relevant the extracted subject-embedded referent is for the assertion expressed by the proposition, then a wide range of acceptable patterns is to be expected, parasitic or otherwise. This includes cases like (48), where both gaps are in Subject Island environments. As Levine & Sag (2003), Levine & Hukari (2006: 256), and Culicover (2013: 161) note, cases like (48) should be completely unacceptable, contrary to fact.

(48)   This is a man who [friends of _] think that [enemies of _] are
       everywhere.

The conclusion that Subject Island effects are contingent on the particular proposition expressed by the utterance and its pragmatics thus seems unavoid-

able (Chaves & Dery 2019). In order to test this hypothesis, Chaves & Dery (2019) examine the the acceptability of sentences like (49), which crucially express nearly-identical truth conditions and have equally acceptable declarative counterparts. This way, any source of acceptability contrast must come from the extraction itself, not from the felicity of the proposition.

(49) a. Which country does the King of Spain resemble [the President of _]?

b. Which country does [the President of _] resemble the King of Spain?

The results indicate that although the acceptability of the SI counterpart in (49b) is initially significantly lower than (49a), it gradually improves. After 8 exposures, the acceptability of near-truth-conditionally equivalent sentences like (49) becomes non-statistically different. What this suggests is that SI effects are at least in part probabilistic: the semantic, syntactic and pragmatic likelihood of a subject-embedded gap likely matters for how acceptable such extractions are. This is most consistent with the claim that – in general – extracted phrases must correspond to the informational focus of the utterance (Erteschik-Shir 1981; Van Valin 1986; Kuno 1987; Takami 1992; Deane 1992; Goldberg 2013), and in particular with the intuition that SI violations are weaker when the extracted referent is relevant for the main predication (Kluender 2004: 495).

7 Adjunct islands

Ross (1967) and Cattell (1976) noted that adjunct phrases often resist extraction, as illustrated in (50), a phenomenon usually referred to as *The Adjunct Island Constraint* (AIC).

(50) a. * What$_i$ did John die [whistling _ $_i$]?

b. * What$_i$ did John build [whistling _ $_i$]?

c. * Which club$_i$ did John meet a lot of girls [without going to _ $_i$]?
      (Cattell 1976: 38)

d. * Who$_i$ did Mary cry [after John hit _ $_i$]?
      (Huang 1982: 503)

Although a constraint on SLASH could effectively ban all extraction from adjuncts, the problem is that the AIC has a long history of exceptions, noted as early as Cattell (1976: 38), and by many others since, including Chomsky (1982: 72), Engdahl (1983), Hegarty (1990: 103), Cinque (1990), Pollard & Sag (1994: ??),

Culicover (1997: 253), and Borgonovo & Neeleman (2000). A sample of representative counterexamples is provided in (51).

(51) a. Who did he buy a book [for _]?
      b. Who would you rather [sing with _]?
      c. What temperature should I wash my jeans [at _]?
      d. That's the symphony that Schubert [died without finishing _].
      e. Which report did Kim [go to lunch without reading _]?
      f. A problem this important, I could never [go home without solving _ first].
      g. What did he [fall asleep complaining about _]?
      h. What did John [drive Mary crazy trying to fix _]?
      i. Who did you [go to Girona in order to meet _]?
      j. Who did you go to Harvard [in order to work with _]?

Exceptions to the AIC include tensed adjuncts, as noted by Grosu (1981: 88), Deane (1991: 29), Kluender (1998), (Levine & Hukari 2006: 287), Goldberg (2006: 144), Chaves (2012b: 471), Truswell (2011: 175, ft.1) and others. A sample is provided in (52).[17]

(52) a. These are the pills that Mary died [before she could take _].
      b. This is the house that Mary died [before she could sell _].
      c. The person who I would kill myself [if I couldn't marry _] is Jane.
      d. Which book will Kim understand linguistics better [if she reads _]?
      e. This is the watch that I got upset [when I lost _].
      f. Robin, Pat and Terry were the people who I lounged around at home all day [without realizing were _ coming for dinner].
      g. Which email account would you be in trouble [if someone broke into _]?
      h. Which celebrity did you say that [[the sooner we take a picture of _], [the quicker we can go home]]?

---

[17]Truswell (2011) argues that the AIC and its exceptions are best characterized in terms of event-semantic constraints, such that the adjunct must occupy an event position in the argument structure of the main clause verb. However, recent experimental research has been unable to validate Truswell's acceptability predictions (Annika et al. ???), and moreover, such an account incorrectly predicts that extractions from tensed adjuncts is impossible (Truswell 2011: 175, ft.1).

To be sure, some of these sentences are complex and difficult to process, which in turn can lead speakers to prefer the insertion of an 'intrusive' resumptive pronoun at the gap site, but they are certainly more acceptable than the classic tensed AIC violations examples like Huang's (50d). Acceptable tensed AIC violations are more frequent in languages like Japanese, Korean, and Malayalam.

Like Subject Islands, AIC violations sometimes improve 'parasitically' in the presence of a second gap as in (53). First of all, note that these sentences express radically different propositions, and so there is no reason to assume that all of these are equally felicitous. Second, note that (53a,c) describe plausible states-of-affairs in which it is clear what the extracted referent has to do with the main predication and assertion, simply because of the fact that *document* is predicated by *read*. In contrast, (53b) describes an unusual state-of-affairs in that it is unclear what the extracted referent has to do with the main predication *read the email*, out-of-the-blue. Basically, what does reading emails have to do with filing documents?

(53) a. Which document did John read _ before filing _ ?
      b. * Which document did John read the email email before filing _ ?
      c. Which document did John read _ before filing a complaint?

If AIC violations were truly only salvageable parasitically, then counterexamples like (54a) should not exist. As Levine & Sag (2003) and Levine & Hukari (2006: 256) note, both gaps reside in island environments and should be completely out and less acceptable than (54b,c), contrary to fact.

(54) a. What kinds of books do [the authors of _] argue about royalties [after writing _ ?
      b. * What kinds of books do [authors of _] argue about royalties after writing malicious pamphlets?
      c. * What kinds of books do authors of malicious pamphlets argue about royalties [after writing _]?

In (54a), there is no sense in which the gap inside the subject is parasitic on the gap inside the adjunct, or vice-versa – under the assumption that neither gaps is supposed to be licit without the presence of a gap outside an island environment. In conclusion, the notion of parasitic gap is rather dubious. See Levine & Hukari (2006: ??) for a more in-depth discussion of parasitism and empirical criticism of null resumptive pronoun accounts.

As in the case of other island phenomena discussed so far, it is doubtful that any purely syntactic account can describe all the empirical facts. Rather, extractions out of adjuncts are licit to the degree that the extracted referent can be interpreted as being relevant for the assertion.

8 Superiority effects

Contrasts like those below have traditionally been taken to be due to a constraint that prevents a given phrase from being extracted if another phrase in a higher position can be extracted instead (Chomsky 1973; 1980). Thus, the highest *wh*-phrase is extractable, but the lowest is not.

(55) a. Who _ saw what?
     b. * What did who see _ ?

(56) a. Who did you persuade _ to buy what?
     b. * What did you persuade who to buy _ ?

Several different kinds of exceptions to this *Superiority Constraint* (SC) have been noted in the literature. First, it is generally recognized that *which*-phrases are immune to the SC:

(57) a. I wonder which book which of our students read _ over the summer?
     b. Which book did which professor buy _ ?

Pesetsky (1987) proposed to explain the lack of SC effects in (57) by stipulating that *which*-phrases are interpreted as indefinites which do not undergo LF movement. Rather, they require 'D-linking' and obtain wide scope via an entirely different semantic mechanism called unselective binding. In order for a phrase to be D-linked, it must be associated with a salient set of referents. But as Ginzburg & Sag (2000: 248ff.) note, there is no independent evidence for saliency interpretational differences between *which* and other *wh*-phrases like *what* and *who*. For example, it is implausible that speakers have a specific referent in mind for the *which*-phrases in examples like (58).

(58) a. I don't know anything about cars. Do you have any suggestions about which car – if any – I should buy when I get a raise?
     b. I don't know anything about cars. Do you have any suggestions about what – if anything – I should buy when I get a raise?
        (Ginzburg & Sag 2000: 248)

Furthermore, there are acceptable SC violations involving multiple *wh*-questions such as those in (59). See Bolinger (1978), Kayne (1983) and Pesetsky (1987: 109) for more such examples and discussion.[18]

(59)   a.   Who wondered what WHO was doing _ ?

        b.   What did WHO take _ WHERE?

        c.   Where did WHO take WHAT _ ?

Finally, there are also SC violations that involve echo questions like (60) and reference questions like (61). See Ginzburg & Sag (2000: Ch.7) for detailed argumentation that echo questions are not fundamentally different, syntactically or semantically, from other uses of interrogatives.

(60)   a.   What did Agamemnon break?

        b.   What did WHO break _ ?

(61)   a.   What did he break?

        b.   What did WHO break _ ?

There are two different, yet mutually consistent, possible explanations for SC effects in HPSG circles. One potential factor concerns processing difficulty Arnon et al. (2007). Basically, long-distance dependencies where a *which*-phrase is fronted are generally more acceptable and faster to process than those where *what* or *who* if fronted, presumably because the latter are semantically less informative, and thus decay from memory faster, and are compatible with more potential gap sites before the actual gap. The second potential factor is prosodic in nature. Drawing from insights by Ladd (1996: 170–172) about the English interrogative intonation, Ginzburg & Sag (2000: 251) propose that in a multiple *wh*-interrogative construction all *wh*-phrases must in FOCUS except the first. Crucially, focus is typically – but not always – associated with clearly discernible pitch accent. Thus, (55) and (56) are odd because the second *wh*-word is unaccented. In this account, a word like *who* has two possible lexical descriptions, shown in (62).

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[18]Fedorenko & Gibson (2010) and others have found no evidence that the presence of a third *wh*-phrase improves the acceptability of a multiple interrogative, even with supporting contexts. However, the examples in (59) require peculiar intonation phrasings and contours, which may be difficult to elicit with written stimuli.

                                     Draft of 29th November 2018, 11:59

(62) a. *Ex-situ* interrogative *who*:

$$
\begin{bmatrix}
\text{PHON} & \langle who/WHO \rangle \\
\text{SYNSEM} & \begin{bmatrix}
\text{LOC} & \begin{bmatrix}
\text{CAT} & \begin{bmatrix} \text{HEAD} & noun \\ \text{SPR} & \langle \rangle \\ \text{COMPS} & \langle \rangle \end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{IND} & i \\ \text{RESTR} & \{\} \end{bmatrix} \\
\text{STORE} & \left\{ \boxed{1} \begin{bmatrix} \text{IND} & i \\ \text{RESTR} & \{person(i)\} \end{bmatrix} \right\}
\end{bmatrix} \\
\text{NONLOC} & \begin{bmatrix} \text{WH} & \{\boxed{1}\} \\ \text{REL} & \{\} \\ \text{SLASH} & \{\} \end{bmatrix}
\end{bmatrix} \\
\text{ARG-ST} & \langle \rangle
\end{bmatrix}
$$

b. Optionally *ex-situ* interrogative *who*:

$$
\begin{bmatrix}
\text{PHON} & \langle WHO \rangle \\
\text{SYNSEM} & \begin{bmatrix}
\text{LOC} & \begin{bmatrix}
\text{CAT} & \begin{bmatrix} \text{HEAD} & noun \\ \text{SPR} & \langle \rangle \\ \text{COMPS} & \langle \rangle \end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{IND} & i \\ \text{RESTR} & \{\} \end{bmatrix} \\
\text{STORE} & \left\{ \begin{bmatrix} \text{IND} & i \\ \text{RESTR} & \{person(i)\} \end{bmatrix} \right\}
\end{bmatrix} \\
\text{NONLOC} & \begin{bmatrix} \text{WH} & \{\} \\ \text{REL} & \{\} \\ \text{SLASH} & \{\} \end{bmatrix}
\end{bmatrix} \\
\text{ARG-ST} & \langle \rangle
\end{bmatrix}
$$

Since only the (optionally accented) lexical entry in (62a) is specified with a non-empty WH value, the theory of extraction proposed in Ginzburg & Sag (2000) predicts that (62a) must appear *ex situ*. In contrast, the accented lexical entry in (62b) is can appear *in situ*. For more discussion see Levine & Hukari (2006: 261).

A related range of island phenomena concern extraction from *whether*-clauses like which are traditionally assumed to be forbidden as (63) illustrates.

(63) a. * Which movie did John wonder wether Bill liked _ ?
      b. * Which movie did John ask why Mary liked _ ?

But again, the oddness of (63) is unlikely to be due to syntactic constraints, given the existence of passable counterexamples like (64).

(64) a. He told me about a book which I can't figure out whether to buy
_ or not.
(Ross 1967)

b. Which glass of wine do you wonder whether I poisoned _ ?
(Cresti 1995:81)

c. Who is John wondering whether or not he should fire _ ?

d. Which shoes are you wondering whether you should buy _ ?
(Chaves 2012b)

As noted by Kroch (1989), the reduced acceptability of an example like (65a) is better explained simply by noting the difficulty of accommodating its presupposition in (65b).

(65) a. How much money was John wondering whether to pay?

b. There was a sum of money about which John was wondering
whether to pay it.

9 The Left Branch Condition

Ross (1967) discovered that the leftmost constituent of an NP cannot be extracted, as in (66), a constraint he dubbed as the *Left Branch Condition* (LBC).[19]

(66) a. * Whose$_i$ did you meet [_ $_i$ friend]?
(cf. with '*You met whose friend?*')

b. * Which$_i$ did you buy [_ $_i$ book]?
(cf. with '*You bought which book?*')

c. * How much$_i$ did you find [_ $_i$ money]?
(cf. with '*You found how much money?*')

These facts are accounted for in versions of HPSG like Sag (2012) where Determiner Phrases (DPs) are not valents of the nominal head. If the DP is not listed in the argument structure of the nominal head, then there is no way for the DP to appear in SLASH. Rather, the DP selects the nominal head:

---

[19]As in other island environments discussed above, the LBC is not operative in constraining semantic scope, as illustrated below.

(i) Someone took a picture of each student's bicycle.
(Copestake et al. 2005: 303)

(67)
$$
\begin{bmatrix}
\text{PHON} & \langle \textit{the} \rangle \\[2pt]
\text{SYNSEM} & \begin{bmatrix}
\text{LOC} & \begin{bmatrix}
\text{CAT} & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix} \textit{determiner} \\ \text{SELECT N}' \begin{bmatrix} \text{IND} & i \\ \text{RESTR} & \{\boxed{1}\} \end{bmatrix} \end{bmatrix} \\
\text{SPR} & \langle\rangle \\
\text{COMPS} & \langle\rangle
\end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{IND} & i \\ \text{RESTR} & \{\} \end{bmatrix} \\
\text{STORE} & \left\{ \begin{bmatrix} \textit{the-rel} \\ \text{VAR} \; i \\ \text{ARG} \; \boxed{1} \end{bmatrix} \right\}
\end{bmatrix} \\
\text{NON-LOC} & \begin{bmatrix} \text{WH} & \{\} \\ \text{REL} & \{\} \\ \text{SLASH} & \{\} \end{bmatrix}
\end{bmatrix} \\
\text{ARG-ST} & \langle\rangle
\end{bmatrix}
$$

Analogously, in Sag (2012: 133) genitive DPs combine with nominal heads and bind their x-ARG index via a dedicated construction, not as valents. For example, in nominalizations like *Kim's description of the problem* the DP *Kim's* is not a valent of *description*, and therefore the genitive DP cannot appear in SLASH. Rather, gentive DPs are instead constructionally co-indexed with the agent role of the noun *description* via x-ARG. Moreover, the clitic *s* in *Kim's* must lean phonologically on the NP it selects, and therefore cannot be stranded for independently motivated phonological reasons, predicting the oddness of **It was Kim who I read 's description of the problem.*

There are various languages which do not permit extraction of left branches from noun phrases, but have a particular PP construction appears to allow LBC violations. This is illustrated below in (9), with French data.

(68)   a. Combien$_i$ a-t-il   vendu [$\_\,_i$ de livres]?
          how-many has-he sold   of books

          'How many books did he sell?'

      b. Quels$_i$ avez-vous acheté [$\_\,_i$ livres]?
          how-many have-you bought   books

          'How many books have you bought'

But the LBC violation is only apparent. The *de livres* is in fact a post-verbal *de*-N' nominal, and thus no LBC violation incurs in (9a). See Abeillé et al. (2004) for details. Finally, Ross (1967) also noted that some languages do not obey the LBC

at all. A small sample is given in (69). However, the languages in question lack determiners, and therefore it is possible that the extracted phrase is has a similar independent status to the French *de-N'* phrase in (9).

(69)   a.   Jaką$_i$ kupiłeś   [_ $_i$ książkę]
            what you-bought   book
            'Which book did you buy?'   (Polish)

       b.   Cju$_i$ citajes   [_ $_i$ knigu]?
            whose you-are-reading   book
            'whose book are you reading?'   (Russian)

       c.   Ki-nek$_i$ akarod,   hogy halljam [_ $_i$ a   hang-já-t]?
            who-DAT you-want that   I-hear   the voice-POSS.3SG-ACC
            'Whose voice do you want me to hear?'   (Hungarian)

10   The Complementizer Constraint

Perlmutter (1968) noted that subject phrases have different extraction properties than that of object phrases, as illustrated in (70). The presence of the complementizer hampers extraction of the subject, but not of the complement.[20]

(70)   a.   * [Who]$_i$ did Tom say (?that) _ $_i$ had bought the tickets?

       b.   * [Who]$_i$ do you believe (?that) _ $_i$ got you fired?

       c.   [The things]$_i$ that they believe (?that) _ $_i$ will happen are disturbing to contemplate.

       d.   * [Who]$_i$ did you ask if _ $_i$ bought the tickets?

       e.   * [Who]$_i$ do you expect for _ $_i$ to fire you?

Bresnan (1977) and others also noted that Complementizer Constraint effects can be reduced in the presence of a adverbial intervening between the complementizer and the gap:

(71)   a.   [Who]$_i$ did Tom say that – as far he could remember – _ $_i$ had bought the tickets?

---

[20]There is no evidence that the Complementizer Constraint applies at the semantic level, however. The subject phrase of the embedded clause can outscope the subject phrase of the matrix:

   (i)   a.   Some teacher claimed that each student had cheated.

         b.   Every teacher claimed that a student had cheated.

    b. [Who]$_i$ do you believe that – for all intents and purposes – _ $_i$ got
       you fired?

    c. [Who]$_i$ do you think that after years and years of cheating death _ $_i$
       finally died?

In Bouma et al. (2001) and Ginzburg & Sag (2000), extracted arguments are typed
as *gap-ss* rather than *canon-ss*. Only the latter are allowed to correspond to *in
situ* signs and to reside in valence lists. However, subject extraction is different.
If a subject phrase is extracted, then the list SUBJ contains the respective *gap-ss*
sign. If one assumes that the lexical entry for the complementizer *that* requires S
complements specified as [SUBJ ⟨ ⟩] then the oddness of (70) follows. For Bouma
et al. (2001) and Ginzburg & Sag (2000), the adverbial circumvention effect in
(71) is the result of assuming that the construction which allows the adverb to
combine with the clause forces the mother node to be [SLASH { }], a rather *ad-hoc*
account.[21]

    A simpler account of the Complementizer Constraint has emerged recently,
however, in principle compatible with any theory of grammar. For Kandybow-
icz (2006; 2009) and others, the Complementizer Constraint is prosodic in nature.
Complementizers must cliticize to the following phonological unit, but if a pause
is made at the gap site then the complementizer cannot do so. Accordingly, if
the pronunciation of *that* is produced with a reduced vowel [ðət] rather than
[ðæt] then the Complementizer Constraint violations in (70) improve in accept-
ability. Though promising, Ritchart et al. (2016) found no experimental evidence
for amelioration of the Complementizer Constraint effects either with phonolog-
ical reduction of the complementizer or with contrastive focus. Further research
is needed to determine the true nature of Complementizer Constraint effects.

11 Island circumvention via ellipsis

Ellipsis somehow renders island constraints inactive, as in (72). A deletion-based
analysis of such phenomena such as Merchant (2001) relies on moving the *wh*-
phrase before deletion takes place, but since movement is assumed to be sensitive
to syntactic island constraints, the prediction is that (72) should be illicit, contrary
to fact.

---

[21]Except that in French, when the subject of the complement CP is extracted, the complementizer
is *qui* instead of *que*, which could easily be captured by such an account.

(72) a. Terry wrote an article about Lee and a book about someone else
          from East Texas, but we don't know who$_i$ (*Terry wrote an article
          about $\_\,_i$ Lee and a book about $\_\,_i$).
          [CSC violation]

     b. Bo talked to the person who discovered something, but I still don't
          know what$_i$ (*Bo talked to the person who discovered $\_\,_i$).
          [CNPC violation]

     c. That he'll hire someone is possible, but I won't divulge who$_i$ (*that
          he'll hire $\_\,_i$ is possible).
          [SSC violation]

     d. She bought a rather expensive car, but I can't remember how
          expensive (*she bought a $\_$ car).
          [LBC violation]

The account adopted in HPSG is one in which remnants are assigned an interpretation based on the surrounding discourse context (Ginzburg & Sag 2000; Culicover & Jackendoff 2005; Jacobson 2008; Sag & Nykiel 2011). See Nykiel & Kim (2018), Chapter 20 of this volume for more detailed discussion. In a nutshell, the *wh*-phrases in (72) are 'coerced' into a proposition-denoting clause via a unary branching construction that taps into contextual information. This straightforwardly explains not only why the antecedent for the elided phrase need not correspond to overt discourse – e.g. sluices like *What floor?* or *What else?* – but also why (72) are immune to island constraints: there simply is no island environment to begin with, and thus, no extraction to violate it.

12 Conclusion

HPSG remains relatively agnostic about many island types given the existence of robust exceptions. It is however clear that many island effects are not purely due to syntactic constraints, and are more likely the result of multiple factors, including pragmatics, semantics and processing difficulty. To be sure, it is yet unclear how these factors can be brought together are articulate an explicit and testable account of island effects. In particular, it is unclear how to combine probabilistic information with syntactic, semantic and pragmatic representations, although one fruitful avenue of approach to this problem may be via *Data-Oriented Parsing* (Neumann & Flickinger 2003; 2015; Arnold & Linardaki 2007; Bod et al. 2003; Bod 2009).

From its inception, HPSG has been meant to be compatible with models of language comprehension and production (Sag 1992; Sag & Wasow 2010; 2015), but not much work has been dedicated to bridging these worlds; see Wasow (2018), Chapter 28 of this volume. The challenge that island effects posit to any theory of grammar is central to linguistic theory and cognitive science: how to integrate theoretical linguistics and psycholinguistic models of on-line language processing so that fine-grained predictions about variability in acceptability judgements across nearly isomorphic clauses can be explained.

Acknowledgements

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Chapter 17

Coordination

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1 Introduction

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orci. Donec faucibus metus dui, nec iaculis purus pellentesque sit amet. Sed fermentum lorem non augue cursus, eu accumsan risus ullamcorper. Suspendisse rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 18

Idioms

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This chapter first sketches basic empirical properties of idioms. The state of the art before the emerge of HPSG is presented, followed by a discussion of four types of HPSG-approaches to idioms. A section on future research closes the discussion.

1 Introdction

In this chapter, I will use the term *idiom* interchangeably with the broader terms such as *phraseme*, *phraseologism*, *phraseological unit*, or *multiword expression*. This means, that I will subsume under this notion expressions such as prototypical idioms (*kick the bucket* 'die'), support verb constructions (*take advantage*), formulaic expression (*Good morning!*) and many more.[1] The main focus of the discussion will, however, be on prototypical idioms, as these have been in the center of the theoretical development.

I will sketch some empirical aspects of idioms in Section 2. In Section 3, I will present the theoretical context within which idiom analyses arose in HPSG. An overview of the development within HPSG will be given in Section 4. Desiderata for future research are mentioned in Section 5, before I close with a short conclusion.

2 Empirical domain

In the context of the present handbook, the most useful characterization of idioms might be the definition of *multiword expression* from Baldwin & Kim (2010).

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[1]I will provide a paraphrase for all idioms at their first mention. They are also listed in the appendix, together with their paraphrase and a remark on which aspects of the idiom are discussed in the text.

For them, any expression counts as a multiword expression if it is syntactically complex and shows some degree of *idiomaticity* (i.e., irregularity), be it lexical, syntactic, semantic, pragmatic, or statistical.[2] Baldwin & Kim's criteria can help us structure the data presentation in this section, expanding them where it seems suitable. My expansions concern the aspects known under *fixedness* in the phraseological tradition as in Fleischer (1997).[3]

For Baldwin & Kim (2010), *lexical idiosyncracy* concerns expressions with words that only occur in an idiom, so-called *phraseologically bound words*, or *cranberry words* (Aronoff 1976). Examples include *make headway* 'make progress', *at first blush* 'at first sight', *in a trice* 'in a moment/very quickly'.[4] For such expressions, the grammar has to make sure that the bound word does not occur outside the idiom, i.e., we need to prevent combinations such as (1b).

(1)   a.   They fixed the problem in a trice.
      b.   *It just took them a trice to fix the problem.

We can expand this type of idiosyncrasy to include a second important property of idioms. Most idioms have a fixed inventory of words. In their summary of this aspect of idioms, Gibbs & Colston (2007: 827–828) include the following examples: *kick the bucket* means *die*, but *kick the pail*, *punt the bucket*, or *punt the pail* do not have this meaning. However, some degree of lexical variation seems to be allowed, as the idiom *break the ice* 'releave tension in a strained situation' can be varied into *shatter the ice*.[5] So, a challenge for idiom theories is to guarantee that the right lexical elements are used in the right constellation.

Syntactic idiomaticity is used in Baldwin & Kim (2010) to describe expressions that are not formed according to the productive rules of English syntax, following

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[2]In the phraseological tradition the aspect of *lexicalization* is added (Fleischer 1997; Burger 1998). This means that an expression is stored in the lexicon. This criterion might have the same coverage as *conventionalization* used in Nunberg et al. (1994). These criteria are addressing the mental representation of idioms as a unit and are, thus, rather psycholinguistic in nature.

[3]Baldwin & Kim (2010) use describe idioms in terms of syntacitc fixedness, but they seem to consider it a derived notion.

[4]See https://www.english-linguistics.de/codii/, accessed 2018-07-25, for a list of bound words in English and German (Trawiński et al. 2008).

[5]While Gibbs & Colston (2007), following Gibbs et al. (1989), present this example as a lexical variation, Glucksberg (2001: 85), from which it is taken, clearly characterizes as having a somewhat different aspect of an "abrupt change in the social climate". Clear cases of synonymy under lexical substitution are found with German *wie warme Semmeln/Brötchen/Schrippen weggehen* (lit.: like warm rolls vanish) 'sell like hotcakes' in which some regional terms for rolls can be used in the idiom.

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Fillmore et al. (1988), such as *by and large* 'on the whole/everything considered', *trip the light fantastic* 'dance'.

In my expanded use of this notion, this also subsumes irregularities/restrictions in the syntactic flexibility of an idiom, i.e., the question whether an idiom can occur in the same syntactic constructions as an analogous non-idiomatic combination. In transformational grammar, such as Weinreich (1969) and Fraser (1970), lists of different syntactic transformations were compiled and it was observed that some idioms allow for certain transformations but not for others. This method has been pursued systematically in the framework of *Lexicon-Grammar* (Gross 1975).[6] Sag et al. (2002) distinguish three levels of fixedness: *fixed*, *semi-fixed*, and *flexible*. Completely fixed idioms include *of course*, *ad hoc* and are often called *words with spaces*. Semi-fixed idioms allow for morpho-syntactic variation, such as inflection. These include some prototypical idioms (*trip the light fantastic*, *kick the bucket*) and complex proper names. In English, semi-flexible idioms show inflection, but cannot easily be passivized or allow for parts of it to be topicalized, see (2).

(2) a. Alex kicked / might kick the bucket.
     b. *The bucket was kicked by Alex.
     c. *The bucket, Alex kicked.

Flexible idioms pattern with free combinations. For them, we do not only find inflection, but also passivization, topicalization or pronominalization of parts etc. Free combinations include some prototypical idioms (*spill the beans* 'reveal a secret', *pull strings* 'exert influence/use one's connections'), but also collocations (*brush one's teeth*) and light verbs (*make a mistake*).

The assumption of two flexibility classes is not uncontroversial: Horn (2003) distinguishes two types among what Sag et al. (2002) consider flexible idioms. Fraser (1970) assumes six flexibility classes, looking at a wide range of syntactic operations. Ruwet (1991) takes issue with the cross-linguistical applicability of the classification of syntactic operations. Similarly, Schenk (1995) claims that for languages such as Dutch and German, automatic/meaningless syntactic processes other than just inflection are possible for semi-fixed idioms, such as verb-second movement and some types of fronting.

The analytic challenge of syntactic idiomaticity is to capture the difference in flexibility in a non-ad hoc way. It is this aspect of idioms that has received particular attention in Generative linguistics, but also in HPSG.

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[6]See Laporte (2018) for a recent discussion of applying this method for a classification of idioms.

Semantic idiomaticity may sound pleonastic, as, traditionally, an expression is called idiomatic if it has a conventional meaning that is different from its literal meaning. Since I use the terms idiom and idiomaticity in a broader sense, the qualification *semantic* idiom(aticity) is needed.

One challenge of the modelling of idioms is to capture the relation between the literal and the idiomatic meaning of an expression. Gibbs & Colston (2007) give an overview over psycholinguistic research on idioms. Whereas it was first assumed that speakers would compute the literal meaning of an expression and, then, derive the idiomatic meaning, evidence has been accumulated that the idiomatic meaning is accessed directly.

Wasow et al. (1984) and Nunberg et al. (1994) explore various semantic relations for idioms, in particular *decomposability* and *transparency*. An idiom is *decomposable* if its idiomatic meaning can be distributed over its component parts in such a way that we would arrive at the idiomatic meaning of the overall expression if we interpreted the syntactic sturcture on the basis of such a meaning assignment. The idiomatic meaning of the expression *pull strings* can be decomposed by interpreting *pull* as *exploit/use* and *strings* as *connections*. The expressions *kick the bucket* and *saw logs* 'snore' are not decomposable.

An idiom is *transparent* if there is a synchronically accessible relation between the literal and the idiomatic meaning of an idiom. For some speakers, *saw logs* is transparent in this sense, as the noise produced by this activity is similar to a snoring noise. For *pull strings*, there is an analogy to a puppeteer controlling the puppets' behavior by pulling strings. A non-transparent idiom is called *opaque*.

Some idioms do not show semantic idiomaticity at all, such as collocations (*brush one's teeth*) or support verb constructions (*take a shower*). Many body-part expressions such as *shake hands* 'greet' or *shake one's head* 'decline/negate' constitute a more complex case they describe a conventionalized activity and denote the social meaning of this activity (Burger 1976).

In addition, we might need to assume a *figurative* interpretation. For some expressions, in particular proverbs or cases like *take the bull by the horns*) we might get a figurative reading rather than an idiomatic reading. Glucksberg (2001) explicitly distinguishes between idiomatic and figurative interpretations. In his view, the above-mentioned case of *shatter the ice* would be a figurative use of the idiom *break the ice*. While there has been a considerable amount of work on figurativity in psycholinguistics, the integration of its results into formal linguistics is still a desideratum.

Pragmatic idiomaticity covers expressions that have a *pragmatic point* in the terminology of Fillmore et al. (1988). These include complex formulaic expres-

sions (*Good morning!*). There has been little work on this aspect of idiomaticity in formal phraseology.

The final type of idiomaticity is *statistical idiomaticity*. Contrary to the other idiomaticity criteria, this is a usage-based aspect. If we find a high degree of co-occurrence of a particular combination of words that is idiosyncratic for this combination, we can speak of a statistical idiomaticity. This category includes *collocations*. Baldwin & Kim (2010) mention *immaculate performance* as an example. Collocations are important in computational linguistics and in foreign-language learning, but their status for theoretical linguistics and for a competence-oriented framework such as HPSG is unclear.

This discussion of the various types of idiomaticity shows that idioms do not form a homogeneous empirical domain but are rather defined negatively. This leads to the basic analytical challenged of idioms: while the empirical domain is defined by absence of regularity in at least one aspect, idioms largely obey the principles of grammar. In other words, there is a lot of regularity in the domain of idioms, while any approach still needs to be able to model the irregular properties.

3 Predecessors to HPSG analyses of idioms

In this section, I will sketch the theoretical environment within which HPSG and HPSG analyses of idioms have emerged.

The general assumption about idioms in Generative grammar is that they must be represented as a complex phrasal form-meaning unit. Such units are inserted *en bloc* into the structure rather than built by syntactic operations. This view goes back to Chomsky (1965: 190). With this unquestioned assumption, arguments for or against particular analyses can be constructed. To give just one classical example, Chomsky (1981) uses the passivizabilty of some idioms as an argument for the existence of Deep Structure, i.e. a structure on which the idiom is inserted holistically. Ruwet (1991) and Nunberg et al. (1994) go through a number of such lines of argumentation showing their basic problems.

The holistic view on idioms is most plausible for idioms that show many types of idiomaticity at the same time, though it becomes more and more problematic if only one or only a few types of idiomaticity are attested. HPSG is less driven by analytical pre-decisions than other frameworks, nonetheless, idioms have been used to motivate assumptions about the architecture of linguistic signs.

Wasow et al. (1984) and Nunberg et al. (1994) are probably the two most influential papers in formal phraseology in the last decades. While there are many

aspects of Nunberg et al. (1994) that have not been integrated into the formal modelling of idioms, there are at least two insights that have been widely adapted in HPSG. First, not all idioms should be represented holistically. Second, the syntactic flexibility of an idiom is related to its semantic decomposability. In fact, they state this last insight even more generally:[7]

(3)   Nunberg et al. (1994: 531):
        We predict that the syntactic flexibility of a particular idiom will
        ultimately be explained in terms of the compatibility of its semantics
        with the semantics and pragmatics of various constructions.

Wasow et al. (1984) and Nunberg et al. (1994) propose a simplified first approach to a theory that would be in line with this quote. They argue that, for English, there is a correlation between syntactic flexibility and semantic decomposability in that non-decomposable idioms are only semi-flexible, whereas decomposable idioms are flexible, to use our terminology from Section 2. This idea has been directly encoded formally in the idiom theory of Gazdar et al. (1985), who define the framework of *Generalized Phrase Structure Grammar* (GPSG).

Gazdar et al. (1985) assume that non-decomposable idioms are inserted into sentences *en bloc*, i.e. as a fully specified syntactic trees which are assigned the idiomatic meaning holistically. This means that the otherwise strictly context-free grammar of GPSG needs to be expanded by adding a (small) set of larger trees. Since non-decomposable idioms are inserted as units, their parts cannot be accessed for syntactic operations, such as passivization or movement. Consequently, the generalization about semantic non-decomposability and syntactic fixedness of English idioms from Wasow et al. (1984) is implemented directly.

Decomposable idioms are analyzed just as free combinations in syntax. The idiomaticity of such expressions is achieved by two assumptions: First, there is lexical ambiguity, i.e. for an idiom like *pull strings*, the verb *pull* has both a literal meaning and an idiomatic meaning. Similarly for *strings*. Second, Gazdar et al. (1985) assume that lexical items are not necessarily translated into total functions but can be partial functions. Whereas the literal meaning of *pull* might be a total function, the idiomatic meaning of the word would be a partial function that is only defined on elements that are in the denotation of the idiomatic meaning of *strings*. This analysis predicts syntactic flexibility for decomposable idioms, just as proposed in Wasow et al. (1984).

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[7]Aspects of this approach are already present in Higgins (1974) and Newmeyer (1974).

4 HPSG-analyses of idioms

HPSG does not make a core-periphery distinction. Consequently, idioms belong to the empirical domain to be covered by an HPSG grammar. Nonetheless, idioms are not discussed in Pollard & Sag (1994) and their architecture of grammar does not have a direct place for an analysis of idioms.[8] They situate all idiosyncrasy in the lexicon, which consists of lexical entries for words. Every word has to satisfy a lexical entry and all principles of grammar, see Davis & Koenig (2018), Chapter 4 of this volume.[9] All properties of a phrase can be inferred from the properties of the lexical items occurring in the phrase and the constraints of grammar.

In their grammar, Pollard & Sag (1994) adhere to *Strict Locality Hypothesis* (SLH), i.e., all lexical entries describe leaf nodes in a syntactic structure, all phrases are constrained by principles that only refer to local (i.e., *synsem*) properties of the phrase and to local properties of its immediate daughters. This hypothesis is summarized in (4).

(4) Strong Locality Hyphothesis (SLH)
     The rules and principles of grammar are statements on a single node of a linguistic structure of on nodes that are immediately dominated by that node.

This precludes any purely phrasal approaches to idioms. Following the heritage of GPSG, we would assume that all regular aspects of linguistic expressions can be handled by mechanisms that follow the SLH, whereas idiomaticity would be a range of phenomena that may violate it. It is, therefore, remarkable that a grammar framework that denies a core-periphery distinction would start with a strong assumption of regularity.

This is in sharp contrast to the basic motivation of Construction Grammar, which assumes that constructions can be of arbitrary depth and of an arbitrary degree of idiosyncrasy. Fillmore et al. (1988) use idiom data and the various types of idiosyncrasy discussed in Section 2 as an important motivation for this assumption. To contrast this position clearly with the one taken in Pollard & Sag (1994), I will state the *Strong Non-locality Hypothesis* (SNH) in (5).

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[8]This section follows the basic structure and argument of Sailer (2012) and Richter & Sailer (2014).

[9]The lexicon can often be expressed by a *Word Principle*, a constraint on words that contains a disjunction of all lexical entries.

(5) Strong Non-locality Hypothesis (SNH)
     The internal structure of a construction can be arbitrarily deep and show
     an arbitrary degree of irregularity at any substructure.

The actual formalism used in Pollard & Sag (1994), King (1989) – see Richter
(2018), Chapter 3 of this volume – does not require the strong versions of the lo-
cality and the non-locality hypotheses, but is compatible with a weaker versions.
I will call these the *Weak Locality Hypothesis* (WLH), and the *Weak Non-locality
Hypothesis* (WNH), see (6) and (7) respectively.

(6) Weak Locality Hypothesis (WLH)
     At most the highest node in a structure is licensed by a rule of grammar
     or a lexical entry.

According to the WLH, just as in the SLH, each sign needs to be licensed by
the lexicon and/or the grammar. This precludes any *en bloc*-insertion analyses,
which would be compatible with the SNH. According to the WNH, in line with
the SLH, a sign can, however, impose further constraints on its component parts,
that may go beyond local (i.e., *synsem*) properties of its immediate daughters.

(7) Weak Non-locality Hypothesis (WNH)
     The rules and principles of grammar can constrain – though not license –
     the internal structure of a linguistic sign at arbitrary depth.

In this section, I will review four types of analyses developed within HPSG, in
a mildly synchronic order: First, I will discuss a conservative extension of Pollard
& Sag (1994) for idioms (Krenn & Erbach 1994) that sticks to the SLH. Then, I will
look at attempts to incorporate constructional ideas more directly, i.e., ways to
include a version of the SNH. The third type of approach will exploit the WLH.
Finally, I will summarize recent apporoaches, which are, again, emphasizing the
locality of idioms.

4.1 Early lexical approaches

Krenn & Erbach (1994), based on Erbach (1992), present the first comprehensive
HPSG account of idioms. They look at a wide variety of different types of German
idioms, including support verb constructions. They only modify the architecture
of Pollard & Sag (1994) marginally and stick to the Strict Locality Hypothesis.
They base their analysis on the apparent correlation between syntactic flexibility

and semantic decomposability from Wasow et al. (1984); Nunberg et al. (1994). Their analysis is a representational variant of the analysis in Gazdar et al. (1985).

To maintain the SLH, Krenn & Erbach (1994) assume that the information available in syntactic selection is slightly richer than what has been assumed in Pollard & Sag (1994): First, they use a lexeme-identification feature, LEXEME, which is located inside the INDEX value and whose value is the semantic constant associated with a lexeme. Second, they include a feature THETA-ROLE, whose value indicates which thematic role a sign is assigned in a structure. In addition to standard thematic roles, they include a dummy value *nil*. Third, as the paper was written in the transition phase between Pollard & Sag (1987) and Pollard & Sag (1994), they assume that the selectional attributes contain complete *sign* objects rather than just *synsem* objects. Consequently, they can assume selection for phonological properties and internal constituent structure, which we could consider a violation of the SLH.

The effect of these changes in the analysis of idioms can be seen in (8) and (9). In (8), I sketch the analysis of syntactically flexible, decomposable idiom, *spill the beans*. There are individual lexical items for the idiomatic words.

(8) a.
$$
\begin{bmatrix} \text{PHON} & \langle \textit{spill} \rangle \\ \text{SYNSEM} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{SUBCAT} & \langle \text{NP}, \text{NP} \begin{bmatrix} \text{LEXEME} & \textit{beans\_i} \end{bmatrix} \rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{REL} & \textit{spill\_i} \end{bmatrix} \end{bmatrix} \end{bmatrix}
$$

b.
$$
\begin{bmatrix} \text{PHON} & \langle \textit{beans} \rangle \\ \text{SYNSEM} & \begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \text{INDEX} & \begin{bmatrix} \text{LEXEME} & \textit{beans\_i} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}
$$

The LEXEME values of these words can be used to distinguish them from their ordinary, non-idiomatic, homonyms. Each idiomatic word comes with its idiomatic meaning, which models the decomposability of the expression. The lexical items satisfying the entries in (8) can undergo lexical rules such as passive.

The idiomatic verb *spill* selects an NP complement with the LEXEME value *beans_i*. The lexicon is built in such a way that no other word selects for this LEXEME value. This models the lexical fixedness of the idiom.

The choice of putting the lexical identifier into the INDEX guarantees that it is shared between a lexical head and its phrase, which allows for syntactic flexibility inside the NP. Similarly, the information shared between a trace and its

antecedent contains the INDEX value. Consequently, participation in unbounded dependency constructions is equally accounted for. Finally, since a pronoun has the same INDEX value as its antecedent, pronominalization is also possible.

I sketch the analysis of a non-decomposable, fixed idioms, *kick the bucket*, in (9). In this case, there is only a lexical entry of the syntactic head of the idiom, the verb *kick*. It selects the full phonology of its complement. This blocks any syntactic processes inside this NP. It also follows that the complement cannot be realized as a trace, which blocks extraction. The special THETA-ROLE value *nil* will be used to ensure that the non-applicability of lexical rules

$$(9) \quad \begin{bmatrix} \text{PHON} & \langle \textit{kick} \rangle \\ \text{SYNSEM} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{SUBCAT} & \left\langle \text{NP, NP} \begin{bmatrix} \text{PHON} & \langle \textit{the, bucket} \rangle \\ \text{THETA-ROLE} & \textit{nil} \end{bmatrix} \right\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{REL} & \textit{die} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

With this analysis, Krenn & Erbach (1994) capture the both, the idiosyncratic aspects and the regularity, of idioms. They show how it generalizes to a wide range of idiom types. There are, however a number of problems. I will just mention few of them here.

There are two problems for the analysis of non-decomposable idioms. First, the approach is too restrictive with respect to the syntactic flexibility of *kick the bucket*, as it excludes cases such as *kick the social/figurative bucket*, which have are discussed in Ernst (1981). Second, it is built on equating the class of non-decomposable idioms with that of semi-fixed idioms. As shown above, this cannot be maintained.

There are also some problems with the LEXEME-value selection. The index-identity between a pronoun and its antecedent would require that the subject of the relative clause in (10) has the same INDEX value as the head noun *strings*. However, the account of the lexical fixedness of idioms is built on the assumption that no verb except for the idiomatic *pull* selects for an argument with LEXEME value *strings_i*.[10]

(10)   Parky pulled the strings that got me the job. (McCawley 1981: 137)

The analytic ingredients of Krenn & Erbach (1994) constitute the basis of later HPSG analyses. In particular, a mechanism for lexeme-specific selection has been

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[10]Pulman (1993) discusses the analogous problem for the denotational theory of Gazdar et al. (1985).

widely assumed in most approaches. The attribute THETA-ROLE can be seen as a simple for of an *inside-out* mechanism, i.e., as a mechanism of encoding information about the larger structure within which a sign appears.

4.2 Phrasal approach

With the advent of constructional analyses within HPSG, starting with Sag (1997), it is natural to expect phrasal accounts of idioms to emerge as well, as idiomaticity is a central empirical domain for Construction Grammar, see Müller (2018), Chapter 37 of this volume. In this version of HPSG, there is an elaborate type hierarchy below *phrase*. Sag (1997) also introduces *defaults* into HPSG, which play an important role in the treatment of idioms in constructional HPSG. The clearest phrasal approach to idioms can be found in Riehemann (2001), which incorporates insights from earlier publications such as Riehemann (1997) and Riehemann & Bender (1999). The overall framework of Riehemann (2001) is constructional HPSG with *Minimal Recursion Semantics* (MRS) (Copestake et al. 1995; 2005), see also Koenig & Richter (2018), Chapter 24 of this volume.

For Riehemann, idioms are phrasal units. Consequently, she assumes a subtype of *phrase* for each idiom, such as *spill-beands-idiomatic-phrase* or *kick-bucket-idiomatic-phrase*. The proposal in Riehemann (2001) is at the same time phrasal and obeys the SLH. To achieve this, Riehemann (2001) assumes and attribute WORDS, whose value contains all words dominated by a phrase. This makes it possible to say that a phrase of type *spill-beans-idiomatic-phrase* dominates the words *spill* and *beans*. This is shown in the relevant type constraint for the idiom *spill the beans* in (11).[11]

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[11]The percolation mechanism for the feature WORDS is rather complex. In fact, in Riehemann (2001: Section 5.2.1) the idiom-specific words appear within an C-WORDS value, the other words dominated by the idiomatic phrase in the value of an attribute OTHER-WORDS, which together form the value of WORDS. While all the values of these features are subject to local percolation principles, the fact that entire words are percolated undermines the locality intuition behind the SLH.

(11) Constraint on the type *spill-beans-idiomatic-phrase* from Riehemann (2001: 185):

$$
\begin{bmatrix}
\textit{spill-beans-ip} \\
\text{WORDS} \left\langle
\begin{bmatrix}
\textit{i\_spill} \\
\text{...LISZT} \left\langle
\begin{bmatrix}
\textit{i\_spill\_rel} \\
\text{UNDERGOER} \quad \boxed{1}
\end{bmatrix}
\right\rangle
\end{bmatrix}
\overset{\leq}{\sqcap}
\begin{bmatrix}
\text{...LISZT} \left\langle \textit{\_spill\_rel} \right\rangle
\end{bmatrix},
\\
\begin{bmatrix}
\textit{i\_bean} \\
\text{...LISZT} \left\langle
\begin{bmatrix}
\textit{i\_bean\_rel} \\
\text{INST} \quad \boxed{1}
\end{bmatrix}
\right\rangle
\end{bmatrix}
\overset{\leq}{\sqcap}
\begin{bmatrix}
\text{...LISZT} \left\langle \textit{\_bean\_rel} \right\rangle
\end{bmatrix}, ...
\right\rangle
\end{bmatrix}
$$

The WORDS value of the idiomatic phrase contains at least two elements, the idiomatic words of type *i_spill* and *i_beans*. The special symbol " $\overset{\leq}{\sqcap}$ " used in this constraint expresses a default. It says that the idiomatic version of the word *spill* is just like its non-idiomatic homonym, except for the parts specified in the left-hand side of the default. In this case, the type of the words and the type of the semantic predicate contributed by the words are changed. Riehemann (2001) only has to introduce the types for the idiomatic words in the type hierarchy but need not specify type constraints on the individual idiomatic words, as these are constrained by the default statement within the constraints on the idioms containing them.

As in the account of Krenn & Erbach (1994), the syntactic flexibilty of the idiom follows from its free syntactic combination and the fact that all parts of the idiom are assigned an independent semantic contribution. The lexical fixedness is a consequence of the requirement that particular words are dominated by the phrase, namely the idiomatic versions of *spill* and *beans*.

The appeal of the account is particularly clear in its application to non-decomposable, semi-flexible idioms such as *kick the bucket* (Riehemann 2001: 212). For such expressions, the constituting idiomatic words are assumed to have an empty semantics and the semantics of the idiom is contributed as a constructional semantic contribution by only by the idiomatic phrase. Since the WORDS list contains entire words, it is also possible to require that the idiomatic word *kick* be in active voice and/or that it takes a complement compatible with the description of the idiomatic word *bucket*. This analysis captures the syntactically regular internal structure of this type of idioms, and is compatible with the occurrence

of modifiers such as *proverbial*. At the same time, it prevents passivization and excludes extraction of the complement.

Riehemann's approach clearly captures the intuition of idioms as phrasal units much better than any other approach in HPSG. However, it faces a number of problems. Frist, the integration of the approach with constructional HPSG is done in such a way that the phrasal types for idioms are cross-classified in complex type hierarchies with the various syntactic constructions in which the idiom can appear. This allows Riehemann to account for idiosyncratic differences in the syntactic flexibility of idioms, but the question is whether such an explicit encoding misses generalizations that should follow from indepedent properties of the components of an idiom and/or of the syntactic construction – in line with the quote from Nunberg et al. (1994) in (3).

Second, the mechanism of percolating dominated words to each phrase is not compatible with the intuitions of most HPSG researchers. Since no empirical motivation for such a mechanism outside idioms is provided in Riehemann (2001), this idea has not been pursued in other papers.

Third, the question of how to block the occurrence of idiomatic words outside idioms is not solved in Riehemann (2001), i.e., while the idiom requires the presence of particular idiomatic words, the occurrence of these words is not restricted.[12]

Before closing this subsection, I would like to point out that Riehemann (2001) and Riehemann & Bender (1999) are the only HPSG papers on idioms that address the question of statistical idiomaticity, based on the variationist study in Bender (2000). In particular, Riehemann (2001: 297–301) proposes phrasal constructions for collocations even if these do not show any lexical, syntactic, semantic, or pragmatic idiosyncrasy but just a statistical co-occurrence preference. She extends this into a larger plea for an *experience-based HPSG*. Bender (2000) discusses the same idea under the notions of *minimal* versus *maximal* grammars, i.e., grammars that are as free of redundancy as possible to capture the grammatical sentences of a language with their correct meaning versus grammars that might be open to an connection with usage-based approaches to language modelling. Bender (2000: 292) sketches a version of HPSG with frequencies/probabilities

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[12]Since the problem of free occurrences of idiomatic words is not an issue for parsing, versions of Riehemann's approach have been integrated in practical parsing systems (Villavicencio & Copestake 2002), see Bender & Emerson (2018), Chapter 29 of this volume. Similarly, the approach to idioms sketched in Flickinger (2015) is part of a system for parsing and machine translation. Idioms in the source language are identified by bits of semantic representation – analogous to the elements in the words set. This approach, however, does not constitute a theoretical modelling of idioms within one language.

attached to lexical and phrasal types.[13]

4.3 Mixed lexical and phrasal approaches

While Riehemann (2001) proposes a parallel treatment of decomposable and non-decomposable idioms – and of flexible and semi-flexible idioms, the devision between fixed and non-fixed expressions is at the core of another approach, the *two-dimensional theory of idioms*. This approach was first outlined in Sailer (2000) and referred to under this label in Richter & Sailer (2009; 2014). It is intended to combine constructional and collocational approaches to grammar.

The basic intuition behind this approach is that signs have internal and external properties. All properties that are part of the feature structure of a sign are called *internal*. Properties that relate to larger feature structures containing this sign are called its *external* properties. The approach assumes that there is a notion of *regularity* and that anything diverging from it is *idiosyncratic* – or idiomatic, in the terminology of this chapter.

This approach is another attempt to reify the GPSG analysis within HPSG. Sailer (2000) follows the distinction of Nunberg et al. (1994) into non-decomposable and non-flexible idioms on the one hand and decomposable and flexible idioms on the other. The first group is considered internally irregular and receives a constructional analysis in terms of a *phrasal lexical entry*. The second group is considered to consists of independent, smaller lexical units that show an external irregularity in being constrained to co-occur within a larger structure. Idioms of the second group receive a collocational analysis. The two types of irregularity are connected by the *Predictability Hypothesis*, given in (12).

(12) Predictability Hypothesis (Sailer 2000: 366):
      For every sign whose internal properties are fully predictable, the
      distributional behavior of this sign is fully predictable as well.

In the most recent version of this approach, Richter & Sailer (2009), there is a feature COLL defined on all signs. The value of this feature specifies the type of internal irregularity. The authors assume a cross-classification of regularity and irregularity with respect to syntax, semantics, and phonology – ignoring

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[13]A so-far unexplored solution to the problem free occurrence of idiomatic words within an experience-based version of HPSG could be to assign the type *idiomatic-word* an extremely low probability of occurring. This might have the effect that such a word can only be used if it is explicitly required in a construction. However, note that neither defaults nor probabilities are well-defined part of the formal foundations of theoretical work on HPSG, see Richter (2018), Chapter 3 of this volume.

pragmatic and statistical (ir)regularity in their paper. Every basic lexical entry is defined as completely irregular as its properties are not predictable. Fully regular phrases such as *read a book* have a trivial value of COLL. A syntactically internally regular but fixed idiom such as *kick the bucket* is classified as having only semantic irregularity, whereas a syntactically irregular expression such as *trip the light fantastic* is of an irregularity type that is a subsort of syntactic and semantic irregularity, but not of phonological irregularity. Following the terminology of Fillmore et al. (1988), this type is called *extra-grammatical-idiom*. The phrasal lexical entry for *trip the light fantastic* is sketched in (13).

(13)   Phrasal lexical entry for the idioms *trip the light fantastic*:

$$
\begin{bmatrix}
\textit{phrase} \\
\text{PHON } \boxed{1} \oplus \langle \textit{the, light, fantastic} \rangle \\
\text{SYNS} \begin{bmatrix} \text{LOC} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD} & \boxed{4} \\ \text{LISTEME } \textit{trip-the-light-fantastic} \\ \text{VAL} & \boxed{5} \begin{bmatrix} \text{SUBJ } \langle \boxed{2} [\ldots\text{INDEX } \boxed{3}] \rangle \end{bmatrix} \end{bmatrix} \\ \text{CONT} \begin{bmatrix} \textit{trip-light-fant} \\ \text{DANSER } \boxed{3} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\
\text{DTRS} \begin{bmatrix} \textit{headed-structure} \\ \text{HEAD-DTR} \begin{bmatrix} \text{PHON } \boxed{1} \\ \ldots\text{CAT} \begin{bmatrix} \text{HEAD} & \boxed{4} \textit{ verb} \\ \text{LISTEME } \textit{trip} \\ \text{VAL} & \boxed{5} \begin{bmatrix} \text{SUBJ} & \langle \boxed{2} \rangle \\ \text{COMPS} & \langle \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\
\text{COLL} \quad \textit{extra-grammatical-idiom}
\end{bmatrix}
$$

In (13), the constituent structure of the phrase is not specified, but the phonology is fixed, with the exception of the head daughter's phonological contribution. This accounts for the syntactic irregularity of the idiom. The semantics of the idiom is not related to the semantic contributions of its components, which accounts for the semantic idiomaticity.

Soehn (2006) applies this theory to German. He solves the problem of the relatively large degree of flexibility of non-decomposable idioms in German by

using underspecified descriptions of the constituent structure dominated by the idiomatic phrase.

For decomposable idioms, the two-dimensional theory assumes a collocational component. This component is integrated into the value of an attribute REQ, which is only defined on *coll* objects of one of the irregularity types. This encodes the Predictability Hypothesis. The most comprehensive version of this collocational theory is given in Soehn (2009), summarizing and extending ideas from Soehn (2006) and Richter & Soehn (2006). Soehn assumes that collocational requirements can be of various types: a lexical item can be constrained to co-occur with particular *licensers* (or collocates). These can be other lexemes, semantic operators, or phonological units. In addition, the domain within which this licensing has to be satisfied is specified in terms of syntactic barriers, i.e., syntactic nodes dominating the externally irregular item.

To give an example, the idiom *spill the beans* would be analyzed as consisting of two idiomatic words *spill* and *beans* with special LISTEME values *spill-i* and *beans-i*. The idiomatic verb *spill* imposes a lexeme-selection on its complement. The idiomatic noun *beans* has a non-empty REQ value, which specifies that it must be selected by a word with LISTEME value *spill-i* within the smallest complete clause dominating it.

The two-dimensional approach suffers from a number of weaknesses. First, it presupposes a notion of regularity. This assumption is not shared by all linguists. Second, the criteria whether an expression should be treated constructionally or collocationally are not always clear. Idioms with irregular syntactic structure need to be analyzed constructionally, but this is less clear for non-decomposable idioms with regular syntactic structure such as *kick the bucket*. Here, the approach inherits the weakness of Wasow et al. (1984) equating syntactic flexibility and semantic decomposability.

4.4 Recent lexical approaches

Kay et al. (2015) marks an important re-orientation in the analysis of idioms: the lexical analysis is extended to all syntactically regular idioms, i.e., to both decomposable (*spill the beans*) and non-decomposable idioms (*kick the bucket*).[14]

Though Kay et al. (2015) use Sign-based Construction Grammar, I consider it legitimate and important to include their analysis here. Kay et al. (2015) achieve a lexical analysis of non-decomposable idioms by two means: (i) an extension

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[14]This idea has been previously expressed within a more generative grammar perspective in Everaert (2010).

of the HPSG selection mechanism, (ii) the assumption of semantically empty idiomatic words.

As in previous accounts, the relation among idiom parts is established through lexeme-specific selection, using a feature LID (for: *lexical identifier*). The authors assume that there is a difference between idiomatic and non-idiomatic LID values. Only heads that are part of idioms themselves can select for idiomatic words.

For the idiom *kick the bucket*, Kay et al. (2015) assume that all meaning is carried by the lexical head, an idiomatic version of *kick*, whereas the other two words, *the* and *bucket* are meaningless. This meaninglessness allows Kay et al. to block the idiom from occurring in constructions which reuqire meaningful constituents, such as questions, *it*-clefts, middle and others. To exclude passivization, the authors assume that English passive cannot apply to verbs selecting a semantically empty direct object.

The approach in Kay et al. (2015) is a recent attempt to maintain the SLH as much as possible. Since the SLH has been a major conceptual motivation for SBCG, Kay et al.'s paper is an important contribution to show the empirical robustness of this assumption.

Bargmann & Sailer (2018) propose a similar lexical approach to non-decomposable idioms. They take as their starting point the syntactic flexibility of semantically non-decomposable idioms in Engish and, in particular, in German. There are two main differences between Kay et al.'s paper and Bargmann & Sailer's: (i), Bargmann & Sailer assume a collocational rather than a purely selectional mechanism to capture lexeme-restrictions of idioms, and (ii), they propose a redundant semantics rather than an empty semantics for idiom parts in non-decomposable idioms. In other words, Bargmann & Sailer (2018) propose that both *kick* and *bucket* contribute the semantics of the idiom *kick the bucket*. Bargmann & Sailer argue that the semantic contiributions of parts of non-decomposable, syntactically regular idioms are the same across languages, whereas the differences in syntactic flexibility are related to the different syntactic, semantic, and pragmatic constraints imposed on various constructions. To give just one example, whereas passive subjects in German are almost non restricted, there are strong discourse-structural constraints on passive subjects in English.

Both Kay et al. (2015) and Bargmann & Sailer (2018) attempt to derive the (partial) syntactic inflexibility of non-decomposable idioms from independent properties of the relevant constructions. As such, they subscribe to the programmatic statement of Nunberg et al. (1994) from (3) above. In this respect, the extension of the lexical approach from decomposable idioms to all syntactically regular expressions has been a clear step forward.

Findlay (2017) provides a recent discussion and criticism of lexical approaches to idioms in general, which applies in particular to non-decomposable expressions. His reservations comprise the following points. First, there is a massive proliferation of lexical entries for otherwise homophonous words. Is is unclear, for example, if a separate definite article is needed for each idiom which contains one, i.e., it might turn out that we need different lexical entries for the word *the* in *kick the bucket*, *shoot the breeze*, and *shit hits the fan*. Second, the lexical analysis does not represent idioms as units, which might make it difficult to connect their theoretical treatment with processing evidence. Findlay refers to psycholinguistic studies, such as Swinney & Cutler (1979), that point to a faster processing of idioms than of free combinations.

5 Where to go from here?

The final section of this article contains short overviews over research that has been done in areas of phraseology that are outside the main thread of this chapter. I will also identify desiderata.

5.1 Neglected phenomena

Not all types of idioms and not all types of idiomaticity mentioned in Section 2 have received an adequate treatment in the (HPSG) literature. I will briefly look at three empirical areas that deserve more attention: neglected types of idiom variation, phraseological patterns, and the literal and non-literal meaning components of idioms.

Most studies on idiom variation have looked at verb- and sentence-related syntactic constructions, such as passive and topicalization. However, not much attention has been payed to lexical variation in idioms. This is illustrated by the following examples from Richards (2001: 184, 191).

(14) a. The Count gives everyone the creeps.
  b. You get the creeps (just looking at him).
  c. I have the creeps.

In (14), the alternation of the verb seems to be very systematic – and has been used by Richards (2001) to motivate a lexical decomposition of these verbs. A similar argument has been made in Mateu & Espinal (2007) for Catalan. We are lacking systematic, larger empirical studies of this type of substitution, and it would be important to see how it can be modeled in HPSG. One option would be

to capture the *give–get–have* alternation(s) with lexical rules. Such lexical rules would be different from the standard cases, however, as they would change the lexeme itself rather than just alternating its morpho-syntactic properties or its semantic contribution.

In the case mentioned in footnote 5, the alternation consists in substituting a word with a (near) synonym and keeping the meaning of the idiom intact. Again, HPSG seems to have all the required tools to model this phemonenon – for example, by means of hierarchies of lexical-id values. However, the extent of this phenomenon across the set of idioms is not known empirically.

In the domain of syntactic variation, the nominal domain has not received the attention it might deserve yet. There is a well-known variation with respect to the marking of possession within idioms. This has been documented for English in Ho (2015), for Modern Hebrew in Almog (2012), for Modern Greek and German in Markantonatou & Sailer (2016). In German, we find a relatively free alternation between a plain definite and a possessive, see (15a). This is, however, not possible with all idioms, (15b).

(15)   a.   Alex hat den / seinen Verstand verloren.
             Alex has the   his   mind   lost
             'Alex lost his mind.'

       b.   Alex hat *den / ihren Frieden mit   der Situation gemacht.
             Alex has the   her   peace   with the situation made
             'Alex made her peace with the situation.'

We can also find a free dative in some cases, expressing the possessor. In (16a), a dative possessor may co-occur with a plain definite or a coreferential possessive determiner, in (16b) only the definite article but not the possessive determiner is possible.

(16)   a.   Alex hat mir   das / mein Herz gebrochen.
             Alex has me.DAT the   my   heart broken
             'Alex broke my heart.'

       b.   Alex sollte mir   lieber aus   den / *meinen Augen gehen.
             Alex should me.DAT rather out of the   my   eyes   go
             'Alex should rather disappear from my sight.'

While they do not offer a formal encoding, Markantonatou & Sailer (2016) observe that a particular encoding of possession in idioms is only possible if it

would also be possible in a free combination. However, an idiom my be idiosyncratically restricted to a subset of the realizations that would be possible in a corresponding free combination. A formalization in HPSG might consist of a treatment of possessively used definite determiners, combined with an analysis of free datives as an extension of a verb's argument structure.

Related to the question of lexical variation are *phraseological patterns*, i.e., very schematic idioms in which the lexical material is largely free. Some examples of phraseological patterns are the *Incredulity Response Construction* as in *What, me worry?* (Akmajian 1984; Lambrecht 1990), or the *What's X doing Y?*-construction (Kay & Fillmore 1999). Such patterns are of theoretical importance as they typically involve a non-canonical syntactic pattern. The different locality and non-locality hypotheses introduced above make different predictions. Fillmore et al. (1988) have presented such constructions as a motivation for the non-locality of constructions, i.e., as support of a SNH. However, Kay & Fillmore (1999) show that a lexical analysis might be possible for some cases at least. Kay & Fillmore provide a detailed lexical analysis of the *What's X doing Y?*-construction.

Borsley (2004) looks at another phraseological pattern, the *the X-er the Y-er*-construction, or *comparative correlative construction*. Borsley analyzes this construction by means of two special (local) phrase structure types: one for the comparative *the*-clauses, and one for the overall construction. He shows that (i), the idiosyncrasy of the construction concerns two levels of embedding and is, therefore, non-local, however, (ii), a local analysis is still possible. This approach raises the question as to whether the WNH is empirically vacuous since we can always encode a non-local construction in terms of a series of idiosyncratic local construction. Clearly, work on more phraseological patterns is needed to assess the various analytical options and their consequences for the architecture of grammar.

A major charge for the conceptual and semantic analysis of idioms is the interaction between the literal and the idiomatic meaning. I presented the basic empirical facts in Section 2. All HPSG approaches to idioms so far basically ignore the literal meaning. This position might be justified, as an HPSG grammar should just model the structure and meaning of an utterance and need not worry about the meta-linguistic relations among different lexical items or among different readings of the same (or a homophonous) expression. This is an important conceptual point that immediately provides possibilities to connect HPSG research to other disciplines and/or frameworks, such as cognitive linguistics, such as Dobrovol'skij & Piirainen (2005), and psycholinguistics.

5.2 Challenges from other languages

The majority of work on idioms in HPSG has been done on English and German. As discussed in Section 4.4, the recent trend in HPSG idiom research necessitates a detailed study of individual syntactic structures. Consequently, the restriction on two closely related languages limits the possible phenomena that can be studied on idioms. It would be essential to expand the empirical coverage of idiom analyses in HPSG to as many different languages as possible. The larger degree of syntactic flexibility of French, German, and Dutch idioms (Ruwet 1991; Nunberg et al. 1994; Schenk 1995) has led to important refinements of the analysis in Nunberg et al. (1994) and, ultimately, to the lexical analyses of all syntactically regular idioms.

Similarly, the above-mentioned data on possessive alternations only become prominent when languages beyond English are taken into account. The languages mentioned above (16) all show the type of external possessor classified as a European areal phenomenon in Haspelmath (1999). It would be important to look at idioms in languages with other types of external possessors.

In a recent paper, Sheinfux et al. (2018) provide data from Modern Hebrew that show that opacity and figurativity of an idiom are decisive for its syntactic flexibility rather than decomposability. This result stresses the importance of the literal reading for an adequate account of the syntactic behavior of idioms. It shows that the inclusion of other languages can cause a shift of focus to other types of idioms or other types of idiomaticity.

To add just one more example, HPSG(-related) work on Persian such as Müller (2010) and Samvelian & Faghiri (2016) establishes a clear connection between complex predicates and idioms. Their insights might also lead to a reconsideration of the similarities between light verbs and idioms, as already set out in Krenn & Erbach (1994).

As far as I can see, the following empirical phenomena have not been addressed in HPSG-approaches to idioms as they do not occur in the main object languages for which we have idiom analyses, i.e. English and German. They are, however, common in other languages: the occurrence of clitics in idioms (found in Romance and Greek); aspectual alternations in verbs (Slavic and Greek); argument alternations other than passive (such as anti-passive, causative, inchoative etc (in part found in Hebrew and addressed in Sheinfux et al. (2018)); displacement of idiom parts into special syntactic positions (focus position in Hungarian).

Finally, so far, idioms have usually been considered as either offering irregular structures or as being more restricted in their structures than free combinations. In some languages, however, we find archaic syntactic structures and function

words in idioms that do not easily fit these two analytic options. To name just a few, Lødrup (2009) argues that Norwegian used to have an external possessor construction similar to that of other European languages, which is only conserved in some idioms. Similarly, Dutch has a number of archaic case inflections in multiword expressions (Kuiper 2018: 129), and there are archaic forms in Modern Greek multiword expressions. It is far from clear what the best way would be to integrate such cases into an HPSG grammar.

6 Conclusion

Idioms are among the topics in linguistics for which HPSG-related publications have had a clear impact on the field and have been widely quoted across frameworks. This handbook article aimed at providing an overview over the development of idiom analyses in HPSG. There seems to be a clear development towards ever more lexical analyses, starting from the holistic approach for all idioms in Chomsky's work, to a lexical account for all syntactically regular expressions. However, it is very likely that phrasal analyses are going to experience a comeback in the near future.

The sign-based character of HPSG seems to be particularly suited for a theory of idioms as it allows to take into consideration syntactic, semantic, and pragmatic aspects and to use them to constrain the occurrence of idioms appropriately.

Appendix: List of used idioms

Some idioms do not show semantic idiomaticity at all, such as collocations (*brush one's teeth*) or support verb constructions (*take a shower*). Many body-part expressions such as *shake hands* 'greet' or *shake one's head* 'decline/negate' constitute a more complex case they describe a conventionalized activity and denote the social meaning of this activity (Burger 1976).

English

idiom	paraphrase	comment
break the ice	relieve tension in a strained situation	non-decomposable
brush one's teeth	clean one's teeth with a tooth brush	collocation, no idiomaticity
give so the creeps	make so feel uncomfortable	systematic lexical variation
Good morning!	(morning greeting)	formulaic expression
immaculate performance	perfect performance	statistical idiomaticity
in a trice	in a moment	bound word: *trice*
kick the bucket	die	non-decomposable
make headway	make progress	bound word: *headway*
pull strings	exert influence/use one's connections	flexible
saw logs	snore	transparent, non-decomposable, semi-flexible
shake hands	greet	body-part expression
shake one's head	decline/negate	body-part expression, possessive idiom
take a shower	clean oneself using a shower	collocation, light verb construction
shake hands	greet	body-part expression
shake one's head	decline/negate	body-part expression
shit hit the fan	there is trouble	subject as idiom component, transparent/figurative, non-decomposable
shoot the breeze	chat	non-decomposable
spill the beans	reveal a secret	flexible
take a shower	to shower	collocation
take the bull by the horns	approach a problem directly	figurative expression
trip the light fantactic	dance	syntactically irregular

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German

idiom	gloss	translation	comment
den/seinen Verstand verlieren	the/one's mind lose	lose one's mind	alternation of possessor marking
jm das Herz brechen	so the heart break	break s.o.'s heart	dative possessor and possessor alternation
jm aus den Augen gehen	so out of the eyes go	disappear from s.o.'s sight	dative possessor, restricted possessor alternation
seinen Frieden machen mit	one's peace make with	make one's peace with	no possessor alternation possible
wie warme Semmeln/Brötchen/Schrippen weggehen	like warm rolls vanish	sell like hotcakes	parts can be exchanged by synonyms

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Abbreviations

GPSG   Generalized Phrase Structure Grammar (Gazdar et al. 1985)
MRS   Minimal Recursion Semantics (Copestake et al. 2005)
MWE   multiword expression
SLH   Strong Locality Hypothesis, see page 295
SNH   Strong Non-locality Hypothesis, see page 296
WLH   Weak Locality Hypothesis, see page 296
WNH   Weak Non-locality Hypothesis, see page 296

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Chapter 19

Negation

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1 Modes of Expressing Negation

Each language has its own way of expressing negation with grammatical restrictions in its surface realizations. This chapter aims to provide an investigation of morpho-syntactic aspects of negation in natural languages, encompassing both empirical and theoretical issues concerning negation as well as related phenomena in question.

There are four main ways of expressing negation in the languages: morphological negative, auxiliary negative verb, adverbial negative, and clitic-like negative (see Dahl (1979), Payne (1985), and Dryer (2005)). Each of these types is illustrated in the following:

(1) a. Turkish:

Ali elmalar-i   ser-me-di-∅.
Ali apples-ACC like-NEG-PST-3SG

'Ali didn't like apples.'

b. Korean:

sensayng-nim-i   o-ci   anh-usi-ess-ta
teacher-HON-NOM come-CONN NEG-HON-PST-DECL

'The teacher didn't come.'

c. French:

Dominique (n')écrivait pas de lettre.
Dominique wrote   NEG of letter

'Dominiquedid not write a letter.'

d. Italian:

Gianni non legge articoli di sintassi.
Gianni NEG reads articles of syntax

'Gianni doesn't read syntax articles.'

As given in (1a), languages like Turkish have typical examples of morphological negatives where negation is expressed by an inflectional category realized on the verb by affixation. Meantime, languages like Korean employ a negative auxiliary verb as in (1b).[1] The negative auxiliary verb here is marked with the basic verbal categories such as agreement, tense, aspect, and mood, while the main verb remains in an invariant, participle form. The third major way of expressing negation is to use an adverb-like particle. This type of negation, forming an independent word, is prevalent in English and French, as given in (1c). In these languages, negative markers behave like adverbs in their ordering with respect to the verb. The fourth type is to introduce a clitic-like element in expressing sentential negation. The negative marker in Italian in (1d), preceding a finite verb like other types of clitics in the language, belongs to this type.

This chapter provides a construction-based HPSG analysis of these four main types of negation we find in natural languages and and further answers the following three questions:

- What are the main ways of expressing sentential negation or negating a sentence or clause?

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[1]Korean is peculiar in that it has two ways to express sentential negation: a negative auxiliary (a long form negation) and a morphological negative (a short form negation) for sentential negation. See Kim (2000; 2016) and references therein for detail.

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- What are the distributional possibilities of negative markers in relation to other main constituents of the sentence?

- What do the answers to these two questions imply for the theory of grammar?

This chapter addresses these questions, based on empirical data, theoretical issues, and analyses of negation.

2 Derivational Views

The derivational view has claimed that the positioning of all of the four types of negatives is basically determined by the interaction of movement operations, a rather large set of functional projections including NegP, and their hierarchically fixed organization.

English and French display systematic differences with respect to negation, adverb position, and subject-aux inversion, as illustrated in the following:

Position of Negation:

(2) a. * Kim likes not Lee.
    b.   Kim does not like Lee.

(3) a. Robin n'aime   pas Stacey.
       Robin (n')likes NEG Stacey

       'Robin does not like Stacey.'
    b. * Robin ne pas aime Stacey.

Position of Adverbs:

(4) a. * Kim kisses often Lee.
    b.   Kim often kisses Lee.

(5) a. * Robin embrasse souvent Stacey.
    b.   Robin souvent embrasse Stacey.

Subject–Verb Inversion in Questions:

(6) a. * Likes he Sandy?
    b.   Does he like Sandy?

(7) a. * Likes Lou Sandy?

　　 b. 　Aime-t-il Sandy?

The examples illustrate that in English, the negator *not* and adverb *often* need to precede a main verb, while in French, the corresponding negator *pas* and adverb *souvent* follow a main verb. In addition, only French allows the main verb inversion. Drawing on the earlier insights of Emonds (1978), Pollock (1989; 1994) and a number of subsequent researchers have interpreted these contrasts as providing critical motivation for the process of head movement and the existence of functional categories such as MoodP, TP, AgrP, and NegP (see Belletti (1990), Zanuttini (1991; 1997; 2001), Chomsky (1991; 1993; 1995), Lasnik (1995), Haegeman (1995; 1997), Vikner (1997), Zeijlstra (2015), inter alia). It has been widely accepted that the variation between French and English illustrated here can be explained only in terms of the respective properties of verb movement and its interaction with a view of clause structure organized around functional projections.

For example, in Pollock (1989)'s proposal, all verbs in French move to a higher structural position, whereas this is possible in English only for the auxiliaries *have* and *be*, as shown in Figure 1.

Why does V-movement happen when it does? This question has been answered in diverse (and sometimes inconsistent) ways in the literature (see Pollock (1989; 1994; 1997b,a), Vikner (1994; 1997)). In Pollock (1989), it is the strength of the Agr feature that determines V-movement: unlike French, English non-auxiliary verbs cannot undergo V-movement because Agr in French is 'transparent' (or 'strong') whereas Agr in English is 'opaque' (or 'weak'). The richness of French verbal morphology is assumed to provide the motivation for the strength of French Agr, in consequence of which the raised verb in French can transmit theta roles to its arguments through AGR, thus avoiding any violation of the theta criterion. But the weakness of English Agr (assumed to follow from the paucity of English verbal morphology) is what blocks lexical verbs from assigning theta roles once they have moved to Tns. Hence movement of a theta-assigning verb in English would result in a violation of the theta criterion.

The basic spirit of Pollock's analysis—that 'morphology determines syntactic movement'—has remained essentially unchanged for the last decades though what triggers V-movement has varied considerably in subsequent work (see, among others, Zanuttini (2001), Bošković (2014), Zeijlstra (2015)). As far as we are aware, there is no agreed upon movement-based analysis of either the English or French systems. In fact, as Lasnik (2000)) stresses, the Minimalist Program as articulated in Chomsky (1993; 1995; 2000) not only fails to deal with the ungrammaticality of simple examples like **John left not* or **John not left*, it also provides no basis for

(a) French　　　　　　　　　　(b) English
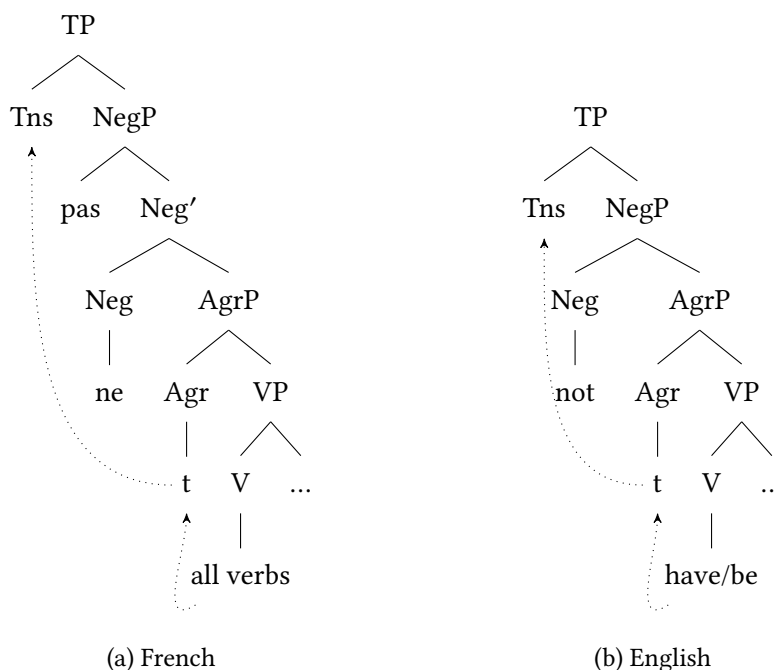
Figure 1: Add caption

explaining the French/English contrasts in adverb position discussed by Pollock (1989) and Cinque (1999) (e.g., *embrasse souvent* vs. *often kisses*).

The derivational view summarized here has focused on adverbial negatives in English and French. This view with movement operations in the hierarchy of functional projections has been extended to account for the other types of negation as well, which we will note in due course.

3 A Construction-based HPSG Analysis

Departing from the derivational view, we herein offer an alternative construction-based view in which the distributional possibilities of negatives are drawn from the interplay among the lexical properties of each negative marker and from the interaction of elementary, independently motivated morphosyntactic and valence properties of syntactic heads, and constructional properties (see Kim (2000), Kim & Sag (2002), Crowgey (2012)).

3.1 Morphological Negation

As noted earlier, languages like Turkish and Japanese employ morphological negation in which the negative marker behaves like a suffix. Consider Turkish and Japanese examples:

(8) a. Git-me-yeceğ-∅-im
         go-NEG-FUT-COP-1SG

         '(I) will not come.'

     b. kare-wa kinoo   kuruma-de ko-na-katta.
         he-TPC   yesterday car-INST   come-NEG-PST

         'He did not come by car yesterday.'

As the examples illustrate, the sentential negation of Turkish and Japanese employ morphological suffixes *-me* and *-na*, respectively. It is possible to state the ordering of these morphological negative markers in derivational or syntactic terms. But it is too strong a claim to take the negative suffix *-me* or *-na* to be an independent syntactic element, and to attribute its positional possibilities to syntactic constraints such as verb movement and other configurational notions (see Kelepir (2001) for Turkish and Kato (1997; 2000) for Japanese). In these languages, the negative morpheme acts just like other verbal inflections in numerous respects. The morphological status of these negative markers comes from their morphophonemic alternation. For example, the vowel of the Turkish negative suffix *-me* shifts from open to closed when followed by the future suffix, as in *gel-mi-yecke* 'come-NEG-FUT'. Their strictly fixed position also indicates their morphological constituenthood. Though these languages allow rather a free permutation of syntactic elements (scrambling), there exist strict ordering restrictions among verbal suffixes including the negative suffix, as can be seen from the following examples:

(9) a. tabe-sase-na-i/*tabe-na-sase-i
         eat-CAUS-NEG-NPST

     b. tabe-rare-na-katta/*tabe-na-rare-katta
         eat-PASS-NEG-PST

     c. tabe-sase-rare-na-katta/*tabe-sase-na-rare-katta
         eat-CAUS-PASS-NEG-PST

The ordering of the negative morpheme is a matter of morphology. If it were a syntactic concern, then the question would arise as to why there is an obvious

contrast in the ordering principles of morphological and syntactic constituents, i.e., why the ordering rules of morphology are distinct from the ordering rules of syntax. The simplest explanation for this contrast is to accept the view that morphological constituents including the negative marker are formed in the lexical component and hence have no syntactic status (see Kim (2000) for detailed discussion).

This being noted, it is more reasonable to assume that the placement of a negative morpheme is regulated by morphological principles, i.e. by the properties of the morphological negative morpheme itself. In the construction-based HPSG, we could take this as an inflectional construction. The negative marker, as we have seen in Turkish and Japanese, is realized as a suffix attached to the verb root. The resulting combination is not a word-level entity but a verb stem to which an aspectual or tense marker can be attached. We could thus take such a morphological process as an inflectional one. For instance, Figure 2 could be a morphological construction in Turkish.[2]

$$
\begin{bmatrix}
\textit{v-neg-stem} \\
\text{FORM} \quad \langle \mathbf{F}_{\text{NEG}} \, (\text{X}) \rangle \\
\text{SYN}|\text{HEAD}|\text{POS} \quad \textit{verb} \\
\text{SEM}|\text{FRAMES} \quad \left\langle \begin{bmatrix} \textit{neg-fr} \\ \text{ARG} \; \boxed{1} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

$$
\begin{bmatrix}
\textit{v-lxm} \\
\text{FORM} \quad \langle \text{X} \rangle \\
\text{SYN}|\text{HEAD}|\text{POS} \quad \textit{verb} \\
\text{SEM}|\text{FRAMES} \quad \langle \boxed{1} \rangle
\end{bmatrix}
$$
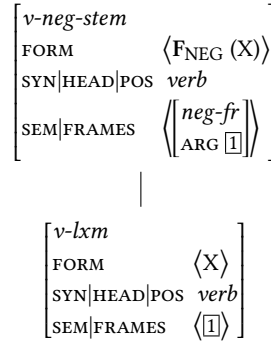
Figure 2: Negative-Infl Construction (↑*infl-cxt*)

This inflectional construction (↑*infl-cxt*) allows us to generate a Turkish inflection construct like *ser-me* 'like-NEG' (in (1a)) from the v-lexeme *ser-* with the change in the root's meaning into a sentential negation. The morphological function F_{NEG} could ensure that the vowel of the negative morpheme *me* is subject to phonological changes depending on its environment. If it is followed by a consonant-initial morpheme, it undergoes vowel harmony with the vowel in the preceding syllable (e.g., *yika-n-ma-di* 'wash-REFL-NEG-PST'). If it is followed by a vowel-initial morpheme, its vowel drops (gel-m-iyor 'come-NEG-PROG') (see

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[2]See Sag (2012) and Hilpert (2016) for a construction-based approach to inflectional as well as derivational processes.

Kelepir (2001)).[3]

The construction-based analysis sketched here has been built upon the thesis that autonomous (i.e. non-syntactic) principles govern the distribution of morphological elements Bresnan & Mchombo (1991). The position of the morphological negation is simply defined in relation to the verb stem it attaches to. There are no syntactic operations such as head-movement or multiple functional projections in forming a verb with the negative marker.

3.2 Negative Auxiliary Verb

Another way of expressing sentential negation, as noted earlier, is to employ a negative auxiliary verb. Head-final languages like Korean and Hindi employ negative auxiliary verbs. Consider a Korean example:

(10) John-un ku chayk-ul ilk-ci   anh-ass-ta.
      John-TPC that book-ACC read-CONN NEG-PST-DECL
      'John did not read the book.'

The negative auxiliary in head-final languages typically appears clause-finally, following the invariant form of the main verb. In head-initial SVO languages, however, the negative auxiliary almost invariably occurs immediately before the lexical verb (see Payne (1985)). Finnish exhibits this property (Mitchell 1991):

(11) Minä e-n   puhu-isi.
      I-NOM NEG-1SG speak-COND
      'I would not speak.'

These negative auxiliaries have syntactic status: they can be inflected, above all. Like other verbs, they can be marked with verbal inflections such as agreement, tense, and mood.

In dealing with auxiliary negative constructions, most of the derivational approaches have followed Pollock's and Chomsky's analyses in factoring out functional information carried by lexical items into various different phrase-structure nodes (see, among others, Hagstrom (1997; 2002), Han et al. (2007) for Korean and Vasishth (2000) for Hindi). This derivational view has been appealing, in that one identical structure could explain different types of negation. However, problems have arisen from the fact that it misses the basic properties of this type

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[3]As for a way of capturing the ordering of suffixes within this kind of system, see Kim (2016).

of negation which, for example, differentiate it from morphological negation (i.e., double negation, lexical idiosyncrasies, phonological restriction, etc.).[4]

In the construction-based HPSG analysis, the negative auxiliary is taken to be an independent lexical verb whose functional information is not distributed over different phrase structure nodes, but incorporated into its precise and enriched lexical entry and an independently motivated construction for other types of auxiliary verbs. The Korean negative auxiliary displays all the key properties of auxiliary verbs in the language. For instance, the typical auxiliary verbs as well as the negative auxiliary all require the preceding main verb to be marked with a specific verb form (VFORM), as illustrated in the following:

(12) a. ilk-ko/*ci   siph-ta.
          read-CONN would.like-DECL

          '(I) would like to read.'

      b. ilk-ci   anh-ass-ta.
          read-CONN not-PST-DECL

          '(I) did not read.'

The auxiliary verb *siph-* in (12a) requires the *-ko* marked main verb while the negative auxiliary verb *anh-* in (12b) asks for the *-ci* marked main verb.

In terms of syntactic structure, there are two possible analyses. One is to assume that the negative auxiliary takes a VP complement and the other is to claim that it forms a verb complex with the preceding main verb, as represented in Figures 3a and 3b, respectively ((Kim 2016)).

The distributional properties of the negative auxiliary in the language, however, support the complex predicate structure (cf. Figure 3b) in which the negative auxiliary verb forms a syntactic/semantic unit with the preceding main verb. For instance, no adverbial expression, including a parenthetical adverb, can intervene between the main and auxiliary verb, as illustrated by the following Korean example:

(13) Mimi-nun (yehathun) tosi-lul (yehathun) ttena-ci   (*yehathun)
      Mimi-TPC anyway   city-ACC anyway   leave-CONN anyway
      anh-ass-ta.
      NEG-PST-DECL

      'Anyway, Mimi didn't leave the city.'

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[4]See Niño (1994) for arguments against a derivational analysis for Finnish negative auxiliary such as that of Mitchell (1991).

(a) Add caption (b) Add caption
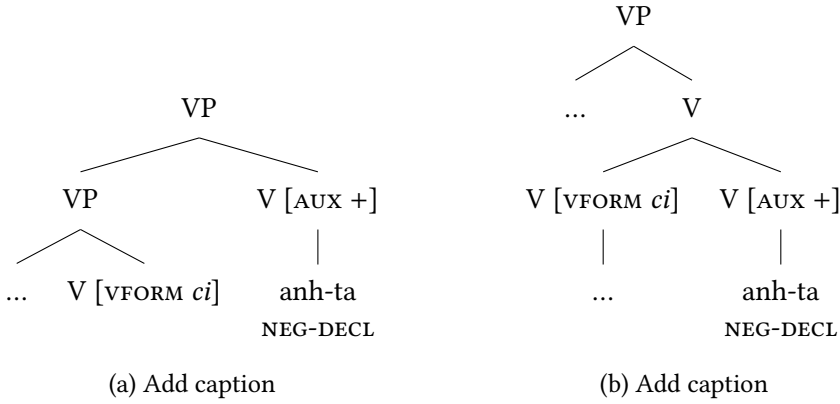
Figure 3: Add caption

Further, in an elliptical construction, a verb complex always occurs together:

(14) a. Kim-i   hakkyo-eyse pelsse   tolawa-ss-ni?
          Kim-NOM school-SRC   already return-PST-QUE
          'Did Kim return from school already?'

     b. ka-ci-to   anh-ass-e
          go-CONN-DEL NOTP-PST-DECL
          '(He) didn't even go.'

     c. * ka-ci-to. go-CONN-DEL

     d. * anh-ass-e NEG-PST-DECL

Neither the main verb nor the auxiliary verb alone can serve as the fragment answer to the polar question. The two verbs must occur together.

These constituent tests indicate that the negative auxiliary forms a syntactic unit with a preceding main verb in Korean. Following Bratt (1996), Chung (1998), and Kim (2016), we then could assume that an auxiliary verb forms a complex predicate, licensed by the following construction:

(15) HEAD-LEX CONSTRUCTION:
$$\begin{bmatrix} hd\text{-}lex\text{-}cxt \\ \text{COMPS } L \end{bmatrix} \Rightarrow \boxed{1}\begin{bmatrix} \text{LEX} + \\ \text{COMPS } L \end{bmatrix}, \text{H}\begin{bmatrix} \text{COMPS } \langle \boxed{1} \rangle \end{bmatrix}$$

This construction rule means that a lexical head expression combines with its lexical (LEX) complement. When this combination happens, there is a kind of argument composition: the COMPS value (*L*) of this lexical complement is passed

up to the resulting mother. The constructional constraint thus induces the effect of argument composition at syntax, as illustrated by the following example:[5]

V′

$$\begin{bmatrix} \textit{hd-lex-cxt} \\ \text{HEAD} \quad \boxed{3} \\ \text{LEX} \quad + \\ \text{COMPS} \ \langle\boxed{2}\text{NP}\rangle \end{bmatrix}$$

Lexical Arg.   H

$\boxed{1}$ V   V

$$\begin{bmatrix} \text{HEAD} \begin{bmatrix} \text{VFORM} \quad \textit{ci} \\ \text{LEX} \quad + \\ \text{COMPS} \ \langle\boxed{2}\text{NP}\rangle \end{bmatrix} \end{bmatrix} \qquad \begin{bmatrix} \text{HEAD} \quad \boxed{3} \\ \text{COMPS} \ \langle\boxed{1}\text{V}\rangle \end{bmatrix}$$

ilk-ci   anh-ass-ta

read-CONN   NEG-PST-DECL
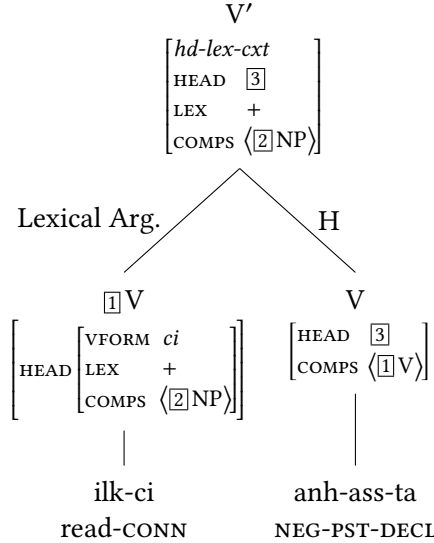
Figure 4: Add caption

The auxiliary verb *anh-ass-ta* 'NEG-PST-DECL' combines with the matrix verb *ilk-ci* 'read-CONN', forming a well-formed head-lex construct.[6] Note that the resulting construction inherits the COMPS value from that of the lexical complement *ilk-ci* 'read-CONN' through the operation of argument composition. It is the HEAD-LEX CONSTRUCTION that licenses the combination of an auxiliary verb with its main verb, while inheriting the main verb's complement value as argument composition. The present system thus allows the argument composition at the syntax level, rather than in the lexicon.

One important property of the auxiliary construction is that there is no limit for auxiliary verbs to occur in sequence as long as each combination observes the morphosyntactic constraint on the preceding expression. Consider the following:

(16) a. sakwa-lul mek-ci   anh-ta.
         apple-ACC eat-CONN NEG-DECL

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[5]The V′ is just a notational variant to indicate that it is a syntactic complex predicate.

[6]The negative auxiliary verb selects two arguments, a subject and a main verb. See Kim (2016) for a detailed analysis.

    b. sakwa-lul mek-ko siph-ci   anh-ta.
         apple-ACC eat-CONN wish-CONN NEG-DECL

    c. sakwa-lul mek-ko siph-e   ha-ci   anh-ta.
         apple-ACC eat-CONN wish-CONN do-CONN NEG-DECL

    d. sakwa-lul mek-ko siph-e   ha-key toy-ci   anh-ta.
         apple-ACC eat-CONN wish-CONN do-CONN become-CONN NEG-DECL

As seen from each of these examples, we can add one more auxiliary verb to the existing construction, with an appropriate connective marker on the preceding one. Theoretically, there is no upper limit to the possible number of auxiliary verbs we can add.

Within the present complex-predicate analysis with the supposition of HEAD-LEX CONSTRUCTION in the language, we could license all these examples. Figure 5 is a simplified structure for (16c):

The bottom structure indicates that the auxiliary verb *siph-e* wish-CONNforms a HEAD-LEX CONSTRUCTION through the combination with the main verb *mek-ko* eat-CONN. This resulting complex predicate, which is still a LEX expression, inherits the main verb's COMPS value as well as the *ae* VFORM head feature from the auxiliary.[7] Meanwhile, the auxiliary verb *ha-ci* also requires a LEX level expression with the VFORM value *ae*, combining with the preceding complex predicate in a legitimate way. This combination, forming a HEAD-LEX CONSTRUCTION, again inherits the COMPS value. The final negative auxiliary then combines this resulting complex predicate, yielding a final complex predicate that can combine with the object. Each combination thus forms a well-formed complex predicate, licensed by the lexical projection of each auxiliary verb and the HEAD-LEX CONSTRUCTION.

The present analysis has taken the negative auxiliary *ahn-ta* NEG-DECLto select the main verb and form a verb complex with it. This verb complex treatment has been supported from constituent tests including adverb intervention and elliptical constructions. Further, the analysis, exploiting the mechanism of argument composition, allows us to capture the properties of this negative auxiliary. The conclusion we can draw from here is that the distribution of a negative auxiliary verb is determined by independent constructional constraints that regulate the placement of other similar verbs.

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[7]Instead, we can adopt the feature LIGHT to a lexical expression, as suggested for the French Auxiliary Construction by Abeillé & Godard (1997).

VP

⟨2⟩NP   V′
$$\begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix}$$

⟨5⟩V′   V
$$\begin{bmatrix} \text{VFORM} & \textit{ci} \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix}$$ $$\begin{bmatrix} \text{COMPS} & \langle \boxed{5} \rangle \end{bmatrix}$$

⟨3⟩V′   V
$$\begin{bmatrix} \text{VFORM} & \textit{ae} \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix}$$ $$\begin{bmatrix} \text{VFORM} & \textit{ci} \\ \text{COMPS} & \langle \boxed{3} \rangle \end{bmatrix}$$

⟨7⟩V   V
$$\begin{bmatrix} \text{VFORM} & \textit{ko} \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix}$$ $$\begin{bmatrix} \text{VFORM} & \textit{ae} \\ \text{COMPS} & \langle \boxed{7} \rangle \end{bmatrix}$$

sakwa-lul	mek-ko	siph-e	ha-ci	anh-ass-ta
apple-ACC	eat-CONN	wish-CONN	do-CONN	NEG-PST-DECL
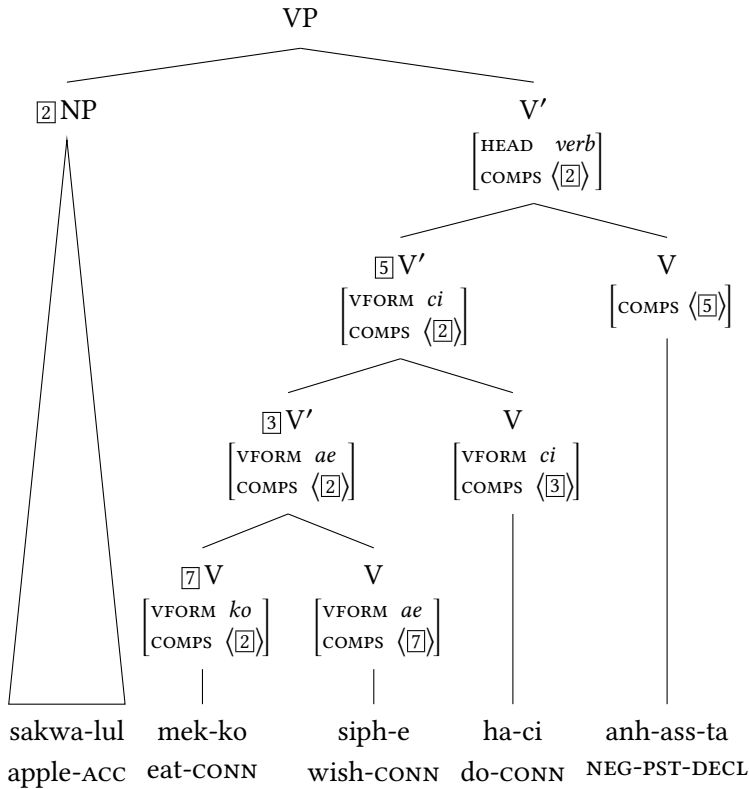
Figure 5: Add caption

3.3 Adverbial Negation

3.3.1 Two Key Factors

The third main type of negation is the adverbial negative marker which most of the Indo-European languages employ. There are two main factors that determine the position of an adverbial negative: finiteness of the verb and its intrinsic properties, namely, whether it is an auxiliary or main verb (see Kim (2000), Kim & Sag (2002)).[8]

The first crucial factor that affects the position of adverbial negatives in English and French concerns the finiteness of the main verb. French shows us how the

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[8]German also employs an adverbial negative *nicht*, which behaves quite differently from the negative in English and French. See Müller (2016) for a detailed review of the previous, theoretical analyses of German negation.

finiteness of a verb influences the surface position of the negative marker *pas*.

(17) a. Robin n'aime pas Stacey.
Robin (n')likes NEG Stacey
'Robin does not like Stacey.'

b. * Robin ne pas aime Stacey.

(18) a. Ne pas parler   Français est un grand désavantage en ce   cas.
ne NEG to.speak French   is a   great   disadvantage in   this case
'Not to speak French is a great disadvantage in this case.'

b. * Ne parler pas Français est un grand désavantage en ce cas.

The negator *pas* cannot precede the finite verb but must follow it. But its placement with respect to the nonfinite verb is the reverse image. The negator *pas* should precede the infinitive verb. English is not exceptional in this respect (Baker 1989; 1991; Ernst 1992). The negation *not* precedes an infinitive verb, but cannot follow a finite main verb.[9]

(19) a. Jon skjønte   aldri dette spørsmålet.
Jon understood never this   question
'John never understood this question.'

b. Han hadde foresatt seg   aldri a sla   hunden.
He   had   decided himself never to beat the.dog
'He had decided himself never to beat the dog.'

(20) a. Kim does not like Lee.

b. * Kim not likes Lee.

c. * Kim likes not Lee.

(21) a. Kim is believed [not [to like Mary]].

b. * Kim is believed to [like not Mary].

The second important factor that determines the position of adverbial negatives concerns the presence of an auxiliary or main verb. Modern English displays a clear example where this intrinsic property of the verb influences the position of the English negator *not*: the negator cannot follow a finite main verb but when the finite verb is an auxiliary verb, this ordering is possible.

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[9]A similar contrast between finiteness and nonfiniteness can be observed in the Scandinavian language like Norwegian (see Platzack 1986; Holmberg & Christer 1988; Vikner 1994; 1997).

(22)   a.   * Kim left not the town.

     b.   Kim has not left the town.

     c.   Kim is not leaving the town.

The placement of *pas* in French infinitival clauses also illustrates that the intrinsic property of the verb affects the position of the adverbial negative *pas*:

(23)   a.   Ne pas avoir de voiture dans cette ville rend la vie difficile.
         'Not to have a car in this city makes life difficult.'

     b.   N'avoir pas de voiture dans cette ville rend la vie difficile.

(24)   a.   Ne pas être triste est une condition pour chanter des chansons.
         'Not to be sad is a prerequisite condition for sining songs.'

     b.   N'être pas triste est une condition pour chanter des chansons.

The negator *pas* can either follow or precede the infinitive auxiliary verb in French, though the acceptability of the ordering in (23b) and (24b) is restricted to certain conservative varieties.

    In capturing the distributional behavior of such negatives in English and French, as we have noted earlier, the derivational view (exemplified by Pollock (1989) and Chomsky (1991)) has relied on the notion of verb movement and functional projections. The most appealing aspect of this view (initially at least) is that it can provide an analysis of the systematic variation between English and French. By simply assuming that the two languages have different scopes of verb movement – in English only auxiliary verbs move to a higher functional projection whereas all French verbs undergo the same process, the derivational view could explain why the French negator *pas* follows a finite verb, unlike the English negator. In order for this system to succeed, nontrivial complications are required in the basic components of the grammar, e.g rather questionable subtheories. For example, the introduction of Pollock's theta and quantification theories has been necessary to account for the obligatory verb movement.[10] However, when these subtheories interact with each other, they bring about a 'desperate' situation, as Pollock (1989: 398) himself concedes: his quantification theory forces all main verbs in English to undergo verb movement, but his theory blocks this. This contradictory outcome has forced him to adopt an otherwise unmotivated mechanism, a dummy nonlexical counterpart of *do* in English (which Chomsky (1989) tries to avoid by adopting the notion of LF re-raising). Leaving the plausibility of

---

[10]His theta theory says only nonthematic verbs move up to the higher functional position, whereas his quantification theory says [+fin] is an operator that must bind a variable.

this mechanism aside, as discussed by Kim (2000) and Kim & Sag (2002), a derivational analysis such as that of Pollock (1989) fails to allow for all the distributional possibilities of English and French negators as well as adverb positioning in various environments

3.3.2 Constituent Negation in English and French

The construction-based, lexicalist analysis we offer here also recognizes the fact that finiteness plays a crucial role in determining the distributional possibilities of negative adverbs. Its main explanatory resource has basically come from the proper lexical specification of these negative adverbs. The lexical specification that *pas* and *not* both modify nonfinite VPs has sufficed to predict their occurrences in nonfinite clauses.

When English *not* negates an embedded constituent, it behaves much like the negative adverb *never*. The similarity between *not* and *never* is particularly clear in nonfinite verbal constructions (participle, infinitival and bare verb phrases), as illustrated in (25) and (26) (Klima (1964), Baker (1989; 1991)).

(25) a.   Kim regrets [never [having read the book]].

  b.   We asked him [never [to try to read the book]].

  c.   Duty made them [never [miss the weekly meeting]].

(26) a.   Kim regrets [not [having read the book]].

  b.   We asked him [not [to try to read the book]].

  c.   Duty made them [not [miss the weekly meeting]].

French *ne-pas* is no different in this regard. *Ne-pas* and certain other adverbs precede an infinitival VP:

(27) a.   [Ne pas [repeindre sa   maison]] est une négligence.
     ne   not paint   one's house   is a   negligence
     'Not to paint one's house is negligent.'

  b.   [Régulièrement [repeindre sa   maison]] est une nécessité.
     regularly   to.paint   one's house   is a   necessity

To account for these properties, we regard *not* and *ne-pas* not as heads of their own functional projection, but rather as adverbs that modify nonfinite VPs. The lexical entries for *ne-pas* and *not* include the information shown in (28).[11]

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[11]Here we assume that both languages distinguish between *fin(ite)* and *nonfin(ite)* verb forms, but

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$$(28) \quad \begin{bmatrix} \text{FORM} \; \langle \textit{not}/\textit{ne-pas} \rangle \\ \text{SYN|HEAD} \begin{bmatrix} \text{POS} \; \textit{adv} \\ \text{MOD} \; \langle \text{VP} \; [\textit{nonfin}]: \boxed{2} \rangle \end{bmatrix} \\ \text{SEM} \begin{bmatrix} \text{FRAMES} \; \left\langle \begin{bmatrix} \textit{neg-fr} \\ \text{ARG} \; \boxed{2} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

The lexical entry in (28) specifies that *not* and *ne-pas* modifies a nonfinite VP and that this modified VP serves as the semantic argument of the negation. This simple lexical specification correctly describes the distributional similarities between English *not* and French *ne-pas*: neither element can separate an infinitival verb from its complements.[12] And both *ne-pas* and *not*, like other adverbs of this type, precede the VPs that they modify:

(29)   a.   [Ne pas $_{\text{VP[inf]}}$[parler   français]] est un grand désavantage   en ce
             ne   not   to.speak French   is   a   great   disadvantage in this
             cas.
             case

       b.   * Ne parler pas français est un grand désavantage en ce cas.

(30)   a.   [Not [speaking English]] is a disadvantage.

       b.   * [Speaking not English] is a disadvantage.

Independent principles guarantee that modifiers of this kind precede the elements they modify, thus ensuring the grammaticality of (29a) and (30a), where *ne-pas* and *not* are used as VP[*nonfin*] modifiers. (29b) and (30b) are ungrammatical, since the modifier fails to appear in the required position—i.e. before all elements of the nonfinite VP.

     The lexical properties of *not* thus ensures that it cannot modify a finite VP, as shown in (31), but it can modify any nonfinite VP:

(31)   a.   * Pat [not $_{\text{VP[fin]}}$[left]].

       b.   * Pat certainly [not $_{\text{VP[fin]}}$[talked to me]].

---

     that certain differences exist regarding lower levels of organization. For example, *prp* (*present participle*) is a subtype of *fin* in French, whereas it is a subtype of *nonfin* in English.

       For ease of exposition, we will not treat cases where the negation modifies something other than VP, e.g. adverbs (*not surprisingly*), NPs (*not many students*), or PPs (*not in a million years*). Our analysis can accommodate such cases by generalizing the MOD specification in the lexical entry for *not*.

[12]The exception to this generalization, namely cases where *pas* follows an auxiliary infinitive (*n'avoir pas d'argent*), is discussed in section 5.2 below.

    c.   * Pat [not ₍ᵥₚ[fin]₎[always agreed with me]].

And much the same is true for French, as the following contrast illustrates:

(32)   a.   * Robin [(ne) pas ₍ᵥₚ[fin]₎[aime Stacey]].
           Robin [(ne) not   likes Stacey]

       b.   Il veut [ne pas publier dans ce journal].
           'He wants not to publish in this journal.'

Note that head-movement transformational analyses stipulate: (1) that negation is generated freely, even in preverbal position in finite clauses and (2) that a post-negation verb must move leftward because otherwise some need would be unfulfilled—the need to bind a tense variable, the need to overcome some morphological deficiency with respect to theta assignment, etc. On our account, no such semantic or morphosyntactic requirements are stipulated; instead, what is specified is a lexical selection property. There is no a priori reason, as far as we are aware, to prefer one kind of stipulation over the other. It should be noted, however, that our proposal only makes reference to selectional properties that are utilized elsewhere in the grammar.

3.3.3 Sentential Negation in English

As just illustrated, the analysis of *not* and *ne-pas* as nonfinite VP modifiers provides a straightforward explanation for much of their distribution. We may simply assume that French and English have essentially the same modifier-head construction and that *not* and *ne-pas* have near-identical lexical entries. With respect to negation in finite clauses, however, there are important difference between English and French.

    It is a general fact of French that *pas* must follow the finite verb, in which case the verb optionally bears negative morphology (*ne*-marking):

(33)   a.   Dominique (n')aime pas Alex.

       b.   * Dominique pas aime Alex.

In English, *not* must follow the finite verb, which must in addition be an auxiliary verb:

(34)   a.   Dominique does not like Alex.

       b.   * Dominique not does like Alex.

       c.   * Dominique likes not Alex.

In contrast to the distribution of *not* in nonfinite clauses as constituent negation, its distribution in finite clauses concerns sentential negation. The need to distinguish the two types of negation comes from scope possibilities in an example like (35) (Klima 1964),(Baker 1989), and (Warner 2000).

(35)   The president could not approve the bill.

Negation here could have the two different scope readings paraphrased in (36).

(36)   a.   It would be possible for the president not to approve the bill.
        b.   It would not be possible for the president to approve the bill.

The first interpretation is constituent negation; the second is sentential negation. As noted, sentential *not* may not modify a finite VP, different from the adverb *never*:

(37)   a.   Lee never/*not left.   (cf. Lee did not leave.)
        b.   Lee will never/not leave.

The contrast in these two sentences shows one clear difference between *never* and *not*. The negator *not* cannot precede a finite VP though it can freely occur as a nonfinite VP modifier.

Another distributional difference between *never* and *not* is found in the VP ellipsis construction. Observe the following contrast:

(38)   a.   Mary sang a song, but Lee never did _.
        b.   * Mary sang a song, but Lee did never _.
        c.   Mary sang a song, but Lee did not _.

The data here indicate that *not* behaves differently from adverbs like *never* in finite contexts, even though the two behave alike in nonfinite contexts. The adverb *never* is a true diagnostic of a VP-modifier, and we use contrasts between *never* and *not* to reason about what the properties of the negator *not* must be.

We saw the lexical representation for constituent negation *not* in (28) above. Sentential *not* typically appears linearly in the same position – following a finite auxiliary verb – but shows different syntactic properties (while constituent negation need not follow an auxiliary as in *Not eating gluten is dumb*). As a way to deal with the sentential negation in English, we follow Bresnan (2001) and Kim & Michalies (2018) in assuming that the sentential negation forms a unit with the preceding finite auxiliary verb. This can be supported from the fact that English

sentential negation requires the proximity of a finite auxiliary or modal auxiliary on its left and that it can function as synthetic negation as *n't*. That is, the auxiliary and the negator *not* are fused into a single lexical expression through contraction, as in *won't, can't*, and so forth.[13]

With this assumption, the present analysis, in particular, assumes that the combination of a finite auxiliary verb with the sentential negation *not* is licensed by the HEAD-LEX CONSTRUCTION (similar to the one in Korean), which licenses the combination of two lexical expressions such as verb and particle (e.g., *figure out, give up*, etc), as well (see Kim & Michalies (2018)). The construction, along with the assumption that the sentential negator *not* bears the LEX feature, projects a structure like in Figure 6.
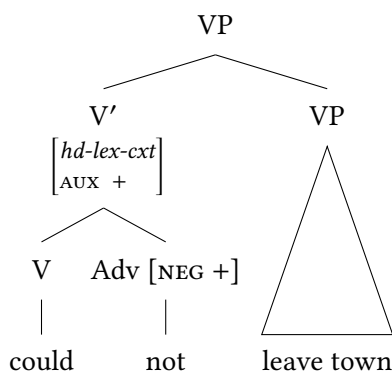
Figure 6: Add caption

Just as a particle combines with the preceding main verb, forming a head-lex structure, expressions like the negator *not*, *too, so* and *indeed* combine with a preceding auxiliary verb:

(39) a.   Kim will not read it.
      b.   Kim will too/so/indeed read it.

Expressions like *too* and *so* are used to reaffirm the truth of the sentence in question and follow a finite auxiliary verb. We assume that the negator and these

---

[13]Zwicky & Pullum (1983) note that the contracted negative *n't* more closely resembles word inflection than it does a 'clitic' or 'weak' word of the kind that often occurs in highly entrenched word sequences (e.g., *Gimme*!). For example, as Zwicky and Pullum observe, *won't* is not the fused form one would predict based on the pronunciation of the word *will*, and such idiosyncrasies are far more characteristic of inflectional endings than clitic words.

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reaffirming expressions form a unit with the finite auxiliary, resulting in a lexical-level construction.

Since the sentential negator is not a modifier of the following VP-type expression, we take it to be selected by a finite auxiliary verb, as a main verb selects a particle. This means a finite auxiliary verb (*fin-aux*) can be projected into a corresponding NEG-introducing auxiliary verb (*neg-fin-aux*), as in Figure 7.

$$
\begin{bmatrix}
\textit{neg-fin-aux} \\
\text{SYN|HEAD} \begin{bmatrix} \text{AUX} & + \\ \text{VFORM} & \textit{fin} \\ \text{NEG} & + \end{bmatrix} \\
\text{ARG-ST} \quad \left\langle \boxed{1}\text{XP}, \text{Adv} \begin{bmatrix} \text{LEX} & + \\ \text{NEG} & + \end{bmatrix}, \boxed{2}\text{XP} \right\rangle
\end{bmatrix}
$$

$$
\begin{bmatrix}
\textit{fin-aux} \\
\text{SYN|HEAD} \begin{bmatrix} \text{AUX} & + \\ \text{NEG} & + \end{bmatrix} \\
\text{ARG-ST} \quad \left\langle \boxed{1}\text{XP}, \boxed{2}\text{XP} \right\rangle
\end{bmatrix}
$$
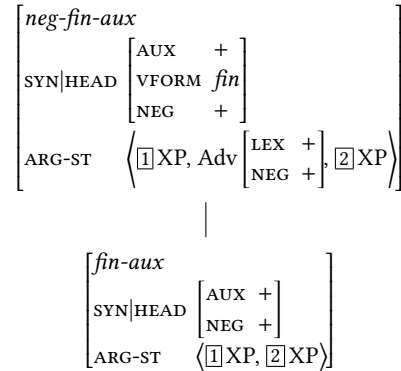
Figure 7: Negative Auxiliary Construction (↑*post-infl-cxt*)

This is a post-inflection construction that allows for words to be derived from other words. We can take this mother-daughter relation as a kind of derivation whose input is a finite auxiliary verb (daughter) and whose output is a neg-finite auxiliary (*fin-aux → neg-fin-aux*). That is, the finite auxiliary verb selecting just a complement XP can be projected into a NEG finite auxiliary that selects the negator as its additional lexical complement that bears the feature NEG as well as the feature LEX. The output construction then licenses the structure in Figure 8 for sentential negation.

As shown here, the negative finite auxiliary verb *could* selects two complements, the negator *not* and the VP *leave town*. The finite auxiliary then first combines with the negator, forming a well-formed head-lex construct. This construct then can combine with a VP complement, forming a Head-Complement construct.

By treating *not* as both a modifier (constituent negation) and a lexical complement (sentential negation), we can account for the scope differences in (35) as well as double negation examples like the following:

(40) a. You [must not] simply [not work].

b. He [may not] just [not have been working].

VP
$$\begin{bmatrix} \text{VFORM} & \textit{fin} \\ \text{AUX} & + \\ \text{COMPS} & \langle \, \rangle \end{bmatrix}$$

V
$$\begin{bmatrix} \textit{hd-lex-cxt} \\ \text{VFORM} & \textit{fin} \\ \text{AUX} & + \\ \text{COMPS} & \langle \boxed{3}\,\text{VP}\rangle \end{bmatrix}$$

$\boxed{3}$ VP

V
$$\begin{bmatrix} \text{VFORM} & \textit{fin} \\ \text{AUX} & + \\ \text{COMPS} & \langle \boxed{2}\,[\text{NEG +}], \boxed{3}\,\text{VP}\rangle \end{bmatrix}$$

$\boxed{2}$ Adv

could   not   leave town
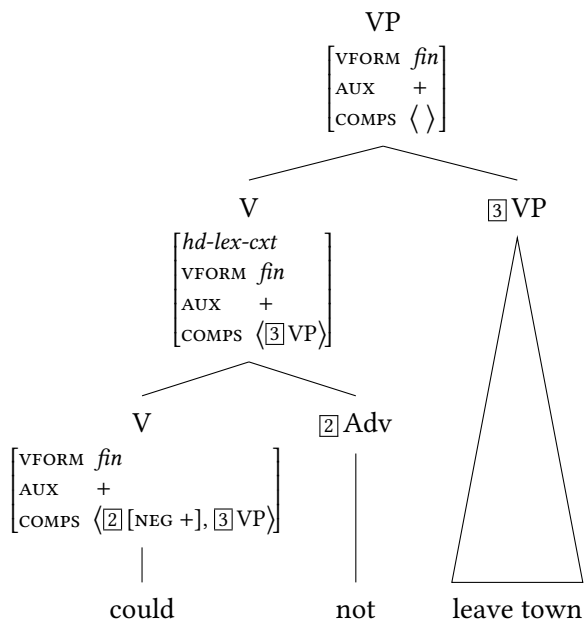
Figure 8: Add caption

In addition, the analysis can account for various other phenomena including VP ellipsis we discussed in (38). The point was that unlike *never*, the sentential negation can host a VP ellipsis. The VP ellipsis after *not* is possible, given that any VP complement can be unexpressed, leaving the sentential complement intact:

> rephrase, reference to figure

V′

V
$$\begin{bmatrix} \text{HEAD}|\text{AUX} & + \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle \boxed{1}\rangle \\ \text{COMPS} & \langle \boxed{2}\,\text{Adv}[\text{NEG +}]\rangle \end{bmatrix} \\ \text{ARG-ST} & \langle \boxed{1}, \boxed{2}, \text{VP}[\textit{bse}]\rangle \end{bmatrix}$$

$\boxed{2}$ Adv
$$\begin{bmatrix} \text{NEG} & + \end{bmatrix}$$

could   not
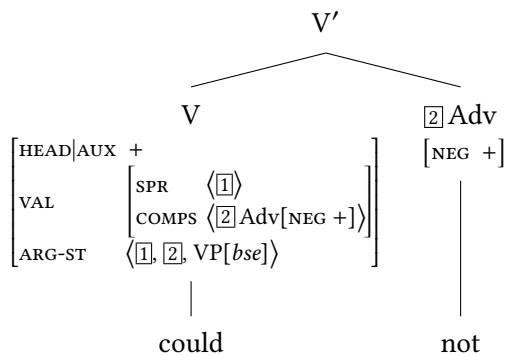
Figure 9: Add caption

As represented here, the auxiliary verb *could* forms a well-formed head-complement construct with *not* while its VP[*bse*] is unrealized (see Kim (2000), Kim & Sells (2008) for detail.).

The sentential negator *not* can 'survive' VPE because it can be licensed in the syntax as the complement of an auxiliary, independent of the following VP. However, an adverb like *never* is only licensed as a modifier of VP. Thus if the VP were elided, we would have the hypothetical structure like the one in Figure 10:
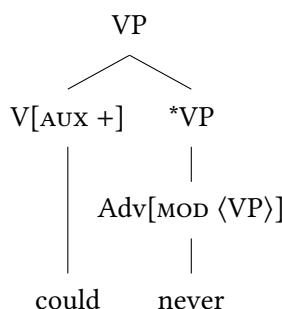
Figure 10: Add caption

Here, the adverb *never* modifies a VP through the feature MOD, which guarantees that the adverb requires the head VP that it modifies. In an ellipsis structure, the absence of such a VP means that there is no VP for the adverb to modify. In other words, there is no rule licensing such a combination – predicting the ungrammaticality of *has never, as opposed to *has not*.

3.3.4 Sentential Negation in French

My analysis in which the negator *not* and *pas* are taken to modify a nonfinite VP and select it through the head feature MOD, provides us with a clean and simple way of accounting for their distribution in infinitive clauses. But at stake is their placement in finite clauses:

(41) a. Lee does not like Kim.

  b. * Lee not likes Kim.

  c. * Lee likes not Kim.

(42) a. * Robin ne [pas ₍ₚ₎[fin][aime   Stacey]].
    Robin ne NEG   likes Stacey

     b.   Robin (n')aime pas Stacey.
           Robin likes   NEG Stacey

Unlike the English negator *not*, *pas* must follow the finite verb. Such a distributional contrast has motivated verb movement analyses (see Pollock 1989; Zanuttini 2001).

By contrast, the present analysis is cast in terms of a lexical rule that maps a finite verb into a verb with a certain adverb like *pas* as an additional complement, as I did for English *not*. The idea of converting modifiers into complements has been independently proposed by Miller (1992) and Abeillé & Godard (1994) for French adverbs including *pas* also. Building upon this previous work, I also assume that the modifier *pas* can be converted to a syntactic complement of a finite verb for French via the lexical rule given in Figure 11.[14]

$$
\begin{bmatrix}
\textit{neg-fin-v} \\
\text{FORM} \quad \langle (\textit{ne}) + \boxed{2} \rangle \\
\text{SYN|HEAD} \begin{bmatrix} \text{VFORM} \ \textit{fin} \\ \text{NEG} \quad + \end{bmatrix} \\
\text{ARG-ST} \quad \langle \boxed{1}\text{XP} \rangle \oplus \langle \text{Adv}_\text{I} \rangle \oplus L
\end{bmatrix}
$$

$$
\begin{bmatrix}
\textit{fin-v} \\
\text{FORM} \quad\quad\quad \langle \boxed{2} \rangle \\
\text{SYN|HEAD|VFORM} \ \textit{fin} \\
\text{ARG-ST} \quad\quad\quad \langle \boxed{1}\text{XP} \rangle \oplus L
\end{bmatrix}
$$

Figure 11: Negative Verb Construction in French (↑*post-infl-cxt*)

The post-inflection construction allows us to build a negative verb from a finite verb in French. That is, a finite verb can give rise to a negative finite verb that selects an Adv$_\text{I}$ adverb including *pas* as the second argument. Adv$_\text{I}$ includes only a small subset of French negative adverbs such as *pas*, *plus* 'no more', *jamais* 'never', and *point* 'not'. This derivational construction has a semantic effect: the negative verb taking *pas* as an additional argument takes the meaning of the input verb ($\boxed{2}$) as its argument.

One direct consequence of adopting this construction-based approach is that it systematically expands the set of basic lexical entries. For example, the construction maps lexical entries like *aime* into its negative counterpart *(n')aime*, as shown in Figure 12.

---

[14]Following Miller (1992), I take *ne* to be an inflectional affix which can be optionally realized in

$$
\begin{bmatrix}
\textit{neg-fin-v} \\
\text{FORM} \quad \langle(\text{n'})\text{aime}\rangle \\
\text{SYN}|\text{HEAD} \begin{bmatrix} \text{VFORM} & \textit{fin} \\ \text{NEG} & + \end{bmatrix} \\
\text{ARG-ST} \quad \left\langle \boxed{1}\text{NP}, \text{Adv}_I \begin{bmatrix} \text{LEX} & + \\ \text{NEG} & + \end{bmatrix}, \boxed{2}\text{NP} \right\rangle
\end{bmatrix}
$$

|

$$
\begin{bmatrix}
\textit{fin-v} \\
\text{FORM} \quad\quad\quad \langle\text{aime}\rangle \\
\text{SYN}|\text{HEAD}|\text{VFORM} \quad \textit{fin} \\
\text{ARG-ST} \quad\quad\quad \langle\boxed{1}\text{NP}, \boxed{2}\text{NP}\rangle
\end{bmatrix}
$$
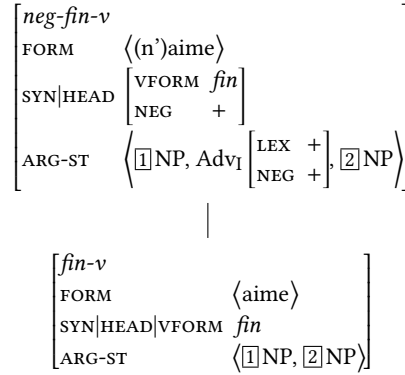
Figure 12: Post-Inflection of *(n')aime*

This output verb *neg-fin-v* then allows the negator *pas* to function as the complement of the verb *naime*, as represented in Figure 13.
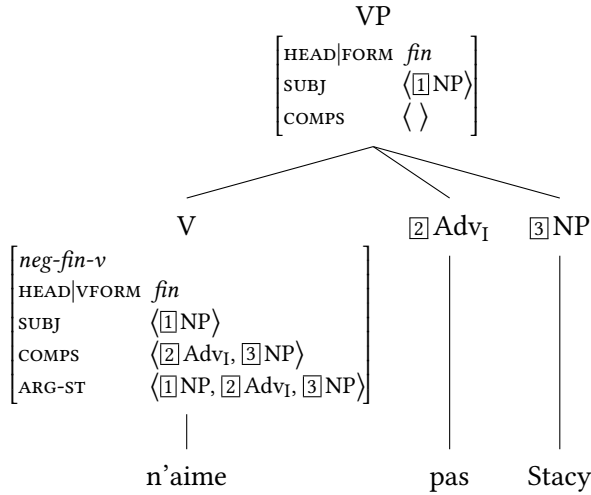
Figure 13: Add caption

The analysis also explains the position of *pas* in finite clauses:

(43)   a. * Jean ne [pas $_{\text{VP[fin]}}$[aime Jan]].
       b. Jean $_{\text{VP[fin]}}$[$_{\text{V[fin]}}$[(n')aime] $_{\text{Adv}}$[pas] $_{\text{NP}}$[Jan]].

the output of the lexical rule in Modern French.

The placement of *pas* in (43a) is unacceptable since *pas* here is used not as a nonfinite VP modifier, but as a finite VP modifier. But due to the present analysis which allows *pas*-type negative adverbs to function as the complement of a finite verb, *pas* can function as the sister of the finite verb *aime*.

Given that the conditional, imperative, and subjunctive, and even present participle verb forms in French are finite, the construction analysis also predicts that *pas* cannot precede any of these verb forms:

(44) a.   Si j'avais de l'argent, je ne achèterais pas.
           'If I had money, I would not buy a car.'

      b.   * Si j'avais de l'argent, je ne pas achèterais.

(45) a.   Ne mange pas ta soupe.
           'Don't eat your soup!'

      b.   * Ne pas mange ta soupe.

(46) a.   Il est important que vous ne répondiez pas.
           'It is important that you not answer.'

      b.   * Il est important que vous ne pas répondiez.

(47) a.   Ne parlant pas Français, Stacey avait des difficultés.
           'Not speaking French, Stacey had difficulties.'

      b.   * Ne pas parlant Français, Stacey avait des difficultés.

Another important consequence of the present construction-based analysis is that it allows us to reduce the parametric differences between French and English negation to be a matter of lexical properties. The negators *not* and *pas* are identical in that they both are VP[*nonfin*] modifying adverbs. But they are different with respect to which verbs can select them as complements. A comparison between the French Negative Construction and the English Negative Construction shows that *not* can be the complement of a finite auxiliary verb, whereas *pas* can be the complement of a finite verb. So the only difference is the morphosyntactic value [AUX +] and this induces the difference in positioning the negators.

This surface-oriented approach is in a sense similar to Pollock's viewpoint that the verb's finiteness plays a crucial role in the distribution of adverbs and negation. But there is one fundamental difference. I claim that it is not the interaction of verb movement and his subtheories such as the theta theory and 'quantification theory' but the morphosyntactic value (VFORM value) of the verb and lexical rules that affect the position of adverbs including *pas* and *not*. All surface structures are directly generated by X′ theory without movement. The conclusion we

can draw from these observations is that the position of adverbial negatives is determined not by the respective properties of verb movement, but by their lexical properties, the morphosyntactic (finiteness) features of the verbal head, and independently motivated Linear Precedence constraints.

3.4 Clitic-like Negative Verb

As we have seen, the negative markers *non* and *no* are the main way of expressing negation in Italian and Spanish. These negative markers always precede the main verb, whether finite or non-finite, as can be observed from the repeated Italian examples:[15]

(48) a. Gianni non legge articoli di sintassi.
Gianni NEG reads articles of syntax
'Gianni doesn't read syntax articles.'

b. Gianni vuole che io non legga articoli di sintassi.
Gianni wants that I NEG read articles of syntax.

c. Non leggere articoli di sintassi è un vero peccato.
NEG to.read articles of syntax is a real shame

d. Non leggendo articoli di sintassi, Gianni trova la linguistica noiosa.
NEG reading articles of syntax, Gianni finds linguistics boring

Various properties of the negator *non* in Italian and *no* in Spanish are shared with those of pronominal clitics. Like pronominal clitics, the Italian negator *non* must occupy the pre-auxiliary position:

(49) a. Gianni non ha parlato.
Gianni NEG has talked
'Gianni has not talked.'

b. * Gianni ha non parlato. (Belletti 1990: 12)

However, one key difference from pronominal clitics is that negators *non* in Italian and *no* in Spanish can appear alone, especially in ellipsis-like constructions. Consider Spanish examples from Crowgey (1994).

(50) a. * Juan no ha comido, pero Susana ha.
Juan NEG has eaten but Susana has
'John has not eaten, but Susana has.'

---

[15]Languages like Welsh also employ a clitic-like negative. See Borsley & Jones (2000) for detailed discussion of Welsh negation.

    b. * Juan ha comido, pero Susana no   ha.
          Juan has eaten   but Susana NEG has

    c.   Juan ha comido pero Susana no.
          Juan has eaten   but Susana NEG

The derivational view again attributes the distribution of this negative marker to the reflex of verb movement and functional projections (see Belletti (1990), Zanuttini (1991)). This line of analysis also appears to be persuasive in that the different scope of verb movement application could explain the observed variations among typologically and genetically related languages. Such an analysis, however, fails to capture unique properties of clitic-like negators from inflectional negators, negative auxiliaries, or adverb negatives.

The analysis which I defend here is to take *non* to be an independent lexical head element though it is a clitic. This claim follows the spirit of Monachesi (1993; 1998)'s analysis claiming that there are two types of clitics, affix-like clitics and word-like clitics: pronominal clitics belong to the former, whereas the bisyllabic clitic *loro* 'to-them' to the latter. The present analysis thus suggests that *non* also belongs to the latter group.[16] One key difference from pronominal clitics is thus that it functions as an independent word. Treating *non* as a word-like element will allow us to capture its word-like properties such as the possibility of stress on the negator and its separation from the first verbal element. But it is not a phrasal modifier, but a clitic, which combines with the following main verb. Adopting the treatment of English expressions like *than, as, of, a/an, the* as functor expressions that select a head expression (Van Eynde 2007; Sag 2012), the present analysis takes *non* as a functor, as represented by the following lexical specifications:

(51)   Lexical specifications for *non*:

$$
\begin{bmatrix}
\text{FORM } \langle \text{non} \rangle \\
\text{SYN} \begin{bmatrix} \text{HEAD|POS } \textit{clitic} \\ \text{SEL} \left\langle \begin{bmatrix} \text{HEAD|POS } \textit{verb} \\ \text{FRAMES } \langle \boxed{1} \rangle \end{bmatrix} \right\rangle \end{bmatrix} \\
\text{SEM} \begin{bmatrix} \text{FRAMES} \left\langle \begin{bmatrix} \textit{neg-fr} \\ \text{ARG } \boxed{1} \end{bmatrix} \right\rangle \end{bmatrix}
\end{bmatrix}
$$

This lexical entry roughly corresponds to the entry for Italian auxiliary verbs (and restructuring verbs with clitic climbing), in that the negator selects for a

---

[16]But one main difference between *non* and *loro* is that *non* is a head element, whereas *loro* is a complement XP. See Monachesi (1993; 1998) for further discussion of the behavior of *loro* and its treatment.

verbal complement. The combination of these two expressions is licensed by the HEAD-FUNCTOR CONSTRUCTION:

(52) HEAD-FUNCTOR CONSTRUCTION:
$$\begin{bmatrix} \textit{hd-functor-cxt} \\ \text{SEM } \boxed{2} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{SEL } \langle \boxed{1} \rangle \\ \text{SEM } \boxed{2} \end{bmatrix}, \boxed{1}\text{H}[\text{POS } \textit{verb}]$$

The construction allows a functor expression to combine with a head expression, whose resulting semantics is identical to the functor. This then licenses the combination of the clitic *non* with the following verb. In order to see how this system works, let us consider an example where the negator combines with a transitive verb as in (53).

(53)   Gianni non legge articoli di sintassi.
       Gianni NEG reads articles of syntax

       'Gianni doesn't read syntax articles.'

The negator *non* combines with the finite verb *legge*, whose lexical entry is given in (54):

(54)   Lexical specifications for the word *legge*:
$$\begin{bmatrix} \text{FORM } \langle \text{legge} \rangle \\ \text{SYN } \begin{bmatrix} \text{HEAD}|\text{POS } \textit{verb} \\ \text{VAL } \begin{bmatrix} \text{SUBJ } \langle \boxed{1}\text{NP} \rangle \\ \text{COMPS } \langle \boxed{2}\text{NP} \rangle \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST } \langle \boxed{1}\text{NP}, \boxed{2}\text{NP} \rangle \\ \text{SEM } \begin{bmatrix} \text{FRAMES } \langle [\textit{legge-fr}] \rangle \end{bmatrix} \end{bmatrix}$$

This lexical construction will license the following structure, interacting with the HEAD-FUNCTOR CONSTRUCTION (cf. Figure 14).

The HD-FUNCTOR CONSTRUCTION licenses the combination of the functor *non* with the following finite verb. The resulting combination inherits the subcategorization value of the head verb *legge*, but the meaning is identical to that of the functor.

Given that a functor in Italian precedes the head it selects, the functor treatment of *non* can easily account for the fact that the negator *non* precedes an auxiliary verb either in finite or infinitive clauses, but cannot follow it in either clause-type .

> add glosses to tree

(55)   a.   Maria non ha sempre pagato le   tasse.
            Maria NEG has always paid   the taxes
            'Maria hasn't always paid taxes.'
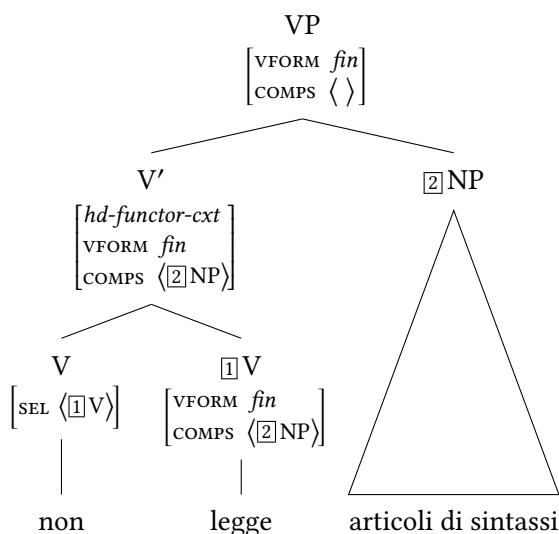
Figure 14: Add caption

    b.   * Maria ha sempre non pagato le tasse. (Zanuttini 1991: 123)

(56)   a.   Gianni sostiene di non essere uscito.
           Gianni claims   to NEG have   gone.out
           'Gianni claims not to have gone out.'

    b.   * Gianni sostiene di essere non uscito.
            Gianni claims   to have NEG gone.out   (Belletti 1990: 90)

In the nonderivational, lexicalist analysis just sketched here, the negator is taken to be a functor clitic that combines with a following verb. This analysis not only allows us to capture its dual properties – clitic-like and word-like properties, but also correctly predicts the positioning of *non* in various contexts. The conclusion we can draw from Italian type of sentential negation is that the distribution of a clitic-like negator is determined in relation to the head that this negative selects.

4 Concluding Remarks

The types of negation we have seen are identical in that they negate a sentence or clause in the given language. Does this entail that there is a universal functional category Neg that, interacting with other grammatical constraints such as

movement operations, allows all their distributional possibilities? My answer to this question is no.

One of the most attractive consequences of the derivational perspective has been that one uniform category, given other syntactic operations and constraints, explains the derivational properties of all types of negation in natural languages, and further can provide a surprisingly close and parallel structure among languages, whether typologically related or not. However, this line of thinking, first of all, runs the risk of missing the peculiar properties of each type of negation. Each individual language has its own way of expressing negation, and further has its own restrictions in the surface realizations of negation which can hardly be reduced to one uniform category. The supposition of a uniform syntactic category notion abstracts away only the common denominator (presumably a semantic notion), sweeping the particular lexical or syntactic characteristics of each type of negation under the carpet. This uniform NegP analysis has eventually forced nontrivial complications of other grammatical components in order to allow all the surface possibilities of each type of negation. For instance, by placing morphological negation in the realm of syntax, we miss the fundamental generalization that the formation and distribution of word and sentence are subject to different principles and operations and correspond to different modules of the grammar, namely, morphology and syntax.

In the nonderivational analysis, there is no uniform syntactic element, though a certain universal aspect of negation does exist, viz. its semantic contribution. Languages appear to employ various possible ways of negating a clause or sentence. Negation can be realized as different morphological and syntactic categories. By admitting morphological and syntactic categories, we have been able to capture their idiosyncratic properties in a simple and natural manner. Further this theory has been built upon the lexical integrity principle, the thesis that the principles that govern the composition of morphological constituents are fundamentally different from the principles that govern sentence structures. The obvious advantage of this perspective is that it can capture the distinct properties of morphological and syntactic negation, and also of their distribution, in a much more complete and satisfactory way.

One can view the difference between the derivational view and the nonderivational, lexicalist view as a matter of a different division of labor. In the derivational view the syntactic components of grammars bear almost all the burden of descriptive as well as explanatory resources. But in the nonderivational view, it is both the morphological and syntactic components that carry the burden. It is true that a derivational grammar whose chief explanatory resources are func-

tional projections including NegP and syntactic movement, also has furthered our understanding of negation and relevant phenomena in certain respects. But in so doing it has also brought other complexities into the basic components of the grammar. The present research strongly suggests that a more conservative division of labor between morphology and syntax is far more economical and feasible.

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Chapter 20

Ellipsis

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1 Introduction

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orci. Donec faucibus metus dui, nec iaculis purus pellentesque sit amet. Sed fermentum lorem non augue cursus, eu accumsan risus ullamcorper. Suspendisse rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 21

Binding

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1 Introduction

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rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Part III

Other levels of description

Chapter 22

Phonology

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1 Introduction: PHONOLOGY in the HPSG sign

The PHONOLOGY attribute in (Pollard & Sag 1987) and (Pollard & Sag 1994):

- rudimentary PHON value

- basic Phonology Principle constrained by Linear Precedence rules: corresponds to simple terminal spell-out of the phrase structure tree

- "Phonology-Free Syntax" (Miller et al. 1997): PHON information inaccessible for selection via SYNSEM

There has been relatively little work within HPSG on phonological representation and the analysis of phonological phenomena. Most references to the PHON attribute use it simply as a lexical identifier, or they are dealing with phenomena at the phonology-syntax interface (e.g. constituent order, ellipsis). For such applications, the actual content of the PHON value is unimportant. These topics are covered in other chapters.

2 Phonological representations in HPSG

Proposals for the detailed content of PHON values:

- encoding of phonological constituents (Bird & Klein 1994; Klein 2000; Höhle 1999)

- syllable structure Tseng (2008)

- metrical phonology (Klein 2000; Bonami & Delais-Roussarie 2006)

3 Phonological analysis in HPSG

- principles of constraint-based phonology vs derivational phonology (Bird & Klein 1994): compositionality, monotonicity

- compositional construction of prosodic structure in parallel with phrase structure (Klein 2000)

But HPSG is formally compatible with many approaches, and there is as yet no emerging consensus among practitioners.

- Finite state phonology (Bird 1992; 1995)

- need for abstract underlying forms (Skwarski 2009); phonologically empty categories

- OT in HPSG (Orgun 1996)

4 Specific phenomena and case studies

- shape conditions (Asudeh & Klein 2002)

- French (Tseng 2003; Bonami et al. 2004)

- phonological idioms [already covered in Manfred's chapter]

- ...

Abbreviations

Acknowledgements

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Chapter 23

Morphology

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1 Introduction

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rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 24

Semantics

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1 Introduction

Duis pulvinar lacus id gravida ornare. Phasellus eu mauris sed tortor maximus condimentum ultrices in leo. Donec non erat nec nulla ullamcorper ornare sed id ex. Integer risus mauris, aliquet vel aliquam sed, feugiat quis nisi. Suspendisse quis nunc a turpis porttitor mollis. In luctus nulla id nunc dapibus, id rhoncus lorem pretium. Nunc eget fringilla velit, semper commodo diam. Suspendisse odio odio, euismod ac ornare sed, tincidunt ac arcu. Pellentesque vitae fringilla

orci. Donec faucibus metus dui, nec iaculis purus pellentesque sit amet. Sed fermentum lorem non augue cursus, eu accumsan risus ullamcorper. Suspendisse rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 25

Information structure

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Information structure as the hinge between sentence and discourse has been at the center of interest for linguists working in different areas such as semantics, syntax or prosody for several decades. A constraint-based grammar formalism such as HPSG encoding multiple levels of linguistic representation within the architecture of signs opens up the possibility to elegantly integrate such information about discourse properties. In this article, we discuss a number of approaches that have explored how to best integrate information structure as a separate level into the representation of signs. We discuss, which lexical and phrasal priciples have been implemented in these approaches and how they constrain the distribution of the various information structural features. Finally, we discuss how the various approaches are used to formulate theories about the interaction of syntax, prosody and information structure. In particular, we will see several cases where (word order) principles that used to be stipulated in syntax can now be formulated as an interaction of syntax and discourse properties.

1 Introduction

The *information structure* of a sentence captures how the meaning expressed by the sentence is integrated into the discourse. The *information structure* thus encodes which part of an utterance is informative in which way, in relation to a particular context. A wide range of approaches exists with respect to the question what should be regarded as the primitives of the information structure.

It is now commonly assumed that there are three basic dimension of information structure that are encoded in natural languages and that have been assumed as the basic primitives: (i) A distinction between what is new information advancing the discourse (*focus*) and what is known, i.e., anchoring the sentence in

existing (or presupposed) knowledge or discourse (*background*), (ii) A distinction between what the utterance is about (*topic*, *theme*) and what the speaker has to say about it (*comment*, *rheme*), and (iii) and a dimension referred to as *information status* where entities that have already been mentioned in the discourse *given* ares distinguished from those that haven't been mentioned. (*new*). For all three ways of partitioning the information structure, we find approaches within the HPSG framework. Example (1) illustrated, how one utterance in the context of a question can be structured according to different partitionings of information structure.

(1)   Q: What does Sarah drink?

	background	*focus*
A:	Sarah	drinks	TEA.

| | *topic* | *comment* |

The focus/background division with focus as the part of an utterance that is informative with respect to the discourse is one of the most commonly adopted partitioning when studying information structure, and thus many approaches within the HPSG architecture as well assume a division into focus and background, such as the ones that will be discussed in this article: Engdahl & Vallduví (1996), De Kuthy (2002), Webelhuth (2007), Song & Bender (2012), Paggio (2009), Bildhauer (2008). Less common within the HPSG framework are approaches that take topic, i.e. the material that an utterance is about, as the central notion and assume topic and comment (or theme and rheme) as the primitives of the information structure. Most approaches discussed here assume that the background has one designated (mostly referential) element functioning as the topic (or link), among them are Engdahl & Vallduví (1996), De Kuthy (2002), Paggio (2009).

A third aspect of the information structure is captured under the notion of information status with primitives such as new and given. Here the discourse status of referential elements is of interest, i.e. whether they can be linked to previously mentioned items, i.e. whether they are (discourse) old or given, or whether they haven't been mentioned before and are thus (discourse) new. The representation of information status has received comparatively little interest within the HPSG community, the approach by De Kuthy & Meurers (2011) is one of the few approaches that explicitly integrate this dimension into their information structural architecture.

The need to represent discourse properties in a grammar architecture of signs results from the insight that in many, if not all, languages the way utterances are realized via their syntactic structure, morphological patterns and prosody very

often interacts with discourse requirements of these utterances. In other words, approaches dealing with constraints on word order in a particular construction need to encode that this particular word order is only grammatical given a particular context, or a particular accent pattern has to be connected to a particular discourse status of the accented elements. Most of the approaches discussed here include deal with such interface questions, and we therefore discuss the particular word order and phonetic theories that have been implemented in sections 6 and 7 in detail. As a starting point, however, we will first discuss the various architectural designs that have been implemented in order to be able to formulate the specific theories integrating discourse constraints.

2 Information structure in the architecture of signs

Several ways of representing information structure within the architecture of signs have been pursued as part of the HPSG framework: one of the earliest approaches, which is similar to the idea of F-marking as pursued in many syntax-based approaches to information structure in generative grammar (such as Jackendoff (1972),Selkirk (1982)), has been proposed by Manandhar (1994). He assumes that all signs have an additional appropriate feature INFO-STRUC which takes as its value objects of the sort *info-type*. A sign can then be specified for the subtypes of *info-type* shown in Figure 1 as its informational marking.
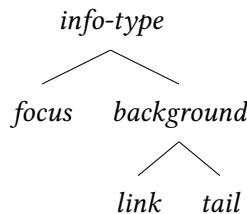
Figure 1: Type hierarchy under *info-type* of Manandhar (1994)

The distribution of the INFO-STRUC values in a sign is determined by the *Focus Inheritance Principle*, which enforces that in every phrase, the INFO-STRUC value of the mother subsumes the values of the INFO-STRUC of all of its daughters. The consequence of this principle is that if one daughter in a phrase is in the focus and the other one in the ground, then the mother's INFO-STRUC value is the smallest common super-type of both, namely *info-type*.

There are two problematic aspects of such an architecture. Firstly, it leads to a proliferation of syntactic markup of non-syntactic properties, in particular once one considers the full range of information structure notions, such as focus and focus projection, multiple foci, and the marking of other discourse functions such as topic. And secondly, the perspective of information structure as resulting from an independent interpretation process of syntactic markup does not support a view of syntax, information structure, and intonation as directly interacting modules, a view that can be nicely implemented in a multi-layer frameworks such as HPSG. More common are thus approaches that encode the information structure as a separate layer, i.e., a feature with its own structural representation.

In the original setup of signs introduced in Pollard & Sag (1994), the feature CONTEXT is introduced as part of *local* objects as a place to encode information relating to the pragmatic context (and other pragmatic properties) of utterances. In Engdahl & Vallduví (1996) it is argued that it would be most natural to also represent information structural information as part of this CONTEXT feature. Engdahl & Vallduví (1996) thus introduce the feature INFO-STRUC as part of the the CONTEXT and since they couch their approach into Vallduví (1992) information packaging account, INFO-STRUC is further divided into FOCUS and GROUND. All INFO-STRUC features take entire signs as their values. The complete specification is shown in Figure 2.

$$\begin{bmatrix} sign \\ \\ \text{SYNSEM|LOCAL|CONTEXT|INFO-STRUC} \begin{bmatrix} \text{FOCUS} & sign \\ \\ \text{GROUND} & \begin{bmatrix} \text{LINK} & sign \\ \text{TAIL} & sign \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Figure 2: Information structure in Engdahl & Vallduví (1996)

Another approach locating the representation of information structure within the CONTEXT feature is the one by Paggio (2009) as part of a grammar for Danish. The INFOSTR feature TOPIC, FOCUS and BG take as their values list of indices. Since Paggio (2009) includes Minimal Recursion Semantics (MRS, (Copestake et al. 2005)) as the semantic representation[1], these indices can be structure shared with the argument indices of the semantic relations collected on the RELS list of the content of a sign. The basic setup is illustrated in Figure 3.

Several approaches encode infostruc as part of the CONTENT, such as Song

---

[1]A detailed discussion of the properties and principles of MRS as implemented in HPSG can be found in Koenig & Richter (2018), Chapter 24 of this volume.

$$
\begin{bmatrix}
\textit{sign} \\[2pt]
\textsc{synsem}|\textsc{local}|\textsc{context}|\textsc{infostr}
\begin{bmatrix}
\textsc{focus} & \textit{list-of-indices} \\
\textsc{topic} & \textit{list-fo-indices} \\
\textsc{bg} & \textit{list-of-indices}
\end{bmatrix}
\end{bmatrix}
$$

Figure 3: Information structure in Paggio (2009)

(2017) and Song & Bender (2012). Since they also use MRS as the semantic representation language, they enrich the architecture of *mrs* structures. The information structure itself is encoded via a feature ICONS (Individual Constraints), that is introduced parallel to HCONS (handle constraints) as part of the CONTENT.

$$
\begin{bmatrix}
\textit{sign} \\[2pt]
\textsc{synsem}|\textsc{local}|\textsc{content}
\begin{bmatrix}
\textit{mrs} \\
\textsc{hook}
\begin{bmatrix}
\textit{hook} \\
\textsc{icons-key} & \textit{info-str} \\
\textsc{clause-key} & \textit{event}
\end{bmatrix} \\
\textsc{rels} & \textit{diff-list} \\
\textsc{hcons} & \textit{diff-list} \\
\textsc{icons} & \langle ..., \begin{bmatrix} \textit{info-str} \\ \textsc{clause} & \textit{individual} \\ \textsc{target} & \textit{individual} \end{bmatrix}, ... \rangle
\end{bmatrix}
\end{bmatrix}
$$

Figure 4: Information structure in Song & Bender (2012)

As pointed out by De Kuthy (2002), assuming that the information structure is part of *local* objects (which it is if it is part of the CONTEXT in HPSG as proposed by Engdahl & Vallduví (1996) or part of the CONTENT) is problematic in connection with a trace-based account of unbounded dependencies. Traces should not contribute anything to the information structure of a sentence. If one wants to develop an information structure approach which is independent of the decision of which kind of UDC theory one assumes, the only options for placing the information structure attribute are *synsem* objects or signs.

Information structure as part of *synsem* objects would suggest that it plays a role in syntactic selection. This possibility is assumed in Bildhauer & Cook (2011), and they thus represent INFO-STRUC as a feature appropriate for *synsem* objects (their account will be discussed in more detail in section 6. A third possibility is argued for in De Kuthy (2002) and Bildhauer (2008), namely that information structure should not be part of *synsem* objects. As a result, they encode information structure again as an additional feature of signs (similar to Manandhar (1994)

approach discussed above), but it is argued that the appropriate values should be semantic representations.

In De Kuthy (2002), a tripartite partition of information structure into focus, topic, and background is introduced. As to the question what kinds of objects should be defined as the values of these features, De Kuthy proposes the values of the INFO-STRUC features to be chunks of semantic information. It is argued that the semantic representation proposed in Pollard & Sag (1994) is not appropriate for her purpose, because the semantic composition is not done in parallel with the syntactic build-up of a phrase. Instead, the Montague-style semantic representation for HPSG proposed in Sailer (2000) is adopted, in which CONTENT values are regarded as representations of a symbolic language with a model-theoretic interpretation. As the semantic object language under CONTENT the language Ty2 (cf., Gallin (1975)) of two-sorted type theory is chosen. The resulting feature architecture is shown in Figure 5.

$$
\begin{bmatrix}
sign \\
\text{PHON} & list \\
\text{SYNSEM} & synsem \\
\text{INFO-STRUC} & \begin{bmatrix} info\text{-}struc \\ \text{FOCUS} & list\text{-}of\text{-}mes \\ \text{TOPIC} & list\text{-}of\text{-}mes \end{bmatrix}
\end{bmatrix}
$$
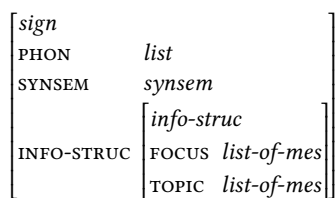
Figure 5: The structure of INFO-STRUC in De Kuthy (2002)

The information structure is encoded in the attribute INFO-STRUC that is appropriate for signs and has the appropriate features FOCUS and TOPIC, with lists of so-called meaningful expressions (semantic terms, cf. Sailer (2000)) as values.

3 Information structure principles

The above sketched approaches all assume that signs contain some kind of structural representation of information structure, with the consequence that they need to introduce principles that constrain the values of the information structural features. Most approaches thus formulate two types of principles as part of their grammar fragment, one set of principles on the lexical level tying information structure to word level properties such as accents, and another set of principles on the phrasal level determining the distribution of information structure values between mother and daughters in a phrase.

3.1 Instantiating information structure on the word level

In the approach of Engdahl & Vallduví (1996) prosodic properties of English, in particular accent placement, are tied to specific information structural properties of words and phrases. On the word level, they thus introduce two principles that instantiate the information structure FOCUS and LINK when the word has a particular accent. The two principles are shown in Figure 6. Words with an A accent

$$word \rightarrow \boxed{1}\begin{bmatrix} \text{PHON|ACCENT} & A \\ \text{INFO-STRUC|FOCUS} & \boxed{1} \end{bmatrix}$$

$$word \rightarrow \boxed{1}\begin{bmatrix} \text{PHON|ACCENT} & B \\ \text{INFO-STRUC|GROUND|LINK} & \boxed{1} \end{bmatrix}$$

Figure 6: Information structure of words

always contribute focal information, i.e. the entire sign is structure-shared with the INFO-STRUC|FOCUS value, words carrying a B accent contribute link information, i.e. the entire sign is structure-shared with the INFO-STRUC|GROUND|LINK value.

A similar set of word level principles is introduced in the approach of De Kuthy (2002), where the information structure of utterance in German is also tied to words carrying particular accent patterns. The phonology of signs is altered as shown in Figure 7 to include an ACCENT attribute to encode whether a word receives an accent or not, and whether it is a rising or a falling accent in case it receives one.

accent

unaccented *accented*

$$\begin{bmatrix} sign \\ \text{PHON} \begin{bmatrix} \text{PHON-STRING } list \\ \text{ACCENT } accent \end{bmatrix} \end{bmatrix}$$

rising-accent *falling-accent*
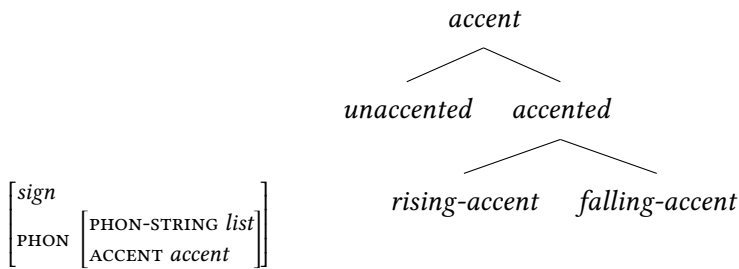
Figure 7: Representing pitch accents

The information structure of words is defined through the principle shown in Figure 16 which assigns the semantic contribution of the word to the focus or topic specification in the information structure representation of that word, depending on the type of accent the word receives.

$$word \rightarrow \begin{bmatrix} \text{PHON|ACCENT} & \textit{falling-accent} \\ \text{SS|LOC|CONT|LF} & \boxed{1} \\ \text{INFO-STRUC} & \begin{bmatrix} \text{FOCUS} & \langle\boxed{1}\rangle \\ \text{TOPIC} & \langle\rangle \end{bmatrix} \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{PHON|ACCENT} & \textit{unaccented} \\ \text{INFO-STRUC} & \begin{bmatrix} \text{FOCUS} & \langle\rangle \\ \text{TOPIC} & \langle\rangle \end{bmatrix} \end{bmatrix}$$

$$\vee \ldots$$

Figure 8: Relating intonation and information structure

3.2 Information structure principles on the phrasal level

3.2.1 Information packaging (Engdahl & Vallduví 1996)

One of the first approaches integrating an explicit representation of information structure into the HPSG architecture, Engdahl & Vallduví (1996) encode the information structure as part of the CONTEXT of signs with the help of an additional feature INFO-STRUC. As discussed above, on the lexical level the instantiation of these features can be triggered by phonetic properties, such as certain accents, for intonation languages like English. Phrasal signs must then satisfy the INFO-STRUC instantiation constraints in (2).

(2) INFO-STRUC *instantiation principles for English:*

> Either (i) if a DAUGHTER's INFO-STRUC 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).

As a result, the resulting structure including a wide VP focus with the relevant INFO-STRUC values is shown in Figure 9.

According to the principle in (2), since the rightmost NP daughter carries an A accent, the entire sign is structure-shared with the focus value (or, in Engdahl and Valluvi's terms the focus value "is instantiated"), the second clause of the principle in (2) applies and the focus value of the VP mother is the sign itself, which is then inherited by the sentence itself.
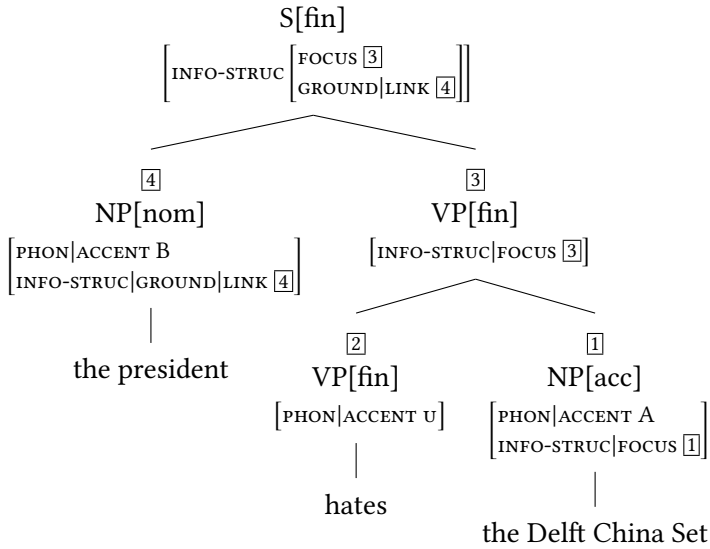
Figure 9: An example for VP focus in Engdahl & Vallduví (1996)

3.2.2 Information structure as structured meanings (De Kuthy 2002)

The structured meaning approach (von Stechow 1981; Jacobs 1983; Krifka 1992) provides a compositional semantic mechanism based on separate representations of the semantic contribution of the focus and that of the background. De Kuthy (2002) and Webelhuth (2007) worked out how such a structured meaning approach can be integrated into the HPSG architecture.

As discussed above, in De Kuthy (2002), the information structure is encoded in the attribute INFO-STRUC that is appropriate for signs and has the appropriate features FOCUS and TOPIC, with lists of so-called meaningful expressions as values. The background of a sentence in De Kuthy's approach is then defined to be that part of the logical form of the sentence which is neither in focus nor in topic. This characterization of background closely resembles the definition of background employed by the so-called *structured meaning* approaches to focus of von Stechow (1981), Jacobs (1983), or Krifka (1992). The INFO-STRUC value of a simple sentence with the focus as indicated in 3 is thus structured as shown in Figure 10.

The information-structure values of phrases are constrained by principles such as the one in Figure 11. The simplest case are those sentences where the focus or the topic does not project, i.e., only the words bearing an accent are in the topic

(3) Peter [[liest ein BUCH.]]$_F$
Peter reads a   book

$$\begin{bmatrix} \text{S|LOC|CONT|LF } \exists x[book'(x) \wedge read'(p,x)] \\ \text{INFO-STRUC} \begin{bmatrix} \text{FOCUS } \langle \lambda y \exists x[book'(x) \wedge read'(y,x)] \rangle \\ \text{TOPIC } \langle \rangle \end{bmatrix} \end{bmatrix}$$

Figure 10: A sign representation including information structure

or in the focus of an utterance. In this case, the mother of a phrase just collects

$$phrase \rightarrow \begin{bmatrix} \text{INFO-STR|FOCUS } \boxed{1} \oplus \text{COLLECT-FOCUS}\left(\boxed{2}\right) \\ \text{HEAD-DTR|INFO-STR|FOCUS } \boxed{1} \\ \text{NON-HEAD-DTRS } \boxed{2} \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{PHON|PHON-STR } \boxed{1} \oplus \boxed{2} \\ \text{SS|LOC} \begin{bmatrix} \text{CAT|HEAD } noun \vee prep \\ \text{CONT|LF } \boxed{3} \end{bmatrix} \\ \text{INFO-STR|FOCUS } \langle \boxed{3} \rangle \\ \text{ANY-DTR} \begin{pmatrix} \begin{bmatrix} \text{PHON|PHON-STR } \boxed{2} \\ \text{SS|L|CONT|LF } \boxed{4} \\ \text{INFO-STR|FOCUS } \langle \boxed{4} \rangle \end{bmatrix} \end{pmatrix} \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{SYNSEM|LOC} \begin{bmatrix} \text{CAT|HEAD } verb \\ \text{CONT|LF } \boxed{3} \end{bmatrix} \\ \text{INFO-STR|FOCUS } \langle \boxed{3} \rangle \\ \text{NON-HEAD-DTRS } \langle .., \begin{bmatrix} \text{SYNSEM} \begin{bmatrix} \text{FPP } plus \\ \text{LOC|CONT|LF } \boxed{4} \end{bmatrix} \\ \text{INFO-STR|FOCUS } \langle \boxed{4} \rangle \end{bmatrix}, .. \rangle \end{bmatrix}$$

$$\vee ...$$

Figure 11: Extended focus projection principle

the focus values of all her daughters as ensured by the principle in Figure 11 [2]. A similar principle is needed to determine the TOPIC value of phrases.

For cases of so-called focus projection in NPs and PPs, it is assumed in De Kuthy (2002) that it is sufficient to express that the entire NP (or PP) can be focused if the rightmost constituent in that NP (or PP) is focused, as expressed by the second disjunct of the principle in Figure 11. If focus projection is possible in a

---

[2]The presentation differs from that in De Kuthy (2002), it is the one from De Kuthy & Meurers (2003). Definitions of the auxiliary relations:

Draft of 29th November 2018, 11:59

certain configuration then this is always optional, therefore the focus projection principle for nouns and prepositions is formulated as a disjunct. The second disjunct of the principle in Figure 11 ensures that a phrase headed by a noun or a preposition can only be in the focus (i.e., its entire logical form is token identical to its focus value) if the daughter that contributes the rightmost part of the phonology of the phrase is entirely focused itself. Again, a similar principle needs to be provided for the TOPIC value of nominal and prepositional phrases.

For the verbal domain, the regularities are known to be influenced by a variety of factors, such as the word order and lexical properties of the verbal head (cf., e.g., von Stechow & Uhmann 1986). Since verbs need to be able to lexically mark which of their arguments can project focus when they are accented, De Kuthy & Meurers (2003) introduce the boolean-valued feature FOCUS-PROJECTION-POTEN-TIAL (FPP) for objects of type *synsem*. Figure 12 shows the relevant part of the lexical entry of the verb *lieben* (love) which allows projection from the object but not the subject:

$$
\begin{bmatrix}
\text{PHON|PHON-STR } \langle \textit{lieben} \rangle \\[4pt]
\text{ARG-S } \left\langle
\begin{bmatrix}
\text{LOC|CAT|HEAD} \begin{bmatrix} \textit{noun} \\ \text{CASE } \textit{nom} \end{bmatrix} \\[8pt]
\text{FPP } \textit{minus}
\end{bmatrix},
\begin{bmatrix}
\text{LOC|CAT|HEAD} \begin{bmatrix} \textit{noun} \\ \text{CASE } \textit{acc} \end{bmatrix} \\[8pt]
\text{FPP } \textit{plus}
\end{bmatrix}
\right\rangle
\end{bmatrix}
$$

Figure 12: The focus projection potential of *lieben*

The third disjunct of the principle in Figure 11 then specifies under which circumstances focus can project in the verbal domain: a phrase headed by a verb can only be in the focus (i.e., its entire logical form is token identical to an element of its focus value) if the daughter that has the focus projection potential (FPP *plus*) is entirely focused itself.

3.2.3 Information structure inheritance in MRS

As introduced above, in the MRS based approach of Paggio (2009) the information structure is part of the CONTEXT, consisting of FOCUS, TOPIC and BACK-GROUND features which are structure shared with the respective INDEX values

---

$$\text{ANY-DTR}\left(\boxed{1}\right) := \left[\text{HEAD-DTR } \boxed{1}\right].$$

$$\text{ANY-DTR}\left(\boxed{1}\right) := \left[\text{NON-HEAD-DTRS } \textit{element}\left(\boxed{1}\right)\right].$$

$$\text{COLLECT-FOCUS}\left(\langle\,\rangle\right) := \langle\,\rangle.$$

$$\text{COLLECT-FOCUS}\left(\left\langle \left[\text{INFO-STRUC|FOCUS } \langle\boxed{1}\rangle\right] \mid \boxed{2}\right\rangle\right) := \left\langle \boxed{1} \mid \text{COLLECT-FOCUS}\left(\boxed{2}\right)\right\rangle.$$

of the semantic representation of a phrase. Paggio (2009) connects the distribution of information structure values to particular clausal types and introduces new phrasal subtypes which constrain the distribution of information structure in the respective phrase. One example for such a new phrasal subtype is the *focus-inheritance* as defined in figure 13, which then has to be cross-classified with every basic phrasal subtype (such as *hd-comp, hd-spec, had-adj*, etc.) in order to constrain the distribution of focus values across all phrasal subtypes.

$$
\begin{bmatrix}
\textit{focus-inheritance} \\[4pt]
\text{SYNSEM|LOC|CONTEXT} & \begin{bmatrix} \text{FOCUS} & \langle \boxed{2},\boxed{1} \rangle \\ \text{BG} & \boxed{3} \end{bmatrix} \\[10pt]
\text{HD|SYNSEM|LOC|CONTEXT} & \begin{bmatrix} \text{FOCUS} & \boxed{1} \\ \text{BG} & \boxed{3} \end{bmatrix} \\[10pt]
\text{NON-HD} & \begin{bmatrix} \text{SYNSEM|LOC|CONTEXT|FOCUS} & \langle \boxed{2} \rangle \\ \text{ACCENT} & \textit{true} \end{bmatrix}
\end{bmatrix}
$$

Figure 13: focus-inheritance in Paggio (2009)

The principle in 13 ensures that the list of focus values of the mother is the list of focus values of the head daughter plus the focus value of the non-head daughter, in case it is accented. Similar principles are defined for the inheritance of background values, also depending on the accent status of the non-head daughter. Paggio further assumes that each phrasal subtype has further subtypes connecting it to one of the information structure inheritance phrasal types. For examples, she assumes that there is a phrasal subtype *focus-hd-adj* that is a subtype both of *hd-adj* and of *focus-inheritance*. Finally, clausal types are introduced that account for the information structure values at the top level of a clause. For example, the *decl-main-all-focus* as shown in figure 14, is a clause, in which both the background and the topic values are empty and the mother collects the focus values from the head and the non-head daughter.

Different from Paggio's approach, Song (2017), Song & Bender (2012) locate the representation of information structure within the MRS based CONTENT value of signs. The list elements of information structural values build up for a phrase consists of focus, background or topic elements co-indexed with the semantic INDEX values of the daughters of that phrase. The main point of their approach is that they want to be able to represent underspecified information structural values, since very often a phrase, for example with a certain accent pattern, is ambiguous with respect to the context in which it can occur and thus is ambiguous with respect to its information structure values. An example they discuss is the one in (4), where the first sentence could be an answer to the question

$$
\begin{bmatrix}
\textit{decl-main-all-focus} \\
\text{CTXT}|... \begin{bmatrix} \textit{all-focus} \\ \text{TOPIC} \quad \langle \rangle \\ \text{FOCUS} \quad \langle \boxed{2},\boxed{1} \rangle \\ \text{BG} \qquad \langle \rangle \end{bmatrix}
\end{bmatrix}
$$

$$
\begin{bmatrix} \text{CTXT}|...|\text{FOCUS} \; \langle \boxed{1} \rangle \end{bmatrix} \qquad \begin{bmatrix} \text{CTXT}|...|\text{FOCUS} \; \boxed{2} \end{bmatrix}
$$
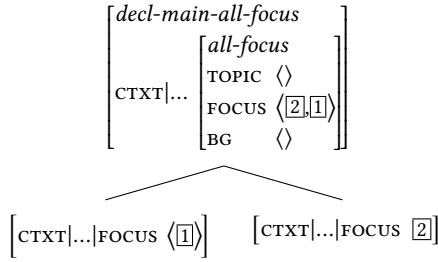
Figure 14: Declarative all-focus construction

What barks? and thus signal narrow focus, whereas the second utterance could be answer to the question *What happened?* and signal broad focus.

(4)   a.   [[The DOG]]$_F$ barks.
      b.   [[The DOG barks]]$_F$.

The approach pursued in Song & Bender (2012) thus assumes, that the two possible readings in (4) are further specializations of one MRS which is associated with one syntactic structure and includes underspecified values, in particular the type of the ICONS element for the constituent *barks*, leaving it open whether it is part of the focus or not. Unfortunately they don't specify how a potential focus projection or focus instantiation principle for a non-ambiguous phrase could look like in their approach. They only mention that "it at least plausible that MRS and ICONS will contain enough information to calculate the range of fully-specified information structures for each sentence".

4 Topics

Most HPSG approaches are based on a focus/background division of the information structure. To capture aspects of a topic vs. comment distinction, or to be able to specify topics as a special element in the background, they include an additional feature or substructure for topics. Engdahl & Vallduví (1996), for example, divide the GROUND into LINK and TAIL, where the link is a special element of the background linking it to the previous discourse, just like topics. In the approaches of De Kuthy (2002), Song & Bender (2012), Paggio (2009), and additional feature TOPIC is introduced, parallel to FOCUS and BACKGROUND, in order to distinguish discourse referents as topics from the rest of the background.

Most approaches don't introduce separate mechanisms for the distribution of

TOPIC values, but assume that similar principles as the ones introduced for focus can constrain topic values, as mentioned above for the approach of De Kuthy (2002). A more specific example can be found in Paggio (2009), where a constraint on topicalization constructions including a topic-comment partitioning is formulated, as illustrated in Figure 15. This *inv-topic-comment* phrasal type con-

$$
\begin{bmatrix}
\textit{inv-topic-comment} \\[4pt]
\text{CTXT}|\ldots
\begin{bmatrix}
\textit{topic-comment} \\
\text{TOPIC} & \langle\boxed{1}\rangle \\
\text{FOCUS} & \boxed{2} \\
\text{BG} & \langle\boxed{3},\boxed{1}\rangle
\end{bmatrix}
\end{bmatrix}
$$

$$
\begin{bmatrix}
\text{CTXT}|\ldots
\begin{bmatrix}
\text{TOPIC} & \langle\boxed{1}\rangle \\
\text{BG} & \langle\boxed{1}\rangle
\end{bmatrix}
\end{bmatrix}
\qquad
\begin{bmatrix}
\text{CTXT}|\ldots
\begin{bmatrix}
\text{FOCUS} & \boxed{2} \\
\text{BG} & \boxed{3}
\end{bmatrix}
\end{bmatrix}
$$
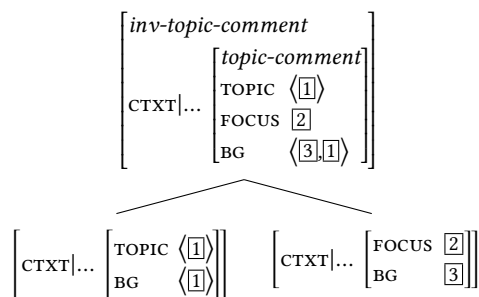
Figure 15: Topicalization construction with extracted topic

strains the information structure values of topicalization constructions in Danish characterized by subject verb inversion, where the topic corresponds to the topicalized complement, as illustrated by the example in (5) from Paggio (2009).

(5) og [i det nederste vindue]$_T$ [tager man og saetter urtepotten]$_F$
     and in the lowest window takes one and puts flowerpot.DEF
     'And in the lowest window you put the flowerpot.'

5 Givenness

In De Kuthy & Meurers (2011), it is shown how the HPSG approach to information structure of De Kuthy (2002) and colleagues can be extended to capture givenness and to make the right predictions for so-called *deaccenting*, which has been shown to be widespread (Büring 2006). In contrast to Schwarzschild (1999), who spells out his approach in the framework of alternative semantics Rooth (1992), they show how the notion of givenness can be couched in a standard structured meaning approach – thereby preserving the explicit, compositional representations of focus.

The example in in (6) illustrated the necessity to include information about the givenness into information structural setup.

(6) The conference participants are renting all kind of vehicles. Yesterday, Bill came to the conference driving a red convertible and today he's arrived with a blue one.

    a. What did John rent?

    b. He (only) rented [[a GREEN convertible]]$_F$.

The context in (6) introduces some conference participants, Bill, the rental of vehicles, and red and blue convertibles into the discourse. Based on this context, when considering the question (6a) asking for the object that John is renting as the focus, one can answer this question with sentence (6b), where *a green convertible* is the focus: Out of all the things John could have rented, he picked a green convertible. In this focus, only *green* is new to the discourse, whereas convertibles were already given in the context, and still the entire NP is in the focus

To capture such cases of focus projection, an additional feature GIVEN is introduced as part of the setup of De Kuthy (2002) as already discussed in section 3.2.2. The relation between pitch accents and the information structure of words is still defined by the principle shown in Figure 16 depending on the type of accent the word receives.

$$
word \rightarrow \begin{bmatrix} \text{PHON|ACCENT} & accented \\ \text{SS|LOC|CONT|LF} & \boxed{1} \\ \text{STRUC-MEANING} & \begin{bmatrix} \text{FOCUS} & \langle\boxed{1}\rangle \\ \text{GIVEN} & \langle\rangle \end{bmatrix} \end{bmatrix} \vee \begin{bmatrix} \text{PHON|ACCENT} & unaccented \\ \text{STRUC-MEANING} & \begin{bmatrix} \text{FOCUS} & \langle\rangle \\ \text{GIVEN} & \langle\rangle \end{bmatrix} \end{bmatrix} \vee \dots
$$

Figure 16: Relating intonation and information structure for words

We extend the Focus Projection Principle of De Kuthy & Meurers (2003) with a disjunct capturing focus projection in the presence of givenness. Figure 17 shows the resulting principle.

The fourth disjunct of the Focus Projection Principle[3] captures the previously unaccounted cases where given material in a focused phrase is deaccented. Focus in those examples can project from a focused daughter in a position which normally does not allow focus projection. This only is an option if all other daughters

---

[3]The auxiliary relations are defined as:

$$
\text{DTRS-LIST}\left(\langle\boxed{1}|\boxed{2}\rangle\right) = \begin{bmatrix} \text{HEAD-DTR} & \boxed{1} \\ \text{NON-HD-DTRS} & \boxed{2} \end{bmatrix}
$$

$$
\text{GIVEN-SIGN-LIST} := \langle\rangle.
$$

$$
\text{GIVEN-SIGN-LIST} := \left\langle \begin{bmatrix} \text{SS|L|CONT|LF} & \boxed{1} \\ \text{STRUC-MEANING} & \begin{bmatrix} \text{GIVEN} & \langle\boxed{1}\rangle \end{bmatrix} \end{bmatrix} \middle| \text{GIVEN-SIGN-LIST} \right\rangle.
$$

$$phrase \rightarrow$$

$$\begin{bmatrix} \text{STRUC-MEANING}|\text{FOCUS} \; \boxed{1} \oplus \text{COLLECT-FOCUS}\left(\boxed{2}\right) \\ \text{HEAD-DTR}|\text{INFO-STR}|\text{FOCUS} \; \boxed{1} \\ \text{NON-HEAD-DTRS} \; \boxed{2} \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{PHON}|\text{PHON-STR} \; \boxed{1} \oplus \boxed{2} \\ \text{SS}|\text{LOC} \begin{bmatrix} \text{CAT}|\text{HEAD} \quad noun \vee prep \\ \text{CONT}|\text{LF} \quad \boxed{3} \end{bmatrix} \\ \text{STRUC-MEANING}|\text{FOCUS} \; \langle\boxed{3}\rangle \\ \text{ANY-DTR} \left(\begin{bmatrix} \text{PHON}|\text{PHON-STR} \qquad \boxed{2} \\ \text{SS}|\text{L}|\text{CONT}|\text{LF} \qquad \boxed{4} \\ \text{STRUC-MEANING}|\text{FOCUS} \quad \langle\boxed{4}\rangle \end{bmatrix} \right) \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{SYNSEM}|\text{LOC} \begin{bmatrix} \text{CAT}|\text{HEAD} \quad verb \\ \text{CONT}|\text{LF} \quad \boxed{3} \end{bmatrix} \\ \text{STRUC-MEANING}|\text{FOCUS} \; \langle\boxed{3}\rangle \\ \text{NON-HEAD-DTRS} \; \langle .., \begin{bmatrix} \text{SYNSEM} \begin{bmatrix} \text{FPP} \; plus \\ \text{LOC}|\text{CONT}|\text{LF} \; \boxed{4} \end{bmatrix} \\ \text{STRUC-MEANING}|\text{FOCUS} \; \langle\boxed{4}\rangle \end{bmatrix} ,.. \rangle \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT}|\text{LF} \; \boxed{3} \\ \text{STRUC-MEANING}|\text{FOCUS} \; \langle\boxed{3}\rangle \\ \text{DTRS-LIST} \left(\text{GIVEN-SIGN-LIST} \; \bigcirc \left\langle \begin{bmatrix} \text{SS}|\text{L}|\text{CONT}|\text{LF} \qquad \boxed{4} \\ \text{STRUC-MEANING} \begin{bmatrix} \text{FOCUS} \; \langle\boxed{4}\rangle \end{bmatrix} \end{bmatrix} \right\rangle \right) \end{bmatrix}$$

Figure 17: Focus Projection Principle

in that focused phrase are *given*. Spelling this out, the fourth disjunct of the principle in Figure 17 specifies that the mother of a phrase can be in the focus (i.e., the entire LF value of the mother's CONTENT is token identical to an element on the mother's FOCUS list) if it is the case that the list of all daughters (provided by *dtrs-list*) consists of *given* signs into which a single *focused* sign is shuffled ($\bigcirc$).[4] As before, a sign is focused if its LF value is token identical to an element of its FOCUS value; and a sign is given if its LF value is token identical to an element of its GIVEN value.

The pitch accent in this example is on the adjective *green* so that the principle in Figure 16 licenses structure sharing of the adjective's content with its FOCUS value. In the context of the question (6a), the entire NP *a green convertible* of example (6b) is in the focus. In the phrase *green convertible*, the clause licensing focus projection in NPs does not apply since the adjective *green*, from which

---

[4]If only binary structures are assumed, as in the examples in this paper, the principle can be simplified. We here kept the general version with recursive relations following De Kuthy & Meurers (2003), which also support flatter structures.

the focus has to project in this case, is not the rightmost element of the phrase. What does apply is the fourth disjunct of the principle licensing focus projection in connection with givenness. Since the noun *convertible* is given, the adjective *green* is the only daughter in the phrase that is not given and focus is allowed to project to the mother of the phrase. In the phrase *a green convertible*, focus projection is again licensed via the clause for focus projection in noun phrases, since the focused phrase *green convertible* is the rightmost daughter in that noun phrase.

6 Information structure and word order

The explicit representation of information structure as part of signs in HPSG opens up the possibility of providing explanations for constraints previously stipulated in syntax, such as word order constraints, by deriving the constraints from the nature of the integration of a sentence into the discourse. Many of the approaches discussed in the previous section employ the information structural architecture exactly in this way and formulate principles linking word order to discourse properties.

One first such approach is presented in Engdahl & Vallduví (1996), where word order constraint for Catalan are couched into the information structure set up discussed in section 3.2. The basic observation is that in Catalan the word order within the sentential core is VOS and that every constituent within this sentential core is interpreted as focal. If an argument of the main verb of a sentence is to be interpreted as non-focal, it mus be clitic-dislocated. The example in 7 from Engdahl & Vallduví (1996) illustrated such two cases.

(7)　a.　Ahir　　[[va tornar a　Barcelona el　PRESIDENT.]]$_F$
　　　　　yesterday return　　　to Barcelona the president

　　b.　A Barcelona$_1$ [[hi$_1$ va tornar el　PRESIDENT.]]$_F$
　　　　　to Barcelona　　　 returned　the president

　　c.　[[Hi$_1$ va tornar el PRESIDENT]]$_F$a Barcelona.
　　　　　'Yesterday, the president returned to Barcelona.'

With respect to modelling this within the HPSG account, they assume that phrases associated with a LINK interpretation should be constrained to be left dislocated whereas phrases associated with a TAIL interpretation should be right attached. They thus introduce the following ID schema for Catalan:

(8) *Head-Dislocation Schema for Catalan:*
The DTRS value is an object of sort *head-disloc-struc* whose HEAD-DTR|SYN-SEM|LOCAL|CATEGORY value satisfies the description
$\left[\text{HEAD } \textit{verb}\left[\text{VFORM } \textit{finite}\right], \text{SUBCAT } \langle\rangle\right]$, and whose DISLOC-DTRS|CONTEXT|INFO-STRUC value is instantiated and for each DISLOC-DTR, the HEAD-DTR|SYNSEM|LOCAL|CONTENT value contains an element which stands in a *binding* relation to that DISLOC-DTR.

The principle requires that the information structure value dislocated daughters of a finite sentences has to be GROUND. An additional LP statement then captures the relation between the directionality of the dislocation and a further restriction of the GROUND value, as illustrated in Figure 18. This LP statement is

LINK > FOCUS > TAIL

Figure 18: LP constraint on information structure in Catalan

meant to ensure that link material must precede focus material and focus material must precede tails. By this, Engdahl & Vallduví (1996) want to ensure that left-detached constituents are always interpreted as links and right-detached constituents as tails.

The insights from Engdahl and Vallduví's approach are the basis for an approach accounting for clitic left dislocation in Greek presented by Alexopoulou & Kolliakou (2002). The representation of information structure with the features FOCUS, and GROUND (further divided into LINK and TAIL, is taken over as well as the phonological constraints on words and the information-structure instantiation principle. In order to account for clitic left dislocation, as illustrated in example 9, an additional feature CLITIC is introduced as appropriate for *nonlocal* objects.

(9) a. Pii simetehoun s' afti tin paragogi?
     b. Tin parastasi   *ti* skinothetise o   Karolos KOUN …
         the performance   directed   the Karolos Koun

The Linkhood Constraint shown in Figure 19 ensures that links (i.e. elements whose INFOSTRUC|LINK value is instantiated) can only be fillers that are "duplicated" in the morphology by a pronominal affix, i.e. it is required that there is an element on the CLITIC list of the head daughter.

The Linkhood Constraint thus has two purposes, it ensures clitic doubling and it connects the particular word order of left dislocated phrase to discourse properties by requiring the filler daughter to be the link of the entire clause.

$$\begin{bmatrix} \textit{clitic-left-disloc-phrase} \\ \text{INFO-STRUC|LINK} \quad \boxed{2} \\ \text{CLITIC} \qquad\qquad \boxed{\Sigma_2} \end{bmatrix} \rightarrow \boxed{2}\begin{bmatrix} \text{PHON|ACCENT} \quad u \\ \text{HEAD} \qquad\qquad \boxed{1} \end{bmatrix}, \mathbf{H}\begin{bmatrix} \textit{phrase} \\ \text{HEAD} \quad \textit{verb} \\ \text{CLITIC} \quad \boxed{1} \uplus \boxed{\Sigma_2} \end{bmatrix}$$

Figure 19: The Linkhood Constraint for clitic left dislocation phrases

The approach of De Kuthy (2002) relates the occurrence of discontinuous NPs in German to specific information-structural contexts, and De Kuthy & Meurers (2003) show that the realization of subjects as part of fronted non-finite constituent and its constraints can be accounted for based on independent information-structure conditions.

Based on the setup discussed in section 3.2.2 above, constraints are formulated that constrain the occurrence of discontinuous NPs and fronted VPs based on their information structure properties. The type of discontinuous NPs that are at the center of De Kuthy's approach are so-called NP-PP split construction, in which a PP occurs separate from its nominal head, as exemplified in (10).

Example (10) illustrated the type of discontinuous NPs

(10) a. *Über Syntax* hat Max sich [ein Buch] ausgeliehen.
about syntax has Max self a book borrowed
'Max borrowed a book on syntax.'

b. [Ein Buch] hat Max sich *über Syntax* ausgeliehen.
a book has Max self about syntax borrowed

The information structure propertied of discontinuous noun phrases are summarized in De Kuthy (2002) in the following principle:

In an utterance, in which a PP occurs separate from an NP, either the PP or the NP must be in the focus or in the topic of the utterance, but they cannot both be part of the topic or the same focus projection.

The last restriction can be formalized as: they cannot be part of the same meaningful-expression on the FOCUS list or the TOPIC list of the INFO-STRUC value of the utterance.

As discussed in De Kuthy & Meurers (2003), it has been observed that in German it is possible for ergative and unergative verbs to realize a subject as part of a fronted non-finite verbal constituent. This is exemplified in (11).

(11) a. [Ein Fehler unterlaufen] ist meinem Lehrer noch nie.
an$_{nom}$ error crept in is my teacher still never
'So far my teacher has never made a mistake.'

b. [Haare   wachsen] können ihm nicht mehr.
    hair$_{nom}$ grow   can   him not   anymore
   'His hair cannot grow anymore.'

c. [Ein   Außenseiter gewonnen] hat hier noch nie.
    an$_{nom}$ outsider   won   has hier still   never
   'An outsider has never won here yet.'

In order to account for the context-sensitive occurrence of such fronted verbal constituents, specific information structure properties of fronted verb phrases need to be expressed in a principle expressing what De Kuthy and Meurers refer to as Webelhuth's generalization: In an utterance in which a verb phrase occurs as a fronted constituent (i.e., the filler of a head-filler phrase) this entire verb phrase must be in the focus of the utterance (i.e., the FOCUS value of the fronted constituent must be identical to its semantic representation). Figure 20 shows the formalization of this principle.

$$\begin{bmatrix} \textit{head-filler-phrase} \\ \text{NON-HEAD-DTR}|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{HEAD} \quad \textit{verb} \end{bmatrix} \rightarrow$$

$$\begin{bmatrix} \text{INFO-STRUC}|\text{FOCUS} \left\langle \boxed{1} \right\rangle \\ \text{NON-HEAD-DTR} \begin{bmatrix} \text{INFO-STRUC}|\text{FOCUS} \quad \left\langle \boxed{1} \right\rangle \\ \text{SYNSEM}|\text{LOC}|\text{CONT}|\text{LF} \quad \boxed{1} \end{bmatrix} \end{bmatrix}$$

Figure 20: Webelhuth's generalization

Combining the new lexical specifications, the focus projection rule for the verbal domain, and the partial fronting focus requirement with the basic setup of De Kuthy (2002) one obtains a theory which predicts that subjects can only be part of a fronted verbal projection if they can be the focus exponent. The sketch of an analysis for an example such as (??) is illustrated in Figure 21. The entry of *gewinnen* (to win) (the base form of the verb *gewonnen* in example (11c) in figure 22 encodes the lexical property that the subject of this intransitive verb has focus projection potential.

Under the assumption that in example (11c) the noun *Außenseiter* carries a pitch accent, the information-structure principle for words in Figure 16 ensures that the noun contributes its LOGICAL-FORM value to its FOCUS value. The focus projection principle of Figure 11 ensures that the focus can project over the entire NP *ein Außenseiter*, i.e., its FOCUS element is identical to its LF value. Since *ein Außenseiter* as the subject of *gewonnen* in the tree in Figure 21 is lexically marked

$$\begin{bmatrix} \text{P|PS} \left\langle \textit{Ein Außenseiter gewonnen hat hier noch nie} \right\rangle \\ \text{IS|FOCUS} \left\langle \boxed{1}\exists x[\textit{aussenseiter}'(x) \land \textit{gewinnen}'(x)] \right\rangle \end{bmatrix}$$

F
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{Ein Außenseiter gewonnen} \right\rangle \\ \text{S|L} \boxed{2}\begin{bmatrix} \text{CONT|LF} \boxed{1} \end{bmatrix} \\ \text{IS|FOCUS} \left\langle \boxed{1} \right\rangle \end{bmatrix}$$

H
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{hat hier noch nie} \right\rangle \\ \text{IS|FOCUS} \left\langle \right\rangle \end{bmatrix}$$

C
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{Ein Außenseiter} \right\rangle \\ \text{S} \begin{bmatrix} \text{L|CO|LF} \boxed{3}\lambda Q \exists x[\textit{aussenseiter}'(x) \land Q(x)] \\ \text{FPP } \textit{plus} \end{bmatrix} \\ \text{IS|FOCUS} \left\langle \boxed{3} \right\rangle \end{bmatrix}$$

H
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{gewonnen} \right\rangle \\ \text{IS|FOCUS} \left\langle \right\rangle \end{bmatrix}$$

$$\begin{bmatrix} \text{P|PS} \left\langle \textit{Ein} \right\rangle \\ \text{IS|FOCUS} \left\langle \right\rangle \end{bmatrix} \begin{bmatrix} \text{P} \begin{bmatrix} \text{PS} \left\langle \textit{Außenseiter} \right\rangle \\ \text{ACCENT } \textit{falling} \end{bmatrix} \\ \text{S|L|CO|LF} \boxed{4}\lambda x\, \textit{aussenseiter}'(x) \\ \text{IS|FOCUS} \left\langle \boxed{4} \right\rangle \end{bmatrix}$$

H
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{hat} \right\rangle \\ \text{IS|FOCUS} \left\langle \right\rangle \end{bmatrix}$$

C
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{hier} \right\rangle \\ \text{IS|FOCUS} \left\langle \right\rangle \end{bmatrix}$$

C
$$\begin{bmatrix} \text{P|PS} \left\langle \textit{noch nie} \right\rangle \\ \text{IS|FOCUS} \left\langle \right\rangle \end{bmatrix}$$

C
$$\begin{bmatrix} \text{P|PS} \left\langle \right\rangle \\ \text{S} \begin{bmatrix} \text{L} & \boxed{2} \\ \text{N|I|SLASH} \left\{ \boxed{2} \right\} \end{bmatrix} \end{bmatrix}$$

Figure 21: Partial VP fronting in De Kuthy & Meurers (2003)

$$\begin{bmatrix} \text{PHON} & \left\langle \textit{gewinnen} \right\rangle \\ \text{ARG-S} & \left\langle \begin{bmatrix} \text{FPP } \textit{plus} \\ \text{LOC|CAT|HEAD|CASE } \textit{nom} \end{bmatrix} \right\rangle \end{bmatrix}$$

Figure 22: The lexical entry of *gewinnen* (to win)

as FPP *plus*, the principle governing focus projection in the verbal domain in Figure 11 licenses the focus to project over the entire fronted verbal projection *ein Außenseiter gewonnen*. The fronted constituent thus contributes its LF value to its FOCUS value. In this example, the focus does not project further so that in the head-filler phrase the focus values of the two daughters are simply collected as licensed by the first disjunct of the focus principle in Figure ??. As a result, the FOCUS value of the fronted verbal projection is the FOCUS value of the entire sentence. Finally, note that the example satisfies Webelhuth's generalization, which requires a fronted verbal projection to be the focus of the utterance as formalized in Figure 20.

In the same spirit, Bildhauer & Cook (2010) show that sentences in which multiple elements have been fronted are directly linked to specific types of information structure. In German as a V2 language, normally exactly one constituent oc-

curs in the position before the finite verb in declarative sentences. But so-called multiple fronting examples with more than one constituent occurring before the finite verb have been well attested in naturally occurring data, two examples from Bildhauer & Cook (2010) are shown in (12).

(12)   a.   [Dem Saft] [eine kräftige   Farbe] geben Blutorangen.
            to.the juice a   more.vivid colour give   blood.oranges
            'What give the jiuce a more vivid colour is blood oranges.'

        b.   [Stets] [einen Lacher] [auf ihrer Seite] hatte die Bubi Ernesto
            always a   laugh   on   their side   had the Bubi Ernesto
            Familie.
            Family
            'Always good for a laugh was the Bubi Ernesto Family.'

But, as discussed by Bildhauer and Cook, such multiple fronting examples seem to require very special discourse conditions in order to be acceptable. Just like the fronted verb phrases discussed in De Kuthy & Meurers (2003) above, Bildhauer & Cook (2010) propose to analyze multiple fronting constructions in German as head-filler phrases, which in this case introduce a topic shift. Following the approach by Müller (2005), multiple fronting configurations can be identified via the filler daughter which must have a HEAD|DSL (double shlash) value of type *local*. As introduced above, Bildhauer & Cook (2010) assume that an information structure attribute is specified in *symsem* objects, with the features FOCUS and TOPIC taking lists of *elementary predications* as their values. In general, multiple fronting *head-filler* phrases are restricted by the constraint in 23.

$$\begin{bmatrix} \textit{head-filler-phrase} \\ \text{NON-HEAD-DTRS} \ \langle [\text{HEAD}|\text{DSL} \ \textit{local}] \rangle \end{bmatrix} \rightarrow \begin{bmatrix} \text{IS} \ \textit{pres} \lor \textit{a-top-com} \lor \ldots \end{bmatrix}$$

$$\begin{bmatrix} \textit{head-filler-phrase} \\ \text{IS} \ \textit{pres} \end{bmatrix} \rightarrow \begin{bmatrix} \text{SS}|\text{LOC}|\text{CAT}|\text{HEAD}|\text{DT} \ \langle [\text{LOC}|\text{CONT}|\text{RELS} \ \boxed{1}] \rangle \\ \text{HD-DTR}|\text{SS}|\text{IS}|\text{FOCUS} \ \langle \boxed{1} \rangle \end{bmatrix}$$

Figure 23: Relating multiple fronting to focus

The first constraint ensures that *head-filler* phrases that are instances of multiple frontings are restricted to have an *is*-value of an appropriate type[5] The second

---

[5]Bildhauer & Cook (2010) assume that the type *is* as the appropriate value for IS has several subtypes specifying specific combinations of TOPIC and FOCUS values, such as *pres* for presentational focus or *a-top-com* for assessed-topic-comment.

constraint then ensures that in presentational multiple frontings the designated topic of the non-head daughter (i.e. the verbal head of the *head-filler* phrase) must be focused. The feature DT lexically specifies which element, if any, is normally realized as the Topic for a particular verb. This constraint thus encoded what Bildhauer & Cook (2010) call "topic shift": the non-fronted element in a multiple fronting construction that would preferably be the topic is realized as a focus. A similar constraint is introduced for another instance of multiple frontings, which is called *propositional assessment* multiple frontings. Here it has to be ensured that the designated topic must be realized as the topic somewhere in the head-daughter and the head-daughter must also contain a focused element.

Webelhuth (2007) provides another account of the special information structural requirements of fronted constituents, in this case of predicate fronting in English that is based on the interaction of word order and information structural constraints.

(13)   I was sure that Fido would bark and *bark he did.*

The principles part of Webelhuth's account require that in such cases of predicate fronting the auxiliary is focussed and the remainder of the sentence is in the background. The interaction of the two principles in Figure 24. The first

$$
\begin{bmatrix} \textit{aux-wd} \\ \textsc{arg-s} \ \langle NP, \textit{gap-ss} \rangle \end{bmatrix} \rightarrow \begin{bmatrix} \textsc{ss|status} \ \textit{foc} \\ \textsc{arg-s} \quad \langle [\textsc{status} \ \textit{bg}], \textit{gap-ss} \rangle \end{bmatrix}
$$

$$
\begin{bmatrix} \textit{PRED-PREPOS-PH} \end{bmatrix} \rightarrow \begin{bmatrix} \textsc{hd-fill-ph} \\ \textsc{non-hd-dtr} \ [\textsc{ss|status} \ \textit{bg}] \end{bmatrix}
$$

Figure 24: Predicate preposing phrases

constraint ensure that auxiliary words whose predicate complement could be preposed (i.e. is of type *gap-ss* have the information status *focus*, whereas the status of the first argument (the subject) is *background*. Additional constraints then ensure that auxiliary words with a gapped second argument can only occur in predicate preposing phrases, and vice versa, that predicate preposing phrases contain the right kind of auxiliary.

7 Information structure and prosody

A lot of languages mark information structure prosodically, as for example English and German, where pitch accents of various shapes are used to mark focus.

Accordingly, several of the above discussed approaches include a component, which enriches the phonology representation of signs such that is allows the integration of the necessary prosodic aspects, as for example accents.

Engdahl & Vallduví (1996) assume, that signs can be marked for particular accents signalling focus or links in English, so-called A and B accents. In a similar way, De Kuthy (2002) extend the PHON value such that it includes a feature AC-CENT, in order to formulate constraints on the connection between accents and information structure markings. Since most of the above discussed approaches don't include a detailed analysis of the prosodic properties of the respective language that investigated with respect to discourse properties, most approaches don't go beyond the postulation of one or two particular accents, that are somehow encoded as part of the PHON value. These accents then more or less serve as an illustration how lexical principles can be formulated within a particular theory that constrain the distribution of information structural values on the lexical level. The more articulate such a representation of PHON values including accent pattern, intonation contours, boundary tone etc is, the more detailed the principles could be that are needed to connect information structure to prosodic patterns in languages that signal discourse properties via intonation contours.

In Bildhauer (2008) such a detailed account of the prosodic properties of Spanish is developed together with a proposal how to integrate prosodic aspects into the PHON value, also allowing a direct linking of the interaction of prosody and information structure. In his account, the representation of PHON values in HPSG is enriched to include four levels of prosodic constituency, i.e., phonological utterance, intonational phrases, phonological phrases and prosodic words. The lowest level, prosodic words of type *pwrd*, include the features SEGS, which correspond to the original PHON value assumed in HPSG, and additional features such as PA for pith accents or BD for boundary tones, to encode whether a boundary tone is realized on that word. The additional features UT (phonological utterance), IP (intonational phrase) and PHP (phonological phrase) encode via the the typ EPR (edges and prominence) which role a prosodic word plays in higher level constituents. For examples, the feature DTE (designated terminal element) specifies, whether the word is the most prominent in a phonological phrase. A sign's PHON list then contains all *pwrd* objects and relational constraints define the roles each prosodic word plays in the higher prosodic constituents. This flat representation of prosodic constituency still allows to express constraints about intonational contours associated with certain utterance types. One example discussed in Bildhauer's work is the contour associated with broad focus declaratives in Spanish, which can be decomposed into a sequence of late-rise (L*H) prenuclear accents,

followed by an early-rise nuclear accent (LH*), followed by a low boundary tone
(L%). The constraint introduced to model this contour for declarative utterances
thus instantiates the BD value (boundary tone) of the last PWRD in the PHON list
to low, instantiates a nuclear pitch accent *low-hig-star* on this rightmost prosodic
word and ensures that the a prenuclear pitch accent *low-star-high* is instantiated
on every preceding compatible prosodic word. The resulting constraint is shown
in Figure 25.

$$
\textsc{decl-tune}\left(\boxed{1}\right) \leftrightarrow \boxed{1} = \boxed{2} \oplus \left\langle \begin{bmatrix} \text{PA} & \textit{low-high-star} \\ \text{BD} & \textit{low} \end{bmatrix} \right\rangle \quad \wedge
$$

$$
\boxed{2} = \textsc{list}\left(\begin{bmatrix} \text{BD} & \textit{none} \end{bmatrix}\right) \wedge
$$

$$
\boxed{2} = \textsc{list}\left(\begin{bmatrix} \text{PA} & \textit{none} \end{bmatrix}\right) \bigcirc \textsc{list}\left(\begin{bmatrix} \text{PA} & \textit{low-star-high} \end{bmatrix}\right)
$$

$$
\begin{bmatrix} \textit{SIGN} \\ \text{EMBED} & \text{-} \end{bmatrix} \rightarrow \begin{bmatrix} \text{PHON } \boxed{1} \end{bmatrix} \wedge \textsc{decl-tune}\left(\boxed{1}\right)
$$

Figure 25: Intonational contour of Spanish declarative utterances

The second constraint in Figure 25 ensure that only unembedded utterances
can be constrained to the just described declarative tune. That this specific con-
tour is then compatible with a broad focus reading is ensured by an additional
principle expressing a general focus prominence constraint for Spanish, namely
that focus prominence has to fall on the last prosodic word in the phonological
focus domain, which in the case of a broad focus can be the entire utterance. Fig-
ure 26 shows the resulting principle in Bildhauer's account. Since only words

$$
\begin{bmatrix} \textit{sign} \\ \text{CONT} & \boxed{1} \\ \text{FOC} & \boxed{1} \end{bmatrix} \rightarrow \begin{bmatrix} \text{PHON LIST} \oplus \left\langle \begin{bmatrix} \text{UT|DTE} & + \end{bmatrix} \right\rangle \end{bmatrix}
$$

Figure 26: Focus Prominence in Spanish

that are the designated terminal element (DTE) can bear a pitch accent, the inter-
play of the two above principles ensures, that in utterances with a declarative
contour the entire phrase can be in the focus. These principles thus nicely illus-
trate, how not only lexical elements can contribute to the information structure
via their prosodic properties, but how entire phrases with specific prosodic prop-
erties can be constrained to have specific information structural properties.

8 Conclusion

We have discussed various possibilities of how to represent information structure within the HPSG's sign-based architecture. Several approaches from the HPSG literature were presented which all have in common that they introduce a separate feature INFO-STRUC into the HPSG setup, but they differ in (i) where they locate such a feature, (ii) what the appropriate values are for the representation information structure, and (iii) how they encode principles constraining the distribution and interaction of information structure with other levels of the grammatical architecture. Finally, we discussed a number of theories in which phenomena such as word order are constrained to be only well-formed in case they exhibit specific information structural properties.

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Part IV

Other areas of linguistics

Chapter 26

Diachronic syntax

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Universität Potsdam

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1 Introduction

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Abbreviations

Acknowledgements

Chapter 27

Acquisition

Jonathan Ginzburg
Université Paris Diderot

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1 Introduction

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rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 28

Processing

Tom Wasow

Although not much psycholinguistic research has been carried out in the framework of HPSG, the architecture of the theory fits well with what is known about human language processing. This chapter enumerates aspects of this fit. It then discusses two phenomena, island constraints and relative clauses, in which the fit between experimental evidence on processing and HPSG analyses seems particularly good.

1 Introduction

Little psycholinguistic research has been guided by ideas from HPSG (but see Konieczny (1996) for a notable exception). This is not so much a reflection on HPSG as on the state of current knowledge of the relationship between language structure and the unconscious processes that underlie language production and comprehension. Other theories of grammar have likewise not figured prominently in theories of language processing, at least in recent decades.[1] The focus of this chapter, then, will be on how well the architecture of HPSG comports with available evidence about language production and comprehension.

My argument is much the same as that put forward by Sag et al. (2003: Chapter 9), and Sag & Wasow (2011; 2015), but with some additional observations about the relationship between competence and performance. I presuppose the "competence hypothesis" (see Chomsky 1965: Chapter 1), that is, that a theory of language use (performance) should incorporate a grammar representing the

---

[1]Half a century ago, the Derivational Theory of Complexity (DTC) was an attempt to use psycholinguistic experiments to test aspects of the grammatical theory that was dominant at the time. The DTC was discredited in the 1970s, and the theory it purported to support has long-since been superseded. See Fodor et al. (1974) for discussion.

knowledge of language (competence) that is drawn on in everyday comprehension and production, as well as in other linguistic activities, such as language games and the (often artificial) tasks employed in psycholinguistic experiments.

The primary reason for adopting the competence hypothesis is parsimony: a theory of language use is simpler if it does not have to repeat much the same information about the language in both its production and comprehension components. This information would include things like the vocabulary, the preferred word orders, and most of the rest of what linguists encode in their grammars. A performance theory that incorporates a grammar only needs to include such information once.[2] Moreover, to the extent that the theoretical constructs of the grammar play a role in modeling both production and comprehension, the overall theory is simpler.

There is also, however, an empirical reason for preferring a model with a good fit between competence and performance. As noted by Bresnan et al. (2001), preferences that are only statistical tendencies in some languages can show up in others as categorical requirements. The example they discuss in detail is the avoidance of clauses with third-person subjects but first- or second-person objects or obliques. In English, this is a powerful statistical tendency, which they document by showing that the passivization rate in the Switchboard corpus is very significantly lower when the agent is first- or second-person than when it is third-person. In Lummi (a Salish language of British Columbia), this preference is categorical: clauses with third-person subjects but first- or second-person objects or obliques are simply unacceptable. Hawkins (2004; 2014) argues that such examples are by no means exceptional, and formulates the following "Performance-Grammar Correspondence Hypothesis" (PGCH):

> Grammars have conventionalized syntactic structures in proportion to their degree of preference in performance, as evidenced by frequency of use and

---

[2]There are of course some discrepancies between production and comprehension that need to be accounted for in a full theory of language use. For example, most people can understand some expressions that they never use, including such things as dialect-specific words or accents. But these discrepancies are on the margins of speakers' knowledge of their languages. The vast majority of the words and structures that speakers know are used in both production and comprehension. Further, it seems to be generally true that what speakers can produce is a proper subset of what they can comprehend. Hence, the discrepancies can plausibly be attributed to performance factors such as memory or motor habits. See Gollan et al. (2011) for evidence of differences between lexical access in production and comprehension. See Momma & Phillips (2018) for arguments that the structure building mechanisms in production and comprehension are the same. For a thoughtful discussion of the relationship between production and comprehension, see MacDonald (2013) and the commentaries published with it.

ease of processing.[3]

There are two ways in which a processing model incorporating a grammar might capture this generalization. One is to give up the widespread assumption that grammars provide categorical descriptions, and that any quantitative generalizations must be extra-grammatical; see Francis (2018) for arguments supporting this option, and thoughtful discussion of literature on how to differentiate processing effects from grammar. For example, some HPSG feature structures might allow multiple values for the same feature, but with probabilities (adding up to 1) attached to each value.[4] I hasten to add that fleshing out this idea into a full-fledged probabilistic version of HPSG would be a large undertaking, well beyond the scope of this chapter; see Linadarki (2006), and Miyao & Tsujii (2008) for work along these lines. But the idea is fairly straightforward, and would allow, for example, English to have *in its grammar* a non-categorical constraint against clauses with third-person subjects and first- or second-person objects or obliques.

The second way for a theory adopting the competence hypothesis to represent Hawkins's PGCH would be to allow certain generalizations to be stated either as grammatical constraints (when they are categorical) or as probabilistic performance constraints. This requires a fit between the grammar and the other components of the performance model that is close enough to permit what is essentially the same generalization to be expressed in the grammar or elsewhere. In the case discussed by Bresnan et al. for example, treating the constraint in question as part of the grammar of Lummi but a matter of performance in English would require that both the theory of grammar and models of production would include, minimally, the distinction between third-person and other persons, and the distinction between subjects and non-subjects. Since virtually all theories of grammar make these distinctions, this observation is not very useful in choosing among theories of grammar. I will return later to phenomena that bear on

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[3]In the Bresnan et al. example, I know of no experimental evidence that clauses with third-person subjects and first- or second-person objects are difficult to process. But a plausible case can be made that the high salience of speaker and addressee makes the pronouns referring to them more accessible in both production and comprehension than expressions referring to other entities. In any event, clauses with first- or second-person subjects and third-person objects are far more frequent than clauses with the reverse pattern in languages where this has been checked. Thus, the Bresnan et al. example falls under the PGCH, at least with respect to "frequency of use" .

[4]I discussed this idea many times with the late Ivan Sag . He made it clear that he believed grammatical generalizations should be categorical. In part for that reason, this idea was not included in our joint publications on processing and HPSG.

the choice among grammatical theories, at least if one accepts the competence hypothesis.

Since its earliest days, HPSG research has been motivated in part by considerations of computational tractability (see Flickinger, Pollard & Wasow (2018), Chapter 2 of this volume, for discussion). Some of the design features of the theory can be traced back to the need to build a system that could run on the computers of the 1980s. Despite the obvious differences between human and machine information processing, some aspects of HPSG's architecture that were initially motivated on computational grounds have turned out to fit well with what is known about human language processing. A prime example of that is the computational analogue to the competence hypothesis, namely, the fact that the same grammar is used for parsing and generation. In Section 3, I will discuss a number of other high-level design properties of HPSG, arguing that they fit well with what is known about human language processing, which I very briefly summarize in Section 2. In Section 4, I will briefly discuss two phenomena that have been the locus of much discussion about the relationship between grammar and processing, namely, island constraints and differences between subject and object relative clauses.

2 Key facts about human language processing

In this section I review a number of well-known general properties of human language processing. Most of them seem evident from subjective experience of language use, but there is supporting experimental evidence for all of them.

2.1 Incrementality

Both language production and comprehension proceed incrementally, from the beginning to the end of an utterance. In the case of production, this is evident from the fact that utterances unfold over time. Moreover, speakers very often begin their utterances without having fully planned them out, as is evident from the prevalence of disfluencies. On the comprehension side, there is considerable evidence that listeners (and readers) begin analyzing input right away, without waiting for utterances to be complete. A grammatical framework that assigns structure and meaning to initial substrings of sentences will fit more naturally than one that doesn't into a processing model that exhibits this incrementality we see in human language use.

I hasten to add that there is also good evidence that both production and comprehension involve anticipation of later parts of sentences. While speakers may not have their sentences fully planned before they begin speaking, some planning of downstream words must take place. This is perhaps most evident from instances of nouns exhibiting quirky cases determined by verbs that occur later in the clause. For example, objects of German *helfen*, 'help', take the dative case, rather than the default accusative for direct objects. But in a sentence like (1), the speaker must know that the verb will be one taking a dative object at the time the dative case article *dem* is uttered.

(1) Wir werden dem   Kind bald helfen.   (German)
     we   will   the.DAT child soon help
     'We will help the child soon.'

Likewise, in comprehension there is ample evidence that listeners and readers anticipate what is to come. This has been demonstrated using a variety experimental paradigms. Eye-tracking studies (see Tannenhaus, et al 1995, Altmann & Kamide 1999, Arnold et al. 2007, among many others) have shown that listeners use semantic information and world knowledge to predict what speakers will refer to next.

Thus, a theory of grammar that fits comfortably into a model of language use should provide representations of initial substrings of utterances that can be assigned (partial) meanings and be used in predicting later parts of those utterances.

2.2 Non-modularity

Psycholinguistic research over the past four decades has established that language processing involves integrating a wide range of types of information on an as-needed basis. That is, the various components of the language faculty interact throughout their operation. A model of language use should therefore *not* be modular, in the sense of Jerry Fodor's influential (1983b) book, *The Modularity of Mind*.[5]

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[5]Much of the psycholinguistic research of the 1980s was devoted to exploring modularity – that is, the idea that the human linguistic faculty consists of a number of distinct "informationally encapsulated" modules. While Fodor's book was mostly devoted to arguing for modularity at a higher level, where the linguistic faculty was one module, many researchers at the time extended the idea to the internal organization of the linguistic faculty, positing largely autonomous mechanisms for phonology, syntax, semantics, and pragmatics, with the operations of each of these sub-modules unaffected by the operations of the others. The outcome of years

Some casual observations argue against modular language processing. For example, the famously ambiguous sentences (2a) and (2b) can be disambiguated in speech by the stress patterns.

(2)   a. I forgot how good beer tastes.

   b. Dogs must be carried.

The two meanings of (2a) correspond to two different parses (one with *good* as part of the noun phrase *good beer* and the other with *how good* as a verb phrase modifier). The two meanings of (2b) have the same syntactic structure, but differ in whether the requirement is that all dogs be carried, or that everyone carry a dog. This interaction of prosody with syntax (in the case of (2a)) and with semantics (in the case of (2b)) is produced and perceived before the end of the utterance, suggesting that phonological information is available in the course of syntactic and semantic processing.

Moreover, non-linguistic knowledge influences the disambiguation in both of these cases. If (2a) is preceded by "I just finished three weeks without alcohol," the natural interpretation of *good* is as a modifier of *tastes*; but following "I just finished three weeks drinking only Bud Light," *good* is more naturally interpreted as a modifier of *beer*. In the case of (2b), only one interpretation (that anyone with a dog must carry it) is plausible, given our knowledge of the world. Indeed, most non-linguists fail to see the ambiguity of (2b) without a lengthy explanation.

More rigorous evidence of the non-modular character of language processing has been provided by a variety of types of experiments. The work of Michael Tanenhaus and his associates, using eye-tracking to investigate the time-course of sentence comprehension, played an important role in convincing most psycholinguists that human language understanding is non-modular. See, for example, Eberhard et al. (1995), McMurray et al. (2008), Tanenhaus et al. (1995), Tanenhaus et al. (1996), and Tanenhaus & Trueswell (1995). A recent survey of work arguing against modularity in language processing is provided by Spevack et al. (2018).

2.3 Importance of words

The individual properties of words play a central role in how people process phrases and sentences. Consider, for example, what is probably the most famous sentence in psycholinguistics, (3), due originally to (Bever 1970).

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of experimental studies on the linguistic modularity idea was that it was abandoned by most psycholinguists. For an early direct response to Fodor, see Marslen-Wilson & Tyler (1987).

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(3)   The horse raced past the barn fell.

The extreme difficulty that people who have not previously been exposed to (3) have comprehending it depends heavily on the choice of words. A sentence like (4), with the same syntactic structure, is far easier to parse.

(4)   The applicant interviewed in the morning left.

Numerous studies (e.g. Ford et al. (1982), Trueswell et al. (1993), MacDonald et al. (1994), Bresnan et al. (2007), Wasow et al. (2011)) have shown that such properties of individual words as subcategorization preferences, semantic categories (e.g. animacy), and frequency of use can influence the processing of utterances.

2.4 Influence of context

Much of the evidence against modularity of the language faculty is based on the influences of non-linguistic context and world knowledge on language processing. The well-known McGurk effect (McGurk & MacDonald (1976)) and the Stroop effect (Stroop (1935)) demonstrate that, even at the word level, visual context can influence linguistic comprehension and production.

Linguistic context also clearly influences processing, as the discussion of examples (2a) and (2b) above illustrates. The same conclusion is supported by numerous controlled studies, including, among many others, those described by Crain & Steedman (1985), Altmann & Steedman (1988), Branigan (2007), Traxler & Tooley (2007), Matsuki et al. (2011), and Spevack et al. (2018). The last of these references concludes (p. 11), "when humans and their brains are processing language with each other, there is no format of linguistic information (e.g., lexical, syntactic, semantic, and pragmatic) that cannot be rapidly influenced by context."

2.5 Speed and accuracy of processing

A good deal of psycholinguistic literature is devoted to exploring situations in which language processing encounters difficulties, notably work on garden paths (in comprehension) and disfluencies (in production). Much more striking than the existence of these phenomena, however, is how little they matter in everyday language use. While ambiguities abound in normal sentences (see Wasow (2015)), comprehenders very rarely experience noticeable garden paths. Similarly, disfluencies in spontaneous speech occur in nearly every sentence but rarely disrupt communication.

People are able to use speech to exchange information remarkably efficiently. A successful account of human language processing must explain why it works as well as it does.

3 Features of HPSG that fit well with processing facts

In this section, I review some basic design features of HPSG, pointing out ways in which they comport well with the properties of language processing listed in the previous section.

3.1 Constraint-based

Well-formedness of HPSG representations is defined by the simultaneous satisfaction of a set of constraints that constitutes the grammar. This lack of directionality allows the same grammar to be used in modeling production and comprehension.

check for crossreferencing other chapters once they are in

Consider, for instance, the example of quirky case assignment illustrated in (1) above. A speaker uttering (1) would need to have planned to use the verb *helfen* before beginning to utter the object NP. But a listener hearing (1) would encounter the dative case on the article *dem* before hearing the verb and could infer only that a verb taking a dative object was likely to occur at the end of the clause. Hence, the partial mental representations built up by the two interlocutors during the course of the utterance would be quite different. But the grammatical mechanism licensing the combination of a dative object with this particular verb is the same for speaker and hearer.

In contrast, theories of grammar that utilize sequential operations to derive sentences impose a directionality on their grammars. If such a grammar is then to be employed as a component in a model of language use (as the competence hypothesis stipulates), its inherent directionality becomes part of the models of both production and comprehension. But production involves mapping meaning onto sound, whereas comprehension involves the reverse mapping. Hence, a directional grammar cannot fit the direction of processing for both production and comprehension.[6]

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[6]This was an issue for early work in computational linguistics that built parsers based on the transformational grammars of the time, which generated sentences using derivations whose direction went from an underlying structure largely motivated by semantic considerations to the observable surface structure. See, for example, Hobbs & Grishman (1975).

Branigan & Pickering (2017) argue at length that "structural priming provides an implicit method of investigating linguistic representations."[7] They go on to conclude (p. 14) that the evidence from priming supports "frameworks that ... assume nondirectional and constraint-based generative capacities (i.e., specifying well-formed structures) that do not involve movement."[8] HPSG is one of the frameworks they mention that fit this description.

3.2 Surface-oriented

The features and values in HPSG representations are motivated by straightforwardly observable linguistic phenomena. HPSG does not posit derivations of observable properties from abstract underlying structures. In this sense it is surface-oriented.

The evidence linguists use in formulating grammars consists of certain types of performance data, primarily judgments of acceptability and meaning. Accounts of the data necessarily involve some combination of grammatical and processing mechanisms. The closer the grammatical descriptions are to the observable phenomena, the less complex the processing component of the account needs to be.

For example, the grammatical theory of Kayne (1994), which posits a universal underlying order of specifier-head-complement, requires elaborate (and directional) transformational derivations to relate these underlying structures to the observable data in languages whose surface order is different (a majority of the language of the world). In the absence of experimental evidence that the production and comprehension of sentences with different constituent orders involve mental operations corresponding to the grammatical derivations Kayne posits, his theory of grammar seems to be incompatible with the competence hypothesis.

Experimental evidence supports this reasoning. As Branigan & Pickering (2017) conclude (p. 9), "[P]riming evidence supports the existence of abstract syntactic representations. It also suggests that these are shallow and monostratal in a way that corresponds at least roughly to the assumptions of ... Pollard & Sag (1994) .... It does not support a second, underlying level of syntactic structure or the

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[7]Priming is the tendency for speakers to re-use linguistic elements that occurred earlier in the context; structural priming (which Branigan and Pickering sometimes call *abstract priming*) is priming of linguistic structures, abstracted from the particular lexical items in those structures.

[8]Branigan and Pickering's conclusions are controversial, as is evident from the commentaries accompanying their target article.

syntactic representation of empty categories associated with the movement of constituents in some transformational analyses."

3.3 Informationally rich representations

The feature structure descriptions of HPSG include all types of linguistic information relevant to the well-formedness and interpretation of expressions. This includes phonological, morphological, syntactic, semantic, and contextual information. They can also incorporate non-linguistic contextual information (e.g. social information), though this has not been extensively explored.

The local cooccurrence of these different types of information within a single representation facilitates modeling production and comprehension processes that make reference to more than one of them. The architecture of the grammar is thus well suited to the non-modularity and context-sensitivity of language processing. It is interesting in this regard to consider the conclusions of two papers by psycholinguists who surveyed experimental evidence and inferred what types of grammatical information was essential for processing.

The following series of quotes captures the essence of what MacDonald et al. (1994) wrote regarding lexical representation, based on a survey of a wide range of psycholinguistic studies:

- "[T]he lexical representation for a word includes a representation of the word's phonological form, orthographic form, semantics, grammatical features (including grammatical category), morphology (at least inflectional), argument structure, and X-bar structure." (p. 684)

- "[T]he connection structure of the lexicon encodes relationships among different types of lexical information."[9] (p. 684)

- "In addition to constraints that hold between various aspects of lexical representations, sentence and discourse contexts also constrain lexical representations during processing..." (p. 686)

With the possible exception of "X-bar structure", this sounds very much like a description of the types of information included in HPSG feature structure descriptions.

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[9]A reviewer asked what feature of HPSG this maps into. The answer is straightforward: a word's phonological form, semantics, grammatical features, morphology, and argument structure are all represented together in one feature structure description, and the different pieces of the description may be linked through coindexing or tagging.

Over twenty years later, Branigan & Pickering (2017) came to the following conclusions about linguistic representations, based on priming studies:

- "The syntactic representations capture local relationships between a 'mother' and its constituent 'daughter(s)' (e.g., a VP comprising a verb and two NPs), independent of the larger context in which the phrase appears (e.g., that the VP occurs within a subordinate clause), or the internal structure of the subphrases that constitute it (e.g., that the first NP comprises a determiner, adjective, and noun)." (p. 9)

- "[S]ome elements that are not phonologically represented may be syntactically represented." (p. 10)

- "Other priming evidence similarly indicates that some semantically specified elements are not specified syntactically." (p. 11)

- "[T]he semantic level of representation contains at least specifications of quantificational information, information structure, and thematic roles." (p. 11)

- "Evidence from priming supports a range of mappings between information encoded in the semantic representation and information encoded in the syntactic representation: between thematic roles and grammatical functions, between thematic roles and word order, between animacy and syntactic structure, and between event structures and syntactic structures." (p. 12)

The two lists are quite different. This is in part because the focus of the earlier paper was on lexical representations, whereas the later paper was on linguistic representations more generally. It may also be attributable to the fact that McDonald, et al, framed their paper around the issue of ambiguity resolution, while Branigan and Pickering's paper concentrated on what could be learned from structural priming studies. Despite these differences, it is striking that the conclusions of both papers about the mental representations employed in language processing are very much like those arrived at by work in HPSG.

3.4 Lexicalism

A great deal of the information used in licensing sentences in HPSG is stored in the lexical entries for words. A hierarchy of lexical types permits commonalities to be factored out to minimize what has to be stipulated in individual entries,

but the information in the types gets into the representations of phrases and sentences through the words that instantiate those types. Hence, it is largely the information coming from the words that determines the well-formedness of larger expressions. Any lexical decomposition would have to be strongly motivated by the morphology.

Branigan & Pickering (2017) note that grammatical structures (what some might call *constructions*) such as V-NP-NP can prime the use of the same abstract structure, even in the absence of lexical overlap. But they also note that the priming is consistently significantly stronger when the two instances share the same verb, a fact known as *the lexical boost*. They write, "To explain abstract priming, lexicalist theories must assume that the syntactic representations [...] are shared across lexical entries." The types in HPSG's lexicon provide just such representations. Branigan and Pickering go on to say that the lexical boost argues for "a representation that encodes a binding between constituent structure and the lemma ... of the lexical entry for the head." In HPSG, this "binding" is simply the fact that the word providing the lexical boost (say, *give*) is an instantiation of a type specifying the structures it appears in (e.g. the ditransitive verb type).

Similarly, the fact, noted in Section 2.3 above, that a given structure may be more or less difficult to process depending on word choice is unsurprising in HPSG, so long as the processor has access to information about individual words and not just their types.

3.5 Underspecification

HPSG allows a class of linguistic structures that share some feature values to be characterized by means of feature structure descriptions that specify only the features whose values are shared. Such underspecification is very useful for a model of processing (particularly a model of the comprehender) because it allows partial descriptions of the utterance to be built up, based on the information that has been encountered. This property of the grammar makes it easy to incorporate into an incremental processing model.

4 Two phenomena of interest

4.1 Island constraints

Ever since Ross's seminal dissertation (1967) introduced the notion of "island constraints", linguists have sought explanations for their existence, often suggesting that they were motivated by processing considerations (notably Grosu (1972),

Fodor (1983a), Deane (1991)). The basic idea is that island constraints restrict the search space the parser needs to consider in looking for a gap to match a filler it has encountered, thereby facilitating processing. This then raises the question of whether island constraints need to be represented in grammar (language particular or universal), or can be attributed entirely to processing and/or other factors, such as pragmatics.

In principle, this question is orthogonal to the choice among theories of grammar. But in recent years, a controversy has arisen between some proponents of HPSG and certain transformational grammarians, with the former (e.g. Chaves (2012 and 2018, Chapter 16 of this volume), Hofmeister & Sag (2010), Hofmeister, Jaeger, Arnon, Sag & Snider (2013)) arguing that certain island phenomena should be attributed entirely to extra-grammatical factors, and the latter (e.g. Phillips (2013), Sprouse et al. (2012)) arguing that island constraints are part of grammar.

I will not try to settle this dispute here. Rather, my point in this subsection is to note that a theory in which there is a close fit between the grammar and processing mechanisms allows for the possibility that some island phenomena should be attributed to grammatical constraints, whereas others should be explained in terms of processing. Indeed, if the basic idea that islands facilitate processing is correct, it is possible that some languages, but not others, have grammaticalized some islands, but not others. That is, in a theory in which the grammar is a tightly integrated component of a processing model, the question of whether a particular island phenomenon is due to a grammatical constraint is an empirical one, whose answer might differ from language to language.

Early work on islands (e.g. Ross (1967) and Chomsky (1973)) assumed that, in the absence of negative evidence, island constraints could not be learned and hence must be innate and therefore universal. But cross-linguistic variation in island constraints, even between closely related languages, has been noted since the early days of research on the topic (see, e.g. Erteschik-Shir (1973) and Engdahl & Ejerhed (1982)).

This situation is what one might expect if languages differ with respect to the extent to which the processing factors that motivate islandhood have been grammaticalized. In short, a theory with a tight fit between its grammatical machinery and its processing mechanisms allows for hybrid accounts of islands that are not available to theories without such a fit.

One example of such a hybrid is Chaves's (2012) account of Ross's Coordinate Structure Constraint. Following much earlier work, he distinguishes between the "conjunct constraint," which prohibits a gap from serving as a conjunct in a

coordinate structure (as in **What did you eat a sandwich and?*) and the "element constraint," which prohibits a gap from serving as an element of a larger conjunct (as in **What did you eat a sandwich and a slice of?*). The conjunct constraint, he argues, follows from the architecture of HPSG and is therefore built into the grammar. The element constraint, on the other hand, has exceptions and, he claims, should be attributed to extra-grammatical factors. See Chaves (2018), Chapter 16 of this volume for a more detailed discussion of islands.

4.2 Subject vs. object relative clauses

One of the most discussed phenomena in the literature on human sentence processing is the difference in processing complexity between relative clauses (RCs) in which the gap is the subject and those in which the gap is the object – or, as they are commonly called, "subject RCs" and "object RCs"; see, among many others, Wanner & Maratsos (1978), Gibson (1998), Traxler et al. (2002), Gennari & MacDonald (2008). Relative clause processing complexity has been shown to be influenced by a number of other factors than the grammatical function of the gap, including the animacy and pronominality of the overt NP in the RC.[10], as well as the frequency, animacy, and discourse properties of the head of the RC. When these factors are controlled for, however, most psycholinguists accept that it has been established that subject RCs are generally easier to process than object RCs, at least in English.[11]

One approach to explaining this asymmetry has been based on the distance between the filler and the gap (see, among others, Wanner & Maratsos (1978), Gibson (1998), Hawkins (2004)). In languages like English, with basic SVO clause

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[10]The stimuli in the experimental studies on this topic always have RCs with one overt NP, either in subject or object position and a gap corresponding to the other grammatical function. In most of the studies, that NP is non-pronominal and animate. See Reali & Christiansen (2007) and Roland et al. (2012) for evidence of the role of these factors in processing complexity.

[11]This processing difference corresponds to the top end of the "accessibility hierarchy" that Keenan & Comrie (1977) proposed as a linguistic universal. Based on a diverse sample of 50 languages, they proposed the hierarchy below, and hypothesized that any language allowing RC gaps at any point in the hierarchy would allow RC gaps at all points higher (to the left) on the hierarchy.

> Subject > Direct Object > Indirect Object > Oblique > Genitive > Object of Comparison

Keenan & Comrie speculated that the generality of this hierarchy of relativizability lay in processing, specifically on the comprehension side. The extensive experimental evidence that has been adduced in support of this idea in the intervening decades has been concentrated on subject RCs vs. (direct) object RCs. The remainder of the hierarchy remains largely untested by psycholinguists.

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order and RCs that follow the nouns they modify, the distance between the filler (the relativizer or head noun) and the gap is greater for an object gap than for a subject gap. If holding a filler in memory until the gap is encountered puts an extra burden on the processor, this could explain why object RCs are harder to process than subject RCs. This distance-based account makes an interesting prediction for languages with different word orders. In languages like Japanese with SOV order and RCs that precede the nouns they modify, the distance relationships are reversed – that is, the gaps in object RCs are closer to their fillers than those in subject RCs. The same is true of Chinese, with basic SVO order and RCs that precede the nouns they modify. So the prediction of distance-based accounts of the subject/object RC processing asymmetry is that it should be reversed in these languages.

The experimental evidence on this prediction is somewhat equivocal. While Hsiao & Gibson (2003) found a processing preference for object RCs over subject RCs in Chinese, their findings were challenged by Lin & Bever (2006) and Vasishth et al. (2013), who claimed that Chinese has a processing preference for subject RCs. In Japanese, Miyamoto & Nakamura (2003) found that subject RCs were processed more easily than object RCs. The issue remains controversial, but, for the most part, the evidence has not supported the idea that the processing preference between subject RCs and object RCs varies across languages with different word orders.

The most comprehensive treatment of English RCs in HPSG is Sag (1997). Based entirely on distributional evidence, Sag's analysis treats (finite) subject RCs as fundamentally different from RCs whose gap does not function as the subject of the RC. The difference is that the SLASH feature, which encodes information about long-distance dependencies in HPSG, plays no role in the analysis of subject RCs. Non-subject RCs, on the other hand involve a non-empty SLASH value in the RC.[12]

Sag deals with a wide variety of kinds of RCs. From the perspective of the processing literature, the two crucial kinds are exemplified by (5a) and (5b), from Gibson (1998).

(5) a. The reporter who attacked the Senatordmitted the error.
     b. The reporter who the Senator attacked admitted the error.

A well-controlled experiment on the processing complexity of subject and object RCs must have stimuli that are matched in every respect except the role of the

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[12]The idea that at least some subject gaps differ in this fundamental way from non-subject gaps goes back to Gazdar (1981).

gap in the RC. Thus, the conclusion that object RCs are harder to process than subject RCs is based on a wide variety of studies using stimuli like (5). Sag's analysis of (5a) posits an empty SLASH value in the RC, whereas his analysis of (5b) posits a non-empty SLASH value.

There is considerable experimental evidence supporting the idea that unbounded dependencies – that is, what HPSG encodes with the SLASH feature – add to processing complexity; see, for example, Wanner & Maratsos (1978), King & Just (1991), Kluender & Kutas (1993), Hawkins (1999). Combined with Sag's HPSG analysis of English RCs, this provides an explanation of the processing preference of subject RCs over object RCs. On such an account, the question of which other languages will exhibit the same preference boils down to the question of which other languages have the same difference in the grammar of subject and object RCs. At least for English, this is a particularly clear case in which the architecture of HPSG fits well with processing evidence.

5 Conclusion

This chapter opened with the observation that HPSG has not served as the theoretical framework for much psycholinguistic research. The observations in Sections 2 through 4 argue for rectifying that situation. The fit between the architecture of HPSG and what is known about human sentence processing suggests that HPSG could be used to make processing predictions that could be tested in the lab.

To take one example, the explanation of the processing asymmetry between subject and object RCs offered above is based on a grammatical difference in the HPSG analysis: all else being equal, expressions with non-empty SLASH values are harder to process than those with empty SLASH values. Psycholinguists could test this idea by looking for other cases of phenomena that look superficially very similar but whose HPSG analyses differ with respect to whether SLASH is empty. One such case occurs with pairs like Chomsky's famous minimal pair in (6).

(6)   a.   Chris is eager to please.
       b.   Chris is easy to please.

Under the analysis of Pollard & Sag (1994), *to please* in (6b) has a non-empty SLASH value but an empty SLASH value in (6a). Processing (6a) should therefore be easier. This prediction could be tested experimentally, and modern methods such as eye-tracking could pinpoint the locus of any difference in processing

complexity to determine whether it corresponds to the region where the grammatical analysis involves a difference in SLASH values.

The current disconnect between theoretical investigations of language structure and psycholinguistic studies is an unfortunate feature of our discipline. Because HPSG comports so well with what is known about processing, it could serve as the basis for a reconnection between these two areas of study.

Acknowledgements

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Chapter 29

Computational linguistics and grammar engineering

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We discuss the relevance of HPSG for computational linguistics, and the relevance of computational linguistics for HPSG.

1 Introduction

From the inception of HPSG in the 1980s, there has been a close integration between theoretical and computational work (for an overview, see Flickinger, Pollard & Wasow 2018, Chapter 2 of this volume). In this chapter, we discuss computational work in HPSG, starting with the infrastructure that supports it (both theoretical and practical) in Section 2. Next we describe several existing large-scale projects which build HPSG or HPSG-inspired grammars (see Section 3) and the deployment of such grammars in applications including both those within linguistic research and otherwise (see Section 4). Finally, we turn to linguistic insights gleaned from broad-coverage grammar development (see Section 5).

2 Infrastructure

2.1 Theoretical considerations

There are several properties of HPSG as a theory that make it well-suited to computational implementation. First, the theory is kept separate from the formalism:

the formalism is expressive enough to encode a wide variety of possible theories. While some theoretical work does argue for or against the necessity of particular formal devices (e.g. the shuffle operator (**FIXME-Reape**)), much of it proceeds within shared assumptions about the formalism. This is in contrast to work in the context of the Minimalist Program (Chomsky 1993), where theoretical results are typically couched in terms of modifications to the formalism itself. From a computational point of view, the benefit of differentiating between theory and formalism is that it means that the formalism is relatively stable. That in turns enables the development and maintenance of software systems that target the formalism, for parsing, generation, and grammar exploration (see Section 2.3 below for some examples).[1]

A second important property of HPSG that supports a strong connection between theoretical and computational work is an interest in both so-called 'core' and so-called 'peripheral' phenomena. Most implemented grammars are built with the goal of handling naturally occurring text.[2] This means that they will need to handle a wide variety of linguistic phenomena not always treated in theoretical syntactic work (**FIXME-Baldwin-et-al-Beauty**). A syntactic framework that excludes research on 'peripheral' phenomena as uninteresting provides less support for implementational work than does one, like HPSG or Construction Grammar, that values such topics (for a comparison of HPSG and Construction Grammar, see Müller 2018, Chapter 37 of this volume).

Finally, the type hierarchy characteristic of HPSG lends itself well to developing broad-coverage grammars which are maintainable over time (**FIXME-find-cite?**)■ The use of the type hierarchy to manage complexity at scale comes out of the work of Flickinger (1987) and others at HP labs in the project where HPSG was originally developed. The core idea is that any given constraint is (ideally) expressed only once on types which serve as supertypes to all entities that bear that constraint.[3] Such constraints might represent broad generalizations that apply to many entities or relatively narrow, indiosyncratic properties. By isolating any given constraint on one type (as opposed to repeating it in mutiple places), we build grammars that are easier to update and adapt in light of new data that

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[1]There are implementations of Minimalism, notably **FIXME-Stabler** and **FIXME-Indianadiss** However, writing an implementation requires fixing the formalism, and so these are unlikely to be useful for testing theoretical ideas as the theory moves on.

[2]It is possible, but less common, to do implementation work strictly against testsuites of sentences constructed specifically to focus on phenomena of interest.

[3]Originally this only applied to lexical entries in Flickinger's work. Now it also applies phrase structure rules, lexical rules, and types below the level of the sign which are used in the definition of all of these.

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require refinements to constraints. Having a single locus for each constraint also makes the types a very useful target for documentation (**FIXME:LTDB**) and grammar exploration (**FIXME:typediff**).

2.2 Practical considerations

The formalism of HPSG allows practical implementations, since feature structures are well-defined data structures. Furthermore, because HPSG is defined to be bi-directional, an implemented grammar can be used for both parsing and generation. In this section, we discuss how HPSG allows tractable algorithms, which enables linguists to empirically test hypotheses, and which also enables HPSG grammars to be used in a range of applications, as we will see in Sections 4.1 and 4.2, respectively.

2.2.1 Computational complexity

One way to measure how easy or difficult it is to use a syntactic theory in practical computational applications is to consider the *computational complexity* of parsing and generation algorithms **FIXME-Hopcroft-and-Ullman?** For example, we can consider how much computational time a parsing algorithm needs to process a particular sentence. For longer sentences, we would expect the amount of time to increase, but the more complex the algorithm is, the more quickly the amount of time increases. If we consider sentences containing n tokens, we can find the average amount of time taken, or the longest amount of time taken. We can then increase n, and see how the amount of time changes, both in the average case, and in the worst case.

At first sight, analysing computational complexity would seem to paint HPSG in a bad light, because the formalism allows us to write grammars which can be arbitrarily complex; in technical terminology, the formalism is *Turing-complete* (Johnson 1988: Section 3.4). However, as discussed in the previous section, there is a clear distinction between theory and formalism. Although the feature-structure formalism rules out the possibility of efficient algorithms that could cope with any possible feature-structure grammar, a particular theory (or a particular grammar) might well allow efficient algorithms.

The difference between theory and formalism becomes clear when comparing HPSG to other computationally-friendly frameworks, such as Combinatory Categorial Grammar (CCG),[4] or Tree Adjoining Grammar (TAG; Joshi 1987; Schabes

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[4]For an introduction, see Steedman & Baldridge (2011). For a comparison with HPSG, see Kubota (2018), Chapter 34 of this volume.

et al. 1988)). The formalisms of CCG and TAG inherently limit computational complexity: for both of them, as the sentence length *n* increases, worst-case parsing time is proportional to n^6 (Kasami et al. 1989). This is a deliberate feature of these formalisms, which aim to be just expressive enough to capture human language, and not any more expressive. Building this kind of constraint into the formalism itself highlights a different school of thought from HPSG. Indeed, Müller (2015) explicitly argues in favor of developing linguistic analyses first, and improving processing efficiency second. As discussed above in Section 2.1, separating the formalism from the theory means that the formalism is stable, even as the theory develops.

It would be beyond the scope of this chapter to give a full review of parsing algorithms, but it is instructive to give an example. For grammars that have a context-free backbone (we can express every derivation as a phrase-structure tree plus constraints between mother and daughter nodes), it is possible to adapt the standard chart-parsing algorithm for context-free grammars. The basic idea is to parse "bottom-up" through the tree, starting by finding analyses for each token in the input, and then finding analyses for increasingly longer sequences of tokens, until we reach the entire sentence. The resulting algorithm is more computationally complex than for a context-free grammar, because we are dealing with feature structures, rather than nonterminal symbols. While a context-free grammar allows a finite number of nonterminals, a feature-structure grammar may allow an infinite number of possible feature structures. For an HPSG grammar without recursive unary rules, this algorithm has a worst-case complexity of exponential time. This is less complex than for an arbitrary grammar (which means that this class of grammars is *not* Turing-complete), but more complex than for CCG or TAG. However, when parsing real corpora, it turns out that the average-case complexity is much better than we might expect. On the one hand, grammatical constructions do not generally combine in the worst-case way, and on the other hand, when a grammar writer is confronted with multiple possible analyses for a particular construction, they may opt for the analysis that is more efficient for a particular parsing algorithm.

2.2.2 Parse ranking

For an ambiguous sentence, a grammar gives multiple valid parses. This is widely known, with attachment ambiguities and coordination ambiguities being particularly well-known examples. However, people are naturally very good at resolving ambiguity, which means most ambiguity is not apparent, even to linguists. It is only with the development of large-scale grammars that the sheer scale of am-

biguity has become clear. For example, (1) might seem unambiguous, but there is a second reading, where *my favorite* is the topicalized object of *speak*, which would mean that town criers generally speak the speaker's favorite thing (perhaps a language) clearly. There is also a third, even more implausible reading, where *my favorite town* is the topicalized object. Such implausible readings don't easily come to mind, but with increasingly long sentences, such ambiguities stack up very quickly. For (2), the first line of a newspaper article,[5] the 2018 version of the English Resource Grammar (Flickinger 2000; 2011) gives TODO readings.

(1)　My favorite town criers speak clearly.

(2)　A small piece of bone found in a cave in Siberia has been identified as the remnant of a child whose mother was a Neanderthal and father was a Denisovan, a mysterious human ancestor that lived in the region.

　While exploring ambiguity can be interesting for a linguist, typical practical applications require just one parse per input sentence and specifically the parse the best reflects the intended meaning (or only the top few parses, in case the one put forward as 'best' might be wrong). Thus, what is required is a *ranking* of the parses, so that the application can only use the most highly-ranked parse, or the top *N* parses. Parse ranking is not usually determined by the grammar itself, because of the difficulty of manually writing disambiguation rules. Typically, a statistical system is used (Oepen et al. 2004). First, a corpus is *treebanked*: for each sentence in the corpus, an annotator (often the grammar writer) chooses the best parse, out of all parses produced by the grammar. The set of all parses for a sentence is often referred to as the *parse forest*, and the selected best parse is often referred to as the *gold standard*. Given the gold parses for the whole corpus, a statistical system is trained to predict the gold parse from a parse forest, based on many features[6] of the parse. From the example in (1), we can see how a number of a different features all influence the preferred interpretation: the likelihood of a construction (such as topicalization), the likelihood of a valence frame (such as transitive *speak*), the likelihood of a collocation (such as *town crier*), the likelihood of a semantic relation (such as speaking a town), and so on.

　Because of the large number of possible parses, it can be helpful to *prune* the search space: rather than ranking the full set of parses, we can restrict attention to a smaller set of parses, which hopefully includes the correct parse. By carefully choosing how to restrict our attention, we can drastically reduce processing time

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[5]https://www.theguardian.com/science/2018/aug/22/offspring-of-neanderthal-and-denisovan-identified-for-first-time

[6]In the machine learning sense of "feature", not the feature-structure sense.

without hurting parsing accuracy. One method, called *supertagging*,[7] exploits the fact that HPSG is a lexicalized theory: choosing the correct lexical entry brings in rich information that can be exploited to rule out many possible parses. Thus if the correct lexical entry can be chosen prior to parsing (e.g. on the basis of the prior and following words), the range of possible analyses the parser must consider is drastically reduced. Although there is a chance that the supertagger will predict the wrong lexical entry, using a supertagger can often improve parsing accuracy, by ruling out parses that the parse-ranking model might incorrectly rank too high. Supertagging was first applied to HPSG by Matsuzaki et al. (2007), building on previous work for TAG (Bangalore & Joshi 1999) and CCG (Clark & Curran 2004). To allow multi-word expressions (such as *by and large*), where the grammar assigns a single lexical entry to multiple tokens, Dridan (2013) has proposed an extension of supertagging, called *ubertagging*, which jointly predicts both a segmentation of the input and supertags for those segments. Dridan manages to increase parsing speed by a factor of four, while also improving parsing accuracy.

2.2.3 Semantic dependencies

In practical applications of HPSG grammars, the full derivation trees and the full feature structures are often unwieldy, containing far more information than necessary for the task at hand. It is therefore often desirable to extract a concise semantic representation.

In computational linguistics, a popular approach to semantics is to represent the meaning of a sentence as a *dependency graph*, as this enables the use of graph-based algorithms.[8] Several types of dependency graph have been proposed based on Minimal Recursion Semantics (MRS; Copestake et al. 2005), with varying levels of simplification. The most expressive is Dependency Minimal Recursion Semantics (DMRS; Copestake 2009), which is fully interconvertible with MRS.[9] In contrast, Elementary Dependency Structures (EDS; Oepen & Lønning 2006) lose some scope information, which, for many applications, is less important

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[7]The name refers to *part-of-speech tagging*, which predicts a part-of-speech for each input token, from a relatively small set of part-of-speech tags. Supertagging is "super", in that it predicts detailed lexical entries, rather than simple tags.

[8]In this section, we are concerned with *semantic* dependencies. For *syntactic* dependencies, see Hudson (2018), Chapter 36 of this volume.

[9]More precisely, there is a one-to-one correspondence between DMRS and MRS structures, if every predicate as a unique *intrinsic variable.* As observed by Oepen & Lønning (2006), this allows a variable-free semantic representation, by replacing each reference to a variable with a reference to the corresponding predicate.

than predicate-argument structure. Finally, DELPH-IN MRS Dependencies (DM; Ivanova et al. 2012) express predicate-argument structure purely in terms of the surface tokens, without introducing any abstract predicates. A comparison of MRS, DMRS, and DM is given in Figure 1. The existence of such dependency graphs has made it easier to use HPSG grammars in a number of practical tasks, as we will discuss in Section 4.2.

2.3 A brief history of HPSG grammar engineering

History: PAGE, VerbMobil, ??
  Current platforms:

- LKB/ACE/PET/Agree

- Trale

- Other

3 Development of HPSG resources

- CoreGram

- DELPH-IN consortium
    – ERG
    – Other large-ish grammars
    – Grammar Matrix

- Systems inspired by HPSG:
    – Alpino
    – Enju

4 Deployment of HPSG resources

4.1 Language documentation and linguistic hypothesis testing

Deployment for linguistic goals.

$$
\begin{bmatrix}
mrs \\
\text{HOOK} \begin{bmatrix} hook \\ \text{LTOP} \quad \boxed{1} \\ \text{INDEX} \quad \boxed{2} \end{bmatrix} \\
\text{RELS} \left\langle \begin{bmatrix} relation \\ \text{PRED} \quad \_the\_q \\ \text{LBL} \quad \boxed{3} \\ \text{ARG0} \quad \boxed{4} \\ \text{RSTR} \quad \boxed{5} \\ \text{BODY} \quad \boxed{6} \end{bmatrix}, \begin{bmatrix} relation \\ \text{PRED} \quad compound \\ \text{LBL} \quad \boxed{7} \\ \text{ARG0} \quad \boxed{8} \\ \text{ARG1} \quad \boxed{4} \\ \text{ARG2} \quad \boxed{9} \end{bmatrix}, \begin{bmatrix} relation \\ \text{PRED} \quad udef\_q \\ \text{LBL} \quad \boxed{10} \\ \text{ARG0} \quad \boxed{9} \\ \text{RSTR} \quad \boxed{11} \\ \text{BODY} \quad \boxed{12} \end{bmatrix}, \right. \\
\left. \begin{bmatrix} relation \\ \text{PRED} \quad \_cherry\_n\_1 \\ \text{LBL} \quad \boxed{13} \\ \text{ARG0} \quad \boxed{9} \end{bmatrix}, \begin{bmatrix} relation \\ \text{PRED} \quad \_tree\_n\_of \\ \text{LBL} \quad \boxed{7} \\ \text{ARG0} \quad \boxed{4} \end{bmatrix}, \begin{bmatrix} relation \\ \text{PRED} \quad \_blossom\_v\_1 \\ \text{LBL} \quad \boxed{1} \\ \text{ARG0} \quad \boxed{2} \\ \text{ARG1} \quad \boxed{4} \end{bmatrix} \right\rangle \\
\text{HCONS} \left\langle \begin{bmatrix} qeq \\ \text{HARG} \quad \boxed{5} \\ \text{LARG} \quad \boxed{7} \end{bmatrix}, \begin{bmatrix} qeq \\ \text{HARG} \quad \boxed{11} \\ \text{LARG} \quad \boxed{9} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

(a) MRS as a feature structure

$$\text{LTOP} : l_5$$
$$\text{INDEX} : e_1$$

$$l_1 : \_the\_q(x_1, h_1, h_2), h_1 \text{ QEQ } l_4$$
$$l_2 : udef\_q(x_2, h_3, h_4), h_3 \text{ QEQ } l_3$$
$$l_3 : \_cherry\_n\_1(x_2)$$
$$l_4 : \_tree\_n\_of(x_1), compound(e_2, x_1, x_2)$$
$$l_5 : \_blossom\_v\_1(e_1, x_1)$$

(b) MRS, abstractly
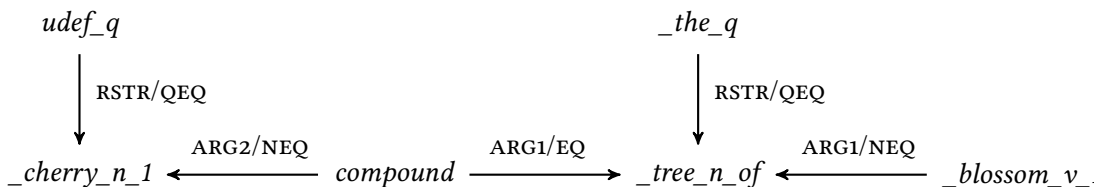
(c) DMRS

...

(d) DM

Figure 1: Comparison of MRS, DMRS, and DM, for the sentence "the cherry tree blossomed". For simplicity, we have omitted some details, including features such as number and tense, individual constraints (ICONS), and the use of difference lists. *Draft of 29th November 2018, 11:59*

4.1.1 CoreGram

4.1.2 Grammar Matrix

4.1.3 AGGREGATION

4.1.4 Derived resources: Redwoods-style treebanks

4.2 Downstream applications

Deployment for other tasks. Large number of applications. Focus on several important applications below. See also http://moin.delph-in.net/DelphinApplications▮

4.2.1 Language teaching

Redbird (McGraw-Hill)

4.2.2 NLP tasks

Information extraction
Summarisation
Machine translation

4.2.3 Data for machine learning

Unlike the previous sections, not providing analyses, but providing data. Not used at test time, only at training time.

Training deep learning systems – semantic parsing – skip over HPSG, go straight to semantic representations

Evaluation of deep learning systems – ShapeWorld – use a grammar to produce annotations

4.3 Other?

Alpino?
Enju?

5 Linguistic Insights

- Ambiguity

- Long-tail phenomena (raising and control?)

- Scaling up (thematic roles)

- CLIMB methodology

6 Summary

Abbreviations

Acknowledgements

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Chapter 30

Grammar in dialogue

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> "It takes two to make a truth."
> Austin (1950: 124, fn. 1)

This chapter portrays some phenomena, technical developments and discussions that are pertinent to analysing natural language use in face-to-face interaction from the perspective of HPSG and closely related frameworks. The use of the CONTEXT attribute in order to cover basic pragmatic meaning aspects is sketched. With regard to the notion of common ground it is argued how to complement CONTEXT by a dynamic update semantics. Furthermore, this chapter discusses challenges posed by dialogue data such as clarification requests to unification-based, model-theoretic grammars. Responses to these challenges in terms of a type-theoretical underpinning (TTR, a Type Theory with Records) of both the semantic theory and the grammar formalism are reviewed. Finally, the dialogue theory *KoS* is sketched that emerged in this way from work in HPSG.

1 Introduction

The archaeologists Ann Wesley and Ray Jones are working in an excavation hole, Ray Jones is looking at the excavation map. Suddenly, Ray discovered a feature

that catches his attention. He turns to his colleague Ann and initiates the following exchange (the example is slightly modified from Goodwin (2003: 222); underlined text is used to indicate overlap, italic comments in double round brackets are used to describe non-verbal actions, numbers in brackets quantify the duration of pauses):

(1) 1. RAY: Doctor Wesley?
     2.   (0.7) ((*Ann turns and walks towards Ray*))
     3. ANN: EHHH HEHH ((*Cough*))
     4.   Yes Mister Jones.
     5. RAY: I was gonna see:
     6. ANN: °Eh heh huh huh
     7.   °eh heh <u>huh huh</u>
     8. RAY: <u>Uh::m,</u>
     9. ANN: Ha huh HHHuh
    10. RAY: ((*Points with trowel to an item on the map*))
                I think I finally found **this** feature
                ((*looks away from map towards a location in the surrounding*))
    11.   (0.8) Cause I: hit the **nail**
    12. ((*Ann looks at map, Ray looks at Ann, Ann looks at Ray*))

Contrast the archaeological dialogue from (1) with a third person perspective text on a related topic. In a recent archaeology paper, the excavation of gallery grave Falköping stad 5 is described, among others (Blank et al. 2018: 4):

> During excavation the grave was divided in different sections and layers and the finds were documented in these units. The bone material lacking stratographic and spatial information derives from the top layer […]. Both the antechamber and the chamber contained artefacts as well as human and animal skeletal remains, although most of the material was found in the chamber.

The differences between the archaeological dialogue and the paper are obvious and concern roughly the levels of *medium* (spoken vs. written), *situatedness* (degree of context dependence), *processing speed* (online vs. offline), and *standardisation* (compliance with standard language norms) (Klein 1985). Attributing differences between dialogue and text simply to the medium (i.e. spoken vs. written) is tempting but is insufficient. The corresponding characterising features seem to form a continuum, as discussed under the terms *conceptual orality* and *conceptual literacy* in the (mainly German speaking) literature for some

time (Koch & Oesterreicher 1985). For example, much chat communication, although realised by written inscriptions, exhibits many traits of (conceptually) spoken communication, as investigated, for instance, by means of chat corpora (Beißwenger et al. 2012). Face-to-face dialogue stands out due to a high degree of context dependence manifested in shared attention (Tomasello (1998); see also turns 2 and 12 between Ann and Ray), non-verbal actions such as hand and arm gestures (Kendon (2004); McNeill (2000); turn 10; cf. Lücking (2018), Chapter 32 of this volume for a brief overview of non-verbal communication means), disfluencies (Ginzburg et al. 2014; turn 5 to 8), non-sentential utterances (Fernández & Ginzburg 2002; Fernández et al. 2007; turns 1, 4, and 5), laughter (Ginzburg et al. 2015; turn 9), shared knowledge of interlocutors (Clark et al. 1983; turns 10–12), turn-taking (Sacks et al. 1974; Heldner & Edlund 2010; Levinson & Torreira 2015; e.g. question-answering in turns 1 and 4), indirect reference (turn 10, where Ray points to an item on the map but refers to an archaeological artefact in the excavation hole). Such instances of deferred reference (Nunberg 1993) in situated communication actually differ from bridging anaphora (Clark 1975) in written texts (cf. Lücking 2018).

Since these phenomena are usually abstracted away from the linguistic knowledge encoded by a grammar, linguistics is said to exhibit a "written language bias" (Linell 1982). In fact, many of the phenomena exemplified above provide serious challenges to current linguistic theory, as has been argued by Ginzburg (2012), Ginzburg & Poesio (2016) and Kempson et al. (2016). So the question is: how serious is this bias? Is there a single language system with two modes, written and spoken (but obeying the qualifications we made above with respect to conceptual orality and literacy)? Or do written and spoken communication even realise different language systems? Responses can be given from different standpoints. When the competence/performance distinction was proposed (Chomsky 1965), one could claim that linguistic knowledge is more purely realised by the high degree of standardisation manifested in written text, while speech is more likely to be affected by features attributed to performance (e.g., processing issues such as short term memory limitations or impaired production/perception). Once one attaches more importance to dialogical phenomena, one can also claim that there is a single, basic language system underlying written and spoken communication which bifurcates only in some cases, with interactivity and deixis being salient examples (such a position is delineated but not embraced by Klein (1985); in fact, Klein remains neutral on this issue). Some even claim that "grammar is a system that characterizes talk in interaction" (Ginzburg & Poesio 2016: 1). This position is strengthened by the primacy of spoken language in both ontogenetic and lan-

guage acquisition areas (on acquisition see Ginzburg (2018), Chapter 27 of this volume).

Advances in dialogue semantics are compatible with the latter two positions, but their ramifications are inconsistent with the traditional competence/performance distinction (Ginzburg & Poesio 2016; Kempson et al. 2016). Beyond investigating phenomena which are especially related to people engaging in face-to-face interaction, dialogue semantics contributes to the theoretical (re-)consideration of the linguistic competence that grammars encode. Some of the challenges posed by dialogue for the notion of linguistic knowledge – exemplified by non-sentential utterances such as clarification questions and reprise fragments (Fernández & Ginzburg 2002; Fernández et al. 2007) – are also main actors in arguing *against* doing semantics within a unification-based framework (Section 3.1 below). In light of this, the relevant arguments are briefly reviewed below. Subsequently, TTR (a Type Theory with Records) is briefly introduced in Section 3.3. TTR is a strong competitor to other formalisms since it provides an account of semantics that covers dialogue phenomena from the outset. TTR also allows for "emulating" an HPSG kind of grammar, giving rise to a unified home for sign-based SYNSEM interfaces bridging to dialogue gameboards (covered in Section 4). To begin with, however, we give a brief historical review of pragmatics within HPSG.

2 From CONTEXT to update semantics for dialogue

HPSG's interface to pragmatics is the CONTEXT attribute. The CONTEXT attribute accommodates contextual constraints that have to be fulfilled in order for an expression to be used appropriately, or felicitously (Austin 1962), to use a term from speech act theory (Pollard & Sag 1994: 27). It has been used and extended to model the content of indexical and pronominal expressions (see Section 2.1), information packaging (Section 2.2) and shared background assumptions concerning standard meanings (Section 2.3). A further step from such pragmatic phenomena to dialogue semantics is achieved by making signs encode their dialogue context, leading to an architectural revision in terms of *update semantics* (see Section 2.4).

2.1 C-INDS and BACKGROUND

The CONTEXT attribute introduces two sub-attributes, CONTEXTUAL-INDICES (C-INDS) and BACKGROUND. The C-INDS attribute value provides pointers to cir-

cumstantial features of the utterance situation such as speaker, addressee, time and location of speaking. Within the BACKGROUND attribute, assumptions such as presuppositions or conventional implicatures are expressed in terms of *psoas*, *parameterised state of affairs* (see Section 3.2 for some alternative semantic representation formats). For instance, it is part of the background information of the pronoun *she* of the "natural gender language" English that its referent is female (this does not hold for "grammatical gender languages" like French or German). In the HPSG format of Pollard & Sag (1994: 20), this constraint is expressed as in (2):

(2)
$$
\begin{bmatrix}
\textit{word} \\
\text{PHON} \quad \textit{/she/} \\
\text{SYNSEM} \begin{bmatrix}
\textit{synsem} \\
\text{LOCAL} \begin{bmatrix}
\textit{local} \\
\text{CATEGORY} \begin{bmatrix}
\textit{cat} \\
\text{HEAD} \quad \textit{noun[CASE nom]} \\
\text{SUBCAT} \ \langle \ \ \rangle
\end{bmatrix} \\
\text{CONTENT} \begin{bmatrix}
\textit{ppro} \\
\text{INDEX} \ \boxed{1} \begin{bmatrix} \textit{ref} \\ \text{PER} \ \textit{3rd} \\ \text{NUM} \ \textit{sing} \\ \text{GEN} \ \textit{fem} \end{bmatrix} \\
\text{RESTR} \ \{\}
\end{bmatrix} \\
\text{CONTEXT} \begin{bmatrix}
\textit{context} \\
\text{BACKGROUND} \ \left\{ \begin{bmatrix} \textit{psoa} \\ \text{RELN} \ \textit{female} \\ \text{INST} \ \boxed{1} \end{bmatrix} \right\}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$
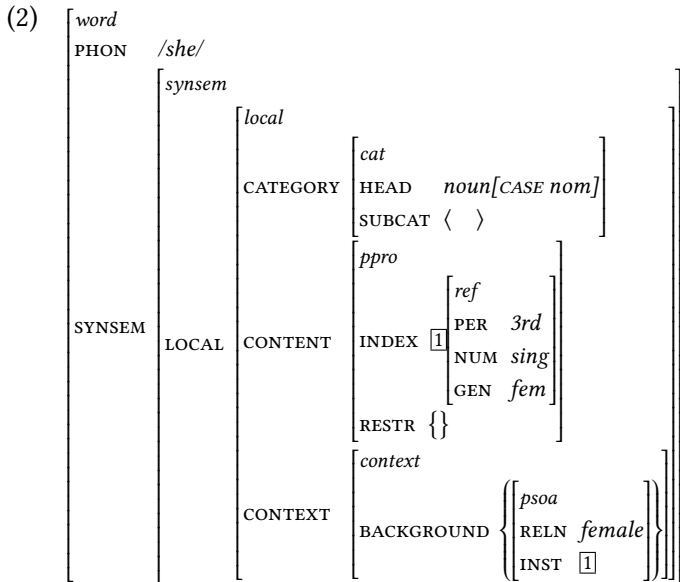
The CONTENT value is of type *ppro* (*personal-pronoun*), which is related to the NP type (+p,−a) from *Government and Binding* theory (Chomsky 1981) and interacts with HPSG's binding theory (see Branco (2018), Chapter 21 of this volume; see also Wechsler (2018), Chapter 6 of this volume). The CONTENT/CONTEXT description in (2) claims that whatever the referent of the pronoun is, it has to be female.

The contextual indices that figure as values for the C-INDS attribute provides semantic values for indexical expressions. For instance, the referential meaning of the singular first person pronoun *I* is obtained by identifying the semantic index with the contextual index "speaker" (for a collection of indirect uses of *I*, or rather its German cognate *Ich*, where identification with the circumstantial speaker role would lead to wrong results, see Kratzer (1978)). This use of CONTEXT

is illustrated in (3), which is part of the lexical entry of *I* (see the Davis & Koenig (2018), Chapter 4 of this volume on the lexicalist orientation of HPSG).

(3)
$$
\begin{bmatrix}
word \\
\text{PHON} \quad /i/ \\
\text{SYNSEM} \quad
\begin{bmatrix}
synsem \\
\text{LOCAL} \quad
\begin{bmatrix}
local \\
\text{CONTENT} \quad
\begin{bmatrix}
ppro \\
\text{INDEX} \quad \boxed{1}
\begin{bmatrix}
ref \\
\text{REF} \quad 1st \\
\text{NUM} \quad sing
\end{bmatrix} \\
\text{RESTR} \quad \{\}
\end{bmatrix} \\
\text{CONTEXT} \quad
\begin{bmatrix}
context \\
\text{C-INDS} \quad
\begin{bmatrix}
psoa \\
\text{SPKR} \quad \boxed{1} \\
\text{ADDR} \quad \boxed{2} \\
\text{TIME} \quad \boxed{3} \\
\text{LOC} \quad \boxed{4}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Inasmuch as the contextual anchors (see Barwise & Perry (1983) or Devlin (1991) on anchors in situation semantics) indicated by a boxed notation from (3) provide a semantic value for the speaker in a directly referential manner (see Marcus (1961) and Kripke (1980) on the notion of direct reference with regard to proper names), they also provide semantic values for the addressee (figuring in the content of *you*), the time (*now*) and the place (*here*) of speaking.[1] Hence, the CONTEXT attribute accounts for the standard indexical expressions and provides present tense marker needed for a semantic of tenses in the line of *Discourse Representation Theory* (Kamp & Reyle (1993); see Partee (1973) on the preeminent role of an indexical time point). We will not discuss this issue further here (see Van Eynde (1998; 2000), Bonami (2002) and Costa & Branco (2012) for HPSG work on tense and aspect), but move on to briefly recapture other phenomena usually ascribed to pragmatics (see also Kathol et al. (2011: Sec. 5.2)).

2.2 Information structure

Focus, expressed by sentence accent in English, can be used for information packaging that may lead to truth-conditional differences even in case the surface structures (i.e. strings; see Section 1 on a brief juxtaposition of spoken and

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[1]Of these, in fact, only the speaker is straightforwardly given by the context; all others can potentially involve complex inference.

written language) are the same. An example is given in (4), taken from Krifka
(2008: 246), where capitalisation indicates main accent and subscript "F" labels
the focused constituent:

(4)   a.   John only showed Mary [the PICTures]$_F$
      b.   John only showed [MARY]$_F$ the pictures.

An analysis of examples like (4) draws on an interplay of phonology, semantic,
pragmatic and constituency and hence emphasise in particular the advantages of
the *fractal* (Johnson & Lappin 1999) architecture of HPSG (see the sections on
Kubota (2018), Chapter 34 of this volume, Borsley & Müller (2018), Chapter 33 of
this volume, Müller (2018), Chapter 37 of this volume, Arnold (2018), Chapter **??**
of this volume and Hudson (2018), Chapter 36 of this volume for a comparison
of HPSG to other grammar theories; a benchmark source is Müller 2016).

At the core of information structure is a distinction between *given* and *new*
information. Accordingly, information structure is often explicated in terms of
dynamic semantics (ranging from *File Change Semantics* (Heim 2002) and *Dis-
course Representation Theory* (Kamp & Reyle 1993) to information state update
semantics proper (Traum & Larsson 2003)) – see for instance Krifka (2008) or
Vallduví (2016) for a discussion and distinction of various notions bound up with
information structure such as *focus*, *topic*, *ground* and *comment* seen from the
perspective of dialogue content and dialogue management. The most influential
approach to information structure within HPSG is that of Engdahl & Vallduví
(1996). Here a distinction between *focus*, that is new information, and *ground*,
the given information, is made (Engdahl & Vallduví 1996: 3). The *ground* is fur-
ther bifurcated into LINK and TAIL, which connect to the preceding discourse in
different ways (basically, the link corresponds to a discourse referent or file, the
tail corresponds to a predication which is already subsumed by the interlocu-
tors' information states). The information packaging of the content values of a
sentence is driven by phonetic information in terms of A-accent and B-accent
(Jackendoff 1972), where "A-stressed" constituents are coindexed (via structure
sharing, see Richter (2018), Chapter 3 of this volume) with FOCUS elements and
"B-stressed" are coindexed with LINK elements – see also de Kuthy (2018), Chap-
ter 25 of this volume. The CONTEXT extension for information structure on this
account is given in (5):

(5)
$$\begin{bmatrix} \textit{context} \\ \text{C-INDS} \quad [\,] \\ \text{BACKGR} \quad \{\} \\ \text{INFO-STR} \quad \begin{bmatrix} \textit{info-struc} \\ \text{FOCUS} \quad \textit{Set(content)} \\ \text{GROUND} \quad \begin{bmatrix} \textit{ground} \\ \text{LINK} \quad \textit{Set(content)} \\ \text{TAIL} \quad \textit{Set(content)} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$
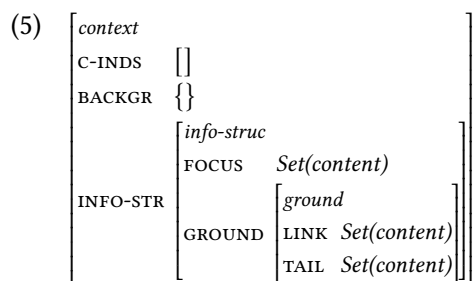
Part of the analysis of the sample sentences from (4) is that in (4a) the content value of the indirect object NP *the pictures* is the focused constituent, while it is the content value of the direct object NP *Mary* in (4b). The FOCUS-LINK-TAIL approach entails, however, that the packages of information structure coincide with syntactic constituents. This assumption is given up in the approach to *prosodic constituency* of Klein (2000) – see also Tseng (2018), Chapter 22 of this volume. Information structure realised by prosodic stress is also part of the speech-gesture interfaces within multimodal extensions of HPSG (cf. Lücking (2018), Chapter 32 of this volume).

2.3 Mutual beliefs

A strictly pragmatic view on meaning and reference is presented by Green (1996). Green provides a CONTEXT extension for the view that restrictions on the index actually are background assumption concerning standard uses of referential expressions. One of the underlying observations is that people can, for example, use the word *dog* to refer to, say, toy dogs or even, given appropriate context information, to a remote control (we will come back to this example shortly). The fact that the word *dog* can be used without further ado successfully to refer to instances of the subspecies *Canis lupus familiaris*[2] is due to shared assumptions about the standard meaning of *dog*. Green represents this account in terms of mutual beliefs between EXPERIENCER and STANDARD standard as part of the background condition of the CONTEXT of referential NPs. The semantic part of the lexical structure of *dog* is given in (6). The analysis of proper names is pursued in similar manner, amounting to the requirement that for a successful use of a

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[2]Green (1996: Ex. (73)) actually restricts the standard use of *dog* to the family *Canis* (regiven in our example (6)), which seems to be too permissive. The *Canis* family also include foxes, coyotes and wolves, which are, outside of biological contexts, usually not described as being dogs. This indicates that the EXPERIENCER group should be further restricted and allowed to vary over different language communities and genres.

proper name the interlocutors have to know that the intended referent of this name actually bears the name in question.

(6)

```
⎡ word                                                                    ⎤
⎢ PHON    /dog/                                                           ⎥
⎢                                                                         ⎥
⎢         ⎡ ref        ⎤                                                  ⎥
⎢ CONTENT ⎢ INDEX  [1] ⎥                                                  ⎥
⎢         ⎣            ⎦                                                  ⎥
⎢                                                                         ⎥
⎢         ⎡ context                                                    ⎤  ⎥
⎢         ⎢                                                            ⎥  ⎥
⎢         ⎢          ⎡ psoa       ⎤                                    ⎥  ⎥
⎢         ⎢  C-INDS  ⎢ SPKR   [2] ⎥                                    ⎥  ⎥
⎢         ⎢          ⎢ ADDR   [3] ⎥                                    ⎥  ⎥
⎢         ⎢          ⎣            ⎦                                    ⎥  ⎥
⎢         ⎢                                                            ⎥  ⎥
⎢         ⎢              ⎧ ⎡ mutually-believe ⎤                     ⎫ ⎥  ⎥
⎢ CONTEXT ⎢              ⎪ ⎢ EXPERIENCER  [2] ⎥                     ⎪ ⎥  ⎥
⎢         ⎢              ⎪ ⎢ STANDARD     [3] ⎥                     ⎪ ⎥  ⎥
⎢         ⎢              ⎪ ⎢                  ⎥                     ⎪ ⎥  ⎥
⎢         ⎢  BACKGROUND  ⎨ ⎢     ⎡ normally-believe             ⎤ ⎥ ⎬ ⎥  ⎥
⎢         ⎢              ⎪ ⎢     ⎢ EXPERIENCER  English speakers ⎥ ⎥ ⎪ ⎥  ⎥
⎢         ⎢              ⎪ ⎢ SOA ⎢            ⎡ canis     ⎤      ⎥ ⎥ ⎪ ⎥  ⎥
⎢         ⎢              ⎪ ⎣     ⎣ SOA        ⎢ INST  [1] ⎥      ⎦ ⎦ ⎪ ⎥  ⎥
⎢         ⎣              ⎩                    ⎣           ⎦          ⎭ ⎦  ⎥
⎣                                                                         ⎦
```
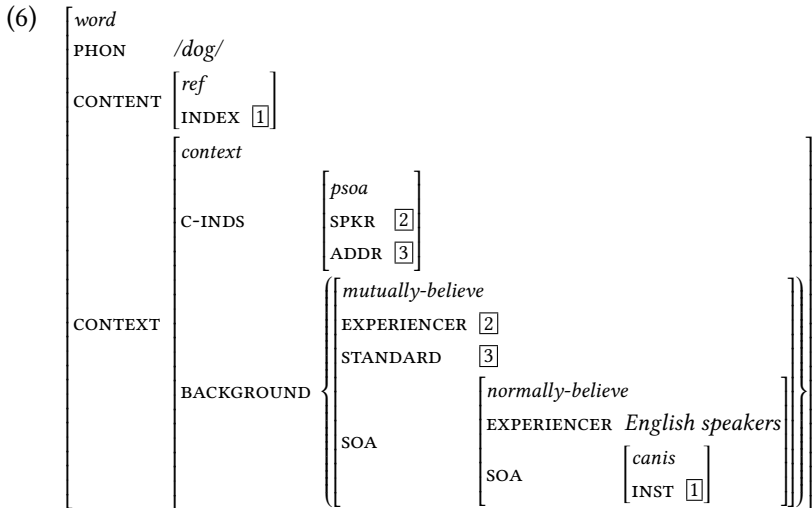
Adding beliefs to CONTEXT provides the representational means to integrate (at least some kinds of) presuppositions, illocutionary force and deferred reference (Nunberg 1978) into grammar. However, a fuller model of speech acts and meaning transfers is still needed (Kathol et al. 2011: 94).

Taking a closer look at the argument underlying adding mutual beliefs to CONTEXT, one notices a striking similarity of shared assumptions about standard uses with *community membership* as a source for common ground (but see Footnote 2 for a hint on a possible refinement). However, community membership is just one of three sources of information on which the common ground between two interlocutors (scaling up to multilogue is obvious) can be based according to Clark & Marshall (1981) and Clark et al. (1983):

> The first is *perceptual evidence*, what the two have jointly experienced or are jointly experiencing at the moment. The second is *linguistic evidence*, what the two have jointly heard said or are now jointly hearing as participants in the same conversation. The third is *community membership*. They take as common ground everything they believe is universally, or almost universally, known, believed, or supposed in the many communities and subcommunities to which they mutually believe they both belong. (Clark et al. 1983: 247)

Reconsidering the "*dog*-used-to-refer-to-remote-control" example mentioned

above: in order for this kind of reference to happen, one can imagine a preparatory sequence like the following:

(7)   Can you please give me the …what's the name? …the …ah, let's call it "dog" …can you please give me the dog?

In this monologue, the speaker establishes a name for the remote control. After this baptism, the situationally re-coined termed can be used referentially (see Lücking et al. (2006) on situated conventions). Obviously, the felicity of reference is due to *linguistic evidence* provided and agreed upon in dialogical exchange. Dialogue contexts and the dynamics of common ground is a dimension which is absent in the static CONTEXT representations surveyed above. This is where dynamic update semantics enters the stage.

2.4 Towards an update semantics for dialogue

Starting from Stalnakerian contexts (Stalnaker 1978; see also Lewis 1979), that is, contexts which consist of mutually known propositions (also corresponding roughly to the mutual belief structures employed by Green 1996, cf. Section 2.3), Ginzburg argues in a series of works that this context actually has a more elaborate structure (Ginzburg 1994; 1996; 1997). One motivation for this refinement is found in data like (8), an example given by Ginzburg (1994: 2) from the London-Lund corpus (Svartvik 1990).

(8)   1.   A: I've been at university.
      2.   B: Which university?
      3.   A: Cambridge.
      4.   B: Cambridge, um.
      5.   what did you read?
      6.   A: History and English.
      7.   B: History and English.

There is nothing remarkable about this dialogical exchange, it is a mundane piece of natural language interaction. However, given standard semantic assumptions and a *given-new* information structuring as sketched in Section 2.2, (8) poses two problems. The first problem is that one and the same word, namely *Cambridge*, plays a different role in different contexts as exemplified by turns 2 to 3 on the one hand and turns 3 to 4 on the other hand. The reason is that the first case instantiates a question-answering pair, where *Cambridge* provides the requested referent. The second case is an instance of *accept*: speaker B not only signals that she heard what A said (what is called *acknowledge*), but also that she

updates her information state with a new piece of information (namely that A studied in Cambridge).

The second problem is that neither of B's turns 4 and 7 is redundant although neither of them contribute new information (or *foci* in the terminology of Section 2.2): the turns just consist of a replication of A's answer. The reason for non-redundancy obviously is that in both cases the repetition manifests an *accept* move in the sense just explained.

In order to make grammatical sense out of such dialogue data – eventually in terms of linguistic competence – contextual background rooted in language is insufficient, as discussed. The additional context structure required to differentiate the desired interpretation of (8) from redundant and co-text insensitive ones is informally summarised by Ginzburg (1994: 4) in the following way:

- FACTS: a set of commonly agreed upon facts;

- QUD ("question under discussion"): partially ordered set that specifies the currently discussable questions. If *q* is topmost in QUD, it is permissible to provide any information specific to *q*.

- LATEST-MOVE: content of *latest move* made: it is permissible to make whatever moves are available as reactions to the latest move.

Intuitively, turn 2 from question-answer pair in turns 2 and 3 from (8) directly introduces a *question under discussion*. Given that in this case the *latest move* is a question, turn 3 is interpreted as an answer relating to the most recent question under discussion. This answer, however, is not simply added to the dialogue partners' common knowledge, that is, the *facts*. Rather, the answer receiver first has to *accept* the response offered to him – this is the dialogue reading of "It takes two to make a truth". After acceptance, the answer can be *grounded* (see Clark (1996: Chap. 4) for a discussion of common ground), that is, *facts* is *updated* with the proposition bound up with the given answer, the resolved question under discussion is removed from the QUD list (*downdating*) – in a nutshell, this basic mechanism is also the motor of dialogue progressing. This mechanism entails an additional qualification compared to a static mutual belief contexts: dialogue update does not abstract over the individual dialogue partners. A dialogue move does not present the same content to each of the dialogue partners, nor does the occurrence of a move lead automatically to an update of the common ground (or mutual beliefs). Dialogue semantics accounts for this fact by distinguishing *public* from *private* information. Public information consists of observable linguistic behaviour and its conventional interpretations, collected under the notion of *dialogue gameboard* (DGB). The DGB can be traced back to the *commitment-stores* of

Hamblin (1970) that keep track of the commitments made at each turn by each speaker.

Private information is private since it corresponds to interlocutors' mental states (MS). The final ingredient is that the (fourfold) dynamics between the interlocutors' dialogue game boards and mental states unfolds in time, turn by turn. In sum, a minimal participant-sensitive model of dialogue contributions is a tuple of DGB and MS series the form $\langle \text{DGB} \times \text{MS} \rangle^+$ for each dialogue agent. Here the "Kleene +" indicates a temporally ordered sequence of objects of a given type (i.e., DGB and MS in case of dialogue agents' information state models) which is witnessed by a *string* of respective events (see Cooper & Ginzburg (2015: Sec. 2.7) on a type-theoretical variant of the string theory of events of Fernando (2011)).

Guided by a few dialogue-specific semantic phenomena we moved from various extensions to CONTEXT to minimal participant models and updating/downdating dynamics. In Sections 3 and 4 further progress is reviewed which mainly consists in inverting the theory's strategic orientation: instead of extending HPSG in order to cover pragmatics and dialogue semantics, it is argued that there are reasons to start with an interactive semantic framework and then embed an HPSG variant therein.

In order to move on, a remaining issue has to be resolved: what happens if an addressee for some reason refuses to accept a contribution of the previous speaker? In this case, the addressee (now taking the speaker role) poses a *clarification request*. Clarification potential plays an important methodological role in the dialogue semantic business, as exemplified in Section 3.1 subsequently.

3 Type-theoretical pragmatics and dialogue semantics

A minimal primer for the rich type theory TTR (a Type Theory with Records) is given in Section 3.3. But why should (dialogue) semantics make use of a type theory at all? Subsequently two sources of motivation are presented, the one drawing on semantic data gained from the clarification potential of reprise fragments (Section 3.1), the other resulting from HPSG's struggle with connecting to semantic theories (Section 3.2).

3.1 Sub-sentential meanings: unification vs. reprise content

In (9), B poses a clarification request in terms of a reprise fragment concerning the verb used by A (Ginzburg 2012: 115):

(9) A: Did Bo finagle a raise? B: finagle?

The reprise fragment has at least two interpretations: it can query the phonetic component of the verb ("did I hear correctly that you said 'finagle'?"), or it can query the meaning of the verb ("what does 'finagle' mean?") Both queried aspects are available as part of the PHON-SYNSEM structure of signs, emphasizing the significance of HPSG's fractal design (cf. the remark on fractality in Section 2.2) However, when B uses the reprise fragment to clarify the content of the expression reprised, then B queries *only* the meaning of the reprised fragment (Purver & Ginzburg 2004; Ginzburg & Purver 2012) – in our example (9) this is *finagle.* This can be seen when answers are given that target the head verb or the verb phrase (head verb plus direct object argument *a raise*):

(10) a. Yeah, like wangle.
      b. Yeah, he wangled a wage increase.

From the continuations in (10) only the first one provides an answer to B's clarification question in (9). The second continuation can also answer a clarification request, but this clarification request is *finagle a raise?* That is, "[a] nominal fragment reprise question queries exactly the standard semantic content of the fragment being reprised.", which is the strong version of the *reprise content hypothesis* put forth by Purver & Ginzburg (2004: 288).[3] In case of the example given in (9), the content of the head verb is queried, and not the meaning of the verb phrase (verb plus direct object) or the sentence (verb plus direct object and subject), since they correspond to constructions that are larger than the reprised fragment. In other words, a reprise fragment allows us to access the meaning of any expression regardless of its syntactic degree of embedding. However, this is not what follows from unification-based semantics. Due to structure sharing, certain slots of a head are *identified* with semantic contributions of modifier or argument constructions (see Wechsler, Koenig & Davis (2018), Chapter 9 of this volume). In case of *finagle a raise* this means that once the content of the VP is composed, the patient role (or whatever semantic composition means are employed – see Koenig & Richter (2018), Chapter 24 of this volume for an overview) of the verb *finagle* is instantiated by the semantic index contributed by *a raise.* At this stage one cannot recover the V content from the VP content – unification appears to be too strong a mechanism to provide contents at all levels as required by reprise fragments.

---

[3]The weak version (Purver & Ginzburg 2004: 287) only claims that a nominal fragment reprise question queries a part of the standard semantic content of the fragment being reprised.

3.2 Semantic objects: data structures vs. types

Aiming at a declarative characterisation of natural languages, the model theoretic set-up of HPSG has to define models for its domain of linguistic objects (Levine & Meurers (2006: Sec. 3); see also Richter (2018), Chapter 3 of this volume). In particular with regard to the values of the CONTENT and CONTEXT attribute, the crucial question is "[…] how types in the [feature] logic should correspond to the semantic types being represented." Penn (2000: 70). In order to provide an answer to this crucial question one has to clarify what a semantic type is. This question, however, is perhaps even more far-reaching and intricate than the initial one and following it further would lead us to undertake a considerable diversion and probably even turn away from the actual point of the initial question (but for a recent related discussion on the status of propositions see (King et al. 2014)). A pragmatic interpretation of the crucial question probably is this: "how do the types in the feature logic correspond to the semantic types employed in semantic theories?" There is a justification for this restatement from the actual semantics practice in HPSG (cf. Koenig & Richter (2018), Chapter 24 of this volume).

For the purpose of the present discussion, a semantic theory can be conceived as consisting of two components, *semantic representations* and an extensional *domain* or *universe* within which the semantic representations are interpreted (Zimmermann 2011; Kempson 2011). That is, another reformulation of the question is how the HPSG model theory is related to a semantic model theory. Further concreteness can be obtained by realising that both kinds of theories aim to talk about the same extensional domain.Given this, the question becomes: how do HPSG's semantic representations correspond to the semantic representation of the semantic theory of choice. A closely related point is made by Penn (2000: 63): "A model-theoretic denotation could be constructed so that nodes, for example, are interpreted in a very heterogeneous universe of entities in the world, functions on those entities, abstract properties that they may have such as number and gender and whatever else is necessary – the model theories that currently exist for typed feature structures permit that […]" Formulating things in this way has a further advantage: the question is independent from other and diverging basic model theoretic assumptions made in various versions of HPSG, namely whether the linguistic objects to model are types (Pollard & Sag 1994) or tokens (Pollard & Sag 1987) and whether they are total objects (Pollard & Sag 1994) or partial information (Carpenter 1992) However, such a semantic model-theoretic denotation of nodes is not available in many of the most influential versions of HPSG.

The semantic structures of the HPSG version developed by Pollard & Sag (1994)

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rests on a situation-theoretic framework. However, the (parameterised) states of affairs used as semantic representations lack a direct model-theoretic interpretation; they have to be translated into a situation-theoretic formulæ first (such a translation from typed feature structures to situation theory is developed by Ginzburg & Sag 2000). That is, the semantic structures do not encode semantic entities; rather they are data structures that represent descriptions which in turn correspond to semantic objects. This is also the conclusion drawn by Penn. The quotation by him given above continues: "[...] but at that point feature structures are not being used as a formal device to represent knowledge but as a formal device to represent data structures that encode formal devices to represent knowledge." (Penn (2000: 63); see also the discussion given by Ginzburg (2012: Sec. 5.2.2).)

There are two options in order to unite typed feature structures and semantic representations. The first is to use logical forms instead of (p)soas and by this means connect directly to truth-conditional semantics. This option makes use of what Penn (see above) calls a *heterogeneous universe*, since syntactic attributes receive a different extensional interpretation than semantic attributes (now consisting of first or second order logic formulæ). The second option is to resort to a homogeneous universe and take phon-synsem structures as objects in the world, as is done in type-theoretical frameworks – signs nonetheless stand out from ordinary objects due to their sem part, which makes them representational signs in the first place.

The first option, using logical forms instead of situation-semantic (p)soas, was initiated by Nerbonne (1992). The most fully worked out semantics for HPSG from this strand has been developed by Richter and Sailer, by providing a mechanism to use the higher-order Ty2 language as semantic descriptions (Richter & Sailer 1999). This approach has been worked out in terms of *Lexical Resource Semantics* (LRS) where logical forms are constructed in parallel with attribute-value matrices (Richter & Sailer 2004).

The most popular underspecification mechanism is *(Robust) Minimal Recursion Semantics* (Copestake et al. 2005; Copestake 2007). (r)mrs formulæ may have unfilled argument slots so that they can be assembled in various ways. However, resolving such underspecified representations is not part of the grammar formalism, so (r)mrs representations do not provide an autonomous semantic component for HPSG.

The second option, using the type-theoretical framework TTR (a Type Theory with Records), has been developed by Cooper (2008; 2014; 2018) and Ginzburg (2012). TTR, though looking similar to feature structures, directly provides se-

mantic entities, namely types (Ginzburg 2012: Sec. 5.2.2). TTR also has a model-theoretic foundation (Cooper 2018), so it complies with the representation-domain format we drew upon above.

Turning back to the issue discussed in Section 3.1, there is a difference between the two semantic options. Relevant observations are reported by Purver & Ginzburg (2004) concerning the clarification potential of noun phrases. They discuss data like the following (bold face added):

(11)   a.   TERRY: Richard hit the ball on the car.
           NICK: **What ball**?   [⤳ *What ball do you mean by 'the ball'?*]
           TERRY: James [last name]'s football.

                                  (BNC file KR2, sentences 862, 865–866)

     b.   RICHARD: No I'll commute every day
           ANON 6:   **Every day**?   [⤳ *Is it **every** day you'll commute?*]
                              [⤳ *Is it every **day** you'll commute?*]
                              [⤳ *Which days do you mean by **every day**?*]
           RICHARD: as if, er Saturday and Sunday
           ANON 6:   And all holidays?
           RICHARD: Yeah [pause]

As testified in (11), the accepted answers which are given to the clarification requests are in terms of an *individual* with regard to *the ball* (11a) and in terms of *sets* with regard to *every day* in (11b). The expressions put to a clarification request (*the ball* and *every day*, respectively) are analysed as *generalised quantifiers* in semantics (Montague 1974). A generalised quantifier, however, denotes a *set of sets*, which it at odds with its clarification potential in dialogue. Accordingly, in a series of works a theory of quantified noun phrases (QNPs) have been developed that refrains from type raising and analyses QNPs in terms of the intuitively expected and clarificationally required denotations of types *individual* and *sets of individuals*, respectively (Purver & Ginzburg (2004), Ginzburg & Purver (2012), Ginzburg (2012), Cooper (2013), Lücking & Ginzburg (2018) and Cooper (2018)). Since this dialogue-friendly improvement has been given in terms of the second, type-theoretical option and is lacking in the first, logical form-based option (which usually involves generalised quantifier analyses), there is an empirical advantage for the former over the latter at least from a pragmatic, dialogue semantics viewpoint.

There are further distinguishing features, however. Types are intensional entities so they directly provide belief objects as touched upon in Section 2.3 and needed for intensional readings as figuring in attitude reports such as in Paul

Reilley's question *Is there a scientist who believes that the earth is flat?* posed on quora[4] (see also Cooper (2005a) on attitute reports in TTR).

Furthermore, TTR is not susceptible to the *slingshot argument* (Barwise & Perry 1983: 24–26): explicating propositional content on a Fregean account (Frege 1892) – that is, denoting the true or the false – in terms of sets of possible worlds is too coarse-grained since two sentences which are both true (or false) but have nonetheless different meanings cannot be distinguished. In this regard, TTR provides a *structured theory of meaning*, where types are not traded for their extensions. Accordingly and to conclude this chapter, a brief introduction to TTR is given in Section 3.3 and the architecture of the dialogue theory *KoS* incorporating a type-theoretic HPSG variant is sketched in Section 4.

3.3 A brief primer to TTR[5]

TTR (a Type Theory with Records) provides semantic objects at both the token and the type level, structures to organize these objects (viz., records and record types), and (Montagovian) λ-abstraction and functional application (see Cooper (2005b), Cooper (2005a), Cooper (2012), Cooper (2017), and Cooper & Ginzburg (2015) for expositions). The basic notion in TTR is a *judgement* of the form $a : T$, meaning that object a is of type T. Judgements are used to capture basic classifications like *Marc Chagall is an individual* ($mc : Ind$), as well as propositional descriptions of situations like *The cat is on the mat* for the situation depicted in (13), where Fritz the cat sits on mat m33. In order to characterise more complex types, TTR provides *record types*. The record type for the example sentence (ignoring the semantic contribution of the definite article for the sake of exposition[6]) will be (12):

(12)
$$
\begin{bmatrix}
\text{x} & : & Ind \\
\text{c1} & : & cat(x) \\
\text{y} & : & Ind \\
\text{c2} & : & mat(y) \\
\text{c3} & : & on(x,y)
\end{bmatrix}
$$

A *witness* for the record type in (12) will be a *record* that provides suitable objects for each field of the record type (and possibly more). A record is a set of fields which consist of assignments from labels to values. The situation depicted

---

[4]https://www.quora.com/Is-there-a-scientist-who-believes-that-the-earth-is-flat, accessed on October 31, 2018.

[5]The primer is closely related to the one given in Lücking (2018: Sec. 4.1).

[6]This record type corresponds to *a cat is on a mat.*

in (13) can be represented as the record in the left-hand part of (14), where recognition procedures are assumed to be *proofs* for the predicational types from (12). The objects in the fields labelled c1–3 can also be thought of as situations which show Fritz to be a cat, m33 to be a mat and Fritz to be on m33.

(13)

Fritz

m33
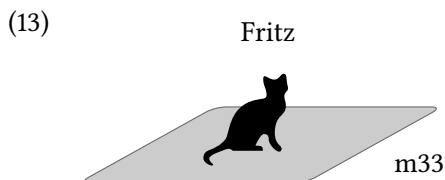
Since the record is of the type required by the record type – which is represented in (14) – the type correctly classifies the situation in question.

(14)
$$
\begin{bmatrix}
\textsc{x} & = & \textit{Fritz} \\
\textsc{c1} & = & \textit{cat recognition} \\
\textsc{y} & = & \textit{m33} \\
\textsc{c2} & = & \textit{mat recognition} \\
\textsc{c3} & = & \textit{relation recognition}
\end{bmatrix}
:
\begin{bmatrix}
\textsc{x} & : & \textit{Ind} \\
\textsc{c1} & : & \textit{cat(x)} \\
\textsc{y} & : & \textit{Ind} \\
\textsc{c2} & : & \textit{mat(y)} \\
\textsc{c3} & : & \textit{on(x,y)}
\end{bmatrix}
$$

Although record types will be represented in the above-given format, technically they involve functions from individuals, not labels, to predicational types. That is, officially the "cat part" of the record type in (14) has the following structure:

(15)
$$
\begin{bmatrix}
\textsc{x} & : & \textit{Ind} \\
\textsc{c1} & : & \langle \lambda v{:}\textsc{ind} \, . \, \textsc{cat}(v), \langle \textsc{x} \rangle \rangle
\end{bmatrix}
$$

The predicational type c1 from (15) is a function from individuals onto cats, i.e. it is of the Montagovian type $\langle e, t \rangle$, where the object abstracted over is to be found at path x in the record type. This function is characterised by the set of ordered pairs $\{\langle v, cat(v) \rangle \mid v : \textit{Ind}\}$ and thereby is linked to a set theoretical notion of extension.

4 Putting things together: HPSG$_{\text{TTR}}$ and Dialogue game boards

Signs as construed within HPSG can be reconstructed as record types of a specific kind (Cooper 2008). For instance, (16) shows the record type for a general sign according to Pollard & Sag (1994) (where *PhonType*, *CategoryType* and *SemType* denote obvious types – see the Appendix for a minimal HPSG fragment defined in terms of TTR).

(16)
$$\begin{bmatrix} \text{PHON} & : \textit{List(PhonType)} \\ \text{SYNSEM} & : \begin{bmatrix} \text{LOCAL} & : \begin{bmatrix} \text{CAT} & : \textit{CategoryType} \\ \text{CONTENT} & : \textit{SemType} \\ \text{CONTEXT} & : \textit{SemType} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Signs are extended by an interface to circumstantial features of the utterance situation in terms of the DGB-PARAMS attribute, which corresponds to the C-INDS from Section 2.1. The attribute's name abbreviates *dialogue gameboard parameters* since its values have to be instantiated (that is, witnessed) in the process of grounding. Thus, if the content of an NP α is part of DGB-PARAMS, then α gets a referential interpretation. However, NPs need not be used referentially, there are descriptive uses as in *The thief (however he is) stole my credit card.* To this end, there is a "coercion" operation from DGB-PARAMS to Q-PARAMS (*quantificational parameters*) involving an abstraction from individuals to α's descriptive condition (Purver & Ginzburg (2004); see the Appendix for the respective operation).

These HPSG$_{\text{TTR}}$ signs figure as constituents within an architecture known as *dialogue gameboard*, giving rise to a grammar-dialogue interface within the dialogue theory *KoS* (Ginzburg 1994; 1996; 2003; 2012). A Dialogue Game Board (DGB) is an information-state based sheet for describing communicative interactions. The DGB from KoS tracks the interlocutors (*spkr* and *addr* fields), a record of the dialog history (*Moves*), dialog moves that are in the process of grounding (*Pending*), the question(s) currently under discussion (*QUD*), the assumptions shared among the interlocutors (*Facts*), and the dialogue participant's view of the visual situation and attended entities (*VisualSit*). The TTR representation of a DGB following Ginzburg (2012) is given in (17), where *LocProp* is the type of a *locutionary proposition* (see (19) below) and *poset* abbreviates "partially ordered set".

(17)
$$\begin{bmatrix} \text{SPKR} & : \textit{Ind} \\ \text{ADDR} & : \textit{Ind} \\ \text{UTT-TIME} & : \textit{Time} \\ \text{C-UTT} & : \textit{addressing(spkr, addr, utt-time)} \\ \text{FACTS} & : \textit{Set(Prop)} \\ \text{VISUALSIT} & : \textit{RecType} \\ \text{PENDING} & : \textit{list(LocProp)} \\ \text{MOVES} & : \textit{list(LocProp)} \\ \text{QUD} & : \textit{poset(Question)} \end{bmatrix}$$

Propositions in TTR can be developed in an explicit Austinian (1950) way, where a proposition is individuated in terms of a situation and situation type (Ginzburg 2011: 845) – this is the truth-making (and Austin's original) interpretation of "It takes two to make a truth". The type of propositions and the relation

to a situation semantics conception of 'true' (Barwise & Perry 1983) is given in
(18):

(18) a. $Prop =_{def} \begin{bmatrix} \text{SIT} & : \ Record \\ \text{SIT-TYPE} & : \ RecType \end{bmatrix}$

　　　b. A proposition $p = \begin{bmatrix} \text{SIT} & = \ s \\ \text{SIT-TYPE} & = \ T \end{bmatrix}$ is true iff $s : T$.

A special kind of proposition, namely *locutionary propositions* (*LocProp*) (Ginz-
burg 2012: 172), can be defined as follows:

(19) $LocProp =_{def} \begin{bmatrix} \text{SIGN} & : \ Record \\ \text{SIGN-TYPE} & : \ RecType \end{bmatrix}$

Locutionary propositions are sign objects utilized to explicate clarification po-
tential (see Section 3.1) and grounding.

Given the dialogue-awareness of signs just sketched, a content for interjec-
tions such as "EHHH HEHH" which constitutes turn 3 from the exchange be-
tween Ann and Ray in (1) at the beginning of this chapter can be given. Intu-
itively, Ann signals with these sounds that she heard Ray's question, which in
turn is neither grounded nor clarified at this point of dialogue but waits for re-
sponse, what is called *pending*. This intuition can be made precise by means of
the following lexical entry (which is closely related to the meaning of *mmh* given
by Ginzburg (2012: 163)):

(20) $\begin{bmatrix} \text{PHON} : \text{EHH HEHH} \\ \text{CAT} : \begin{bmatrix} \text{HEAD} = interjection \ : \ syncat \end{bmatrix} \\ \text{DGB-PARAMS} : \begin{bmatrix} \text{SPKR} & : \ Ind \\ \text{ADDR} & : \ Ind \\ \text{PENDING} & : \ LocProp \\ \text{C2} & : \ address(spkr,addr,pending) \end{bmatrix} \\ \text{CONT} = Understand(\text{SPKR},\text{ADDR},\text{DGB-PARAMS.PENDING}) : IllocProp \end{bmatrix}$

Knowing how to use feedback signals such as the one in (20) can be claimed
to be part of linguistic competence. It is difficult to imagine how to model this
aspects of linguistic knowledge if not by means of *grammar in dialogue.*

5 Outlook

Given a basic framework for formulating and analysing content in dialogue con-
text, there are various direction to explore, including the following ones.

- One of the main challenges of dialogue semantics is the integration of *non-verbal communication* means, like gaze, gestures, body posture, timing and non-language vocal sounds (e.g., laughter (Ginzburg et al. 2015; Tian et al. 2016)). Since non-verbal communication means are informative, not only a (dialogue) semantic representation has to be developed, but also the rules of their interaction with speech has to be formulated.

- Duologue is the interaction between *two* interlocutors. How can one scale up to *multilogue* (Ginzburg & Fernández 2005)? Given the increased number of participants, problems that emerge include *grounding by proxy*, where a representative represents the dialogue gameboard of a group and of course *turn taking*.

- People do not process natural language input sentence-wise. Rather, processing begins with the initial sound and proceeds word for word or even on smaller units like morphemes and phonemes – that is, processing is incremental (e.g. Sedivy et al. (1999); see also Wasow (2018), Chapter 28 of this volume). This is a key ingredient in the efficient (relatively gap-free and interruption-less) managing of turn taking. One direction of dialogue theories therefore is to bring psycholinguistics and formal semantics closer together by devising incremental grammar and dialogue gameboard models (Hough et al. 2015; Demberg et al. 2013; Poesio & Rieser 2011).

Finally, we want to mention two other dialogue-theoretic frameworks that have been worked out to a substantial degree, namely PTT (Traum 1994; Poesio 1995; Poesio & Traum 1997; Poesio & Rieser 2010), and *Segmented Discourse Representation Theory* (SDRT) (Asher 1993; Asher & Lascarides 2003; 2013; Hunter & Asher 2015). The phenomena and outlook directions discussed in this chapter apply to all theories of dialogue semantics, of course.

Appendix: A HPSG$_{\text{TTR}}$ fragment

The appendix provides a fragment of HPSG$_{\text{TTR}}$. The grammar framework used is oriented at a *Head-driven Phrase Structure Grammar* variant (Sag et al. 2003), respectively its TTR implementation (Cooper 2008). We use HPSG, because its architecture satisfies the property of *incremental correspondence* (Johnson & Lappin 1999) – utterance representations encode phonological, syntactic, semantic, and contextual information *fractally*. This is crucial *inter alia* for any treatment

of clarification interaction (cf. Section 3.1). We use HPSG$_{\text{TTR}}$, because the type-theoretical version allows us to directly incorporate semantic objects (cf. Section 3.2).

TTR has a counterpart to unification, namely the *merge* construction.

(21)   a. If R_1 and R_2 are record types, then $R_1 \wedge_{merge} R_2$ is a record type and is called the *merge* of R_1 and R_2.

       b. Since merge types are complicated to define (but see Cooper 2012), we follow the strategy of Cooper (2017) and illustrate the working of merges by means of some examples:

$$\text{(i)} \quad \begin{bmatrix} \text{A} & : & T \\ \text{B} & : & R \end{bmatrix} \quad \wedge_{MERGE} \quad \begin{bmatrix} \text{C} & : & S \end{bmatrix} \quad = \quad \begin{bmatrix} \text{A} & : & T \\ \text{B} & : & R \\ \text{C} & : & S \end{bmatrix}$$

$$\text{(ii)} \quad \begin{bmatrix} \text{A} & : & T \end{bmatrix} \quad \wedge_{MERGE} \quad \begin{bmatrix} \text{A} & : & R \end{bmatrix} \quad = \quad \begin{bmatrix} \text{A} & : & T \wedge_{merge} R \end{bmatrix}$$

Structure sharing is indicated by a "tag type" notation. Tag type are defined in terms of manifest fields.[7] The notational convention is exemplified in (22) by means of head-specifier agreement, where the tag type from (22a) abbreviates the structure in (22b):

(22)   a.
$$\begin{bmatrix} \text{CAT} & : & \begin{bmatrix} \text{HEAD} & : & \begin{bmatrix} \text{AGR}_{\boxed{1}} & : & Agr \end{bmatrix} \\ \text{SPR} & : & \left\langle \begin{bmatrix} \text{CAT} & : & \begin{bmatrix} \text{HEAD} & : & \begin{bmatrix} \text{AGR}=\boxed{1} & : & Agr \end{bmatrix} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

       b.
$$\begin{bmatrix} \text{CAT} & : & \begin{bmatrix} \text{HEAD} & : & \begin{bmatrix} \text{AGR} & : & Agr \end{bmatrix} \\ \text{SPR} & : & \left\langle \begin{bmatrix} \text{CAT} & : & \begin{bmatrix} \text{HEAD} & : & \begin{bmatrix} \text{AGR}=/\text{CAT.HEAD.AGR} & : & Agr \end{bmatrix} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

The tag type notation alludes to the box notation common in HPSG work.

Agr is defined as usual:

(23) $Agr := \begin{bmatrix} \text{NUM} & : & Num \\ \text{PERS} & : & Per \\ \text{GEN} & : & Gen \end{bmatrix}$

A basic *sign* is a pairing of phonetic, syntactic and semantic information and follows the geometry in (24):

(24) $sign := \begin{bmatrix} \text{PHON} & : & Phoneme \\ \text{CAT} & : & SynCat \\ \text{DGB-PARAMS} & : & RecType \\ \text{CONT} & : & SemObj \end{bmatrix}$

---

[7]*NB:* technically, tag types apply singleton types to record types, instead of to objects, thereby making use of a revision of the notion of singleton types introduced by Cooper (2013: p. 4, footnote 3).

Signs employ dgb-params, which host referential meanings that are witnessed among interlocutors. Quantificational abstraction is achieved by coercing parts of dgb-params to q-params:

(25)   If dgb-params : R_2 and for two record types R_0 and R_1 lacking any mutual dependencies[8] $R_2 = R_0 \wedge_{merge} R_1$, then R_0 can be moved to q-params, resulting in the following structure:

$$\begin{bmatrix} \text{DGB-PARAMS} & : & R_1 \\ \text{CONT} & = & \begin{bmatrix} \text{Q-PARAMS} & : & R_0 \end{bmatrix} \end{bmatrix}$$

A word is a sign with constituent type ("cxtype") *word*. Using the merge operation, the word extension on signs can represented compactly as in (26a), which expands to the structure given in (26b):

(26)   a.   *word* := *sign* $\wedge_{merge}$ $\begin{bmatrix} \text{CXTYPE} & : & word \end{bmatrix}$: *RecType*

      b. $\begin{bmatrix} \text{CXTYPE} & : & word \\ \text{PHON} & : & Phoneme \\ \text{CAT} & : & SynCat \\ \text{DGB-PARAMS} & : & RecType \\ \text{CONT} & : & SemObj \end{bmatrix}$

Words – that is, cxtype *word* – are usually the result of lexical rules, whose input are lexemes. Lexemes differ from words in their constituent type:

(27)   *lexeme* := *sign* $\wedge_{merge}$ $\begin{bmatrix} \text{CXTYPE} & : & lexeme \end{bmatrix}$: *RecType*

A phrasal sign can be seen as a word with daughters:

(28)   a.   *phrase* := *sign* $\wedge_{merge}$ $\begin{bmatrix} \text{CXTYPE} & : & phrase \\ \text{DTRS} & : & \begin{bmatrix} \text{NHD-DTRS} & : & List(Sign) \end{bmatrix} \end{bmatrix}$: *RecType*

      b. $\begin{bmatrix} \text{CXTYPE} & : & phrase \\ \text{PHON} & : & List(Phoneme) \\ \text{CAT} & : & SynCat \\ \text{DGB-PARAMS} & : & RecType \\ \text{CONT} & : & SemObj \\ \text{DTRS} & : & \begin{bmatrix} \text{NHD-DTRS} & : & List(Sign) \end{bmatrix} \end{bmatrix}$

A headed phrase is a phrase with a prominent daughter, i.e., the head daughter:

(29)   a.   *hd-phrase* := *phrase* $\wedge_{merge}$ $\begin{bmatrix} \text{DTRS} & : & \begin{bmatrix} \text{HD-DTR} & : & Sign \end{bmatrix} \end{bmatrix}$: *RecType*

---

[8]None of the labels occurring in R_0 occur in R_1 and vice versa.

b.
$$\begin{bmatrix} \text{CXTYPE} & : phrase \\ \text{PHON} & : List(Phoneme) \\ \text{CAT} & : SynCat \\ \text{DGB-PARAMS} & : RecType \\ \text{CONT} & : SemObj \\ \text{DTRS} & : \begin{bmatrix} \text{HD-DTR} & : Sign \\ \text{NHD-DTRS} & : List(Sign) \end{bmatrix} \end{bmatrix}$$

The head daughter is special since it (as a default at least) determines the syntactic properties of the mother construction. This aspect of headedness is captured in terms of the *head-feature principle* (HFP), which can be implemented by means of tag types as follows:

(30) HFP :=
$$\begin{bmatrix} \text{CXTYPE} & : phrase \\ \text{CAT} & : \begin{bmatrix} \text{HEAD}\boxed{2} & : PoS \end{bmatrix} \\ \text{DTRS} & : \begin{bmatrix} \text{HD-DTR} & : \begin{bmatrix} \text{CAT} & : \begin{bmatrix} \text{HEAD}=\boxed{2} & : PoS \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The fact that the daughters' locutions combine to the mother's utterance is captured in terms of a "phon principle" (we use a slash notation in order to indicate paths starting at the outermost level of a feature structure):

(31) PHON :=
$$\begin{bmatrix} \text{CXTYPE} & : phrase \\ \text{PHON} & : List(/dtrs.hd.dtr/phon, /dtrs.nhd.dtrs/pos1.phon, \\ & \quad ..., /dtrs.nhd.dtrs/posn.phon) \end{bmatrix}$$

Since semantic composition rests on predication rather than unification, there is no analog to the semantic compositionality principle of Sag et al. (2003) on our account. There is, however, something akin to semantic inheritance: we need to keep track of the contextual resp. quantificational paramaters contributed by the daughters of a phrase. This is achieved in terms of a *dgb-params principle* (*DGBPP*) in (32) which unifies the daughters' dgb-params into the mother's dgb-params (see Ginzburg (2012: 126 *et seq.*) for a similar principle):

(32) DGBPP :=

$$\begin{bmatrix} \text{CXTYPE} & : phrase \\ \text{DGB-PARAMS} & : \begin{bmatrix} /\text{DTRS.HD-DTR.DGB-PARAMS} \wedge_{MERGE} /\text{DTRS.NHD-DTRS.POS1.DGB-PARAMS} \wedge_{MERGE} \\ ... \wedge_{MERGE} /\text{DTRS.NHD-DTRS.POS}n.\text{DGB-PARAMS} \end{bmatrix} \\ \text{DTRS} & : \begin{bmatrix} \text{HD-DTR} & : \begin{bmatrix} \text{Q-PARAMS} & : RecType \end{bmatrix} \\ \text{NHD-DTRS} & : \langle \text{POS1} : \begin{bmatrix} \text{Q-PARAMS} : RecType \end{bmatrix}, ..., posn : \begin{bmatrix} \text{Q-PARAMS} : RecType \end{bmatrix} \rangle \end{bmatrix} \end{bmatrix}$$

A headed phrase is well-formed just in case it is a headed phrase and it obeys the head feature principle, the phon principle and the dgb-params principle, which is expressed by extending *hd-phrase* by the following constraint:

(33)   *hd-phrase* := *hd-phrase* $\wedge_{merge}$ HFP $\wedge_{merge}$ PHON $\wedge_{merge}$ DGBPP

Using this set-up, lexical entries, lexical rules and syntactic constructions can be formulated straightforwardly.

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Chapter 31

Sign languages

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1 Introduction

Duis pulvinar lacus id gravida ornare. Phasellus eu mauris sed tortor maximus condimentum ultrices in leo. Donec non erat nec nulla ullamcorper ornare sed id ex. Integer risus mauris, aliquet vel aliquam sed, feugiat quis nisi. Suspendisse quis nunc a turpis porttitor mollis. In luctus nulla id nunc dapibus, id rhoncus lorem pretium. Nunc eget fringilla velit, semper commodo diam. Suspendisse odio odio, euismod ac ornare sed, tincidunt ac arcu. Pellentesque vitae fringilla

orci. Donec faucibus metus dui, nec iaculis purus pellentesque sit amet. Sed fermentum lorem non augue cursus, eu accumsan risus ullamcorper. Suspendisse rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

$$
\begin{bmatrix}
\textit{some-type} \\
\text{FEAT-A}\;\boxed{10}
\begin{bmatrix}
\textit{type-a} \\
\text{FEAT-AA}\;\textit{type-aa} \\
\text{FEAT-AB}\;\left\langle
\begin{bmatrix}
\text{SYNSEM|LOC|CAT|HEAD}\;\textit{type-aba} \\
\text{FEAT-ABC}\;\textit{type-abc}
\end{bmatrix}, \text{NP}
\right\rangle
\end{bmatrix} \\
\text{FEAT-B}\;\boxed{10}\textit{type-b}
\end{bmatrix}
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\begin{bmatrix}
\textit{some-type} \\
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\textit{type-a} \\
\text{FEAT-AA}\;\textit{type-aa} \\
\text{FEAT-AB}\;\left\langle
\begin{bmatrix}
\text{SYNSEM|LOC|CAT|HEAD}\;\textit{type-aba} \\
\text{FEAT-ABC}\;\textit{type-abc}
\end{bmatrix}, \text{NP}
\right\rangle
\end{bmatrix} \\
\text{FEAT-B}\;\boxed{10}\textit{type-b}
\end{bmatrix}
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Figure 1: Type hierarchy for *sign*

Abbreviations

Acknowledgements

Chapter 32

Gesture

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The received view in (psycho-)linguistics, dialogue theory and gesture studies is that co-verbal gestures, i.e. hand and arm movement, are part of the utterance and contribute to meaning. The relationships between gesture and speech obey regularities which are consequently captured in grammar by means of a gesture-grammar interface. This chapter provides basic snapshots from gesture research, reviews constraints on speech-gesture integration and summarises their implementations into HPSG frameworks. Pointers to future developments conclude the exposition. Since there are already a couple of overviews on gesture such as Özyürek (2012); Wagner et al. (2014); Abner et al. (2015), this chapter aims at distinguishing itself in that it provides a guided tour, where the guiding force is drawn from semantics and general semiotics and focuses, of course, on gesture work within HPSG.

1 Why gestures?

People talk with their whole body. A verbal utterance is couched into an intonation pattern that, *via* prosody, articulation speed or stress, function as *paralinguistic* signals (e.g. Birdwhistell 1970). The temporal dimension of paralinguistics gives rise to *chronemic* codes (Poyatos 1975; Bruneau 1980). *Facial expressions* are commonly used to signal emotional states (Ekman & Friesen 1978), even without speech (Argyle 1975), and are correlated to different illocutions of the speech

acts performed by a speaker (Domaneschi et al. 2017). Interlocutors use *gaze* as a mechanism to achieve joint attention (Argyle & Cook 1976) or provide social signals (Kendon 1967). Distance and relative direction of speakers and addressees are organised according to culture-specific radii into social spaces (*proxemics*, Hall 1968). Within the inner radius of private space, tactile codes of *tacesics* (Kauffman 1971) are at work. Since the verbal and nonverbal communication means of face to face interaction may occur simultaneously, *synchrony* is a signal in its own (Wiltshire 2007). A special chronemic case in signalling at the right moment – or, for that matter, to the contrary: missing the right moment (an aspect of communication dubbed *kairemics* by Lücking & Pfeiffer (2012: 600)). Besides the manifold areas of language use, the conventionalised, symbolic nature of language secures language's primacy in communication, however (de Ruiter 2004). For thorough introductions into semiotics and multimodal communication see Nöth (1990), Posner et al. (1997) or Müller et al. (2013).

The most conspicuous non-verbal communication means of everyday interaction are hand and arm movements, known as *gestures*. In seminal works, McNeill (1985; 1992) and Kendon (1980; 2004) argue that co-verbal gestures, i.e. hand and arm movements, can be likened to words in the sense that they are part of a speaker's utterance. Accordingly, integrated speech-gesture production models have been devised (Kita & Özyürek 2003; de Ruiter 2000; Krauss et al. 2000) that treat utterance production as a multimodal process. Given gestures' imagistic and often spontaneous character, it is appealing to think of them as "postcards from the mind" (de Ruiter 2007: p. 21). Clearly, given this entrenchment in speaking, non-verbal communication means have repercussions to areas hitherto taken to be purely linguistic (in the sense of being related to the verbal domain). This section highlights some phenomena particularly important for grammar, including, for instance, *mixed syntax* (Slama-Cazacu 1976), or *pro-speech gesture*:

(1)   He is a bit [*circular movement of index finger in front of temple*].

In (1), a gesture replaces a position that is usually filled by a syntactic constituent. The gesture is emblematically related to the property of *being mad* so that the mixed utterance from (1) is equivalent to the proposition that the referent of *he* is a bit mad.

Probably the most conspicuous gestures accompanying speech are pointing gestures (or deictic gestures). Given that the pronoun in (1) is used exophorically (that is, referring to someone from the physical utterance situation instead to a discourse referent from the preceding discourse), a pointing signal is required indicating where to find the referent. With regard to deictic gestures Fricke (2012:

Sec. 5.4) argues that deictic words within noun phrases – her prime example is German *so* (*like this*) –, provide a *structural*, that is, *language-systematic* integration point between the vocal plane of conventionalized words and the non-vocal plane of body movement. Therefore, on this conception, not only utterance production but *grammar* is inherently multimodal.

Moving from sentence to dialogue, *interactive gestures* are bound up with , among others (Bavelas et al. 1992; 1995). For instance, pointing gestures can be used to indicate the next speaker (Rieser & Poesio 2009). Thus, inasmuch as grammar is multimodal, also dialogue theory has to deal with specific non-verbal interaction means (see also Lücking, Ginzburg & Cooper (2018), Chapter 30 of this volume, this volume).

It should be noted, however, that not all gestures are as clearly a part of a sentence or an utterances as those in the examples given so far. A prominent counter-example in particular for interactive gesture views is gesturing on the telephone (see Bavelas et al. (2008) for an overview of a number of respective studies). Since such gestures are not observable for the addressee, they cannot reasonably taken to be a constituent of the intended content. Rather, "telephone gestures" seem to be purely speaker-oriented, presumably facilitating word retrieval. Furthermore, the lion's share of everyday gestures seem to consist of rather sloppy movements that do not contribute to the content of the utterance – they are *contingent* as opposed to be an obligatory semantic component (Lücking 2013). Based on such dividing evidence, gestures have broadly been distinguished into *foreground* vs. *background* gestures (Cooperrider 2017). This distinction aims to cover a basic difference in gestures and in the way a gesture is integrated into an utterance. Roughly, foreground gesture, but not background gestures, are semantically interpretable components of an utterance. This chapter focuses on foreground gestures.

2 Kinds of gestures

Gestures come in various kinds and are usually assigned to a number of gesture classes. These gesture classes are characterized by the function performed by a gesture and the meaning relation the gesture bears to its content (if any). A classic taxonomy consists of the following classes (McNeill 1992):

- iconic (or representational) gestures. Spontaneous hand and arm movements that are commonly said to be based on some kind of resemblance

relation.[1]. Iconic gestures employ a mode of representation such as *drawing*, *modeling*, *shaping* or *placing* (Streeck 2008; Müller 1998).

- deictic gestures (pointing). Typically hand and arm movements that perform a demonstration act. In which way pointing is standardly accomplished is subject to culture-specific conventions, though (Wilkins 2003). In principle, any extended body part, artifact or locomotor momentum will serve the demonstrative purpose. Accordingly, there are deictic systems that involve lip-pointing (Enfield 2001) or nose-pointing (Cooperrider & Núñez 2012). Furthermore, under certain circumstances, pointing with the eyes (gaze-pointing) is also possible (Hadjikhani et al. 2008). Note further that the various deictic means can be interrelated. For instance, manual pointing can be differentiated by cues of head and gaze (Butterworth & Itakura 2000).

- beats (rhythmic gestures). Hand and arm movements that are coupled to the intonational or rhythmic contour of the accompanying speech. Beats lack representational content but are usually used to an emphasising effect.

- emblem (lexicalized gestures). In contrast to the other classes, emblems are special in that they follow a fully conventionalized form-meaning relation. A common example in Western countries is the thumbs-up gesture, signalling "approval or encouragement" (Merriam Webster online dictionary[2]).

In addition to classifying gestures according to the above-given functional groups, a further distinction is usually made with regard to the ontological place of their referent: representational and deictic gestures can relate to concrete or to abstract objects or scenes. For instance, an iconic drawing gesture can metaphorically display the notion "genre" (McNeill 1992: 14). Likewise, pointing into a location within gesture space as a proxy for a real-world place is a point in case. An example is provided in Figure 5 below. Accordingly, gestures can be cross-classified into concrete and *abstract* or *metaphorical* ones.

Besides categorially distinguished gesture classes, gestures can also be specified according to multi-dimensional or functional characteristics (McNeill 2005;

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[1]But see footnote 5 in Section 4.4 for pointers to critical discussions of resemblance as a sign-bearing relation.

[2]https://www.merriam-webster.com/dictionary/thumbs-up, accessed 20th August 2018. The fact that emblems can be lexicalized in dictionaries emphasizes their special, conventional status among gestures.

Gerwing & Bavelas 2004). See Özyürek (2012) for an overview of various gesture classification schemes.

On the most basic, kinematic level the movement of a prototypical gesture follows an "anatomic triple": gestures have to be partitioned into at least a preparation, a stroke, and a retraction phase (Kendon 1972). The stroke is the movement part that carries the gesture's meaning. Preparation and retraction phase bring hand and arms into respectively out of the stroke. Unless stated otherwise, when talking about gestures what follows, the stroke phase, which is the "gesture proper" or the "semantic interpretable" phase, is referred to.

In any case, the spontaneous, usually co-verbal hand and arm movement considered in this chapter are different from the signed signs of sign languages (see Steinbach & Holler (2018), Chapter 31 of this volume) and pantomime (not spontaneous and co-verbal).[3]

3 Basic empirical phenomena of grammatical gesture integration

With regard to grammar-gesture integration, three main phenomena have to be dealt with:

- What is the meaning of a gesture? How to assign semantic representations or truth conditions to hand and arm movements?

- What is the affiliate of a gesture, that is, its verbal attachment site?

- What is the result of multimodal integration, that is, composing verbal and non-verbal meaning?

The following example, (2) and Figure 1, (taken from Lücking (2013: 189)) illustrates these issues:

(2) Ich g[laube das   sollen TREP]pen   sein.
     I   think   those should STAIRCAses be.

     'I think those should be staircases.'

The first syllable of the German noun *Treppen* (*staircases*) carries main stress, indicated by capitalization. The square brackets indicate the temporal overlap

---

[3]In languages like German the difference between free gesticulation and sign language signs is also reflected terminologically: the former are called *Gesten*, the latter *Gebärden*.
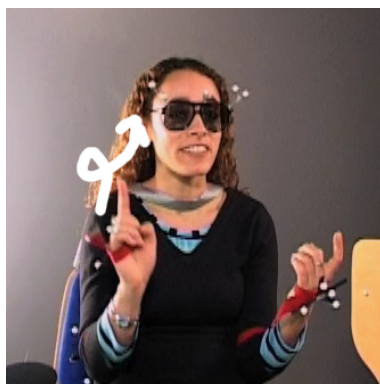
Figure 1: "I think those should be staircases."

between speech and gesture stroke, which is shown in Figure 1. The gesture attributes to the noun it attaches to: from the multimodal utterance the observer retrieves the information that the speaker talks about spiral staircases. This interpretation assumes that the common noun is the affiliate of the iconic gesture. Obviously, mere temporal synchrony is too weak to be an indicator of affiliation. In fact, there are speech-gesture affiliations without temporal overlap between gesture and verbal affiliate at all (e.g. Lücking et al. 2004). Therefore, temporal overlap or vicinity is just one indicator of affiliation, a second one is intonation: a gesture is usually related to a stressed element in speech (McClave 1994; Nobe 2000; Loehr 2004; 2007). As a result, multimodal communication gives rise to complex "peak pattern" (Tuite 1993; Loehr 2004; Jannedy & Mendoza-Denton 2005).

The interpretation of a gesture changes with different affiliations. Suppose the gesture from Figure 1 is produced in company to stressed *glaube* (*think*) instead of *staircases*:

(3) Ich G[LAUbe das   sollen Trep]pen sein.
     I   THINK   those should staircases be

     'I think those should be stairscases.'

Now the spiral movement is interpreted as a metaphorical depiction of a psychological process. Thus, the interpretation of a gesture depends on the integration point (affiliation), which in turn is marked by prosody. Note that the resulting may express a richer content than speech alone, as in (2), or a content equivalent to speech content, as in (3); it can even express less than speech or contradict

speech:[4]

> The nonverbal act can repeat, augment, illustrate, accent, or contradict the
> words; it can anticipate, coincide with, substitute for or follow the verbal
> behavior; and it can be unrelated to the verbal behavior. (Ekman & Friesen
> 1969: 53)

Given the linguistic significance of gestures as sketched in the preceding sections grammar-oriented accounts on speech-gesture integration have recently been developed that try to deal with (at least one of) the three basic phenomena, though with different settings of priorities, including Alahverdzhieva (2013), Alahverdzhieva & Lascarides (2010), Ebert (2014), Giorgolo (2010), Giorgolo & Asudeh (2011), Lücking (2013; 2016), Rieser (2008; 2011; 2015), Rieser & Poesio (2009), Schlenker (2018).

The HPSG-related approaches are briefly reviewed below. For grammars for sign languages see Steinbach & Holler (2018), Chapter 31 of this volume. There also belong investigations into iconic features of American Sign Language (Schlenker et al. 2013; Schlenker 2014).

4 Gestures in HPSG

Integrating a gesture's (pointing) contribution to speech was initiated in computer science. Coincidentially, these early works used typed feature structure description akin to HPSG grammars. Though linguistically limited, the crucial invention has been a *multimodal chart parser*, that is, an extension of chart parsing that allows to process input on two modalities (namely speech and gesture). Such approaches are reviewed in Section 4.1. Afterwards, a more elaborate gesture representation format is introduced that allows to encode the observable form side of a gesture in terms of kinematically derived attribute-value structures (Section 4.2). Following the basic semiotic distinction between deictic (or indicating or pointing) gestures and iconic (or representational or imagistic) gestures, the analysis of both classes of gestures is exemplified in Sections 4.3 and 4.4, respectively.

---

[4]In case of contradiction, that, speech-gesture mismatch, the resulting multimodal utterance is perceived as ill-formed and induces N400 effects (Wu & Coulson 2005; Kelly et al. 2004).

4.1 Precursors

Using typed feature structure descriptions in order to represent the form and meaning of gestures goes back to computer science approaches to human-computer interaction (HCI). The *QuickSet* system (Cohen et al. 1997) allows users to operate on a map and move objects or create barb wires (the project was funded by a grant from the US army) by giving verbal commands and manually indicating coordinates. The system processes voice and pen (gesture) input by assigning signals from both media representations in the form of attribute-value matrices (AVMs) (Johnston 1998; Johnston et al. 1997). For instance, *QuickSet* will move a vehicle to a certain location on the map when asked to *Move this*[☞] *motorbike to here*[☞], where '☞' represents an occurrence of touch gesture (i.e., pen input).

Since a linguistic unification-based grammar rests on a conventional, "unimodal" parser, Johnston (1998) and Johnston et al. (1997) developed a *multimodal chart parser*, which are still a topic of computational linguistics (Alahverdzhieva et al. 2012) (see also Bender & Emerson (2018), Chapter 29 of this volume). A multimodal chart parser consists of two or more layers and allows for layer-crossing charts. The multimodal NP *this*[☞] *motorbike*, for instance, is processed in terms of a multimodal chart parser covering of a speech (s) and a gesture (g) layer:

(4) s:

g:
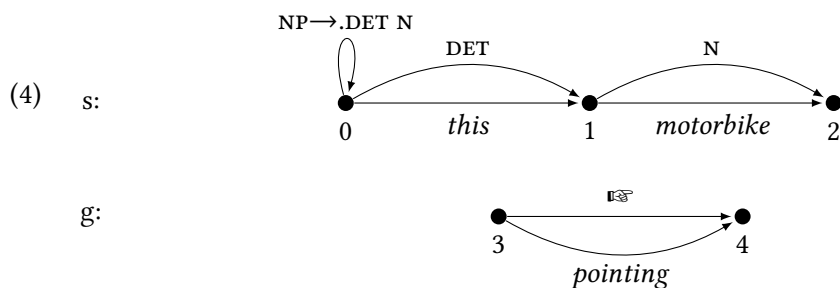
A multimodal chart or *multichart* is defined in terms of sets of identifiers from both layers. Possible multicharts from (4) include the following ones:

(5)   multichart 1: {[s,0,1], [g,3,4]}
      multichart 2: {[s,1,2], [g,3,4]}
      ...

The basic rule for integrating spatial gestures with speech commands is the *basic integration scheme* (Johnston 1998; Johnston et al. 1997), reproduced in (6):

(6)
$$
\begin{bmatrix}
\text{LHS :} & \begin{bmatrix} \text{CAT :} & command \\ \text{MODALITY :} & \boxed{2} \\ \text{CONTENT :} & \boxed{1} \\ \text{TIME :} & \boxed{3} \end{bmatrix} \\[4em]
\text{RHS :} & \begin{bmatrix} \text{DTR1 :} & \begin{bmatrix} \text{CAT :} & located\_command \\ \text{MODALITY :} & \boxed{6} \\ \text{CONTENT :} & \boxed{1}[location\ \boxed{5}] \\ \text{TIME :} & \boxed{7} \end{bmatrix} \\[4em] \text{DTR2 :} & \begin{bmatrix} \text{CAT :} & spatial\_gesture \\ \text{CONTENT :} & \boxed{5} \\ \text{MODALITY :} & \boxed{9} \\ \text{TIME :} & \boxed{10} \end{bmatrix} \end{bmatrix} \\[4em]
\text{CONSTRAINTS :} & \left\{ \begin{array}{l} \text{OVERLAP}(\boxed{7},\boxed{10}) \lor \text{FOLLOW}(\boxed{7},\boxed{10},4s) \\ \text{TOTAL-TIME}(\boxed{7},\boxed{10},\boxed{3}) \\ \text{ASSIGN-MODALITY}(\boxed{6},\boxed{9},\boxed{2}) \end{array} \right\}
\end{bmatrix}
$$

The AVM in (6) implements a mother-daughter structure along the lines of a context free grammar rule, where a left-hand side (LHS) expands to a right-hand side (RHS). The right-hand side consists of two constituents (daughters DTR1 and DTR2), a verbal expression (*located_command*) and a gesture. The semantic integration between both modalities is achieved in terms of structure sharing, see tag $\boxed{5}$: the spatial gesture provides the location coordinate for the verbal command.

The bimodal integration is constrained by a set of restrictions, mainly regulating the temporal relationship between speech and gesture (see tags $\boxed{7}$ and $\boxed{10}$ in the CONSTRAINTS set): the gesture may overlap with its affiliated word in time, or follow it in at most four seconds.

An integration scheme akin to that displayed in (6) also underlies current grammar-oriented approaches to deictic and iconic gestures (see Sections 4.3 and 4.4 below).

4.2 Representing gestures with AVMs

Representing the formal features of gestures in terms of attribute-value matrices has been initiated in robotics (Kopp et al. 2004). A representation format that captures the "phonological", physical-kinematic properties of a gesture is designed according to the moveable junctions of arms and hands. For instance, the representation of the gesture in Figure 1 according to the format used in Lücking et al. (2010) is given in (7):

(7)

$$
\begin{bmatrix}
\textit{right hand} & \\
\text{HANDSHAPE} & \begin{bmatrix} \text{SHAPE} & G \\ \text{PATH} & 0 \\ \text{DIR} & 0 \end{bmatrix} \\
\text{PALM} & \begin{bmatrix} \text{ORIENT} & \textit{PAB>PAB/PUP>PAB} \\ \text{PATH} & 0 \\ \text{DIR} & 0 \end{bmatrix} \\
\text{BOH} & \begin{bmatrix} \text{ORIENT} & \textit{BUP>BTB/BUP>BUP} \\ \text{PATH} & \textit{arc>arc>arc} \\ \text{DIR} & \textit{MR>MF>ML} \end{bmatrix} \\
\text{WRIST} & \begin{bmatrix} \text{POSITION} & \textit{P-R} \\ \text{PATH} & \textit{line} \\ \text{DIR} & \textit{MU} \\ \text{DIST} & \textit{D-EK} \\ \text{EXTENT} & \textit{small} \end{bmatrix} \\
\text{SYNC} & \begin{bmatrix} \text{CONFIG} & \textit{BHA} \\ \text{REL.MOV} & \textit{LHH} \end{bmatrix}
\end{bmatrix}
$$

The formal description of a gestural movement is given in terms of the handshape, the orientations of the palm and the back of the hand (BOH), the movement trajectory (if any) of the wrist and the relation between both hands (synchronicity, SYNC). The handshape is drawn from the fingerspelling alphabet of American Sign Language, as illustrated in Figure 2. The orientations of palm and back of hand are specified with reference to the speaker's body (e.g., *PAB* encodes "palm away from body" and *BUP* encodes "back of hand upwards"). Movement features are specified with respect to the wrist: the starting position is given and the performed trajectory is encoded in terms of the described path and the direction and extent of the movement. Position and extent are given with reference to the *gesture space*, that is the structured area within the speaker's immediate reach (McNeill 1992: 86–89) – see the left-hand side of Figure 3. Originally, McNeill considered the gesture space as "a shallow disk in front of the speaker, the bottom half flattened when the speaker is seated" (McNeill 1992: 86). However, acknowledging also the distance of the hand with respect to the speaker's body (feature DIST) turns the shallow disk into a volume, giving rise to the three-dimensional model displayed in the right-hand side of Figure 3. The gesture space regions known as *center-center*, *center* and *periphery*, possible modified by location modifiers (*upper right*, *right*, *lower right*, *upper left*, *left*, *lower left*), are now modeled as nested hexahedrons. Thus, gesture space is structured according to all three body axes: the sagittal, the longitudinal, and the transversal axis. Annotations straightfowardly transfer to the three-dimensional gesture space model. Such a
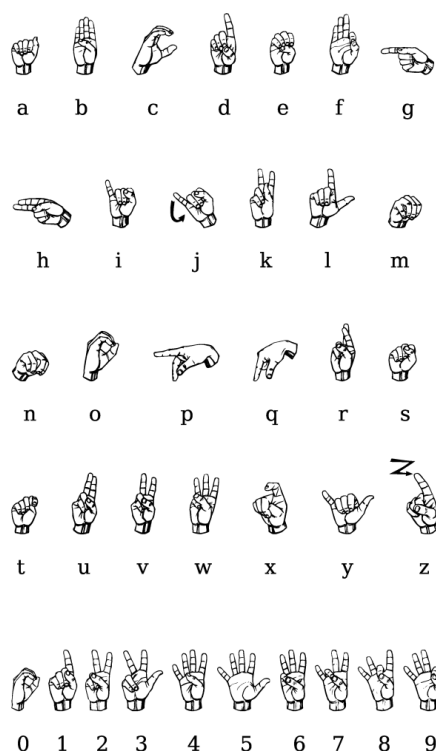
Figure 2: American Sign Language fingerspelling alphabet (image released to Public Domain by user Ds13 in the English Wikipedia at 18th December 2004, https://commons.wikimedia.org/wiki/File:Asl_alphabet_gallaudet.png).

three-dimensional gesture space model is assumed throughout this chapter. Rectangular and roundish movement are distinguished in terms of *line* or *arc* values of feature PATH. An example is given in Figure 4. For a documentation of gesture representation along this line see Lücking et al. (2016). For related formats see Martell (2002) and Gibbon et al. (2003). For a different approach see Lausberg & Sloetjes (2009).

The "phonological" representation of gestures is slightly refined in Lücking (2016: 385–386), where gestures are analysed in terms of a formal event framework (Fernando (2011), Cooper & Ginzburg (2015: Sec. 2.7)) in order to account for Gestalt properties of gesture movements (see also the example discussed by Rieser (2008)).
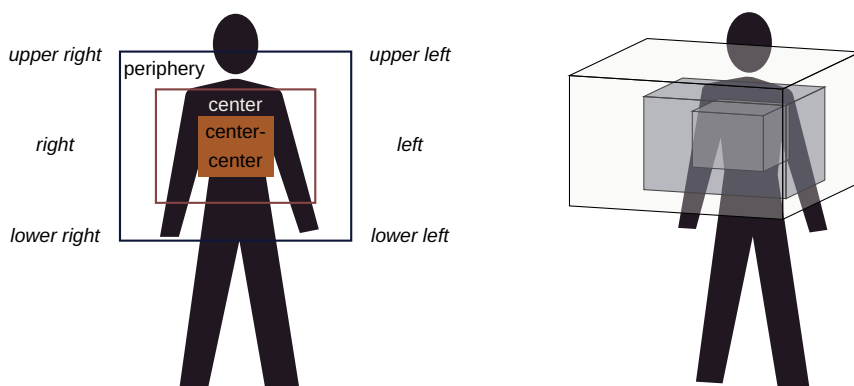
Figure 3: Gesture Space (left hand side is simplified from McNeill (1992: 89).) Although originally conceived as a structured "shallow disk" McNeill (1992: 86), adding distance information gives rise to a three-dimensional gesture space model as illustrated on the right-hand side and assumed in the main text.
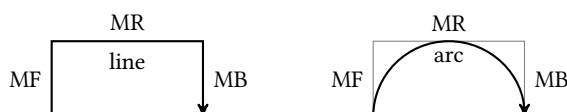
Figure 4: The same sequence of direction labels can give rise to an open rectangle or a semicircle, depending on the type of concatenation (Lücking 2016: 385).

4.3 Pointing Gestures

Pointing gestures are *the* referring device: they probably pave a way to reference in both an evolutionary and language acquisition perspective. (Bruner 1998; Masataka 2003; Matthews et al. 2012); they are predominant inhabitants of the "deictic level" of language, interleaving the symbolic (and the iconic) ones (Levinson (2008), see also Bühler (1934)); they underlie reference in *Naming Games* in computer simulation approaches (Steels 1995) (for a semantic assessment of naming and categorisation games see Lücking & Mehler (2012)). The referential import of pointing gesture has been studied experimentally to some detail (Bangerter & Oppenheimer 2006; Kranstedt et al. 2006b,a; van der Sluis & Krahmer 2007). As a result, it turns out that pointings do not rest on a direct "laser"- or "beam" mechanism (McGinn 1981). Rather, they serve a (more or less rough) locating function (Clark 1996) that can be modelled in terms of a *pointing cone* (Lücking et al. 2015). These works provide an answer to the first basic question

Figure 5: Driving towards/heading straight

(cf. Section 3): pointing gestures have a "spatial meaning" which focuses or high-lights a region in relation to the direction of the pointing device. Such a spatial semantic model has been introduced in Rieser (2004) under the name of *region pointing*, where the gesture adds a locational constraint to the restrictor of a noun phrase. The spatial model is also adopted in Lascarides & Stone (2009), where the region denoted by a pointing is represented by a vector $\vec{p}$. This region is an argument to function v, however, which maps the projected cone region to $v(\vec{p})$, the space-time talked about, which may be different from the gesture space (many more puzzles of local deixis are collected by Klein (1978) and Fricke (2007)).

Let us illustrate some aspects of pointing gesture integration by means of a real world example (taken from dialogue V5 of the SaGA corpus (Lücking et al. 2010)). The speaker in (8) and Figure 5 places a pond with his left hand into gesture space. He then points at his left hand/the pond (on *dual points* see Goodwin (2003), on *deferred reference* see Quine (1950); Nunberg (1993)), depicting *driving towards* or *heading straight*. The movement aspect is subsequently enacted by moving the right hand/driver towards the left hand/pond.

(8) wenn du dort eingefahren bist, fährst Du geradeaus auf einen Teich zu ..
     'n Teich .. und .. [*gesture from Figure 5 occurs here*]

     when you drive in there , you're heading straight for a pond .. a pond .. and ..
     [*gesture from Figure 5 occurs here*]

This example highlights two crucial phenomena: firstly, the region pointed

at is not the region referred to. The indicated location in gesture space has to be mapped onto a spatial area of the described situation. Such mapping are accounted for by $v(\vec{p})$. Secondly, the gesture is produced *after* speech. This means that in order to identify the gesture's verbal attachment site something beyond mere temporal synchrony (the second basic question, see Section 3) has to be exploited. To this end, phonological information on top of the basic integration scheme in (6) are used (Alahverdzhieva & Lascarides 2011; Lücking 2013). Within a temporal window (basic integration scheme), a pointing gesture is affiliated to a stressed expression. This relaxation captures also post-speech gestures as in example (8)/Figure 5. Within HPSG, such constraints can be formulated within an interface to metrical trees from the phonological model of Klein (2000) or phonetic information packing from Engdahl & Vallduví (1996) – Tseng (2018), Chapter 22 of this volume. In order to deal with gestures that are affiliated with expressions that are larger than single words, Alahverdzhieva & Lascarides (2011) also develop a phrase or sentence level integration scheme, where the stressed element has to be a semantic head (in the study of Mehler & Lücking (2012) 18.8% of the gestures had a phrasal affiliate). On this account, semantic integration of gesture location and verbal meaning (the third basic question from Section 3) is brought about using underspecification mechanism of *Multiple Recursion Semantics* (MRS) (Copestake et al. 2005).

(Pointing) gestures that occur in company to a demonstrative expression in speech have received special attention, since they manifest the transition point between the symbolic realm of language and the deictic realm of perception (Levinson 2008; Fricke 2012). Building on this phenomenon, Ebert (2014) argue within in a dynamic semantic framework that co-demonstrative gestures contribute to at-issue content while other gestures contribute to non-at-issue content. Within a presuppositional framework, this picture has been refined due to gestures that are entailed in local contexts in terms of "cosuppositions" Schlenker (2018).

A dialogue-oriented focus is taken in Lücking (2018): here pointing gesture play a role in formulating processing instructions that guide the addressee in understanding demonstrative noun phrases (see also Lücking, Ginzburg & Cooper (2018), Chapter 30 of this volume).

Semantic aspects of iconic features of pointing as discourse referent indication in American Sign Language have been investigated and formally modelled by Schlenker et al. (2013); Schlenker (2014).

4.4 Iconic Gestures

There is nearly no semantic work on how and which meanings can be assigned to iconic gestures (first basic question from Section 3). Two exceptions being the approaches of Rieser (2010) and Lücking (2013; 2016). Rieser (2010) tries to extract a "depiction typology" out of a speech-and-gesture corpus where formal gesture features are correlated with topological clusters consisting of geometrical constructs. These geometrical objects are used in order to provide a possibly underspecified semantic representation for iconic gestures which is integrated into word meaning (Hahn & Rieser 2010; Rieser 2011). Lücking (2013; 2016) draws on Goodman's notion of *exemplification* (Goodman 1976), iconic gestures are connected to semantic predicates in terms of a reversed denotation relation: the meaning of an iconic gesture is given in terms of the set of predicates which have the gesture event within their denotation. In a further step, common perceptual features are extracted and represented as part of a lexical extension of lexemes. This conception is motivated by psychophysic theories of the perception of biological events (Johansson 1973), draws on philosophical similarity conception beyond isomorphic mappings (Peacocke 1987),[5] and, using a somewhat related approach at least, has been proven to work in robotics (Sowa 2006). These perceptual features serve as the integration locus for iconic gestures, using standard unification techniques. With regard to conventionalized sign language, iconic aspects have also been captured in terms of presuppositions that map, for instance, height specifications of signed loci to social properties and relations like power (that is, a higher locus indicates more power) (Schlenker et al. 2013).

The richer formal, functional and representational features of iconic gestures as compared to deictic gestures (cf. Section 4.3) is accounted for in Alahverdzhieva & Lascarides (2010) by assigning a formal predicate to each "phonological" feature of a gesture representation (cf. Section 4.2). These formal gesture predicates are highly underspecified, using *Robust Multiple Recursion Semantics* (RMRS) (Copestake 2007). That is, they can be assigned various (so far postulated) predicates (which are assumed to be constrained by iconicity (Alahverdzhieva & Lascarides 2010)) with differing arity in the gesture resolution process. Similar to pointing gesture integration, phonetic constraints on word and sentence level apply and semantic integration is achieved using underspecification techniques of *Multiple Recursion Semantics* (MRS) (Copestake et al. 2005). The received integrated representation are then resolved using the SDRT tools of Lascarides & Stone (2009).

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[5]That mere resemblance, usually associated with iconic signs, is too empty a notion to provide the basis for a signifying relation has been emphasised on various occasions (Burks 1949; Bierman 1962; Eco 1976; Goodman 1976; Sonesson 1998).

Iconic gestures in particular are involved in a short-term dynamic phenomenon: on repeated co-occurrence, iconic gestures and affiliated speech can fuse into a *multimodal ensemble* (Kendon 2004; Lücking et al. 2008; Mehler & Lücking 2012). The characteristic feature of such an ensemble is that their gestural part, their verbal part, or even both parts can be simplified without changing the meaning of the ensemble. Ensembles, thus, are the result of a process sign formation as studied, for instance, in experimental semiotics Galantucci & Garrod (2011). Such grammaticalisation process eventually might lead to conventional signs. However, most conventional, emblematic everyday gesture seem to be the result of circumventing a taboo: something you should not name is gesticulated (Posner 2002).

5 Outlook

What are (still) challenging issues with respect to grammar-gesture integration, in particular from a semantic point of view? Candidates include:

- gestalt phenomena: the trajectories described by a gesture are often incomplete and have to be completed by drawing on gestalt principles or everyday knowledge (Lücking 2016);

- negligible features: not all formal features of a gesture are meaning-carrying features in the context of utterance. For instance, in a dynamic gesture the handshape often (though not always) does not provide any semantic information. How to distinguish between significant and negligible gesture features?

- "semantic endurance": due to holds, gestural meanings can kept fixed for some time is keeps available for semantic attachment. This may call for a more sophisticated algebraic treatment of speech-gesture integration than offered by typed feature structures (Rieser 2015).

Finally, the empirical domain of "gesture" has to extended to other non-verbal signals such as laughter (Ginzburg et al. 2015), facial expressions or gaze (see Section 1 for a brief list of non-verbal signals), in isolation as well as in mutual combination. Thus, there is still some way to go in order to achieve a fuller understanding of natural language interaction and thereby natural languages.

Acknowledgements

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Part V

The broader picture

Chapter 33

HPSG and Minimalism

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This paper compares work done under the heading *Minimalist Program* with work done in Head-Driven Phrase Structure Grammar. We discuss differences in the respective approaches and the outlook of theories. We have a look on the procedural/constraint-based views on grammar and discuss the differences in complexity of the structures that are assumed. We also address psycholinguistic issues like processing and language acquisition.

1 Introduction

The Minimalist framework, which was first outlined by Chomsky in the early 1990s (Chomsky 1993; 1995b), still seems to be the dominant approach to syntax. It is important, therefore, to consider how HPSG compares with this framework. In a sense both frameworks are descendants of the transformation-generative approach to syntax, which Chomsky introduced in the 1950s. HPSG is a result of the questioning of transformational analyses that emerged in the late 1970s. This led to Lexical Functional Grammar (Bresnan & Kaplan 1982) and Generalized Phrases Structure Grammar (Gazdar et al. 1985), and then in the mid 1980s to HPSG (Pollard & Sag 1987, see Flickinger, Pollard & Wasow (2018), Chapter 2 of this volume for more on the origins of HPSG). Minimalism in contrast remains committed to transformational, i.e. movement, analyses. It is simpler in some respects than the earlier Government and Binding framework (Chomsky 1981), but as we will see below, it involves a variety of complexities.

The relation between the two frameworks is clouded by the rhetoric that surrounds Minimalism. At one time "virtual conceptual necessity" was said to be its guiding principle. A little later, it was said to be concerned with the "perfection of language", with "how closely human language approaches an optimal solution to design conditions that the system must meet to be usable at all" (Chomsky 2002: 58). Much of this rhetoric seems designed to suggest that Minimalism is quite different from other approaches and should not be assessed in the same way. In the words of Postal (2003: 19), it looks like "an attempt to provide certain views with a sort of privileged status, with the goal of placing them at least rhetorically beyond the demands of serious argument or evidence". However, the two frameworks have enough in common to allow meaningful comparisons.

Both frameworks seek to provide an account of what is and is not possible both in specific languages and in language in general. Moreover, both are concerned not just with local relations such as that between a head and its complement or complements but also with non-local relations such as those in the following:

(1)   a.   The student knows the answer.
      b.   It seems to be raining.
      c.   Which student do you think knows the answer?

In (1a), *the student* is subject of *knows* and is responsible for the fact that *knows* is a third person singular form, but *the student* and *knows* are not sisters if they form a VP. In (1b) the subject is *it* because the complement of *be* is *raining* and *raining* requires an expletive subject, but *it* and *raining* are obviously not sisters. Finally, in (1c), *which student* is understood as the subject of *knows* and is responsible for the fact that it is third person singular, but again the two elements are structurally quite far apart. Both frameworks provide analyses for these and other central syntactic phenomena, and it is quite reasonable to compare them and ask which is the more satisfactory.[1]

Although HPSG and Minimalism have enough in common to permit comparisons, there are obviously many differences. Some are more important than others, and some relate to the basic approach and outlook, while others concern the nature of grammatical systems and syntactic structures. In this chapter we will explore the full range of differences.

The chapter is organized as follows: in Section 2, we look at differences of approach between the two frameworks. Then in Section 3, we consider the quite different views of grammar that the two frameworks espouse, and in Section 4,

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[1]As noted below, comparison is complicated somewhat by the fact that Minimalists typically provides only sketches of analyses in which various details are left quite vague.

we look at the very different syntactic structures which result. Finally, in Section 5, we consider how the two frameworks relate to psycholinguistic issues, namely processing and language acquisition.

2 Differences of approach and outlook

add brief intro

2.1 Sociological differences

A difference between MGG and HPSG that should not be underestimated is the fact that MGG has one very important key figure, the by far most-cited linguist (and scientist in general) Noam Chomsky. This is how Carl Pollard put it:

> There is no Chomsky-like figure who is always assumed to be basically on the right track no matter what s/he proposes. HPSG research is normal science: the testing of hypotheses that appear plausible given accepted assumptions. The goal is not to fill in the details of a vague theory which is assumed to be basically right, but to successively replace empirical hypothesis with ones that make better predictions. (Pollard 1997: Section 1.2.1)

While Ivan Sag is perceived as the leading figure by outsiders, the fact that Ivan Sag's recent switch to Sign-Based Construction Grammar (Sag 2012) is not unanimously adopted by the HPSG community (see Müller (2018), Chapter 37 of this volume and Müller (2018b: Section 10.6.2) for discussion), that empty elements are assumed by various researchers (Bender 2000; Müller 2014; Borsley 1999; 2009; 2013) even though Ivan Sag argued against them since 1994 (Sag & Fodor 1994) and that defaults are not used by all researchers even though they play a prominent role in Ivan Sag's work (e.g., in Ginzburg & Sag 2000) shows that Pollard's claim is correct. Of course Ivan Sag is the most influential HPSG grammarian but this influence is based on properly argued empirically interesting research.

one Borsley paper is enough. which one?

2.2 Formalization and exhaustivity

As many of the chapters in this volume emphasize, HPSG is a framework which places considerable emphasis on detailed formal analyses of the kind that one

might expect within Generative Grammar.[2] Thus, it is not uncommon to find lengthy appendices setting out formal analyses. See, for example, Sag's (1997) paper on English relative clauses, Van Eynde's (2015) book on predicative constructions and especially Ginzburg & Sag (2000), which has a 50 page appendix. One consequence of this is that HPSG has had considerable influence in computational linguistics. Sometimes theoretical work comes paired with computer implementations, which show that the analyses are consistent and complete (e.g., all publications coming out of the CoreGram project (Müller 2015b) and the HPSG textbook for German that comes with implementations corresponding to the individual chapters of the book (Müller 2007b)). For more on the relation of HPSG and computational linguistics see Bender & Emerson (2018), Chapter 29 of this volume.

In Minimalism things are very different. Detailed formal analyses are virtually non-existent. There appear to be no appendices like those in Sag (1997) and Ginzburg & Sag (2000). In fact the importance of formalization has long been downplayed in Chomskyan work (e.g., by Chomsky in an interview with Huybregts & Riemsdijk (1982: 73) and in discussions between Pullum (1989) and Chomsky (1990: 146)), and this view seems fairly standard within Minimalism (see also the discussion in Müller (2016a: Section 3.6.2)). Chomsky & Lasnik (1995: 28) attempt to justify the absence of detailed analyses when they suggest that providing a rule system from which some set of phenomena can be derived is not "a real result" since "it is often possible to devise one that will more or less work". Instead, they say, "the task is now to show how the phenomena [...] can be deduced from the invariant principles of UG with parameters set in one of the permissible ways". In other words, providing detailed analyses is a job for unambitious drudges, and real linguists pursue a more ambitious agenda. Postal (2004: 5) comments that what we see here is "the fantastic and unsupported notion that descriptive success is not really that hard and so not of much importance". He points out that if this were true, one would expect successful descriptions to be abundant

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[2]We follow Ginzburg & Sag (2000: 2) in counting HPSG among Generative Grammar in the sense it was defined by Chomsky (1965: 4), namely as a framework that provides an explicit characterization of the theories developed within it. When we refer to work in Government & Binding or Minimalism, we follow Culicover & Jackendoff (2005: 3) in using the term *Mainstream Generative Grammar* (MGG). It should be kept in mind that there is another meaning associated with the term *generative*. A generative grammar in the latter sense generates a set (Chomsky 1957: 13. HPSG is not generative in this sense but rather model-theoretic. See Pullum & Scholz (2001) for differences between generative-enumerative and model theoretic approaches. See also Richter (2018), Chapter 3 of this volume and Wasow (2018), Chapter 28 of this volume.

within transformational frameworks. However, he suggests that "the actual descriptions in these frameworks so far are not only not successful but so bad as to hardly merit being taken seriously". Postal does much to justify this assessment with detailed discussions of Chomskyan work on strong crossover phenomena and passives in Chapters 7 and 8 of his book.

There has also been a strong tendency within Minimalism to focus on just a subset of the facts in whatever domain is being investigated. As Culicover & Jackendoff (2005: 535) note, "much of the fine detail of traditional constructions has ceased to garner attention". This tendency has sometimes been buttressed by a distinction between core grammar, which is supposedly a fairly straightforward reflection of the language faculty, and a periphery of marked constructions, which are of no great importance and which can reasonably be ignored. However, as Culicover (1999) and others have argued, there is no evidence for a clear cut distinction between core and periphery. It follows that a satisfactory approach to grammar needs to account both for such core phenomena as *wh*-interrogatives, relative clauses, and passives but also with more peripheral phenomena such as the following:

(2) a. It's amazing the people you see here.
    b. The more I read, the more I understand.
    c. Chris lied his way into the meeting.

These exemplify the nominal extraposition construction (Michaelis & Lambrecht 1996), the comparative correlative construction (Culicover & Jackendoff 1999; Borsley 2011), and the *X's Way* construction (Salkoff 1988; Sag 2012). As has been emphasized in other chapters, the HPSG system of types and constraints is able to accommodate broad linguistic generalizations and highly idiosyncratic facts and everything in between.

The general absence in Minimalism of detailed formal analyses is quite important. It means that Minimalists may not be fully aware of the complexity of the structures they are committed to and this allows them to sidestep the question whether it is really justified. It also allows them to avoid the question of whether the very simple conception of grammar that they favour is really satisfactory. Finally, it may be that they are unaware of how many phenomena remain unaccounted for. These are all important matters.

The general absence of detailed formal analyses has also led to Minimalism having little impact on computational linguistics. There has been some work that has sought to implement Minimalist ideas (Stabler 2001; Fong & Ginsburg 2012; Fong 2014), but Minimalism has not had anything like the productive relation

with computational work that HPSG has enjoyed. Existing Minimalist implementations are rather toy grammars analyzing very simple sentences, some are not faithful to the theories they are claimed to be implementing,[3] and some do not even parse natural language but require pre-segmented, pre-formatted input. For example, Stabler's test sentences have the form as in (3).

(3)   a. the king will -s eat
      b. the king have -s eat -en
      c. the king be -s eat -ing
      d. the king -s will -s have been eat -ing the pie

See Müller (2016a: Section 4.7.2) for discussion.

2.3 Empirical quality

There are, then, issues about the quantity of data that is considered in Minimalist work. There are also issues about its quality. Research in HPSG is typically quite careful about data and often makes use of corpus and experimental data (see for example An & Abeillé 2017; Müller 1999b; 2002; Bildhauer & Cook 2010; Müller, Bildhauer & Cook 2012; Van Eynde 2015: Chapter 7 for examples of work with attested examples and for experimental work). This use of corpus data and attested examples is based on the insight that introspection alone is not sufficient, given that an enormous amount of time is spent to work out analyses and it would be unfortunate if these analyses were built on a shaky empirical basis. See Müller (2007a) and Meurers & Müller (2009) for the discussion of introspection vs. corpus data. Research in Minimalism is often rather less careful.[4] In a review of a collection of Minimalist papers, Bender (2002: 434) comments that: "In these papers, the data appears to be collected in an off-hand, unsystematic way, with unconfirmed questionable judgments often used at crucial points in the argumentation". She goes on to suggest that the framework encourages "lack of concern for the data, above and beyond what is unfortunately already the norm in formal syntax, because the connection between analysis and data is allowed to be

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[3]Fong's grammars are simple Definite Clause Grammars, that is, context-free phrase structure grammars, and hence nowhere near an implementation of Minimalism, contrary to claims by Berwick, Pietroski, Yankama & Chomsky (2011: 1221).

[4]We hasten to say that we do not claim this to be true for all Minimalist work. There are researchers working with corpora or at least with attested examples (Wurmbrand 2003) and there is experimental work. Especially in Germany there were several large scale Collaborative Research Centers with a strong empirical focus which also fed back into theoretical work, including Minimalist work. The fact that we point out here is that there is work, including work by prominent Minimalists, that is rather sloppy as far as data is concerned.

remote.". Similar things could be said about a variety of Minimalist work. Consider, for example, Aoun & Li (2003), who argue for quite different analyses of *that*-relatives and *wh*-relatives on the basis of the following (supposed) contrasts, which appear to represent nothing more than their own judgements (p. 110–112):

(4) a.   The headway that Mel made was impressive.

   b. ?? The headway which Mel made was impressive.

(5) a.   We admired the picture of himself that John painted in art class.

   b.   * We admired the picture of himself which John painted in art class.

(6) a.   The picture of himself that John painted in art class is impressive.

   b. *? The picture of himself which John painted in art class is impressive.

None of the native speakers we have consulted find significant contrasts here which could support different analyses. The example in (7a) with a *which* relative clause referring to *headway* can be found in Cole et al. (1982), Williams (1989: 437) and Falk (2010: 221) have examples with a reflexive coreferential with a noun in a relative clause introduced by *which* as in William's (7b) and corpus examples like (7c,d) can be found as well:

(7) a. The headway which we made was satisfactory.

   b. the picture of himself which John took

   c. The words had the effect of lending an additional clarity and firmness of outline to the picture of himself which Bill had already drawn in his mind–of a soulless creature sunk in hoggish slumber.[5]

   d. She refused to allow the picture of himself, which he had sent her, to be hung, and it was reported that she ordered all her portraits and busts of him to be put in the lumber attics.[6]

Given that it is relatively easy to come up with counter examples it is surprising that authors do not do a quick check before working out rather complex analyses.

   Another quite important example of ignoring relevant data is Chomsky's work on Labeling.

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[5]Wodehouse, P.G. 1917. *Uneasy Money*, London: Methuen & Co., p. 186, http://www. literaturepage.com/read.php?titleid=uneasymoney&abspage=186, 2018-09-18.

[6]Jerrold, Clare. 1913. *The married life of Queen Victoria*, London: G. Bells & Sons, Ltd. https://archive.org/stream/marriedlifeofque00jerruoft/marriedlifeofque00jerruoft_djvu. txt, 2018-09-19.

As I say elsewhere I think any detailed discussion of labelling should be in section 3 though it seems reasonable to make the point here that the discussion of these issues has been marred by a failure to notice some fairly obvious examples.

Labeling is concerned with the question of the category that results when two items are combined. As is discussed in more detail below, Chomsky assumes that the combination of two items with the labels X and Y has to be either X or Y. Chomsky defines which label is used in two different cases: the first case defines that the label is the label of the head if the head is a lexical item and the second case defines the label to be the label of the category from which something is extracted (Chomsky 2008: 145). As Chomsky notes, these rules are not unproblematic since the label is not uniquely determined in all cases. An example is the combination of two lexical elements since in such cases both elements can be the label of the resulting structure. Chomsky notices that this could result in deviant structures, but claims that this concern is unproblematic and ignores it. This means that rather fundamental notions in a grammar theory were ill-defined. A solution to this problem was provided in his 2013 paper (published five years later). However, this paper is inconsistent (Müller 2016a: Section 4.6.2) and even insiders find it incomprehensible. But this is not the point we want to focus on here. Rather we want to show one more time that empirical standards are not met. Chomsky uses underdetermination in his labeling rules to account for two possible structures in (8), an approach going back to Donati (2006):

(8)   what [C [you wrote *t*]]

(8) can be an interrogative clause as in *I wonder what you wrote.* or a free relative clause as in *I will read what you wrote..* According to the labeling rule that accounts for sentences from which an item is extracted, the label will be CP since the label is taken from the clause. However, since *what* is a lexical item, *what* can determine the label as well. If this labeling rule is applied *what you wrote* is assigned DP as a label and hence the clause can function as a DP argument of *read.*

Chomsky's proposal is interesting but it does not extend to cases involving free relative clauses with complex *wh*-phrases (so-called pied-piping) as they are attested in examples like (9):

(9)   I'll read [whichever book] you give me.

The example in (9) is from one of the standard references on free relative clauses: Bresnan & Grimshaw (1978: 333), which is also cited in other mainstream generative work as for example (Groos & van Riemsdijk 1981).

Apart from the fact that complex *wh*-phrases are possible there is even more challenging data in the area of free relative clauses: the examples in (10) and (11) show that there are non-matching free relative clauses:

(10) Sie kocht, worauf   sie Appetit hat.[7]   (German)
      she cooks where.on she appetite has
      'She cooks what she feels like eating.'

(11) a. Worauf   man sich mit   einer Pro-form beziehen kann, […] ist
          where.upon one self with a   Pro-form refer   can   is
          eine Konstituente.[8]
          a   constituent
          'If you can refer to something with a Pro-form, […] it is a constituent.'

      b. [Aus wem] noch etwas   herausgequetscht werden kann, ist
           out who   yet something out.squeezed   be   can   is
          sozial   dazu   verpflichtet, es abzuliefern; …[9]
          socially there.to obliged   it to.deliver
          'Those who have not yet been bled dry are socially compelled to hand
          over their last drop.'

In (10) a relative clause with a PP relative phrase functions as an accusative object. In (11) the relative clauses function as subjects. (11b) is another example of a relative clause with a complex *w* phrase. See Bausewein (1990) and Müller (1999a) for further discussion of free relative clauses and attested data.

According to Donati (2006: Section 5), pied piping does not exist in free relatives (see also Citko (2008: 930–932) for a rejection of this claim). Given how much attention the issue of Labeling got and how central this is to Minimalist analyses this situation is quite surprising: an empirically wrong claim made in 2002/2003[10] is the basis for foundational work from 2002 until 2013 even though the facts are common knowledge in the field. Ott (2011) develops an analysis in which the category of the relative phrase is projected, but he does not have a solution for nonmatching free relative clauses, as he admits in a footnote on

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[7]Bausewein (1990: 154).

[8]From the main text of: Günther Grewendorf, *Aspekte der deutschen Syntax. Eine Rektions-Bindungs-Analyse*. Studien zur deutschen Grammatik, number 33. Tübingen: Gunter Narr Verlag. 1988, p. 16, quoted from Müller (1999a: 61).

[9]Wiglaf Droste, taz, 01.08.97, p. 16, quoted from Müller (1999a: 61).

[10]Versions of Donati's paper were presented at *Going Romance* in 2002 and the most important Mainstream Generative Grammar conference in Europe GLOW in 2003.

page 187. The same is true for Citko's analysis (2008), in which the extracted XP can provide the label. So, even though the data is known for decades, it is ignored by authors and reviewers and foundational work is build on shaky empirical grounds. See Müller (2016a: Section 4.6.2) for a more detailed discussion of labeling.

Note that we are not just taking one bad example of Minimalist work. It is probably the case that papers with dubious judgments can be found in any framework if only this is due to the repetitions of unwarranted claims made by others. The point is that Aoun & Li are influential (quoted by 455 other publications as of 2018-09-14). Others rely on these judgments or the analyses that were motivated by them. New conclusions are derived from analyses since theories make predictions. If this process continues for a while an elaborated theoretical building results that is not empirically supported. Note furthermore that the criticism raised here is not the sqabble of two authors working in an alternative framework. This criticism also comes from practitioners of Mainstream Generative Grammar. For example, Wolfgang Sternefeld and Hubert Haider, both very prominent figures in the German Generative Grammar school criticized the scientific standards in Minimalism heavily (Sternefeld & Richter 2012; Haider 2018). As Sternefeld & Richter (2012: 266–268) point out it is not just the case that Minimalist publications are based on empirically problematic foundations, it is even worse: researchers like Epstein & Seely (2006: Section 1.1) publish statements about research methodology that can only be understood as an immunization strategy. The authors discuss the two curves in Figure 1: one has a sinus-like shape and hits three out of seven of the data points on a straight line and the other one is parallel to the line with the data points and hence hits none of the data points. The second approach gets none of the data right. Nevertheless the authors argue that one should prefer this theory since it was closer to the truth and more illuminating: "Clearly, Theory 1 is 'empirically preferable' by a 'winning score' of 3–0. The point […] is that Theory 2, despite getting none of the data correct, […] is 'closer to the truth' or 'more illuminating' than the empirically preferable Theory 1. Hence, we believe, Theory 2 is a better working or guiding hypothesis upon which to base future research." (Epstein & Seely 2006: 2)

2.4 Argumentation for invisible entities and the assumption of innate linguistic knowledge

There are also differences in the kind of arguments that the two frameworks find acceptable. It is common within Minimalism to assume that some phenomenon which cannot be readily observed in some languages must be part of their gram-
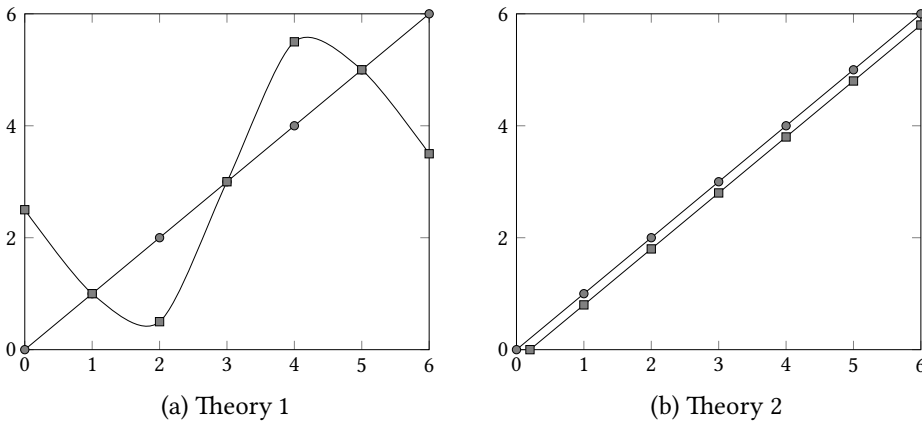
Figure 1: Immunization in Minimalist work: According to Epstein & Seely (2006: Section 1.1) Theory 2, which gets none of the data points, is preferable to Theory 1 with three data points since Theory 2 is "more illuminating" and "closer to to the truth"

matical system because it is clearly present in other languages. Notable examples would be case (Li 2008) or (object) agreement (Meinunger 2000: Chapter 4), which are assumed to play a role even though there are no visible manifestations within some languages (e.g., Mandarin Chinese and German, respectively). This stems from the longstanding Chomskyan assumption that language is the realization of a complex innate language faculty. From this perspective, there is much in any grammatical system that is a reflection of the language faculty and not in any simple way of the observable phenomena of the language in question. If some phenomenon plays an important role in many languages it is viewed as a reflection of the language faculty, and hence it must be a feature of all grammatical systems even those in which it is hard to see any evidence for it. An example – taken from a textbook on Minimalism (Hornstein, Nunes & Grohmann 2005: 124) – is an analysis of prepositional phrases in English. Figure 2 shows the analysis.[11] Due to theory internal assumptions the case requirement of the preposition cannot be checked in the P-DP combination. According to the version of the theory adopted by the authors, case has to be checked in specifier positions. Therefore it was assumed that the preposition moves to an Agr head and the DP moves to the specifier position of this Agr head. The problem is of course that DP and

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[11]This analysis is actually a much simpler variant of the PP analysis which appeared in an earlier textbook by Radford (1997: 452). For discussion of this analysis see Sternefeld (2006: 549–550) and Müller (2016a: Section 4.6.1.2).

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                        AgrP
                       ╱    ╲
                    DP      Agr′
                            ╱   ╲
                         Agr     PP
                                  │
                                  P′
                                 ╱  ╲                    PP
                               P     DP               ╱    ╲
                               │     │              P       NP
                               │     │              │       │
                  me_j  with_j  _i    _j           with      me
```
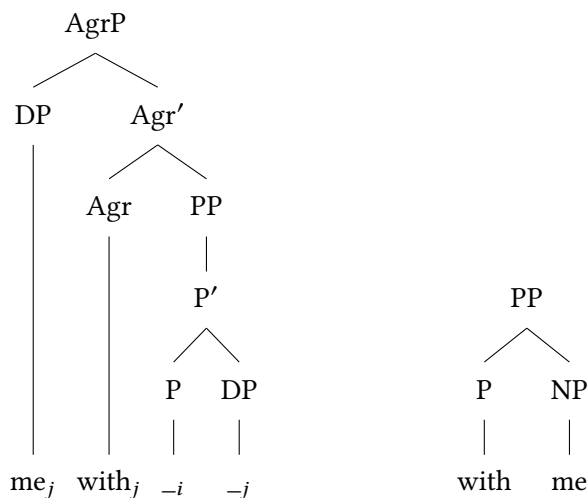
Figure 2: Minimalist analysis of a PP according to (Hornstein, Nunes & Grohmann 2005: 124) and the analysis assumed in HPSG and all other phrase structure-based frameworks

P are in the wrong order now. However, the authors argue that this is the order that is manifested in Hungarian and that Hungarian is a language which has postpositions and these are agreeing with their nominal dependent. The authors assume that Hungarian postpositions are prepositions underlyingly and that the DP following the preposition moves to the left because of a movement process that is triggered by agreement. It is claimed that this movement exists both in Hungarian and in English but that the movement is covert (that is, invisible) in the latter language.

This line of argument would be reasonable if a complex innate language faculty was an established fact, but it isn't, and since Hauser, Chomsky & Fitch (2002), it seems to have been rejected within Minimalism. It follows that ideas about an innate language faculty should not be used to guide research on individual languages. Rather, as Müller (2015b: 25) puts it, "grammars should be motivated on a language-specific basis". Does this mean that other languages are irrelevant when investigating a specific language? Clearly not. As Müller also puts it, "In situations where more than one analysis would be compatible with a given dataset for language X, the evidence from language Y with similar constructs is most welcome and can be used as evidence in favor of one of the two analyses for language X." (2015b: 43). In practice, any linguist working on a new language will use apparently similar phenomena in other languages as a starting point.

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It is important, however, to recognize that apparently similar phenomena may turn out on careful investigation to be significantly different.[12]

3 Different views of grammar

We turn now to more substantive differences between HPSG and Minimalism, differences in their conceptions of grammar, especially syntax, and differences in their views of syntactic structure. As we will see, these differences are related. In this section we consider the former, and in the next we will look at the latter.

3.1 Constraint-based vs. derivational and generative-enumerative approaches

As is emphasized throughout this volume, HPSG assumes a declarative or constraint-based view of grammar. It also assumes that the grammar involves a complex systems of types and constraints. Finally, it assumes that syntactic analyses are complemented by separate semantic and morphological analyses. In each of these areas, Minimalism is different. It assumes a procedural view of grammar. It assumes that grammar involves just a few general operations. Finally, it assumes that semantics and morphology are simple reflections of syntax. We comment on each of these matters in the following subsections.

Whereas HPSG is a declarative or constraint-based approach, Minimalism seems to be firmly committed to a procedural approach. Chomsky (1995b: 219) remarks that: "We take L [a particular language] to be a generative procedure that constructs pairs (π, λ) that are interpreted at the articulatory-perceptual (A-P) and conceptual-intentional (C-I) interfaces, respectively, as 'instructions' to the performance systems.". Various arguments have been presented within HPSG for a declarative view, but no argument seems to be offered within Minimalism for a procedural view. Obviously, speakers and hearers do construct representations and must have procedures that enable them to do so, but this is a matter of performance, and there is no reason to think that the knowledge that is used in performance has a procedural character (see Section 5.1 on processing). Rather, the fact that it is used in both production and comprehension suggests that it should be neutral between the two and hence declarative.

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[12]Equally, of course, apparently rather different phenomena may turn out on careful investigation to be quite similar. For further discussion of HPSG and comparative syntax, see Borsley (2018).

Another difference between constraint-based and generative-enumerative approaches is that the first type of proposals provides a way to get graded acceptability into the picture (Pullum & Scholz 2001: Section 3.1). Since HPSG grammars are basically feature-value pairs with equality (or other relations) between values, it is possible to weigh constraints and it is possible to admit constraint violations and work with structures with violated constraints. So looking at the sentences in (12) we see that more and more constraints are violated:

Add footnote on cumulative constraint violation.

(12) a. I am the chair of my department.
      b. * I are the chair of my department.
      c. * Me are the chair of my department.
      d. * Me are the chair of me's department.
      e. * Me are chair the of me's department.
      f. * Me are chair the me's department of.

In comparison to this a generative-enumerative grammar enumerates a set and a sequence either is in the set or it is not.[13]

For further discussion of the issues, see Section 5.1 of this paper and e. g. Pullum & Scholz (2001), Postal (2003), Sag & Wasow (2011; 2015), and Wasow (2018), Chapter 28 of this volume.

3.2 Underspecification

Minimalism: Only what is explicitly ruled in works. HPSG: Everything that is not ruled out works.

work this out

3.3 Types and constraints vs. general operations

The declarative-procedural contrast is an important one, but the contrast between the complex systems of types and constraints that are assumed within HPSG and the few general operations that form a Minimalist grammar is arguably more important.[14] Much work in Minimalism has three main operations Merge, Agree, and Move or Internal Merge. Merge combines two expressions, either words or phrases, to form a larger expression with the same label as one of

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[13]For a discussion of Chomsky's (1964; 1975: Chapter 5) proposals to deal with different degrees of acceptability see Pullum & Scholz (2001: 29).

[14]A procedural approach doesn't necessarily involve a very simple grammatical system. The Standard Theory of Transformational Grammar (Chomsky 1965) is procedural but has many different rules, both phrase structure rules and transformations.

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the expressions (Chomsky 1995b: 244; 2008: 140). Its operation can be presented as shown in Figure 3. In the case of English, the first alternative is represented
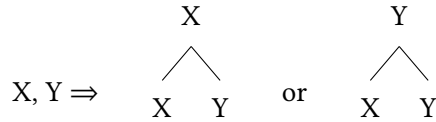
Figure 3: Merge

by situations where a lexical head combines with a complement while the second is represented by situations where a specifier combines with a phrasal head. Chomsky (2008: 146) calls items merged with the first variant of Merge *first-merged* and those merged with the second variant *later-merged*.

Agree, as one might suppose, offers an approach to various kinds of agreement phenomena. It involves a probe, which is a feature or features of some kind on head, and a goal, which the head c-commands.[15] At least normally, the probe is a linguistic object with an uninterpretable feature or features with no value and the goal has a matching interpretable feature or features with appropriate values (Chomsky 2001: 3–5). Agree values the uninterpretable feature or features and they are ultimately deleted, commonly after they have triggered some morphological effect. Agree can be represented as in Figure 4 (where the "*u*" prefix identifies a feature as uninterpretable). Unsurprisingly subject-verb agreement
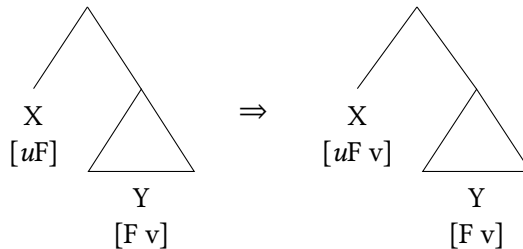
Figure 4: Agree

is one manifestation of Agree, where X is T(ense) and Y is a nominal phase, for

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[15] It is not necessary to state the c-command restriction since it sis assumed that linguistic objects are built bottom-up and when a head is combined with its dependent the head can "see" the dependent but not the context in which the resulting object is embedded. Information about dominating material will be available only later in the derivation. (Guido Mensching, p. c. 2018)

Minimalism a DP, inside the complement of T. Here, and elsewhere, Agree is a non-local relation involving elements which are not sisters. This contrasts with the situation in HPSG, in which subject-verb agreement is a consequence of the subject and its VP sister sharing features and further feature sharing between the VP and the V that heads it.

Finally, Move, also called Internal Merge, is an operation which makes a copy of a constituent of some expression and merges it with the expression (Chomsky 1995b: Section 4.4; 2008: 140). The original element that is copied normally undergoes deletion. The process can be presented as in Figure 5. This covers both the
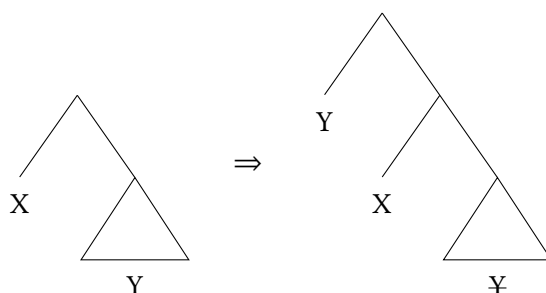
Figure 5: Move

A′-movement process assumed for unbounded dependency constructions such as *wh*-interrogatives and the A-movement process assumed for raising sentences and passives. A question arises about so-called head-movement, where a head moves to a higher head position. This appears to mean that it must be possible for the copy to be merged with the head of the expression that contains it. However, this is incompatible with the widely assumed extension condition, which requires Merge to produce a larger structure. One response is the idea espoused in Chomsky (1995a: 368; 2001: 37) that head-movement takes place not in the syntax but in the PF component, which maps syntactic representations to phonetic representations. It seems that its status is currently rather unclear.

The three operations just outlined interact with lexical items to provide syntactic analyses. It follows that the properties of constructions must largely derive from the lexical items that they contain. Hence, the properties of lexical items are absolutely central to Minimalism. Oddly, the obvious implication – that the lexicon should be a major focus of research – seems to be ignored. As Newmeyer (2005: 95, fn. 9) comments:

> […] in no framework ever proposed by Chomsky has the lexicon been as important as it is in the MP [Minimalist Program]. Yet in no framework

proposed by Chomsky have the properties of the lexicon been as poorly
investigated. (Newmeyer 2005: 95, fn. 9)

Sometimes it is difficult to derive the properties of constructions from the prop-
erties of visible lexical elements. But there is a simple solution: postulate an
invisible element. The result is a large set of invisible functional heads. As we
will see in the next section, these heads do the work in Minimalism that is done
by phrase types and the constraints on them in HPSG.

Although Minimalism is a procedural approach and HPSG a declarative ap-
proach, there are some similarities between Minimalism and early HPSG, the
approach presented in Pollard & Sag (1987; 1994). In much the same way as Min-
imalism has just a few general mechanisms, early HPSG had just a few general
phrase types. Research in HPSG in the 1990s led to the conclusion that this is too
simple and that a more complex system of phrase types is needed to accommo-
date the full complexity of natural language syntax. Nothing like this happened
within Minimalism, almost certainly because there was little attempt within this
approach to deal with the full complexity of natural language syntax. As noted
above, the approach has rarely been applied in detailed formal analyses. It looks
too simple and it appears problematic in various ways. It is also a major source
of the complexity that is characteristic of Minimalist syntactic structures, as we
will see in the next section.

3.4 Feature deletion and "crashing at the interfaces"

We already mentioned uninterpretable features in the previous subsection. It is
assumed in Minimalism that features like case features are not interpretable and
hence have to be consumed since otherwise the derivation would "crash at the
interfaces". This means that Minimalism claims that a case marked NP like *der
Mann* 'the man' is not interpretable unless it is somehow stripped of its case in-
formation.So in Minimalism *der Mann* needs something on top of the DP that
consumes the case features. While this seems cumbersome to most working out-
side Minimalism, there are actually deeper problems connected to the consump-
tion of case features. There are situations in which you need case features more
than once. An example for this are free relative clauses as the one in (13b):

(13) a. der   Mann
         the.NOM man

      b. Ich treffe, wen   ich treffen will.
         I   meet   who.ACC I   meet   want.to
         'I meet whoever I like to meet.'

wen is the accusative object in the relative clause. Since it is an object its case feature will be checked by the governing verb *treffen* 'meet'. *wen* will then be a DP without any case information. However, the case of the relative phrase in free relative clauses is not arbitrary. It is important for the integration of the free relative clause in the matrix clause. The case of *wer* 'who' in a complete relative clause has to be known since it is important for the external distribution of the free relative clause, as the examples in (14) show:

(14)   a.   Wer   mich treffen will,   kann vorbeikommen.
            who.NOM me   meet   wants.to may over.come
            'He who wants to meet me may come over.'

        b.   * Ich treffe, wer   mich treffen will.
            I   meet who.NOM me   meet   wants.to
            'I meet whoever wants to meet me.'

HPSG also consumes resources in a way: items in valence representations are not projected up the tree once the requirement is saturated, but the difference is that objects with a certain structure and with certain features are not modified. A case-marked NP is not deprived of this case information for whatever reasons. We think that this is the right way to deal with morphological markings and with feature specifications in general.

3.5 Some implications

We will look in detail at the implications for syntactic structure of this machinery in the next section. However, we will note some implications in the following paragraphs as a kind of preview of the next section.

First, the fact that Merge combines two expressions entails that syntactic structures are confined to binary branching and excludes various analyses that have been assumed within HPSG and other frameworks. Second, the assumption that expressions produced by Merge have the same label as one of the expressions that they consist of (Chomsky 2008: 145) is essentially the assumption that all complex expressions are headed. For HPSG, as for many other approaches, there are headed expressions and non-headed expressions, e.g., coordination and the NPN construction discussed in Sections 4.2.2 and 4.2.3, respectively.

As emphasized above, a further important feature of Minimalism is the view that semantics and morphology are simple reflections of syntax. The basic architiecture assumed in Minimalism is shown in Figure 6. Both phonology and semantics are read off the structures produced by syntax. The idea that seman-

lexicon ⟶ numeration

lexicon

overt syntax

⟵ Spell-Out

covert syntax

LF/CI   PF/AP
(meaning) (sound)

Transfer

Transfer

PHON   SEM

Transfer

PHON   SEM

Transfer

PHON   SEM

PHON   SEM
...

Transfer

PHON   SEM
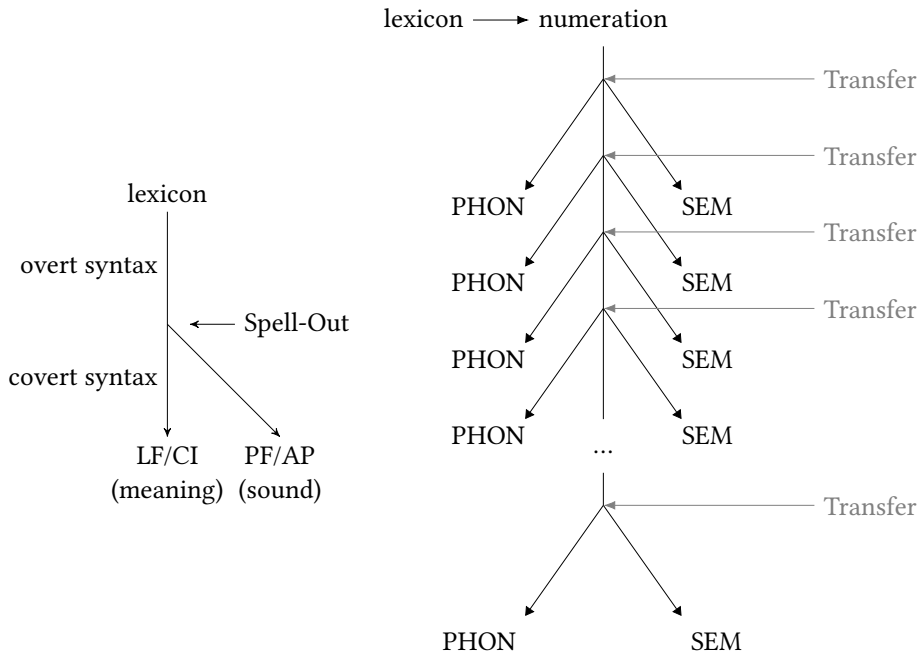
Figure 6: Syntax-centristic architecture in Minimalism before the Phase model (left) and in the Phase model (right) according to Richards (2015: 812, 830))

tics is a simple reflection of syntax goes back to the early years of Transformational Grammar. One aspect of this idea was formalized as the Uniform Theta Assignment Hypothesis (UTAH) by Baker (1988: 46).

(15)   Uniform Theta Assignment Hypothesis
         Identical thematic relationships between items are represented by identical structural relationships between those items at the level of D-structure.

Minimalism abandoned the notion of D-structure, but within Minimalism the Hypothesis can be reformulated as follows:

(16)   Uniform Theta Assignment Hypothesis (revised)
         Identical thematic relationships between items are represented by identical structural relationships between those items when introduced into the structure.

We will look at some of the implications of this in the next section.

The idea that morphology is a simple reflection of syntax is also important. As we will discuss in the next section, it leads to abstract underlying structures and complex derivations and to functional heads corresponding to various suffixes. Again, we will say more about this in the next section.

4 Different views of syntactic structure

The very different views of grammar that are assumed in Minimalism and HPSG naturally lead to very different views of syntactic structure. The syntactic structures of Minimalism are both very complex and very simple. This sounds paradoxical but it isn't. They are very complex in that they involve much more structure than those assumed in HPSG and other approaches. But they are very simple in that they have just a single ingredient – they consist entirely of local trees in which there is a head and a single non-head. From the standpoint of HPSG, they are both too complex and too simple. We will consider the complexity in Section 4.1 and then turn to the simplicity in Section 4.2.

4.1 The complexity of Minimalist structures

For HPSG, as the chapters in this volume illustrate, linguistic expressions have a single relatively simple constituent structure with a minimum of phonologically empty elements.[16] For Minimalism, they have a complex structure containing a variety of empty elements and with various constituents occupying more than one position in the course of the derivation. Thus the structures assumed within Minimalism are not at all minimalist. But this complexity is a more or less inevitable consequence of the Minimalist view of grammar outlined above.

4.1.1 Uniformity of structures due to semantic representation

There are a variety of sources of complexity, and some predate Minimalism.[17] This is true especially of the idea that semantics and morphology are simple reflections of syntax (on morphology see Section 4.1.3). For the syntax-semantics relation, UTAH, which we introduced on p. 523, is particularly important. It leads

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[16]The relatively simple structures of HPSG are not an automatic consequence of its declarative nature. Postal's Metagraph Grammar framework (formerly known Arc Pair Grammar) is a declarative framework with structures that are similar in complexity to those of Minimalism (see Postal 2010).

[17]For interesting discussion of the historical development of the ideas that characterize Minimalism, see Culicover & Jackendoff (2005: Chapters 2 and 3).

to a variety of abstract representations and movement processes. Consider, for example, the following:

(17)   a.   Who did Lee see?
        b.   Lee saw who

Who bears the same thematic relation to the verb *see* in (17a) as in (17b). Assuming UTAH, it follows that *who* in (17a) should be introduced in the object position which it occupies in (17b) and then be moved to its superficial position. Consider next the following:

(18)   a.   Lee was seen by Kim.
        b.   Kim saw Lee.

Here, *Lee* bears the same thematic relation to the verb *see* in (18a) as in (18b). Hence, it follows that *Lee* in (18a) should be introduced in the object position which it occupies in (18b) and then be moved to its superficial subject position. Finally, consider these examples:

(19)   a.   Lee seems to be ill.
        b.   It seems that Lee is ill.

Here, *Lee* bears the same thematic relation to *ill* in (19a) as in (19b). Thus, it follows that *Lee* in (19a) should be introduced in the same position as *Lee* in (19b). The standard Minimalist approach assumes that *Lee* in both examples originates in a position adjacent to *ill* and is moved a short distance in (19b) but a longer distance in (19a).

These analyses are more or less inevitable if one accepts UTAH. But how sound is UTAH? Work in HPSG shows that it is quite possible to capture both the syntactic and the semantic properties of these sentence types without the assumption that the crucial constituents occupy more than one position. Thus, there is no reason to accept UTAH.

4.1.2 Complex derived structures a la Generative Semantics

The idea that semantics is a simple reflection of syntax has led to other kinds of complexity. For example, it has led to revival of the idea once characteristic of Generative Semantics that lexical items may derive from complex expressions which in some sense represent their meanings.[18] Thus, Hale & Keyser (1993)

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[18]For typical Generative Semantics proposals of this kind, see McCawley (1968) and Postal (1970). Like Minimalism, Generative Semantics was characterized by extremely complex syntactic structures and for similar reasons. See Newmeyer (1986: Chapter 4) for discussion.

argue that (20a) derives from a structure like that of (20b).

(20)   a. Kim shelved the books.
       b. Kim put the books on the shelf.

One problem with this proposal is that *shelve X* means more than just *put X on the shelf.* Thus, (21a) is not equivalent to (21b).

(21)   a. Kim put his elbow on the shelf.
       b. Kim shelved his elbow.

Moreover, as Culicover & Jackendoff (2005: 54–55) point out and as Hale & Keyser (1993: 105, Fn. 7) note themselves, denominal verbs can have many different interpretations.[19]

(22)   a. Kim saddled the horse.
          (Kim put the saddle on the horse.)
       b. He microwaved the food.
          (He put the food in the microwave and in addition he heated it.)
       c. Lee chaired the meeting.
          (Lee was the chairperson of the meeting.)
       d. Sandy skinned the rabbit.
          (Sandy removed the skin from the rabbit.)
       e. Kim pictured the scene.
          (Kim constructed a mental picture of the scene.)
       f. They stoned the criminal.
          (They threw stones at the criminal.)
       g. He fathered three children.
          (He was the biological father of three children.)
       h. He mothers his students.
          (He treats his students the way a mother would.)

Denominal verbs need to be associated with the correct meanings, but there is no reason to think that syntax has a role in this.[20]

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[19]The examples in (22c), (22g) and (22h) are taken from (Culicover & Jackendoff 2005: 54–55) or parallel to examples they discussed.

[20]See Culicover & Jackendoff (2005: 53–56) for further discussion.

Draft of 29th November 2018, 11:59

4.1.3 Complex structures and morphology

The idea that morphology is a simple reflection of syntax also leads to syntactic complexity. The fact that verbs in English and many other languages are marked for tense leads to the assumption that there is a T(ense) head at the heart of clause structure. Thus the sentence in (23) has the analysis in Figure 7.

(23)   The cat chased the dog.
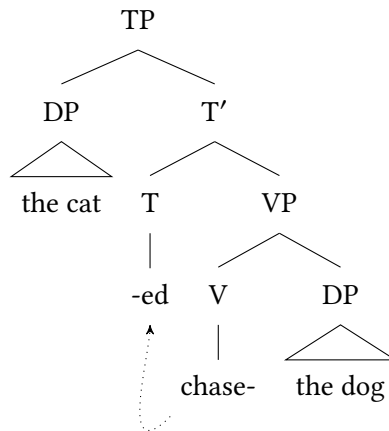
Figure 7: TP/VP analysis of simple English sentences

The verbal stem moves to the T head to pick up the *-ed* suffix.

Similarly the fact that nouns in English and other languages are marked for number leads to the assumption that there is a Num(ber) head at the heart of noun phrase structure. These elements are not solely motivated by morphology. The assumption that verbs move to T and nouns to Num in some languages but not others provides a way of accounting for cross-linguistic word order differences. However, as discussed in Crysmann (2018), Chapter 23 of this volume, HPSG assumes a realizational approach to morphology, in which affixes are just bits of phonology. Hence, analyses like these are out of the question.

4.1.4 Binary branching

Another source of complexity which also predates Minimalism is the assumption that all structures are binary branching. As Culicover & Jackendoff (2005: 112–116) note, this idea goes back to the 1980s. It entails that there can be no structures of the form in Figure 8a. Rather all structure must take the form in

(a) flat branching   (b) binary branching   (c) binary branching
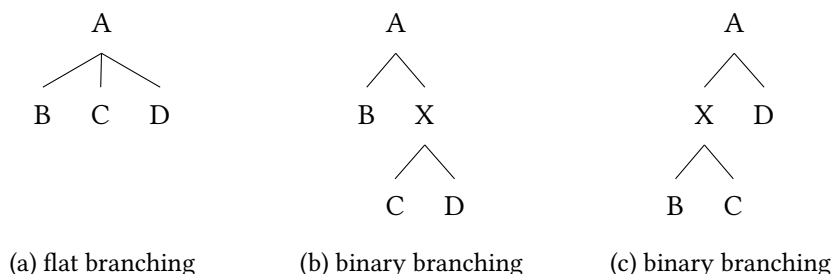
Figure 8: Flat and binary branching

Figure 8b or Figure 8c. As Culicover & Jackendoff discuss, the arguments for the binary branching restriction have never been very persuasive. Moreover, it is incompatible with various analyses which have been widely accepted in HPSG and other frameworks. We will return to this topic in Section 4.2.

4.1.5 Unbounded dependencies

As noted in Section 3, the simplicity of the Minimalist grammatical system means the properties of constructions must largely derive from the lexical items that they contain. Hence, the properties of lexical items are absolutely central to Minimalism and often this means the properties of phonologically empty items, especially empty functional heads. Thus, such elements are central feature of Minimalist syntactic structures. These elements do much the same work as phrase types and the associated constraints in HPSG.

The contrast between the two frameworks can be illustrated with unbounded dependency constructions. Detailed HPSG analyses of various unbounded dependency constructions are set out in Sag (1997; 2010) and Ginzburg & Sag (2000), involving a complex system of phrase types. For Minimalism, unbounded dependency constructions are headed by a phonologically empty complementizer (C) and have either an overt filler constituent or an invisible filler (an empty operator) in their specifier position. Essentially, then, they have the structure in Figure 9. All the properties of the construction must stem from the properties of the C that heads it.

An important unbounded dependency construction is relative clauses. In English there are *wh*-relatives and non-*wh*-relatives and finite and non-finite relatives. *Wh*-relatives are illustrated by the following:

(24)   a.   someone [who you can rely on]
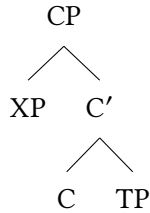
Figure 9: CP structures in Minimalism

    b.   someone [on whom you can rely]

(25) a. * someone [who to rely on]
      b.   someone [on whom to rely]

These show that whereas finite *wh*-relatives allow either an NP or a PP as the filler, non-finite *wh*-relatives only allow a PP. In the HPSG analysis of Sag (1997), the facts are a consequence of constraints on two phrase types. A constraint on the type *fin-wh-fill-rel-cl* allows the first daughter to be an NP or a PP while a constraint on *inf-wh-fill-rel-cl* requires the first daughter to be a PP. For Minimalism, the facts must be attributed to the properties of the complementizer. There must be a complementizer which takes a finite TP complement and allows either an NP or a PP as its specifier and another complementizer which takes a non-finite TP complement (with an unexpressed subject) and only allows a PP as its specifier.

Non-*wh*-relatives require further phrase types within HPSG and further complementizers in Minimalism. However, rather than consider this, we will look at another unbounded dependency construction: *wh*-interrogatives. The basic data that needs to be accounted for is illustrated by the following:

(26) a. Who knows?
      b. I wonder [who knows].
      c. Who did Kim talk to?
      d. I wonder [who Kim talked to].
      e. I wonder [who to talk to].

Like *wh*-relatives, *wh*-interrogatives can be finite and non-finite. When they are finite their form depends on whether the *wh*-phrase is subject of the highest verb or something else. When it is subject of the highest verb, it is followed by what looks like a VP although it may be a clause with a gap in subject position. When

the *wh*-phrase is something else, the following clause shows auxiliary-initial order if it is a main clause and subject-initial order if it is not. Non-finite *wh*-interrogatives are a simple matter, especially as the filler does not have to be restricted in the way that it does in non-finite *wh*-relatives. Ginzburg & Sag (2000) present an analysis which has two types for finite *wh*-interrogatives, one for subject-*wh*-interrogatives such as those in (26a) and (26b), and another for non-subject-*wh*-interrogatives such as those in (26c) and (26d). The latter is subject to a constraint requiring it to have the same value for the features IC (INDEPENDENT-CLAUSE) and INV (INVERTED). Main clauses are [IC +] and auxiliary-initial clauses are [INV +]. Hence the constraint ensures that a non-subject-*wh*-interrogative shows auxiliary-initial order just in case it is a main clause.

How can the facts be handled within Minimalism? As noted above, Minimalism analyses auxiliary-initial order as a result of movement of the auxiliary to C. It is triggered by some feature of C. Thus C must have this feature just in case (a) it heads a main clause and (b) the *wh*-phrase in its specifier position is not the subject of the highest verb. There are no doubt various ways in which this might be achieved, but the key point is the properties of a phonologically empty complementizer are crucial.

Borsley (2006b; 2017) discusses Minimalist analyses of relative clauses and *wh*-interrogatives and suggests that at least eight complementizers are necessary. One is optionally realized as *that*, and another is obligatorily realized as *for*. The other six are always phonologically empty. But it has been clear since Ross (1967) and Chomsky (1977) that relative clauses and *wh*-interrogatives are not the only unbounded dependency constructions. Here are some others:

(27) a. What a fool he is!   (*wh*-exclamative clause)
      b. The bagels, I like.   (topicalized clause)
      c. Kim is more intelligent [than Lee is].   (comparative-clause)
      d. Kim is hard [to talk to].   (*tough*-complement-clause)
      e. Lee is too important [to talk to].   (*too*-complement-clause)
      f. [The more people I met], [the happier I became].   (*the*-clauses)

Each of these constructions will require at least one empty complementizer. Thus, a comprehensive account of unbounded dependency constructions will require a large number of such elements. But with a large unstructured set of complementizers there can be no distinction between properties shared by some or all elements and properties restricted to a single element. There are a variety of shared properties. Many of the complementizers will take a finite complement, many others will take a non-finite complement, and some will take both. There

will also be complementizers which take the same set of specifiers. Most will not attract an auxiliary, but some will, not only the compementizer in an example like (26c) but also the complementizers in the following, where the auxiliary is in italics:

(28)   a.   Only in Colchester *could* such a thing happen.

   b.   Kim is in Colchester, and so *is* Lee.

   c.   Such *is* life.

   d.   The more Bill smokes, the more *does* Susan hate him.

Thus, there are generalizations to be captured here. The obvious way to capture them is with the approach developed in the 1980s in HPSG work on the hierarchical lexicon (Flickinger, Pollard & Wasow 1985; Flickinger 1987), i.e. a detailed classification of complementizers which allows properties to be associated not just with individual complementizers but also with classes of complementizers. With this it should be possible for Minimalism not just to get the facts right but to capture the full set of generalizations. In many ways such an analysis would be mimicking the HPSG approach with its hierarchy of phrase types.[21] But in the present context the main point is the simplicity of the Minimalist grammatical system is another factor which leads to more complex syntactic structures than those of HPSG.

4.1.6 Syntactification of semantic categories

Further complexity arises from the syntactification of semantic properties (Rizzi 2014). This is especially apparent in a sub-school that calls itself "cartographic". Generative Grammar in the Chomskyan tradition comes with strong claims about the autonomy of syntax. There is a syntactic component and than there are the components of Phonological Form (PF) and Logical Form (LF), in more recent versions of the theory this is the articulatory-perceptual system (AP) and the conceptual-intentional system (CI). Figure 6 shows the early Minimalist architecture and the architecture assumed in the Phase-based models. Syntax was always regarded primary and PF and LF derived from syntactic representations. This is similar in Minimalism. The problem is that questions of intonation are connected to semantic and information structural properties (Halliday 1970: 36). A way around this is to stipulate syntactic features that can be interpreted by both PF and LF (Gussenhoven 1983). Another way of dealing with the data is to employ empty elements that are responsible for certain ordering of elements and

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[21]For a fuller discussion of the issues see Borsley (2006b; 2017).

that can be interpreted in the semantics. The accounts of Rizzi and Cinque are very prominent in this school of thought. For example, Rizzi (1997) suggests an analysis of the left periphery of clauses that incorporate special functional projections for topic and focus. His analysis is shown in Figure 10. In comparison no
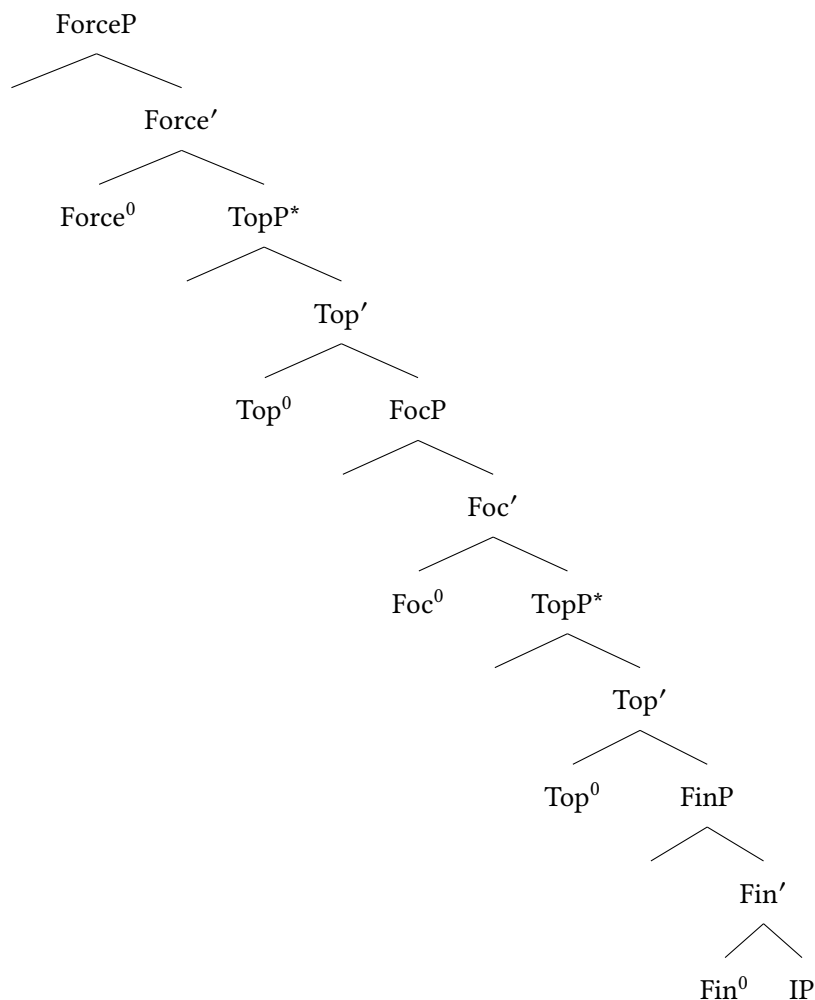
Figure 10: Syntactic structure of sentences following Rizzi (1997: 297)

such projections exist in HPSG theories. HPSG grammars are surface oriented and the syntactic labels correspond to classical part of speech categorizations. So in examples with frontings like (29) the whole object is a verbal projection and

not a Topic phrase, a Focus Phrase or a Force phrase.

(29)   Bagels, I like.

Of course the fronted elements may be topics or foci but this is a property that is represented independently of syntactic information in parts of feature descriptions having to do with information structure. For treatment of information structure in HPSG see Engdahl & Vallduví (1996), De Kuthy (2000) and also de Kuthy (2018), Chapter 25 of this volume. On determination of clause types see Ginzburg & Sag (2000) and Müller (2016b). For general discussion of the representation of information usually assigned to different linguistic "modules" and on "interfaces" between them in theories like LFG and HPSG see Kuhn (2007).

Cartographic approaches also assume a hierarchy of functional projections for the placement of adverbials. Some authors assume that all sentences in all languages have the same structure, which is supposed to explain orders of adverbials that seem to hold universally (e.g., Cinque 1999: 106 and Cinque & Rizzi 2010: 54–55). A functional projection selects for another functional projection to establish this hierarchy of functional projections and the respective adverbial phrases can be placed in the specifier of the corresponding functional projection. Cinque (1999: 106) assumes 32 functional projections in the verbal domain. Cinque & Rizzi (2010: 57, 65) assume at least four hundred functional heads, which are – according to them – all part of a genetically determined UG.

In comparison, HPSG analyses assume that verbs project: a verb that is combined with an argument is a verbal projection. If an adverb attaches, a verbal projection with the same valence but augmented semantics results. Figure 11 shows the Cartographic and the HPSG structures. While the adverbs (Adv_1 and Adv_2 in the figure) attach to verbal projections in the HPSG analysis (S and VP are abbreviations standing for verbal projections with different valence requirements), the Cartographic approach assumes empty heads that select a clausal projection and provide a specifier position in which the adverbs can be realized. For the shake of exposition we called these heads $FAdv_1$ and $FAdv_2$. For example, $FAdv_2$ can combine with the VP and licences an Adv_2 in its specifier position. As is clear from the figure, the Cartographic approach is more complex since it involves two additional categories ($FAdv_1$ and $FAdv_2$) and nine nodes for the adverbial combination rather than five.

An interesting difference is that verbal properties are projected in the HPSG analysis. By doing this it is clear whether a VP contains an infinitive or a participle.

(30)   a. Kim has met Sandy.
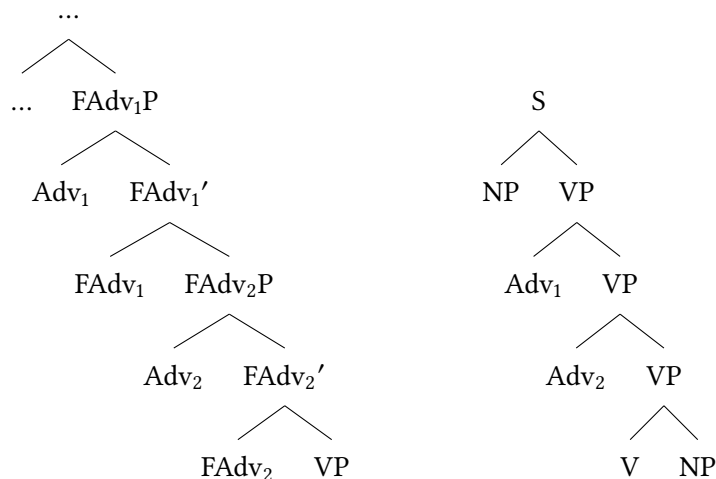
Figure 11: Treatment of adverbial phrases in Cartographic approaches and in HPSG

b. Kim will meet Sandy.

This property is important for the selection by a superordinate head, the auxiliary in the examples in (30). In a Cartographic approach one either has to assume that adverbial projections have features correlated with verbal morphology or one has to assume that superordinate heads may check properties of linguistic items that are deeply embedded.

Bob: I am not sure whether it is worth it to have the last paragraph …
Stefan: For me this is one of the absurdities of the Cartographic approach. The category labels are distribution classes. For Cartographic approaches we have an Aspect Phrase but from the outside we are looking for a VP with certain properties. Of course Cartography works if you always have the full battery of functional projections. But then you have to make sure that it is of the right kind, that is the verbal form deep inside has to be right.
Bob: I now think this is quite important. I assume they think that the full battery of functional projections is always present, but that doesn't alter the fact that you need not just any kind if verb but a verb of the right form to satisfy the requirements of an auxiliary.
However, they have got a way of getting adverbs in the right order and I'm not really sure how we would do that.

add "a complex"

If one believed in Universal Grammar (which researchers working in HPSG usually do not) and in innately specified constraints on adverb order one would not assume that all languages contain the same structures, some of these struc-

tures being invisible. Rather one would assume linearization constraints (see Müller (2018: Section 2), Chapter 10 of this volume) to hold crosslinguistically. If adverbs of a certain type do not exist in a language, the linearization constraints would not do any harm. They just would never apply since there is nothing to apply to (Müller 2015b: 46).

4.1.7 Summary

Having discussed uniformity in theta role assignment, Generative Semantics-like approaches, branching, nonlocal dependencies and Cartographic approaches to the left periphery and adverb order within clauses, we conclude that a variety of features of Minimalism lead to structures that are much more complex than those of HPSG. HPSG shows that this complexity is unnecessary given a somewhat richer conception of grammar.

4.2 The simplicity of Minimalist structures

As we emphasized above, while minimalist structures are very complex, they are also simple in the sense that they have just a single ingredient, local trees consisting of a head and a single non-head. Most outsiders agree that this is too simple.

4.2.1 Binary branching, VPs, and verb-initial clauses

We look first at binary branching.[22] As we noted above, the assumption that all branching is binary is incompatible with various analyses which have been widely accepted in HPSG and other frameworks. For example, it means that the bracketed VP in (31), which contains two complements, cannot have the ternary branching structure in Figure 12, which is suggested in Pollard & Sag (1994: 36) and much other work.

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[22]In addition to structures with two or more branches, HPSG uses unary branching structures both in syntax and in the lexicon (lexical rules basically are unary branching structures, see Meurers (2001) and Davis & Koenig (2018: Section 5), Chapter 4 of this volume. For example, unary branching syntactic rules are used for semantic type shifting (Partee 1987). For respective HPSG analyses see Flickinger (2008: 91–92) and Müller (2009; 2012). The lack of unary branching structures in Minimalism is no problem since empty heads can be used instead. The empty head projects the properties that would be otherwise assigned to the mother node of the unary projection. See for example Ramchand (2005: 370). So, while the effects of unary projections can be modeled, the resulting structures are more complex. For a general discussion of empty elements and unary projections and lexical rules see Müller (2016a: Sections 19.2 and 19.5).

(31)   Kim [gave a book to Lee].
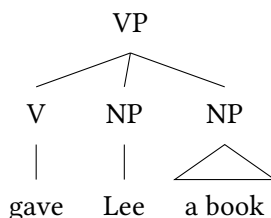
Figure 12: Flat structure for the VP *gave Lee a book*

Instead it has been assumed since Larson (1988) that the VP in examples like (31) has something like the structure in Figure 13. It is assumed that the verb origi-
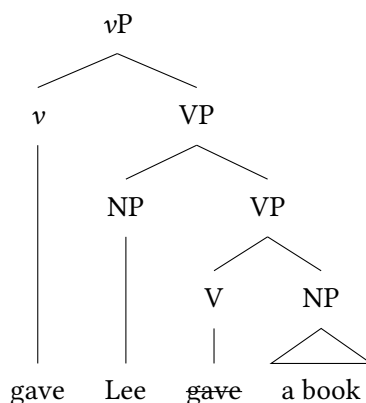
Figure 13: Larson-type analysis of VPs involving little *v*

nates in the lower VP and is moved into the higher VP. The higher V position to which the verb moves is commonly labelled *v* ("little *v*") and the higher phrase *v*P. The main argument for such an analysis appears to involve anaphora, especially contrasts like the following:

(32)   a.   John showed Mary herself in the picture.
       b.   * John showed herself Mary in the picture.

The first complement can be the antecedent of a reflexive which is the second complement, but the reverse is not possible. If constraints on anaphora refer to constituent structure as suggested by Chomsky (1981), the contrast suggests that

the second NP should be lower in the structure than the first NP. But, as suggested by Pollard & Sag (1992), it is assumed in HPSG that constraints on anaphora refer not to constituent structure but to a list containing all arguments in order of obliquenss, in recent versions of HPSG the ARG-ST list (see also Branco (2018), Chapter 21 of this volume). On this view, anaphora can provide no argument for the complex structure in Figure 13. Therefore, both flat structures and binary branching structures with different branching directions as in Figure 14 are a viable option in HPSG. Müller (2015a: Section 2.4; 2018a) argues for such binary
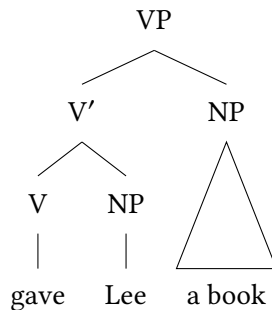
Figure 14: Possible analysis of VPs in HPSG with a branching direction differing from Larson-type structures

branching structures as a result of parametrizing the Head-Complement Schema for various variants of constituent order (head-initial and head-final languages with fixed constituent order and languages like German and Japanese with freer constituent order).

The fact that Merge combines two expressions also means that the auxiliary-initial clause in (33) cannot have a flat structure with both subjects and complement(s) as sisters of the verb, as in Figure 15.

(33)   Will Kim be here?

It is standardly assumed in Minimalism that it has a structure of the form in Figure 16 or more complicated structures, as explained in Section 4.1.6. *Will* is analysed as a T(ense) element which moves to the C(omplementizer) position. An analysis like this is essentially the only possibility within Minimalism.

It is not just English auxiliary-initial clauses that cannot have a ternary branching analysis within Minimalism but verb-initial clauses in any language. A notable example is Welsh, which has verb-initial order in all types of finite clause.
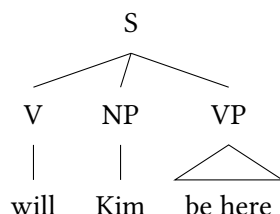
Figure 15: Flat structure for *Will Kim be there?*
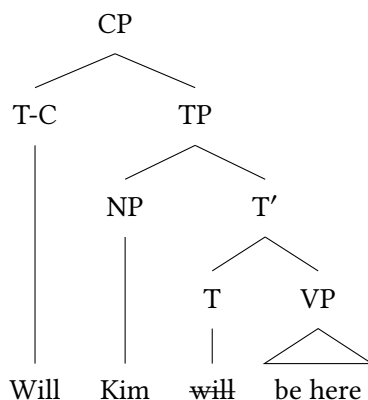
Figure 16: CP/TP structure for *Will Kim be there?*

Here are some relevant examples:[23]

(34) a. Mi/Fe gerddith   Emrys i ’r dre.   (Welsh)
          PRT   walk.FUT.3SG Emrys to the town
          'Emrys will walk to the town.'

      b. Dywedodd Megan [cerddith   Emrys i ’r dre].
          say.PAST.3SG Megan walk.FUT.3SG Emrys to the town
          'Megan said Emrys will walk to the town.'

A variety of transformational work, including work in Minimalism, has argued for an analysis like Figure 16 for Welsh finite clauses (see e.g., Jones & Thomas 1977, Sproat 1985, Sadler 1988, Rouveret 1994, and Roberts 2005). But Borsley

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[23]Positive main clause verbs are optionally preceded by a particle (*mi* or *fe*). We have included this in (34a) but not in (34b). When it appears it triggers so-called soft mutation. Hence (34a) has *gerddith* rather than the basic form *cerddith*, which is seen in (34b).

(2006a) argues that there is no theory-neutral evidence for a structure of this kind. Hence, at least for Welsh, it seems that a simpler flat structure like Figure 15 is preferable.[24] Note, that we do not argue against structures like the one in Figure 16 categorically. The analog to head-movement analyses is standard among HPSG grammarians of German and there is data from apparent multiple frontings that seems to make a head-movement analysis unavoidable. See Müller (2017) for a book-length discussion of German clause structure. Müller (2018: Section 4.1), Chapter 10 of this volume also discusses head-movement in HPSG.

4.2.2 Headedness and coordination

We turn now to the idea that all structures are headed. For HPSG, and many other approaches, there are headed structures and non-headed structure. Probably the most important example of the latter are coordinate structures such as those in (35) (see Sag 2003 for an HPSG analysis).

(35)   that [Kim and Lee] [wrote poems and painted pictures].

Much work in Minimalism assumes that coordinate structures are headed by the conjunction (Larson 1990: 596; Radford 1993: 89; Kayne 1994: Chapter 6; Johannessen 1998; Van Koppen 2005: 8; Bošković 2009: 474; Citko 2011: 27).[25] This suggests that both coordinate structures in (35) are conjunction phrases. This is highly problematic since the category of the phrases plays a role in accounting for their external distribution. So the VPs *wrote poems* and *painted pictures* have to be combined with a DP/NP to form a complete sentence. But according to the ConjP theory *Kim and Lee* is not a DP or NP it is a ConjP and hence incompatible with any requirements. Similarly, a T head in the analysis of (35) requires a VP argument but instead of a VP *wrote poems and painted pictures* there is only a ConjP.[26] It is fairly clear that conjunctions cannot be ordinary heads. Johannessen (1996: 669) suggests an analysis in which the specifier projects its features.

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[24]Borsley (2016) argues for a similar flat structure for the Caucasian ergative SOV language Archi.

[25]Kayne (1994: 57) differs from other proposals in not assuming the category Conj for the conjunction. Instead, he uses X^0 as the category in his structured examples. Since X is an underspecified variable his theory is underdetermined: while a ConjP is not compatible with any requirement by a governing head, an XP could appear as an argument of any dominating head. Kayne needs to work out a theory that determines the properties of the projected XP in relation to the coordinated items. We discuss this below.

[26]If one considers the part of speech labels only, one would expect the two ConjPs to be interchangeable, but of course they are not:

(i)   * [Wrote poems and painted pictures] [Kim and Lee].

Of course the two ConjPs are not exactly of the same category since there may be further

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She depicts the analysis as in Figure 17. The problem is that it is unclear how this

CoP[X]
X   Co′
Co   Y
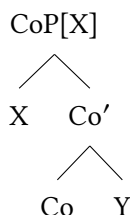
Figure 17: Analysis of coordination with projection of features from the first conjunct according to Johannessen (1996: 669)

should be formalized: either the head category of the complete object is ConjP or it is X. Governing heads have to know where to look for the category. If they look at X, why is the part of speech information of Co projected? Why would governing heads not look at the category of other specifiers rather than their heads? Johannessen's analysis seems to be equivalent to an HPSG analysis assuming two different head features, which would be highly problematic for the reasons just given. Furthermore, coordinations are not equivalent to the first conjunct. There are cases where the coordination is a sum of the parts. For example, *Kim and Sandy* is a plural NP, as the agreement with the verb shows:

(36)   Kim and Sandy laugh.

Johannessen's analysis seems to predict that the coordination of *Kim* and *Sandy* behaves like *Kim*, which is not the case. So, if one wants to assume an analysis with the conjunction as a head, one would have to assume that the head is a functor taking into account the properties of its specifier and complement, and projecting nominal information if they are nominal, verbal if they are verbal, etc (Steedman 1991). This would make them a unique type of a head with a unique relation to their specifier and complement. A problem for this approach is coordinate structures in which the conjuncts belong to different categories, e.g., the following:

(37)   a. Hobbs is [a linguist and proud of it].
        b. Hobbs is [angry and in pain].

---

features that distinguish the two ConjPs. But how these features are distributed between the conjuncts and the mother is not worked out.

For a more detailed critique of the ConjP approach see Borsley (2005).

Such examples have led to HPSG analyses in which coordinate structures have whatever properties are common to the two conjuncts (Sag 2003). Within Minimalism, one might try to mimic such analyses by proposing that conjunctions have whatever properties are common to their specifier and complement. But a problem arises with an example like (38), where the conjuncts are not phrases but words.

(38)   Kim [criticized and insulted] his boss.

To accommodate such examples, conjunctions would have to acquire not only part of speech information from the conjuncts but also selectional information. They would be heads which combine with a specifier and a complement to form an expression which, like a typical head, combines with a specifier and a complement. This would be a very strange situation and in fact it would make wrong predictions since the object *his boss* would be the third-merged item. It would hence be "later-merged" in the sense of Chomsky (2008: 146) and therefore treated as a specifier rather than a complement.[27]

4.2.3 Binary branching and headless structures: The NPN construction

Another problem for Minimalist theories is the NPN Construction discussed by Matsuyama (2004) and Jackendoff (2008). Examples are provided in (39):

(39)   a.   Student after student left the room.
        b.   Day after day after day went by, but I never found the courage to talk to her. (Bargmann 2015)

As Jackendoff argued it is not possible to identify one of the elements in the construction as the head. The construction has several peculiar properties and we share Jackendoff's view that these constructions are best treated by a phrasal configuration in which these highly idiosyncratic properties are handled. The construction is discussed in more detail in Müller (2018), Chapter 37 of this volume and Bargmann's analysis within HPSG is provided. Bargmann's analysis also captures multiple repetitions of the PN sequence as they occur in (39b). Until now there is one proposal for NPN in the Minimalist framework: G. Müller (2011). G. Müller develops a reduplication account. He states that reduplication applies to words only and claims that German differs from English in not allowing adjective noun sequences in NPN constructions. He is aware of the possibility of

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[27]There have been attempts to argue that conjuncts are always phrases (Kayne 1994, Bruening 2018). But this position seems untenable (Abeillé 2006, Müller 2018c: Section 7).

these constructions in English (*miserable day after miserable day*) and states that his analysis is intended to account for the German data only. While this alone is a serious shortcoming of the analysis, the empirical claim does not hold water either as the following example from Müller (2018), Chapter 37 of this volume shows:

(40)   Die beiden tauchten nämlich geradewegs   wieder aus   dem heimischen
         the two   surfaced namely straightaway again   from the   home
         Legoland auf, wo   sie   im   Wohnzimmer, schwarzen Stein um
         Legoland PART where they in.the living.room   black   brick after
         schwarzen Stein, vermeintliche Schusswaffen nachgebaut hatten.[28]
         black   brick alledged   firearms   recreated   had
         'The two surfaced straightaway from their home Legoland where they
         had recreated alledged firearms black brick after black brick.'

Apart from failing on the reduplication of adjective-noun combinations like *schwarzen Stein* 'black brick', the reduplication approach also fails on NPN patterns with several PN repetitions as in (39b): if the preposition is responsible for reduplicating content it is unclear how the first *after* is supposed to combine with *day* and *day after day*. We are convinced that it is possible to design analyses of the NPN construction involving several empty heads but it is clear that these solutions would come at a rather high price.

4.2.4 Movement for more local phenomena like scrambling, passive and raising

We want now to consider the dependencies that Minimalism analyzes in terms of Move/Internal Merge. In the next section we look at unbounded dependencies, but first we consider local dependencies in passives, unaccusatives, rasing sentences, and scrambling. The following illustrate the first three of these:

(41)   a. Kim has been hit.
         b. Kim has disappeared.
         c. Kim seems to be clever.

These differ from unbounded dependency constructions in that whereas the gaps in the latter are positions in which overt NPs can appear, this is not true of the supposed gap positions in (41):

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[28]taz, 05.09.2018, p. 20, quoted from Müller (2018: 603).

(42) a. * It has been hit Kim.

   b. * It has disappeared Kim.

   c. * It seems Kim to be clever.

This is a complication if they involve the same mechanism, but is unsurprising if they involve different mechanisms, as in HPSG and most other frameworks.

4.2.4.1 Passive

In the classical analysis of the passive in MGG, it is assumed that the morphology of the participle suppresses the agent role and removes the ability to assign accusative case. In order to receive case the underlying object has to move to the subject position to Spec,TP where it gets nominative (Chomsky 1981: 124).

(43) a. The mother gave [the girl] [a cookie].

   b. [The girl] was given [a cookie] (by the mother).

The analysis assumed in recent Minimalist work differs in detail but is movement-based as its predecessors. While movement-based approaches seem to work well for SVO languages like English, they are problematic for SOV languages like German. To see why consider the examples in (44):

(44) a. weil   das   Mädchen dem   Jungen den   Ball schenkte
       because the.NOM girl   the.DAT boy   the.ACC ball gave
       'because the girl gave the ball to the boy'

   b. weil   dem   Jungen der   Ball geschenkt wurde
       because the.DAT boy   the.NOM ball given   was
       'because the ball was given to the boy'

   c. weil   der   Ball dem   Jungen geschenkt wurde
       because the.NOM ball the.DAT boy   given   was

In comparison to (44c), (44b) is the unmarked order (Höhle 1982). *der Ball* 'the ball' in (44b) occurs in the same position as *den Ball* in (44a), that is, no movement is necessary. Only the case differs. (44c) is, however, somewhat marked in comparison to (44b). So, if one assumed (44c) to be the normal order for passives and (44b) is derived from this by movement of *dem Jungen* 'the boy', (44b) should be more marked than (44c), contrary to the facts. To solve this problem, an analysis involving abstract movement has been proposed for cases such as (44b): the elements stay in their positions, but are connected to the subject position and receive their case information from there. Grewendorf (1993: 1311) assumes that

there is an empty expletive pronoun in the subject position of sentences such as (44b) as well as in the subject position of sentences with an impersonal passive such as (45):[29]

(45) weil   heute nicht gearbeitet wird
     because today not   worked   is
     'because there will be no work done today'

A silent expletive pronoun is something that one cannot see or hear and that does not carry any meaning. Such entities are not learnable from input and hence innate domain specific knowledge would be required and of course, approaches that do not have to assume very specific innate knowledge are preferable. For further discussion of language acquisition see Section 5.2 and Ginzburg (2018), Chapter 27 of this volume.

HPSG does not have this problem since passive is treated by lexical rules that map verbal stems onto participle forms with a reduced argument structure list. The first element (the subject in the active) is suppressed so that the second element (if there is any) becomes first. In SVO languages like English and Icelandic this element is realized before the verb: there is a valence feature for subjects/specifiers and items that are realized with the respective schema are serialized to the left of the verb. In SOV languages like German and Dutch the subject is treated like other arguments and hence it is not put in a designated position before the finite verb. No movement is involved in this valence-based analysis of the passive. The problem of MGG analyses is that they mix two phenomena: passive and subject requirement. Since these two phenomena are kept separate in HPSG, problems like that discussed above can be avoided. See Müller (2016a: Section 3.4, Chapter 20) for further discussion.

4.2.4.2 Scrambling

Discussing passive, we already touched on problems related to local reordering of arguments, so-called *scrambling*. In what follows, we want to discuss scrambling in more detail. Languages like German have a more liberal constituent order than English. A sentence with a ditransitive verb allows for six permutations of the arguments, two of which are given in (46):

> Stefan: Actually the chapter about order does not deal with SVO vs. SOV and SPR vs. COMPS. Maybe it should.

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[29]See Koster (1986: 11–12) for a parallel analysis for Dutch as well as Lohnstein (2014) for a movement-based account of the passive that also involves an empty expletive for the analysis of the impersonal passive.

(46) a. [weil] der Mann der Frau das Buch gibt
          because the.NOM man the.DAT woman the.ACC book gives

          'because the man gives the book to the woman'

      b. [weil] das Buch der Mann der Frau gibt
          because the.ACC book the.NOM man the.DAT woman gives

It was long argued that scrambling should be handled as movement as well (Frey 1993). An argument that has often been used to support the movement-based
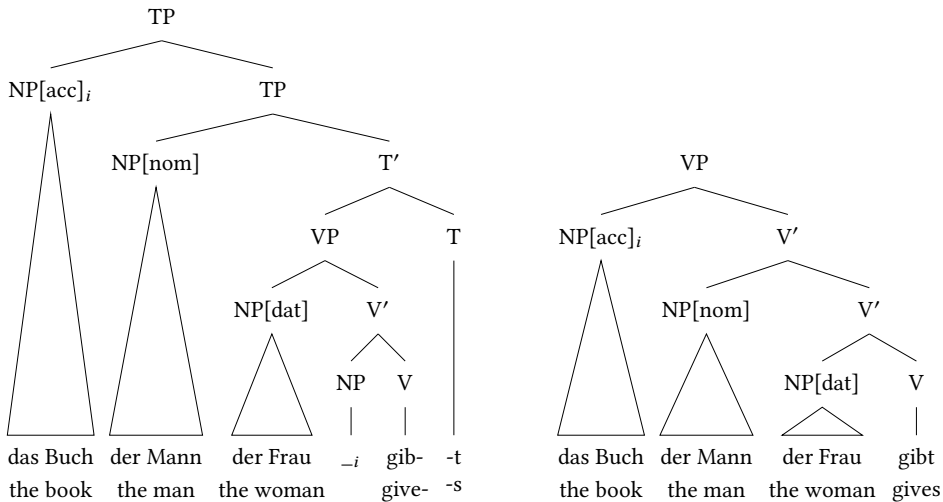
Figure 18: Analysis of local reordering as movement to Spec TP and "base-generation" analysis assumed in HPSG

analysis is the fact that scope ambiguities exist in sentences with reorderings which are not present in sentences in the base order. The explanation of such ambiguities comes from the assumption that the scope of quantifiers can be derived from their position in the superficial structure as well as their position in the underlying structure. If the position in both the surface and deep structure are the same, that is, when there has not been any movement, then there is only one reading possible. If movement has taken place, however, then there are two possible readings (Frey 1993:):

(47) a. Es ist nicht der Fall, daß er mindestens einem Verleger   fast
          it is not the case that he at.least   one   publisher almost

> jedes Gedicht anbot.
> every poem   offered
>
> 'It is not the case that he offered at least one publisher almost every poem.'

  b. Es ist nicht der Fall, daß er fast   jedes Gedicht$_i$ mindestens einem
     it is not   the case that he almost every poem   at.least   one

     Verleger   _$_i$ anbot.
     publisher   offered

     'It is not the case that he offered almost every poem to at least one publisher.'

It turns out that approaches assuming traces run into problems as they predict certain readings for sentences with multiple traces which do not exist (see Kiss 2001: 146 and Fanselow 2001: Section 2.6). For instance in an example such as (48), it should be possible to interpret *mindestens einem Verleger* 'at least one publisher' at the position of _$_i$, which would lead to a reading where *fast jedes Gedicht* 'almost every poem' has scope over *mindestens einem Verleger* 'at least one publisher'. However, this reading does not exist.

(48) Ich glaube, dass mindestens einem Verleger$_i$ fast   jedes Gedicht$_j$ nur
      I   believe that at.least   one   publisher almost every poem   only

      dieser Dichter _$_i$ _$_j$ angeboten hat.
      this   poet   offered   has

      'I think that only this poet offered almost every poem to at least one publisher.'

The alternative to movement-based approaches are so-called "base-generation" approaches in which the respective orders are derived directly. Fanselow (2001), working within the Minimalist Program, suggests such an analysis in which arguments can be combined with their heads in any order. This is the HPSG analysis that was suggested by Gunji (1986) for Japanese and is standardly used in HPSG grammars of German (Hinrichs & Nakazawa 1994; Kiss 1995; Meurers 1999; Müller 2003; 2017). See also Müller (2018), Chapter 10 of this volume.

Sauerland & Elbourne (2002: 308) discuss analogous examples from Japanese, which they credit to Kazuko Yatsushiro. They develop an analysis where the first step is to move the accusative object in front of the subject. Then, the dative object is placed in front of that and then, in a third movement, the accusative is moved once more. The last movement can take place to construct either a structure that is later passed to LF or as a movement to construct the Phonological

Form. In the latter case, this movement will not have any semantic effects. While this analysis can predict the correct available readings, it does require a number of additional movement operations with intermediate steps.

4.2.5 Nonloacl dependencies

Having dealt with phenomena treated via Move/Internal Merge in Minimalism but involving more local phenomena, we now turn to genuine nonlocal dependencies and compare the Move/Internal Merge approach to the HPSG approach to nonlocal dependencies.

4.2.5.1 Gaps without filler

The Move/Internal Merge approach seems quite plausible for typical examples of an unbounded dependency, but issues arise with less typical examples. Within this approach one expects to see a clause-initial filler-constituent and a gap somewhere in the following clause. This is what we commonly find, but there are unbounded dependency constructions in which there is a gap but no visible higher constituent matching it. Consider e.g., the following:

(49) a. the book [Kim bought _]
  b. Lee is too important [for you to talk to _].
  c. Lee is important enough [for you to talk to _].
  d. Kim is easy [for anyone to talk to _].

Within Minimalist assumptions, it is more or less necessary to assume that such examples contain an invisible filler (a so-called empty operator). Unless there is some independent evidence for such invisible fillers, they are little more than an ad hoc device to maintain the Move/Internal Merge approach. Within the HPSG SLASH-based approach to unbounded dependencies, there is no assumption that there should always be a filler at the top of an unbounded dependency (Pollard & Sag 1994: Chapter 4, see also Borsley & Crysmann (2018), Chapter 14 of this volume). Hence, the examples in (49) are completely unproblematic.

4.2.5.2 Filler without gaps: Resumptive pronouns

There are also unbounded dependency constructions which seem to have not a gap but a resumptive pronoun (RP). Among many languages that are relevant here is Welsh, which has RPs in both *wh*-interrogatives and relative clauses, as the following illustrate:

(50)   a.   Pa   ddyn werthodd   Ieuan y ceffyl iddo   *fo*?
            which man sell.PAST.3SG Ieuan the horse to.3SGM he

            'Which man did Ieuan sell the horse to?'

       b.   y   dyn werthodd   Ieuan y   ceffyl iddo   *fo*
            the man sell.PAST.3SG Ieuan the horse to.3SGM he

            'the man that Ieuan sold the horse to'

Willis (2011) and Borsley (2010; 2013) present evidence that Welsh RPs involve the same mechanism as gaps. Within Minimalism, this means that they must involve Move/Internal Merge. But one expects to see a gap where Move/Internal Merge has applied. One Minimalist response suggests that instead of being deleted, the copy left behind by Move/Internal Merge is somehow turned into a pronoun (see McCloskey 2006). A problem for this approach is that it makes it surprising that RPs universally look like ordinary pronouns (McCloskey 2002). Another approach exploits the complexity of Minimalist structures and proposes that there is a gap in the structure somewhere near the RP. Thus, for example, Willis (2011) proposes that examples like those in (50) with an RP in prepositional object position have a coindexed operator in the specifier position of PP, which undergoes movement. Similar approaches are outlined in Aoun et al. (2001) and Boeckx (2003). For detailed objections to both approaches, see Borsley (2013: Section 3). Within the SLASH-based approach of HPSG, there is no reason to think that there will always be a gap at the bottom of a dependency, and it is not difficult to accommodate RPs. See Vaillette (2001), Taghvaipour (2010), Borsley (2013) and Crysmann (2012; 2016) for slightly different approaches.[30] See also Borsley & Crysmann (2018), Chapter 14 of this volume for a more detailed discussion of nonlocal dependencies.

4.3 Conclusion

Thus, there are variety of phenomena which suggest that the Minimalist view of constituent structure is too simple. The restriction to binary branching, the

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[30]Also relevant here are examples with more than one gap such as the following:

(i)   a.   Who does Kim like _ and Lee hate _?

      b.   Which book did you criticize _ without reading _?

There have been various attempts to accommodate such examples within the Move/Internal Merge approach, but it is not clear that any of them is satisfactory. In contrast such examples are expect within the SLASH-based approach (Levine & Sag 2003). See also (Pollard & Sag 1994: Section 4.6).

Draft of 29th November 2018, 11:59

assumption that all structures are headed, and Move/Internal Merge all seem problematic. It looks, then, as if the Minimalist view is both too complex and too simple.

5 Psycholinguistic issues

Although they differ in a variety of ways, HPSG and Minimalism agree that grammatical theory is concerned with linguistic knowledge. They focus first and foremost on the question: what form does linguistic knowledge take? But there are other questions that arise here, notably the following:

- How is linguistic knowledge put to use?

- How is linguistic knowledge acquired?

Both questions are central concerns for psycholinguistics. Thus, in considering the answers that HPSG and Minimalism can give we are considering their relevance to psycholinguistics. Chomskyan approaches, including Minimalism, have focused mainly on the second question and have paid little attention to the first. HPSG has had more to say about the first and has shown less interest in the second. However, there is a large body of work on acquisition in Construction Grammar and since HPSG is a constructionist theory (Müller 2018, Chapter 37 of this volume) all the insights carry over to HPSG. Clearly an adequate grammatical theory should be able to give satisfactory answers to both questions. In this section we will look briefly at the relation of the two theories to processing and then consider more fully their relation to acquisition.

5.1 Processing

We noted in Section 3 that whereas HPSG is a declarative or constraint-based approach to grammar, Minimalism has a procedural view of grammar. This contrast means that HPSG is much more suitable then Minimalism for incorporation into an account of the processes that are involved in linguistic performance.

The most obvious fact about linguistic performance is that it involves both production and comprehension. As noted in Section 3, this suggests that the knowledge that is used in production and comprehension should have a declarative character as in HPSG and not a procedural character as in Minimalism.

A second important feature of linguistic performance is that it involves different kinds of information utilized in any order that is necessary. Sag & Wasow (2011: 367–368) illustrate with the following examples:

(51) a. The sheep that was sleeping in the pen stood up.
      b. The sheep in the pen had been sleeping and were about to wake up.

In (51a), morphological information determines the number of sheep before non-linguistic information determines that *pen* means 'fenced enclosure' and not 'writing implement'. In (51b), on the other hand, non-linguistic information determines that *pen* means 'fenced enclosure' before morphological information determines the number of sheep. This is unproblematic for an approach like HPSG in which linguistic and non-linguistic knowledge takes the form of constraints which are not ordered in any way.[31] It is quite unclear how the facts can be accommodated within Minimalism given that linguistic knowledge with its procedural form is quite different from non-linguistic knowledge.

Other features of HPSG also make it attractive from a processing point of view. Firstly, there is the fact emphasized earlier that linguistic expressions have a single relatively simple constituent structure with a minimum of phonologically empty elements. Secondly there is the fact that all constraints are purely local and never affect anything larger than a local tree consisting of an expression and its daughters. Both these properties make processing easier than it would otherwise be. Minimalism has neither property and hence again seems less satisfactory than HPSG in this area.

Furthermore, it must be said that all approaches based on Chomsky's Phase-based approaches (Chomsky 1999; 2008) are incompatible with psycholinguistic results.

> Bob: Are phase-based approaches any worse than earlier versions of Minimaliism? I would have thought not.
>
> Stefan: True. But how was it back then. I do not remember. Was everything bottom up? When did they send stuff to the interfaces?

Most of Minimalist work assumes that structures are build in a bottom-up fashion. Chomsky assumes that there are so-called Phases and when a Phase is complete the complement of the Phase head is "shipped" to the interfaces (pronounciation and interpretation, see Figure 6). For the example in (52) this would mean that *a liar* is constructed first to be combined with *is*, which is then combined with *Peter* and *Peter is a liar* is combined with *that*. Since *that* is the Phase head *Peter is a liar* is shipped to the interfaces. The *that* clause can then be integrated into more complex constituents like *that Sandy claimed that Peter is a liar* but *Peter is a liar* is a complete unit the internal structure of which is no longer visible.

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[31]See also Lücking (2018), Chapter 32 of this volume on the interaction of gesture and speech.

(52)   Kim believes that Sandy claimed that Peter is a liar.

The problem with this approach is that it uses a rhetoric talking about interfaces and so on that makes the impression as if it was related to processing and to psycho-linguistics, but it is fundamentally against all knowledge we have about language processing: language processing is incremental and all channels are used in parallel (Marslen-Wilson 1975; Tanenhaus et al. 1995; 1996). Information about phonology, morpho-syntax, semantics, information structure and even world knowledge (as in the examples (51) above) are used as soon as they are available. Hence, parsing (52) is an incremental process: the hearer hears *Kim* first and as soon as the first sounds of *believe* reach her the available information is integrated and hypothesis regarding further parts of the utterance are build.[32]

It is sometimes claimed in personal communication that current Minimalist theories are better suited to explain production (generation) than perception (parsing). But these models are as implausible for generation as they are for parsing. The reason is that it is assumed that there is a syntax component that generates structures that are then shipped to the interfaces. This is not what happens in generation though. Usually speakers know what they want to say (at least partly), that is, they start with semantics. If one assumed that information coming from the conceptual-intentional system triggers the creation of syntactic structure, this would not help, since one would then have to build complex utterances by creating linguistic objects starting with the most deeply embedded and keeping them in memory until they are finally spelled out. As Labelle (2007) pointed out this is unrealistic since our availible short-term memory is not sufficient for such tasks.

> references apart from personal communication

So talking about larger syntactic units that are shipped to interpretation is fundamentally wrong from both the parsing and production perspective. Of course one could claim that actual processing is performance and Minimalist theories are dealing with competence but this would beg the question why the vocabulary of performance theories is used in a competence theory.[33]

There are some researchers who are aware of the problematic aspects of the

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[32]Note that the architecture in Figure 6 poses additional problems. An *numeration* is a selection of lexical items that is used in a derivation. Since a multitude of empty elements are assumed in Minimalist analyses it is unclear how such a numeration is constructed since it cannot be predicted at the lexical level which empty elements will be needed in the course of a derivation. Due to the empty elements, there are infinitely many possible numerations that might be appropriate for the analysis of a given input string. The problem would disappear if derivations could draw lexical items from the lexicon directly.

[33]Chomsky (2008), for example, talks of "memory [that] is required to identify these properties at the semantic interface C-I" (p. 145) and "computational resources" (p. 138).

buttom up view standardly assumed in Minimalism: Phillips (2003) and Chesi (2015). Phillips assumes that structures relevant for phenomena such as ellipsis, coordination and fronting are built up incrementally. These constituents are then reordered in later steps by transformations. For example, in the analysis of (53), the string *Wallace saw Gromit in* forms a constituent where *in* is dominated by a node with the label P(P). This node is then turned into a PP in a subsequent step (p. 43–44).

(53)   Wallace saw Gromit in the kitchen.

While this approach is a transformation-based approach, the kind of transformation here is very idiosyncratic and incompatible with other variants of the theory. In particular, the modification of constituents contradicts the assumption of Structure Preservation when applying transformations as well as the *No Tampering Condition* of Chomsky (2008). Furthermore, the conditions under which an incomplete string such as *Wallace saw Gromit in* forms a constituent are not entirely clear. Furthermore, the *Parser is Grammar* approach that Phillips assumes is per definition not process-neutral as Sag & Wasow (2011: 371) point out. Hence, this model is not suited as a competence model that has any relevance for production, which starts out with meaning.

Chesi (2015) suggests a top-down derivational approach. For nonlocal dependencies he assumes a store that is basically equivalent to the percolation mechanism suggested by Gazdar (1981), the one that is used in GPSG and HPSG (Borsley & Crysmann 2018, Chapter 14 of this volume). While this top-down mechanism is better suited for parsing than the bottom-up procedures generally assumed, it fails in cases of noisy input. Humans are capable of working on partial input an this is perfectly compatible with constraint-based models of grammars (Pullum & Scholz 2001: Section 3.2) while derivational models be they top-down or bottom-up will be stuck depending on the situation. Like Phillips' proposal, Chesi's approach is also not suited for performance models of production.

A solution to the problem of compatibility with psycholinguistic results would be to drop the rhetoric about interfaces and any assumptions about directions of processing. This is possible for many of the works currently published in Minimalism. One would then get theories with Internal and External Merge that would basically be variants of Categorial Grammar (Berwick & Epstein 1995; Müller 2013: Section 2.3). As Müller (2013: 938–941) shows, Internal Merge corresponds to HPSG's Filler-Head-Schema and External Merge to the Specifier-Head Schema and the Head-Complement Schema. If statements about Phases and the order of derivations are avoided, certain Minimalist theories are translatable into

HPSG structures and hence are compatible with constraint-based views on grammar.[34]

5.2 Acquisition

Acquisition has long been a central concern for Chomskyans and it has long been argued that acquisition is made possible by the existence of a complex innate language faculty (Chomsky 1965: Section I.8). Since the early 1980s the dominant view has been that the language faculty consists of a set of principles responsible for the properties which languages share and a set of parameters responsible for the ways in which they may differ (Chomsky 1981: 6). On this view acquiring a grammatical system is a matter of parameter-setting (Chomsky 2000: 8). Proponents of HPSG have always been sceptical about these ideas (see e.g., the remarks about parameters in Pollard & Sag (1994: 31) and have favoured accounts with "an extremely minimal initial ontology of abstract linguistic elements and relations" (Green 2011: 378). Thus, the two frameworks appear to be very different in this area. It is not clear, however, that this is really the case.

The idea that acquiring a grammatical system is a matter of parameter-setting is only as plausible as the idea of a language faculty with a set of parameters. It seems fair to say that this idea has not been as successful as was hoped when it was first introduced in the early 1980s. Outsiders have always been sceptical, but they have been joined in recent times by researchers sympathetic to many Chomskyan ideas. Thus, Newmeyer (2005: 75) writes as follows:

> [...] empirical reality, as I see it, dictates that the hopeful vision of UG as providing a small number of principles each admitting of a small number of parameter settings is simply not workable. The variation that one finds among grammars is far too complex for such a vision to be realized.

At least some Minimalists have come to similar conclusions. Thus, Boeckx (2011: 206) suggests that:

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[34]Of course some of the resulting analyses would be very different in spirit. For instance, it is usually not assumed that subjects of non-finite verbs are realized as traces and moved to positions higher up in the tree (see Section 4.2.4). The point here is that representational variants of Minimalism are possible much in the way of the representational variants of GB that were common in the 80ies (Koster 1978; 1987: 235; Kolb & Thiersch 1991; Haider 1993: Section 1.4; Frey 1993: 14; Lohnstein 1993: 87–88, 177–178; Fordham & Crocker 1994: 38). See also Veenstra (1998: 58) for a representational implementation of Minimalism.

> some of the most deeply-embedded tenets of the Principles-and-Parameters approach, and in particular the idea of Parameter, have outlived their usefulness. (Boeckx 2011: 206)

Much the same view is expressed in Hornstein (2009: 164–168).

A major reason for scepticism about parameters is that estimates of how many there are seem to have steadily increased. Fodor (2001: 734) considers that there might be just twenty parameters, so that acquiring a grammatical system is a matter of answering twenty yes/no-questions. Newmeyer (2005: 44) remarks that "I have never seen any estimate of the number of binary-valued parameters needed to capture all of the possibilities of core grammar that exceeded a few dozen". However, Roberts & Holmberg (2005) comment that "[n]early all estimates of the number of parameters in the literature judge the correct figure to be in the region of 50–100". Clearly, a hundred is a lot more than twenty. Newmeyer (2017: Section 6.3) speaks of "hundreds, if not thousands". This is worrying. As Newmeyer (2006: 6) observes, "it is an ABC of scientific investigation that if a theory is on the right track, then its overall complexity decreases with time as more and more problematic data fall within its scope. Just the opposite has happened with parametric theory. Year after year more new parameters are proposed, with no compensatory decrease in the number of previously proposed ones.".

The growing scepticism appears to tie in with the proposal by Hauser, Chomsky & Fitch (2002: 1573) that "FLN [the "Faculty of language–narrow sense"] comprises only the core computational mechanisms of recursion as they appear in narrow syntax and the mappings to the interfaces". On this view there seems to be no place for parameters within FLN. This conclusion is also suggested by Chomsky's remarks (2005) that "There is no longer a conceptual barrier to the hope that the UG [Universal Grammar] might be reduced to a much simpler form" (p. 8) and that "we need no longer assume that the means of generation of structured expressions are highly articulated and specific to language" (p. 9). It's hard to see how such remarks are compatible with the assumption that UG includes 50–100 parameters. But if parameters are not part of UG, it is not at all clear what their status might be.

It looks, then, as Chomskyans are gradually abandoning the idea of parameters. But if it is abandoned, grammar acquisition is not a matter of parameter-setting. Hence, it is not clear that Chomskyans can invoke any mechanisms that are not available to HPSG.

This might suggest that HPSG and Minimalism are essentially in the same boat where acquisition is concerned. However, this is not the case given the very different nature of grammatical systems in the two frameworks. The complex and

abstract structures that are the hallmark of Minimalism and earlier Chomskyan frameworks pose major problems for acquisition.

> There is a related point about acquisition, which I make in my comparative syntax paper as follows:
>
> One might think that the acquisition task is fairly simple if languages have essentially the same structures differing only in what is and what is not visible. But this seems doubtful. As Fodor (2001: 765) puts it, 'It is clear now that even if the structural scaffolding of sentences is everywhere fixed and the same, any particular sentence may be highly ambiguous with respect to how its words are attached to that scaffolding '. Essentially, the more complex the structure of sentences is and the more invisible material it may contain, the harder it is for the learner to determine where anything is. As Fodor (2001: 763) comments, on this view, 'natural language design is extremely cruel to children'.

Furthermore the machinery that is assumed in addition to the basic operations Internal and External Merge are by no means trivial. There are numerations (subsets of the lexicon) that are assumed to play a role in a derivation, there is Agree and it has to be somehow acquired what the restriction on possible probe/goal relations is. There is feature checking, some features are uninterpretable others are not, some are strong others are weak. Certain categories are Phase boundaries others are not. There are complex conditions on Labeling. It is this that has led to the assumption that acquisition must be assisted by a complex language faculty. In contrast, HPSG structures are quite closely related to the observable data and so pose less of a problem for acquisition and hence create less need for some innate apparatus. Thus, HPSG probably has an advantage over Minimalism in this area too.

5.3 Restrictiveness

There is one further issue that we should discuss here. It appears to be quite widely assumed that one advantage that Minimalism has over alternatives like HPSG is that it is more "restrictive", in other words that it makes more claims about what is and is not possible in language. It looks then as if there might be an argument for Minimalism here. It is not clear, however, that this is really the case.

Minimalism would be a restrictive theory making interesting claims about language if it assumed a relatively small number of parameters. However, it seems that the idea that there is just a small number of parameters seems to have been abandoned, and at least some minimalists have abandoned the idea of parame-

ters altogether (see Section 5.2). If there is either a large number of parameters or no parameters at all, Minimalism is not restrictive in the way that it once was. However, it does still embody some restrictions on grammatical systems. The assumption that syntactic structures are confined to binary branching is an important restriction, as is the assumption that expressions produced by Merge have the same label as one of the expressions that they consist of. But we have argued that both assumptions are quite dubious. It also seems to be assumed that case and agreement are features of all grammatical systems. This would be another important restriction, but this also seems dubious given that many languages show no clear evidence for one or both of these features. It looks to us, then, as if the restrictiveness of Minimalism is largely a matter of imposing certain dubious restrictions on grammatical systems.

Note also that there are problems with restrictiveness of a more formal nature. Earlier versions of MGG assumed $\overline{X}$ theory and although this was not assumed initially it was quickly argued that the $\overline{X}$ scheme is universal and that this is a restriction on grammatical systems that aids language acquisition (Haegeman 1994: 106). However, Kornai & Pullum (1990: 41, 47) show that $\overline{X}$ theory is not restrictive at all as soon as empty elements are allowed in grammars: all languages that can be analyzed with a context-free grammar can be analyzed with an $\overline{X}$ grammar with empty heads. Chomsky (1995b: Section 4.3) abandoned $\overline{X}$ theory and replaced it by notions like first-merged and later-merged (Chomsky 1995b: 245; 2008) but the principled problem remains. Since as many empty heads as needed can be assumed in any position the predictions as far as restrictiveness is concerned are limited. See also Hornstein (2009: 165) and Starke (2014: 140) on heads and features and restrictiveness.

An example that is usually discussed when it comes to restrictiveness is question formation (Musso et al. 2003). Researchers in MGG state that certain ways of expressing things do never occur although they may be imaginable. So the question is asked why questions are never formed by reversing the order of words in a string. So rather than (54b) the question that would correspond to (54a) would be (54c):

(54) a. Kim saw Sandy near the swimming pool.
      b. Did Kim see Sandy near the swimming pool?
      c. Pool swimming the near Sandy saw Kim?

Interestingly, such reorderings can be derived in systems that allow for so-called *remnant movement*, as Hubert Haider (p. c. 2018) pointed out. The element 5 can move to the left of 4. The unit containing 4 and 5 can move to the left of 3 and

[[5 [4 _]] [3 _]] can move to the left of 2 and so on.

(55)   a. [1 [2 [3 4]]]

        b. [3 4] → [4 [3 _]] → [2 [4 [3 _]]] → [[4 [3 _]] [2 _]] →
            [1 [[4 [3 _]] [2 _]]] → [[[4 [3 _]] [2 _]] [1 _]]

Of course there are reasons for the absence of certain imaginable constructions
in the languages of the world. The reason for the absence of question forma-
tion like (54c) is simply short-term memory. Operations like those are ruled out
due to performance constraints and hence should not be modeled in competence
grammars. So it is unproblematic that remnant movement systems allow the
derivation of strings with reverse order and it is unproblematic that one might
develop HPSG analyses that reverse strings. Similarly certain other restrictions
have been argued not to be part of the grammar proper. For instance Subjacency
(Baltin 1981: 262; 2006; Rizzi 1982: 57; Chomsky 1986: 38–40) does not hold in
the form stated in MGG (Müller 2004; 2016a: Section 13.1.5) and it is argued that
several of the island constraints should not be modeled by hard constraints in
competence grammars. See Chaves (2018), Chapter 16 of this volume for further
discussion.

It is true that the basic formalism does not pose any strong restrictions on
what could be said in an HPSG theory. As Pollard (1996) points out, this is the
way it should be. The formalism should not be the constraining factor. It should
be powerful enough to allow everything to be expressed in insightful ways and
in fact, the basic formalism of HPSG has Turing-power, the highest power in
the Chomsky hierarchy (Pollard 1999). This means that the general formalism
is above the complexity that is usually assumed for natural languages: mildly
context-sensitive. What is important though is that theories of individual lan-
guages are much more restrictive, getting the generative power down (Müller
2016a: Chapter 17).

These remarks should not be understood as a suggestion that languages vary
without limit, as Joos (1958: 96) suggested. No doubt there are universal tenden-
cies and variation is limited, but the question is whether this is due to innate lin-
guistic constraints or rather the question of what we do with language and how
our general cognitive capabilities are structured. While Minimalism starts out
with claims about universal features about languages and tries to confirm these
claims in language after language, researchers working in HPSG aim to develop
fragments of languages that are motivated by facts from these languages and gen-
eralize over several internally motivated grammars. This leaves the option open
that languages have very little in common as far as syntax is concerned. For

example, Koenig & Michelson (2012) discuss the Northern Iroquoian language Oneida and argue that this language does not have syntactic valence. If they are correct, not even central concepts like valence and argument structure would be universal. The only remaining universal would be that we combine linguistic objects. This corresponds to Merge in Minimalism, without the restriction to binarity.

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6 Todo

feature-driven movement

- there is altruistic movement

- If movement is cyclic and has to consume features and if it is unbounded, there have to be infinitely many lexical items per moved item. This follows from the argumentation of languages as infinite sets. Following the same logic the lexicon has to be infinite. This adds to the problem of determining the numeration.

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Chapter 34

HPSG and Categorial Grammar

Yusuke Kubota

University of Tsukuba

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1 Introduction

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Abbreviations

Acknowledgements

Chapter 35

HPSG and Lexical Functional Grammar

Doug Arnold

University of Essex

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1 Introduction

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Abbreviations

Acknowledgements

Chapter 36

HPSG and Dependency Grammar

Dick Hudson

London

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1 Two centuries of syntactic theory

In the early 19th century, European grammar was still dominated by the Latin grammar of Priscian which focused on individual words, their morphosyntactic properties and their relations (controlled especially by government and agreement); grammars and grammatical theory were mainly focused on school pedagogy, where the dominant model was the parsing of individual words. But these ideas, and especially government, defined 'dependency' relations holding most words together. The exception was the relation between the verb and its subject, which was still described in terms of the dominant classical logic based on the subject-predicate split. Putting these two traditions together, grammarians produced a mixed theory of sentence structure and a number of diagramming systems to represent such structures – most famously, the diagramming system invented in the USA by Reed & Kellogg (1877) (and still taught in the 21st century in some American schools). This is also the theory that Bloomfield brought back to the USA from Germany, and which he developed into Immediate Constituent analysis (which later turned into phrase-structure analysis); as in the earlier theory, the subject and predicate were equal, in contrast with other 'endocentric' constructions. Bloomfield combined this mixed theory with Wundt's theory of cognition, with the sentence as the 'whole' which defines its parts (and the word no longer in prime position), which allowed a consistent geometry, but phrase-structure trees did not appear till the middle of the 20th century. Meanwhile, however, both Humboldt and Grimm had suggested that the verb was

the sole head of the sentence, with the subject as one of its dependents, and by the 1860s and 1870s, grammarians in Hungary, Russia and Germany (apparently working independently) were arguing for this view, half a century before it was formalised by Tesniere and named 'dependency analysis'. The first 'stemma' diagram appeared (in Hungary) in 1873. Another 19th-century reaction against classical logic was the logical tradition started (in Germany) by Frege, who may have learned to draw stemmas at school; this tradition gave rise (in Poland) to categorial grammar, which some (including Chomsky) see as a version of dependency analysis. One outcome of this history was the present-day geographical split between American phrase structure (PS) and European dependency structure (DS). Variations on the dependency theme Unsurprisingly, therefore, dependency theory has had more impact on Europeans than on Americans. The general idea of word-word dependencies was built into a number of different theoretical packages which combined it with other ideas, notably multiple levels (the Russian Mel'cuk) and information structure (the Czechs Sgall and Hajicova). However, dependency structure has also been popular internationally in natural-language processing (represented perhaps most notably by the Stanford Parser). 'Plain-vanilla' versions of DS and PS are very similar and are weakly equivalent, but as with phrase structure, such theories need to be supplemented, giving rise to theories in which structures are much richer. One such theory is Word Grammar (WG), which is probably closer to HPSG than any of the other DS theories. In WG, a word is allowed to depend on more than one other word (like re-entrance in HPSG) and dependencies are combined with extra mechanisms for coordination and for word order. This theory will be the main point of comparison with HPSG in the rest of the chapter.

2 Signs, constructions and levels

The contrast between PS and DS is orthogonal to choices about the number of levels (syntax, morphology, etc) and how they are related, but of course these choices are essential for any theoretical package. As in PS theories, different DS theories assume different answers, but Word Grammar takes a rather conservative position in which syntax is distinct both from morphology and from semantics. This view is hard to reconcile with the claim that language consists of 'constructions' or 'signs', both of which assume a direct link between 'form' and 'meaning'. In this view, units of phonological 'form' are only indirectly linked to units of meaning. Approaches which evoke 'signs' or 'constructions' can also be challenged for their conservative assumptions about plain-vanilla surface PS.

Arguably, DS is a better basis for capturing the fine detail of idiosyncratic constructions since these always involve individual lexical items linked by dependencies, and typically focus on just one dependent of a given lexeme rather than on entire multi-dependent phrases. Networks WG takes the whole of language (not just the lexicon) to be a gigantic network, which is a step further than HPSG (where PS rules are outside the network); the network is also not assumed to be a DAG because mutual dependency is allowed. One of the characteristics of network analyses is the central role of relation types (i.e. HPSG attributes). According to WG, but not HPSG, these types form a typed hierarchy which parallels the typed hierarchy of non-relational 'entities' such as words, phonemes and so on; and in both hierarchies, properties are inherited by (a special formalisation of) default inheritance. One of the consequences of this treatment of relations is that, just like entities, they can freely be created and learned as required, so there is no need to assume a universal hard-wired reservoir of relations. This is particularly helpful in DS, where dependencies are typed but different languages require different classifications and distinctions. Word order Another similarity between WG and HPSG is in the treatment of word order. In both theories, dominance (i.e. daughterhood in HPSG and dependency in WG) is separated from linear precedence. In WG, a word's position is treated as one of the word's property's linked to a second property ('landmark'), the word from which it takes its position; the word's landmark is normally the word on which it depends, but exceptions are allowed in cases such as extraction and pied piping. The landmark relation allows a treatment of pied piping which avoids the feature-percolation of HPSG.

3 Words, nodes and semantic phrases

The final topic is the Achille's heel of DS: the completely flat structures where a word has two or more dependents. This is problematic in DS (but not, of course, in HPSG) in examples such as typical French house, meaning 'typical for a French house', because there is no syntactic node that could carry the meaning 'French house'. Current WG provides a solution which moves WG in the direction of PS by distinguishing types from tokens, and then distinguishing 'sub-tokens' of tokens. In this analysis, the token house is distinct not only from the type HOUSE, but also from the sub-token house' which is modified by the dependent French, which in turn is distinct from house'' modified by typical. Sub-tokens are very similar in function to the phrases of HPSG but arguably not quite equivalent.

Abbreviations

Acknowledgements

References

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Chapter 37

HPSG and Construction Grammar

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This chapter discusses the main tenets of Construction Grammar (CxG) and shows that HPSG adheres to them. This discussion includes surface orientation, language acquisition without UG, inheritance networks and shows how HPSG (and other frameworks) are positioned along these dimensions. Formal variants of CxG will be briefly discussed and their relation to HPSG will be pointed out. It is argued that lexical representations of valence are more appropriate than phrasal approaches, which are assumed in most variants of CxG. Other areas of grammar seem to require headless phrasal constructions (e.g., the NPN construction and certain extraction constructions) and it is shown how HPSG handle these. Derivational morphology is discussed as a further example of an early constructionist analysis in HPSG.

This chapter deals with Construction Grammar (CxG) and its relation to HPSG. The short version of the message is: HPSG is a Construction Grammar. It was one right from the beginning and over the years certain aspects were adapted allowing to capture generalizations over phrasal patterns. In what follows I will first say what Construction Grammars are (Section 1), I will explain why HPSG as developed in Pollard & Sag (1987; 1994) was a Construction Grammar and how it was changed to become even more Constructive (Section 1.2.3). Section 2 deals with so-called argument structure constructions, which are usually dealt with by assuming phrasal constructions in CxG and explains why this is problematic and why lexical approaches are more appropriate. Section 3 explains Construction Morphology, Section 4 shows how cases that should be treated phrasally can be handled in HPSG. Section 5 sums up the paper.

Stefan Müller

1 What is Construction Grammar?

The first question to answer in a chapter like this is: what is Construction Grammar? While it is relatively clear what a Construction is, the answer to the question regarding Construction Grammar is less straight-forward. Section 1.1 provides the definition for the term *Construction* and Section 1.2 states the tenets of CxG and discusses to what extent the main frameworks currently on the market adhere to them.

1.1 The notion Construction

Goldberg (2006: 5) defines Construction as follows:

> Any linguistic pattern is recognized as a construction as long as some aspect of its form or function is not strictly predictable from its component parts or from other constructions recognized to exist. In addition, patterns are stored as constructions even if they are fully predictable as long as they occur with sufficient frequency. (Goldberg 2006: 5)

She provides Table 1 with examples for Constructions.

> BB: I understand her view is that constructions must have a distinctive meaning. I believe Jackendoff argues against this, and Newmeyer and I did here: Borsley & Newmeyer (2009)

Table 1: Examples of constructions, varying in size and complexity according to Goldberg (2009)

Word	e.g., *tentacle, gangster, the*
Word (partially filled)	e.g., *post*-N, V-*ing*
Complex word	e.g., *textbook, drive-in*
Idiom (filled)	e.g., *like a bat out of hell*
Idiom (partially filled)	e.g., *believe* <one's> *ears/eyes*
Covariational Conditional	The Xer the Yer
	(e.g., *The more you watch the less you know*)
Ditransitive	Subj V Obj1 Obj2
	(e.g., *She gave him a kiss*;
	He fixed her some fish tacos.)
Passive	Subj aux VPpp (PPby)
	(e.g., *The cell phone tower was struck by lightening.*)

If one just looks at the definition of Construction, all theories currently on the market could be regarded as Construction Grammars. As Peter Staudacher pointed out in the discussion after a talk by Knud Lambrecht in May 2006 in Potsdam, lexical items are form-meaning pairs and the rules of phrase structure grammars come with specific semantic components as well, even if it is just functional application. So, Categorial Grammar, GB, GPSG, TAG, LFG, HPSG and even Minimalism would be Construction Grammars. If one looks at the examples of Constructions in Table 1 things change a bit. Idioms are generally not the focus of work in Mainstream Generative Grammar (MGG)[1]. MGG is usually concerned with explorations of the so-called Core Grammar as opposed to the Periphery, to which the idioms are assigned. The Core Grammar is the part of the grammar that is supposed to be acquired with help of innate domain specific knowledge, something the existence of which Construction Grammar denies. But if one takes Hauser, Chomsky & Fitch (2002) seriously and assumes that only the ability to form complex linguistic objects out of less complex linguistic objects (Merge) is part of this innate knowledge then the core/periphery distinction does not have much content and after all Minimalists could adopt a version of Sag's local, selection-based analysis of idioms (Sag 2007; Kay et al. 2015; Kay & Michaelis 2017). However, as is discussed in the next subsection, there are other aspects that really set Construction Grammar apart from MGG.

1.2 Basic tenets of Construction Grammar

Goldberg (2003) names the following tenets as core assumptions standardly made in CxG. form-meaning pairs):

Tenet 1 All levels of description are understood to involve pairings of form with semantic or discourse function, including morphemes or words, idioms, partially lexically filled and fully abstract phrasal patterns. (See Table 1)

Tenet 2 An emphasis is placed on subtle aspects of the way we conceive of events and states of affairs.

Tenet 3 A 'what you see is what you get' approach to syntactic form is adopted: no underlying levels of syntax or any phonologically empty elements are posited.

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[1]The term *Mainstream Generative Grammar* is used to refer to work in Transformational Grammar, for example Government & Binding (Chomsky 1981) and Minimalism (Chomsky 1995). Some authors working in Construction Grammar see themselves in the tradition of Generative Grammar in a wider sense, see for example Fillmore, Kay & O'Connor (1988: 501).

Tenet 4 Constructions are understood to be learned on the basis of the input and general cognitive mechanisms (they are constructed), and are expected to vary cross-linguistically.

Tenet 5 Cross-linguistic generalizations are explained by appeal to general cognitive constraints together with the functions of the constructions involved.

Tenet 6 Language-specific generalizations across constructions are captured via inheritance networks much like those that have long been posited to capture our non-linguistic knowledge.

Tenet 7 The totality of our knowledge of language is captured by a network of constructions: a 'construct-i-con.'

I already commented on Tenet 1 above. Tenet 2 concerns semantics and the syntax-semantics interface, which are part of most HPSG analyses. In what follows I want to look in more detail at the other tenets.

1.2.1 Surface orientation and empty elements

Tenet 3 requires a surface-oriented approach. Underlying levels and phonologically empty elements are ruled out. This excludes derivational models of transformational syntax assuming a D-structure and some derived structure or more recent derivational variants of Minimalism. There was a time where representational models of GB that did not assume a D-structure but just one structure with traces (Koster 1978: 1987: 235; Kolb & Thiersch 1991; Haider 1993: Section 1.4; Frey 1993: 14; Lohnstein 1993: 87–88, 177–178; Fordham & Crocker 1994: 38; Veenstra 1998: 58). Some of these analyses are rather similar to HPSG analyses as they are assumed today (Kiss 1995; Bouma & van Noord 1998; Meurers 2000; Müller 2005; 2017a; 2018b). Chomsky's Minimalist work (Chomsky 1995) assumes a derivational model and comes with a rhetoric of building structure in a bottom-up way and sending complete phases to the interfaces for pronunciation and interpretation. This is incompatible with Tenet 3, but in principle Minimalist approaches are very similar to Categorial Grammar, so there could be representational approaches adhering to Tenet 3.

> Rui: In Top-down Phase-based Minimalist Grammar (TPMG) as developed by Chesi (2012; 2007), and Bianchi & Chesi (2006; 2012), there is no movement. Rather, wh-phrases are linked to their "in situ" positions with the aid of a short-term memory buffer that functions like a stack. See also Hunter (2010) and Hunter (2018) for a related account where the information about the presence of a wh-phrase is percolated in the syntax tree, like in GPSG/HPSG. These references may be of use here.

A comment on empty elements is in order: all articles introducing Construction Grammar state that CxG does not assume empty elements. Most of the alternative theories do use empty elements: see König (1999) on Categorial Grammar, Gazdar, Klein, Pullum & Sag (1985: 143) on GPSG, Bresnan (2001: 67) on LFG, Bender (2000) and Sag, Wasow & Bender (2003: 464) on HPSG/Sign-Based Construction Grammar. There are results from the 60s that show that phrase structure grammars containing empty elements can be translated into grammars that do not contain empty elements (Bar-Hillel, Perles & Shamir 1961: 153, Lemma 4.1). Grammars with empty elements often are more compact than those without empty elements and express generalizations more directly. See for example Bender (2000) for copulaless sentences in African American Venacular English and Müller (2014) on nounless NPs in German. The argument against empty elements usually refers to language acquisition: it is argued that empty elements cannot be learned since they are not present in the input. However, if the empty elements alternate with visible material it can be argued that what is learned is the fact that a certain element can be left out. What is true though is that things like empty expletives cannot be learned since these empty elements are neither visible nor do they contribute to meaning. Their only purpose in grammars is to keep uniformity. For example, Grewendorf (1993) suggests an analysis of the passive in German that is parallel to the movement-based analysis of English passives. In order to account for the fact that the subject does not move in German, he suggests an empty expletive pronoun that takes the subject position and that is connected to the original non-moved subject. Such elements cannot be acquired without innate knowledge about the IP/VP system and constraints about the obligatory presence of subjects. The CxG criticism is justified here.

A frequent argumentation for empty elements in MGG is based on the fact that there are overt realizations of an element in other languages (e.g., object agreement in Basque and focus markers in Gungbe). But since there is no language internal evidence for these empty elements they cannot be learned and one would have to assume that they are innate. This kind of empty elements is rightly rejected.

1.2.2 Language acquisition without the assumption of UG

Tenet 4 and 5 are basically what everybody should assume in MGG if Hauser, Chomsky & Fitch (2002) are taken seriously. Of course this is not what is done in large parts of the filed. The most extreme variant being Cinque & Rizzi (2010), who assume at least 400 functional heads being part of Universal Grammar (UG) and being present in all grammars of all languages although sometimes invisibly. Such assumptions beg the question why the genera of Bantu languages should be part of our genome and how they got there. Researchers working on language acquisition realized that the Principles & Parameters approach (Meisel 1995) makes wrong predictions. They now talk about Micro-Cues instead of parameters (Westergaard 2014) and these Micro-Cues are just features that can be learned. However, Westergaard still assumes that the features are determined by UG, a dubious assumption seen from a CxG perspective (and from the perspective of Hauser, Chomsky, Fitch and genetics in general (Bishop 2002)).

Note that even those versions of Minimalism that do not follow the Rizzi-style Cartographic approaches are far from being minimalist in their assumptions. Some distinguish between strong and weak features, some assume enumerations of lexical items from which a particular derivation draws its input from, some assume that all movement has to be feature driven. Some assume that derivations work in so-called phases and that a phase once completed is "shipped to the interfaces". Construction of phases is bottom up, which is incompatible with psycholinguistic results (see also Borsley & Müller 2018: Section 5.1, Chapter 33 in this volume). None of these assumptions is a natural assumption to make from a language acquisition point. Most of these assumptions do not have any real motivation in data, the only motivation usually given is that they result in "restrictive theories". But if there is no motivation for them, this means that the respective architectural assumptions have to be part of our innate domain-specific knowledge, which is implausible according to Hauser, Chomsky & Fitch (2002).

As research in computational linguistics shows, our input is rich enough to form classes, to determine the part of speech of lexical items and even to infer syntactic structure thought to be underdetermined by the input. For instance, Bod (2009) shows that the classical auxiliary inversion examples that Chomsky still uses in his Poverty of the Stimulus arguments (Chomsky 1971: 29–33; Berwick, Pietroski, Yankama & Chomsky 2011) can also be learned from language input available to children. See also Freudenthal et al. (2006; 2007) on input-based language acquisition.

HPSG does not make any assumptions about complicated mechanisms like

feature driven movement and so on. HPSG states properties of linguistic objects like part of speech, case, gender and so on and states relations between such features like agreement and government. In this respect it is like other Construction Grammars and hence experimental results regarding and theories of language acquisition can be carried over to HPSG. See also Ginzburg (2018), Chapter 27 of this volume on language acquisition.

1.2.3 Inhertiance networks

This leaves us with Tenet 6 and 7, that is *inheritance networks* and the constructicon. MGG does not make reference to inheritance hierarchies. HPSG did this right from the beginning in 1985 (Flickinger et al. 1985) for lexical items and since 1995 also for phrasal constructions (Sag 1997). LFG rejected the use of types but used macros in computer implementations. The macros were abbreviatory devices and did not play any role in theoretical work. This changed in 2004 where macros were suggested in theoretical work (Dalrymple, Kaplan & King 2004). And although any connection to constructionist work is vehemently denied by some of the authors, recent work in LFG has a decidedly constructional flavor (Asudeh, Dalrymple & Toivonen 2008; 2014).[2] LFG differs from frameworks like HPSG though in assuming a separate level of c-structure. c-structure rules are basically context free phrase structure rules and they are not modeled by feature value pairs (although they could be (Kaplan 1995)). This means that it is not possible to capture generalizations regarding lexical items, lexical rules and phrasal schemata. While HPSG describes all of these elements with the same inventory and hence can use common supertypes in the description of all three, this is not possible in LFG. TAG is also using inheritance in the Meta Grammar (Lichte & Kallmeyer 2017).

> citep* yields wrong results here

> add reference

Since HPSG's lexical entries, lexical rules and phrasal schemata are all described by typed feature descriptions one could call the set of these descriptions the constructicon. Therefore, tenet 7 is also adhered to.

1.2.4 Summary

If all these points are taken together, it is clear that most variants of MGG are not Construction Grammars. However, CxG had considerable influence on other frameworks so that there are constructionist variants of LFG and TAG. HPSG in the version of Sag (1997) (also called Constructional HPSG) and the HPSG dialect

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[2]See Toivonen (2013: 516) for an explicit reference to construction-specific phrase structure rule in the senese of Construction Grammar.

Sign-Based Construction Grammar are Construction Grammars that follow all the tenets mentioned above.

1.3 Variants of Construction Grammar

The previous section discussed the tenets of CxG and to what degree other frameworks adhere to them. This section deals with frameworks that have Construction Grammar explicitly in their name. The following variants are usually named:

- Berkeley Construction Grammar (Fillmore 1988; Kay & Fillmore 1999; Fried 2015)

- Cognitive Construction Grammar (Lakoff 1987; Goldberg 1995; 2006)

- Cognitive Grammar (Langacker 1987; 2000; 2008; Dąbrowska 2004)

- Radical Construction Grammar (Croft 2001)

- Embodied Construction Grammar (Bergen & Chang 2005)

- Fluid Construction Grammar (Steels & De Beule 2006; Steels 2011)

- Sign-Based Construction Grammar (Sag 2010; 2012)

Berkely Construction Grammar, Embodied Construction Grammar, Fluid Construction Grammar, and Sign-Based Construction Grammar are the ones that are more formal. All of these variants use feature value pairs and are constraint-based. They are sometimes also referred to as unification-based approaches. Berkeley Construction Grammar never had a consistent formalization. The variant of unification assumed by Kay & Fillmore (1999) was formally inconsistent (Müller 2006a: Section 2.4) and the computation of construction-like objects (CLOs) suggested by Kay (2002) did not work either (Müller 2006a: Section 3). Berkeley Construction Grammar was dropped by the authors, who joined forces with Ivan Sag, and Laura Michaelis and eventually came up with an HPSG variant named Sign-Based Construction Grammar (Sag 2012). The differences between Constructional HPSG (Sag 1997) and SBCG are to some extent cosmetic: semantic relations got the suffix *-fr* for *frame* (*like-rel* became *like-fr*), phrases were called constructions (*hd-subj-ph* became *subj-head-cxt*) and lexical rules were called *derivational constructions*.[3] While this renaming would not have changed anything in terms of expressiveness of theories, there was another change that was

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[3]This renaming trick was so successful that it even confused some of the co-editors of the volume about SBCG (Boas & Sag 2012). See for example Boas (2014) and the reply in Müller & Wechsler (2014b).

not motivated by any of the tenets of Construction Grammar but rather by the wish to get a more restrictive theory: Sag, Wasow & Bender (2003) and Sag (2007) changed the feature geometry of phrasal signs in a way that signs do not contain daughters. The information about mother-daughter relations is contained in lexical rules and phrasal schemata (Constructions) only. The phrasal schemata are more like GPSG phrase structure rules in licensing a mother node when certain daughters are present but without the daughters being part of the mother as it was common in HPSG from 1985 till Sag, Wasow & Bender (2003). This differs quite dramatically from what was done in Berkeley Construction Grammar, since BCxG explicitly favored a non-local approach. Arguments were not cancelled but passed up to the mother node. Adjuncts were passed up as well so that the complete internal structure of an expression is available at the top-most node. The advantage of BCxG (Fillmore, Kay & O'Connor 1988) and Constructional HPSG (Sag 1997) is that complex expressions (e.g., idioms and other more transparent expressions with high frequency) can be stored as chunks containing the internal structure. This is not possible with SBCG, since phrasal signs never contain internal structures. For a detailed discussion of Sign-Based Construction Grammar see Müller (2016: Section 10.6.2).

Rui: Head feature principle, LID from Berkeley CxG

Embodied Construction Grammar (Bergen & Chang 2005) uses typed feature descriptions for the description of linguistic objects and allows for discontinuous constituents. As argued by Müller (2016: Section 10.6.3), it is a notational variant of Reape-style HPSG (Reape 1994) (see Müller 2018: Section 6, Chapter 10 of this volume for discontinuous constituents in HPSG).

Fluid Construction Grammar is also rather similar to HPSG. An important difference is that FCG attaches weights to constraints, something that is usually not done in HPSG. But in principle there is nothing that forbids to add weights to HPSG as well and in fact it has been done (Brew 1995; Briscoe & Copestake 1999; Miyao & Tsujii 2008) and it should be done to a larger extent (Miller 2013). Van Trijp (2013) tried to show that Fluid Construction Grammar is fundamentally different from SBCG but I think he failed in every single respect. See Müller (2017b) for a detailed discussion, which cannot be repeated here for space reasons.

What makes SBCG different from other Construction Grammars is that SBCG assumes a strongly lexicalist stance (Sag & Wasow 2011): argument structure is encoded lexically. A ditransitive verb is a ditransitive verb since it selects for three NP arguments. This selection is encoded in valence features of lexical items. It is not assumed that phrasal configurations can license additional arguments as it is in Radical Construction Grammar, Embodied Construction Gram-

mar and in Fluid Construction grammar. The next section discusses phrasal CxG approaches in more detail. Section 4 then discusses patterns that should be analyzed phrasally and which are problematic for entirely head-driven (or rather functor-driven) theories like Categorial Grammar, Dependency Grammar and Minimalism.

2 Valence vs. phrasal patterns

Much work in Construction Grammar starts from the observation that children acquire patterns and get more abstract leaving slots to be filled in in later acquisition stages (Tomasello 2003). The conclusion that is drawn from this is that language should be described with reference to phrasal patterns. Most Construction Grammar variants assume a phrasal approach to argument structure constructions (Goldberg 1996; 2006; Goldberg & Jackendoff 2004), Constructional HPSG and SBCG being the two exceptions.

> Boas

I argued in several publications that the language acquisition facts can be explained in lexical models as well (Müller 2010: Section 6.3; Müller & Wechsler 2014a: Section 9). While a pattern-based approach claims that (1) is analyzed by inserting *Kim*, *loves*, and *Sandy* into a phrasal schema stating that NP[nom] verb NP[acc] or subject verb object are possible sequences in English, a lexical approach would state that there is a verb *loves* selecting for an NP[nom] and an NP[acc] (or for a subject and an object).

(1)   Kim loves Sandy.

Since objects follow the verb in English (modulo extraction) and subjects precede the verb, the same sequence is licensed in the lexical approach. The lexical approach does not have any problems with accounting for patterns in which the sequence of subject, verb and object is discontinuous. For example, an adverb may intervene between subject and verb:

(2)   Kim really loves Sandy.

In a lexical approach it is assumed that verb and object may form a unit (a VP). The adverb attaches to this VP and the resulting VP is combined with the subject. The phrasal approach has to assume that either adverbs are part of phrasal schemata licensing cases like (2) (see Uszkoreit (1987: Section 6.3.2) for such a proposal in a GPSG for German) or that the phrasal construction may license discontinuous patterns. Bergen & Chang (2005: 170) follow the latter approach and assume that subject and verb may be discontinuous but verb and object(s)

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have to be adjacent. While this accounts for adverbs like the one in (2), it does not solve the general problem since there are other examples showing that verb and object(s) may appear discontinuously as well:

(3)   Mary tossed me a juice and Peter a water.

Even though *tossed* and *Peter a water* are discontinuous in (3), they are an instance of the ditransitive construction. The conclusion is that what has to be acquired is not a phrasal pattern but rather the fact that there are dependencies between certain elements in phrases. I return to ditransitive constructions in Section 2.3.

I discussed several phrasal approaches to argument structure and showed where they fail (Müller 2006a,b; 2007; 2010; Müller & Wechsler 2014a,b; Müller 2018a). Of course the discussion cannot be repeated here but I want to repeat two points showing that lexical valence representation is necessary. The first two are problems that were around at GPSG times and basically were solved by abandoning the framework and adopting a new framework which was a fusion of GPSG and Categorial Grammar: HPSG.

2.1 Derivational morphology and valence

The first argument (Müller 2016: Section 5.5.1) is that certain patterns in derivational morphology refer to valence. For example, the *-bar* 'able' derivation productively applies to transitive verbs only, that is to verbs that govern an accusative.

(4)   a.   unterstützbar
           supportable

      b.   * helfbar
           helpable

      c.   * schlafbar
           sleepable

Note that *-bar* 'able' derivation is like passive: it surpresses the subject and promotes the accusative object: the accusative object is the element adjectives derived with *-bar* 'able' derivation predicate over. There is no argument realized with the adjective *unterstützbaren* 'supportable' attaching to *Arbeitsprozessen* 'work.processes' in *unterstützbaren Arbeitsprozessen*.[4] Hence one could not claim that the stem enters a phrasal construction with arguments and *-bar* attaches to

---

[4]Adjectives realize their arguments preverbally in German:

this phrase. It follows that information about valency has to be present at the stem.

Note also that the resultative construction interacts with -*bar* 'able' derivation. (5) shows an example of this construction in which the accusative object is introduced by the construction: it is the subject of *leer* 'empty' but not a semantic argument of the verb *fischt* 'fishes'.

(5) Sie fischt den Teich leer.
     she fishes the pond empty

So even though the accusative object is not a semantic argument of the verb, the -*bar* 'able' derivation is possible and an adjective like *leerfischbar* can be derived. This is explained by lexical analyses of the -*bar* 'able' derivation and the resultative construction since if one assumes that there is a lexical item for *fisch*- selecting the accusative object and the result predicate then this item may function as the input for the -*bar* 'able' derivation. See Section 3 for further discussion of -*bar* 'able' derivation and Verspoor (1997), Wechsler (1997), Wechsler & Noh (2001), Müller (2002: Chapter 5) for lexical analyses of the resultative construction in the framework of HPSG.

2.2 Partial verb phrase fronting

The second argument concerns partial verb phrase fronting (Müller 2016: Section 5.5.2). (6) gives some examples: in (6a) the bare verb is fronted and its arguments are realized in the middle field, in (6b) one of the objects is fronted together with the verb and in (6c) both objects are fronted with the verb.

(6) a. Erzählen wird er seiner Tochter   ein Märchen können.
         tell   will he his   daughter a   fairy.tale can

     b. Ein Märchen erzählen wird er seiner Tochter   können.
         a   fairy.tale tell   will he his   daughter can

     c. Seiner Tochter   ein Märchen erzählen wird er können.
         his   daughter a   fairy.tale tell   will he can

         'He will be able to tell his daughter a fairy tale.'

(i)   der [seiner Frau treue]   Mann
      the his   wife faithful man

      'the man who is faithful to his wife'

unterstützbaren 'supportable' does not take an argument it is a complete adjectival projection like *seiner Frau treue*.

The problem with sentences such as those in (6) is that the valence requirements of the verb *erzählen* 'to tell' are realized in various positions in the sentence. For fronted constituents, one requires a rule which allows a ditransitive to be realized without its arguments or with one or two objects. This basically destroys the idea of a fixed phrasal configuration for the ditransitive construction and points again into the direction of dependencies.

Furthermore, it has to be ensured that the arguments that are missing in the prefield are realized in the remainder of the clause. It is not legitimate to omit obligatory arguments or realize arguments with other properties like a different case, as the examples in (7) show:

(7) a. Verschlungen hat er   es   nicht.
         devoured   has he.NOM it.ACC not
         'He did not devour it.'

     b. * Verschlungen hat er   nicht.
           devoured   has he.NOM not

     c. * Verschlungen hat er   ihm   nicht.
           devoured   has he.NOM him.DAT not

The obvious generalization is that the fronted and unfronted arguments must add up to the total set belonging to the verb. This is scarcely possible with the rule-based valence representation in GPSG. In theories such as Categorial Grammar, it is possible to formulate elegant analyses of (7) (Geach 1970). Nerbonne (1986) and Johnson (1986) both suggest analyses for sentences such as (7) in the framework of GPSG which ultimately amount to changing the representation of valence information in the direction of Categorial Grammar. With a switch to CG-like valence representations in HPSG the phenomenon of partial verb phrase fronting found elegant solutions (Höhle 2018: Section 4; Müller 1996; Meurers 1999).

reference to UDC chapter?

2.3 Coercion

An important observation in constructionist work is that in certain cases verbs can be used in constructions that differ from the constructions they are normally used in. For example, verbs that are usually used with one or two arguments may be used in the ditransitive construction:

(8) a. She smiled.
     b. She smiled herself an upgrade.[5]

---

[5]Douglas Adams. 1979. *The Hitchhiker's Guide to the Galaxy*, Harmony Books. Quoted from Goldberg (2003: 220).

c. He baked a cake.

d. He baked her a cake.

The usual explanation for sentences like (8b) and (8d) is that there is a phrasal pattern with three arguments into which intransitive and strictly transitive verbs may be entered. It is assumed that the phrasal patterns are associated with a certain meaning (Goldberg 1996; Goldberg & Jackendoff 2004). For example, the benefactive meaning of (8d) is contributed by the phrasal pattern (Goldberg 1996; Asudeh, Giorgolo & Toivonen 2014: 81).

page number-ber

The insight that a verb is used in the ditransitive pattern and thereby contributes a certain meaning is of course also captured in lexical approaches. Briscoe & Copestake (1999) suggested a lexical rule-based analysis mapping a transitive version of verbs like *bake* onto a ditransitive one and adding the benefactive semantics. This is parallel to the phrasal approach in that it says: three-place *bake* behaves like other three-place verbs (e.g., *give*) in taking three arguments and by doing so it comes with a certain meaning (see Müller 2018a for a lexical rule-based analysis of the benefactive constructions working for both English and German despite the surface-differences of the respective languages). The lexical rule is a form-meaning pair and hence a construction. As Croft put it 15 years ago: Lexical rule vs. phrasal schema is a false dichotomy (Croft 2003).

> BB: You quote Croft as saying that "lexical rule vs. phrasal schema is a false dichotomy". This might suggest that you think there is no real issue here, but of course you have argued that there is.

Briscoe & Copestake (1999) paired their lexical rules with probabilities to be able to explain differences in productivity. This corresponds to the association strength that van Trijp (2011: 141) used to relate lexical items to phrasal constructions of various kinds.

2.4 Non-predictability of valence

The last subsection discussed phrasal proposals of coercion that assume that verbs can be inserted into constructions that are compatible with the semantic contribution of the verb. Müller & Wechsler (2014a: Section 7.4) pointed out that this is not sufficiently constrained. Müller & Wechsler discussed the examples in (9), among others:

(9) a. John depends on Mary. (*counts, relies,* etc.)

b. John trusts (*on) Mary.

While *depends* can be combined with a *on*-PP, this is impossible for *trusts.* Also the form of the preposition of prepositional objects is not always predictable from semantic properties of the verb. So there has to be a way to state that certain verbs go together with certain kinds of arguments and others do not. A lexical specification of valence information is the most direct way to do this. Phrasal approaches sometimes assume other means to establish connections between lexical items and phrasal constructions. For instance, Goldberg (1995: 50) assumes that verbs are "conventionally associated with constructions". The more technical work in Fluid CxG assumes that every lexical item is connected to various phrasal constructions via coapplication links (van Trijp 2011: 141). This is very similar to Lexicalized Tree Adjoining Grammar (LTAG, Schabes, Abeillé & Joshi 1988), where a rich syntactic structure is associated to a lexical anchor. So, the phrasal approaches that link syntactic structure to lexical items are actually lexical approaches as well. As in GPSG some means makes sure that the lexical items enter into correct constructions. In GPSG this was taken care of by a number. I already discussed the GPSG shortcomings in previous subsections.

Concluding this section, it can be said that there has to be a connection between lexical items and their arguments and that a lexical representation of argument structure is the best way to establish such a relation.

3 Construction Morphology

The first publication in Construction Morphology was the masters thesis of Riehemann (1993), which later appeared as Riehemann (1998). Riehemann called her framework *Type-Based Derivational Morphology* since it was written before influential work like Goldberg (1995) appeared and before the term *Construction Morphology* (Booij 2005) was used. Riehemann did a careful corpus study on adjective derivations with the suffix *-bar* '-able'. She noticed that there is a productive pattern that can be analyzed by a lexical rule relating a verbal stem to the adjective suffixed with *-bar*.[6] The productive pattern applies to verbs governing an accusative as in (10a) but is incompatible with verbs taking a dative as in (10b):

(10) a. unterstützbar
           supportable

      b. * helfbar
           helpable

---

[6]She did not call her rule lexical rule but the difference between her template and the formalization of lexical rules by Meurers (2001) is the naming of the feature MORPH-B vs. DTR.

    c.   * schlafbar
        sleepable

Intransitive verbs are also excluded as (10c) shows. Riehemann suggests the schema in (11):

fix page number

(11)   Schema for productive adjective derivations with the suffix *-bar* in German according to Riehemann (1998: 17):

$$
\begin{bmatrix}
\textit{reg-bar-adj} \\
\textsc{phonology}\ \boxed{1} + \textit{bar} \\
\textsc{morph-b}\ \left\langle
\begin{bmatrix}
\textit{trans-verb} \\
\textsc{phon}\ \boxed{1} \\
\textsc{synsem}|\textsc{loc}
\begin{bmatrix}
\textsc{cat}|\textsc{val}|\textsc{comps}\ \langle\ \text{NP}[acc]{:}\boxed{2}\ \rangle \oplus \boxed{3} \\
\textsc{cont}|\textsc{nuc}\ \boxed{4}
\begin{bmatrix}
\textsc{act} \\
\textsc{und}\ \boxed{2}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\right\rangle \\
\textsc{synsem}|\textsc{local}
\begin{bmatrix}
\textsc{category}
\begin{bmatrix}
\textsc{head}\quad \textit{adj} \\
\textsc{valence}
\begin{bmatrix}
\textsc{subj}\quad \langle\ \text{NP}{:}\boxed{2}\ \rangle \\
\textsc{comps}\quad \boxed{3}
\end{bmatrix}
\end{bmatrix} \\
\textsc{content}|\textsc{nucleus}
\begin{bmatrix}
\textsc{reln}\quad \diamond \\
\textsc{arg1}\quad \boxed{2} \\
\textsc{arg2}\quad \boxed{4}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$
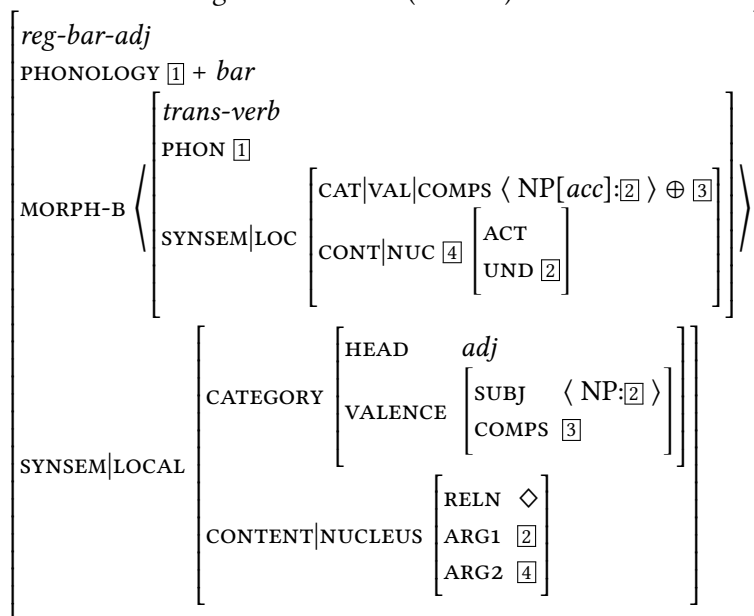
MORPH-B is a list that contains a description of a transitive verb (something that governs an accusative object which is linked to the undergoer role ($\boxed{2}$) and has an actor.[7] The phonology of this element ($\boxed{1}$) is combined with the suffix *-bar* and forms the phonology of the complete lexical item. The resulting object is of category *adj* and the semantics of the accusative object of the input verb ($\boxed{2}$) is identified with the one of the subject of the resulting adjective. The semantics of

---

[7]Note that the specification of the type *trans-verb* in the list under MORPH-B is redundant since it is stated that there has to be an accusative object and that there is an actor and an under-goer in the semantics. Depending on further properties of the grammar the specification of the type is actually wrong: productively derived particle verbs may be input to the *-bar* 'able' derivation and these are not a subtype of *trans-verb* since the respective particle verb rule de-rives both transitive (*anlachen* 'laught at somebody') and intransitive verbs (*loslachen* 'start to laugh') (Müller 2003: 296). *anlachen* does not have an undergoer in the semantic representation suggested by Stiebels (1996). See Müller (2003: 308) for a version of the *-bar* 'able' derivation schema that is compatible with particle verb formations as input.

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the input verb (④) is embedded under a modal operator in the semantics of the adjective.

While the description of *-bar* 'able' derivation given so far captures the situation quite well, there are niches and isolated items that are exceptions. According to Riehemann (1998: 5), this was the case for 7 % of the adjectives she looked at in her corpus study. Examples are verbs ending in *-ig* like *entschuldigen* 'to excuse'. The *-ig* is dropped in the derivation:

(12) entschuldbar
      excuseable

Other cases are lexicalized forms like *essbar* 'safely edible', which have a special lexicalized meaning. Exceptions of the accusative requirement are verbs selecting a dative (13a), a prepositional object (13b), reflexive verbs (13c), and even intransitive, mono-valent verbs (13d):

(13) a. unentrinnbar
          inescapable

      b. verfügbar
          available

      c. regenerierbar
          regenerable

      d. brennbar
          inflammable

To capture generalizations about productive, semi-productive and fixed patterns/items Riehemann suggests a type hierarchy, parts of which are provided in Figure 1. The type *bar-adj* stands for all *-bar* adjectives and comes with the
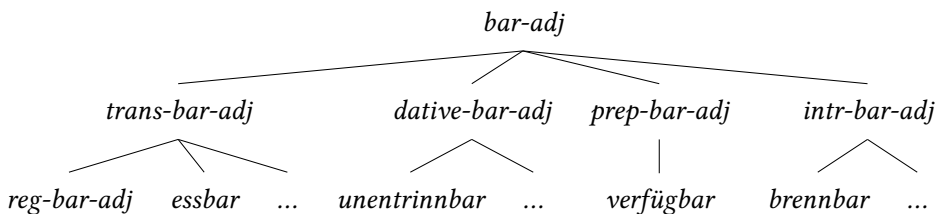
why doesn't the figure start at the left?

Figure 1: Parts of the type hierarchy for *-bar* 'able' derivation adapted from Riehemann (1998: 15)

constraints that apply to all of them. One subtype of this general type is *trans-bar-adj*, which subsumes all adjectives that are derived from transitive verbs. This

includes all regularly derived *-bar*-adjectives, which are of the type *reg-bar-adj* but also *essbar* 'edible' and *sichtbar* 'visible'.

As this recapitulation of Riehemann's proposal shows, the analysis is a typical CxG analysis: V-*bar* is a partially filled word (see Goldberg's examples in Table 1). The schema in (11) is a form-meaning pair. Exceptions and subregularities are represented in an inheritance network.

4 Phrasal patterns

Section 2 discussed the claim that Constructions in the sense of CxG have to be phrasal. I showed that this is not true and that in fact lexical approaches to valence have to be preferred under the assumptions usually made in non-transformational theories. However, there are other areas of grammar that give exclusively head-driven approaches like Categorial Grammar, Minimalism, and Dependency Grammar a hard time. In what follows I discuss the NPN construction and various forms of filler gap constructions.

4.1 The N-P-N Construction

Matsuyama (2004) and Jackendoff (2008) discuss the NPN Construction, examples of which are provided in (14):

(14) a. Student after student left the room.
      b. Day after day after day went by, but I never found the courage to talk to her. (Bargmann 2015)

The properties of the NPN construction (with *after*) are summarized by Bargmann (2015) in a concise way and I will repeat his examples and summarization below to motivate his analysis in (22).

The examples in (14) show that the N-after-N Construction has *NP distribution.*

As (15) shows, the construction is *partially lexically fixed*: *after* cannot be replaced by any other word (Matsuyama 2004: 73).

(15) Alex asked me question { after / * following / * succeeding } question.

The construction is *partially lexically flexible*: The choice of Ns is free, except for that the Ns must be identical (16a), the Ns must be count nouns (16b), Ns must be in the singular (16c), and the Ns must be bare (16d).

(16) a. * bus after car   (N1 ≠ N2)

b. * water after water (Ns = mass nouns)

c. * books after books (Ns = plurals)

d. * a day after a day (Ns have determiners)

The construction is *syntactically fixed*: N-after-N cannot be split by syntactic operations as the contrast in (17) shows (Matsuyama 2004):

(17) a. Man after man passed by.

b. * Man passed by after man.

If extraposition of the *after*-N constituent were possible, (17b) with an extraposed *after man* should be fine but it is not, so NPN seems to be a fixed configuration.

There is a syntax-semantics mismatch: while N-after-N is singular, syntactically as (18) shows, it is plural semantically as (19) shows:

(18) Study after study { reveals / *reveal } the dangers of lightly trafficked streets.

(19) a. John ate { apple after apple / apples / *an apple } for an hour.

b. John ate { *apple after apple / *apples / an apple } in an hour.

Furthermore there is an aspect of semantic sequentiality: N-after-N conveys a temporal or spatial sequence: as Bargmann (2015) states the meaning of (20a) is something like (20b).

(20) a. Man after man passed by.

b. First one man passed by, then another(, then another(, then another(, then …))).

The Ns in the construction do not refer to one individual each, rather they contribute to a holistic meaning.

The NPN construction allows adjectives to be combined with the nouns but this is restricted. N1 can only be preceded by an adjective if N2 is preceded by the same adjective:

(21) a. bad day after bad day (N1 and N2 are preceded by the same adjective.)

b. * bad day after awful day (N1 and N2 are preceded by different adjectives.)

c. * bad day after day (Only N1 is preceded by an adjective.)

d. day after bad day (Only N is preceded by an adjective.)

Finally, *after* N may be iterated to emphasize the fact that there are several referents of N as the example in (14b) shows.

This empirical description is covered by the following phrasal construction, which is adapted from Bargmann (2015):[8]

(22)

$$
\begin{bmatrix}
\text{PHON } \langle \dots N\dots, \text{after}, \dots N\dots \rangle \\
\text{SS|LOC|CAT} \begin{bmatrix}
\text{HEAD} \begin{bmatrix} noun \\ \text{COUNT} - \\ \text{AGR} \quad 3rdsing \end{bmatrix} \\
\text{VAL} \begin{bmatrix} \text{SPR} \quad \langle\rangle \\ \text{COMPS} \langle\rangle \end{bmatrix}
\end{bmatrix} \\
\text{SR } \lambda P.\exists X.|X| > 1 \ \& \ \forall x \in X: N'(x) \ \& \ \exists R^{order} \subseteq X^2 \ \& \ P(x) \\
\text{DTRS } \left\langle \begin{bmatrix}
\text{PHON } \langle \dots N\dots \rangle \\
\text{SS|L|C} \begin{bmatrix}
\text{HEAD} \begin{bmatrix} noun \\ \text{COUNT} + \\ \text{AGR } 3rdsing \end{bmatrix} \\
\text{VAL} \begin{bmatrix} \text{SPR} \quad \langle \text{DET} \rangle \\ \text{COMPS} \langle\rangle \end{bmatrix}
\end{bmatrix} \\
\text{SR} \dots \lambda x.N'(x) \dots
\end{bmatrix}, \left(\begin{bmatrix}
\text{PHON } \langle \text{after} \rangle \\
\dots \text{HEAD } prep \\
\text{SR } \exists R^{order} \subseteq X^2
\end{bmatrix}, \begin{bmatrix}
\text{PHON } \langle \dots N\dots \rangle \\
\text{SS|L|C} \begin{bmatrix}
\text{HEAD} \begin{bmatrix} noun \\ \text{COUNT} + \\ \text{AGR } 3rdsing \end{bmatrix} \\
\text{VAL} \begin{bmatrix} \text{SPR} \quad \langle \text{DET} \rangle \\ \text{COMPS} \langle\rangle \end{bmatrix}
\end{bmatrix} \\
\text{SR} \dots \lambda x.N'(x) \dots
\end{bmatrix} \right)^+ \right\rangle
\end{bmatrix}
$$

There is a list of daughters consisting of a first daughter and an arbitrarily long list of *after* N pairs. The '+' means that there has to be at least one *after* N pair. The nominal daughters select for a determiner via SPR, so they can be either bare nouns or nouns modified by adjectives. The semantic representation, non-standardly represented as the value of SR, says that there have to be several objects in a set X ($\exists X.|X| > 1$) and for all of them the meaning of the $\overline{\text{N}}$ has to hold ($\forall x \in X : N'(x)$). Furthermore there is an order between the elements of X as stated by $\exists R^{order} \subseteq X^2$.

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[8]Jackendoff and Bargmann assume that the result of combining N, P, and N is an NP. However this is potentially problematic as Matsuyama's example in (22) shows (Matsuyama 2004: 71):

> (i)   All ranks joined in hearty cheer after cheer for every member of the royal family …

As Matsuyama points out the reading of such examples is like the reading of *old men and women* in which *old* scopes over both *men* and *women*. This is accounted for in structures like the one indicated in (ii):

> (ii)   hearty [cheer after cheer]

Since adjectives attach to $\overline{\text{N}}$s and not to NPs this means that NPN constructions should be $\overline{\text{N}}$s. Of course (ii) cannot be combined with determiners, so one would have to assume that NPN constructions select for a determiner that has to be dropped obligatorily. This is also the case for mass nouns with a certain reading.

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From looking at this construction it is clear that it cannot be accounted for by standard X̄ rules. Even without requiring X̄ syntactic rules, there seems to be no way to capture these constructions in head-based approaches like Minimalism, Categorial Grammar or Dependency Grammar. For simple NPN constructions one could claim that *after* is the head. *after* would be categorized as 3rd singular mass noun and select for two N̄s. It would (non-compositionally) contribute the semantics stated above. But it is unclear how the general schema with arbitrarily many repetitions of *after* N could be accounted for. If one assumes that *day after day* forms a constituent, then the first *after* in (23) would have to combine an N with an NPN sequence.

(23) day after [day [after day]]

This means that we would have to assume two different items for *after*: one for the combination of N̄s and another one for the combination of N̄ with NPN combinations. Note that an analysis of the type in (23) would have to project information about the N̄s contained in the NPN construction since this information has to be matched with the single N̄ at the beginning. In any case a lexical analysis would require several highly idiosyncratic lexical items (prepositions projecting nominal information and selecting items they usually do not select). It is clear that a reduplication account of the NPN construction as suggested by G. Müller (2011) does not work since patterns with several repetitions of PN as in (23) cannot be accounted for as reduplication. G. Müller (p. 241) stated that reduplication works for word-size elements only (in German) and hence his account does not extend to the English examples given above. (24) shows an attested German example containing adjectives, which means that G. Müller's approach is not appropriate for German either.

(24) Die beiden tauchten nämlich geradewegs wieder aus   dem heimischen
      the two   surfaced namely straightaway again   from the   home
      Legoland auf, wo   sie   im   Wohnzimmer, schwarzen Stein um
      Legoland PART where they in.the living.room   black   brick after
      schwarzen Stein, vermeintliche Schusswaffen nachgebaut hatten.[9]
      black   brick alledged   firearms   recreated had
      'The two surfaced straightaway from their home Legoland where they
      had recreated alledged firearms black brick after black brick.'

This subsection showed how a special phrasal pattern can be analyzed within HPSG. The next section will discuss filler-gap constructions, which were ana-

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[9]taz, 05.09.2018, p. 20

lyzed as instances of a single schema by Pollard & Sag (1994) but which were later reconsidered and analyzed as a family of subconstructions by Sag (2010).

4.2 Specialized sub-constructions

HPSG took over the treatment of nonlocal dependencies from GPSG (Gazdar 1981) (see also Flickinger, Pollard & Wasow (2018), Chapter 2 of this volume on the history of HPSG and Borsley & Crysmann (2018), Chapter 14 of this volume on unbounded dependencies). Pollard & Sag (1994: Chapters 4 and 5) had an analysis of topicalization constructions like (25) and an analysis of relative clauses. However, more careful examination revealed that more fine-grained distinctions have to be made. Sag (2010: 491) looked at the following examples:

(25) a. [My bagels,] she likes.   (topicalized clause)
      b. [*What* books] do they like?   (*wh*-interrogative)
      c. (the person) [*who* (*se* book)] they like   (*wh*-relative)
      d. [*What a* play] he wrote!   (*wh*-exclamative)
      e. [*the more* books] they read …   (the-clause)

As Sag shows, the fronted element is specific to the construction at hand:

(26) a. * [*Which* bagels] / [*Who*], she likes.   (topicalized clause)
      b. * [*What a* book] do they like?   (*wh*-interrogative)
      c. % the thing [[*what*] they like]   (*wh*-relative)
      d. * [*Which* bagels] / [*What*] she likes!   (*wh*-exclamative)
      e. * [*which* books] they read, the more they learn. (the-clause)

A topicalized clause should not contain a *wh* item (26a), a *wh*-interrogative should not contain a *what a* sequence as known from *wh*-exclamatives (26b) and so on.

Furthermore, some of these constructions allow non-finite clauses and others do not:

(27) a. * Bagels, (for us) to like.   (topicalized clause)
      b. * It's amazing [what a dunce (for them) to talk
          to].   (*wh*-exclamative)
      c. * The harder (for them) to come, the harder (for them) to
          fall.   (the-clause)
      d. I know how much time (* for them) to take.   (*wh*-interrogative)
      e. The time in which (*for them) to finish.   (*wh*-relative)

So there are differences as far as fillers and as far as sentences from which something is extracted are concerned. Sag discussed further differences like invertion/ non-invertion in the clauses out of which something is extracted. I do not repeat the full discussion here but refer the reader to the original paper.

In principle there are several ways to model the phenomena. One could assume empty heads as Pollard & Sag (1994: Chapter 5) suggested for the treatment of relative clauses. Or one could assume empty heads as they are assumed in Minimalism: certain so-called operators have features that have to be checked and cause items with the respective properties to move. Borsley (2006) discussed potential analyses of relative clauses involving empty heads and showed that one would need a large number of such empty heads and since there is no theory of the lexicon in Minimalism, generalizations are missed (see also Borsley & Müller (2018), Chapter 33 of this volume). The alternative suggested by Sag (2010) is to assume a general Filler-Head Schema of the kind assumed in Pollard & Sag (1994) and then define more specific sub-constructions. To take an example, the wh-exclamative is a filler-head structure, so it inherits everything from the more general construction, but in addition it specifies the filler daughter to contain a *what a* part and states the semantics that is contributed by the exclamative construction.

5 Summary

This paper summarized the properties of Construction Grammar or rather Construction Grammars and showed that HPSG can be seen as a Construction Grammar. I showed why lexical analyses of argument structure should be preferred over phrasal ones and that there are other areas in grammar where phrasal analyses are superior to lexical ones. I showed that they can be covered in HPSG while they are problematic for proposals assuming that all structures have to have a head.

6 Appendix: Sign-Based Construction Grammar

Acknowledgements

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