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Verb Second by Underspecification *

Anette Frank
Institute for Computational Linguistics
University of Stuttgart
Azenbergstr. 12 70174 Stuttgart
e-mail: anette@ims.uni-stuttgart.de

The paper presents an HPSG analysis of Verb Second (V2) in German by underspecification, making use of a categorial type hierarchy. We begin by discussing some shortcomings of the HPSG analysis of V2 by lexical rule in Kiss/Wesche(1991), which can be remedied by integration of the concept of functional categories, originally introduced in HPSG by Netter(1994). Based on these insights, and largely inspired by the GB analysis of Haider(1993), we develop an alternative analysis of V2 in HPSG, which is based on the concept of underspecification. The finite verb is represented in the lexicon as an abstract category type which is underspecified for functional and complementation properties. In conjunction with the type hierarchy, these properties get appropriately defined depending on the actual syntactic context the verb appears in. We end up with an analysis of the V2 dependency relation which restricts the information structure shared by antecedent and trace to (enriched) HEAD attributes, as opposed to LOCAL attributes for phrasal constituents. This accounts for the locality of the V2 dependency. The analysis by underspecification makes interesting predictions for the interdependence of syntactic and semantic properties. This is most transparent for the ungrammaticality of V2 in embedded wh-clauses.

Introduction

A central concern in the area of computational syntax is to exploit insights gained in syntactic theory. An enormous amount of valuable work on syntax has been done in the GB framework, and efforts are made to come up with formalizations and parsing systems that directly transfer GB analyses to working computational systems (for a recent overview see [Sta]). Without going into a discussion about this line of research, this paper proposes an alternative way to the same end: making available insights about natural language syntax, gained e.g. in GB theory, to computational applications.
For the intricate problem of the verb second (V2) phenomenon in German, it will be shown that the GB analysis convincingly argued for in Haider(1993) [Hai] can be naturally transposed into an HPSG-style analysis which is equivalent in the relevant aspects. In accordance with the strict conception of a one-level (S-structure) representation in [Hai], we develop an HPSG account of V2 by underspecification as opposed to the lexical rule approach of Kiss/Wesche(1991) [K/W]. The finite verb is represented in the lexicon as an underspecified category type, which - by the definition of the type hierarchy - will be instantiated appropriately to a lexical or functional category type, depending on the syntactic context. The analysis of V2 by underspecification makes interesting predictions for the interdependence of syntactic and semantic properties. By the definition of functional categories in terms of (underspecified) feature specifications, the HPSG analysis presented overcomes two serious representational problems any GB account of head movement – and therefore any direct GB implementation effort – is confronted with.

*The research underlying this paper has been funded by the Sonderforschungsbereich 340 of the German National Research Foundation, DFG. A more comprehensive discussion of the analysis is given in [Fra]. The analysis has been implemented in the CUF system, developed at IMS Stuttgart (see [D/D]). The grammar makes direct use of the underspecified representation of the finite verb in the lexicon. The new analysis of V2 has been successfully integrated into the refined framework of HPSG driven UDRS-construction, originally described in [F/R].

1 German Sentence Structure

The basic assumptions about German sentence structure developed in [Hai] can be summarized as follows: The finite verb in sentence initial position is in a derived position.[1] The complementizer and the finite verb in initial position both occupy a functional head position. There is only one functional projection in German clause structure.[2] The functional head is represented by a category variable F in the abstract sentence structure (1), which can be instantiated by a complementizer C^0 in verb final sentences (2) or a finite verb V^0_{fin} in verb initial sentences (3).

(1) $[_{FP}$ SpecF $[_{F'}$ F^0 $[_{VP}$ $]]]$
(2) $[_{CP}$ SpecC $[_{C'}$ C^0 $[_{VP}$ $]]]$
(3) $[_{FP_{(Vfin)}}$ SpecF $[_{F'_{(Vfin)}}$ $F^0_{(Vfin)_i}$ $[_{VP}$ .. $V^0_{e_i}]]]$ ([Hai]:84)

The generalization for obligatory V2 structure in German main clauses is covered by a *Functional Licensing Condition in V2 languages* (4) together with a visiblity condition on empty heads. ([Hai]:84)

(4) The projection of a functionally marked lexical X^0-category must be functionally licensed. The projection XP of a X^0-category is functionally licensed if XP is licensed by a functional head as its complement.

1.1 Representational Problems in GB Analyses of V2

Categorial Specification of Finiteness in Verb Initial and Verb Final Sentences On a categorial view of finiteness, i.e. the assumption of a category INFL (I), as generally held in the GB literature, the verb initial structure would have to be represented as in (5) rather than (3). As a consequence, the finite verb in sentence final position would have to be specified contradictorily as a I^0 head category in the VP's V^0 head position (6).[3] Also, if we assume a substitution analysis of head movement, given that substitution is category preserving, the representation of verb movement in (5) as involving an I^0 antecedent and V^0 trace is contradictory.[4]

(5) $[_{IP}$ SpecI $[_{I'}$ I^0_i $[_{VP}$ $\ldots V^0_{e_i}$ $]]]$
(6) $[_{CP}$ SpecC $[_{C'}$ C^0 $[_{VP}$ $\ldots I^0]]]$

These problems of categorial specification can be overcome if functional properties like finite inflection are encoded by feature specifications on abstract category labels instead of atomic categorial status.

Formal Representation of Verb Movement Even if we choose a feature specification for the finite verb in the functional head position as illustrated in (3), the problem of the formal representation of V2 is not yet solved. The relation move-α is constrained to hold between elements of identical category. Now, the functional category F^0_{Vfin} and the lexical category trace V^0_{fin} are inherently different in their functional status and complementation properties. But the distinction between functional and lexical categories is crucial for the analysis of the V2 phenomenon (see (4)). It also proves advantagous for the definition of linear precedence constraints in HPSG analyses of V2 in terms of a dependency relation (see Section 3). The distinction between functional and lexical categories should therefore not be eliminated.

[1] This empirically motivated claim contradicts [Pol].

[2] The latter claim is one of the reflexes of the conception of a 'projective grammar', pursued in [Hai], which does not postulate a universally fixed structural skeleton for sentence structure.

[3] [Hai] argues convincingly that there is no distinct sentence final I^0 head, i.e. distinct from V^0, in German.

[4] This has been pointed out by Tilman Höhle in a talk presented at Stuttgart University, January 1993.

2 Towards an HPSG Analysis of V2

2.1 Functional Categories in HPSG

Netter(1994) [Net94] develops a concept of functional categories in the HPSG framework, which he successfully applies to the analysis of German nominal phrases.[5] Lexical and functional categories are distinguished by the head features MAJOR, defining the substantial lexical categories, and MINOR for functional attributes. A functional category type, defined in (7), subcategorizes for a single complement and is required by the Functional Complementation Principle[6] to share the MAJOR categorial head features with its complement ([Net94]:16).

$$(7)\quad \textit{func-cat} = \begin{bmatrix} \text{LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{MAJ} & \boxed{1} \\ \text{MIN} & \begin{bmatrix} \text{FCOMPL} & + \end{bmatrix} \end{bmatrix} \\ \text{SUBCAT} & < \begin{bmatrix} \text{LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{MAJ} & \boxed{1} \\ \text{MIN} & \begin{bmatrix} \text{FCOMPL} & - \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} > \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The specification FCOMPL – in the MINOR attribute of a *lexical* category reflects the intuition that the projection of this lexical category is not by itself a "functionally complete" projection. The notion of "functional completeness" is used to define a new type *max-cat* which requires maximal phrases to be functionally complete:

(8) Constraint on f-complete maximal phrases:[7]

$$\textit{max-cat} = \begin{bmatrix} \text{LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{MIN} & \begin{bmatrix} \text{FCOMPL} & + \end{bmatrix} \end{bmatrix} \\ \text{SUBCAT} & <> \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Given (8), the functional category type (7), marked by the specification FCOMPL +, is characterized as a *functionally complete* syntactic category which effects – via subcategorization – functional completeness for its *functionally incomplete* complement by taking it as its complement to build up a wellformed, functionally complete maximal phrase.

2.2 V2 as Functional Licensing

Most of the assumptions about German sentence structure in [Hai] (see Section 1) are naturally translated into the HPSG framework by using the functional notions provided in [Net94].
The finite verb is functionally marked and – following (4) – requires to be functionally licensed by a functional head. This constraint for functional licensing of functionally marked elements will be defined by (i) specifying the finite verb as a functionally incomplete category by (9), which (ii) together with the constraint (8) – placed on sentential projections – and the definition of a functional category as 'a functionally licensing element' in (7) requires the projection of the finite verb to appear as a complement of a functional head, e.g. a complementizer.

$$(9)\quad \begin{bmatrix} \text{LOC} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD} \begin{bmatrix} \text{MIN} \begin{bmatrix} \text{VFORM} & fin \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{LOC} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD} \begin{bmatrix} \text{MIN} \begin{bmatrix} \text{FCOMPL} & - \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Thus, by the definition of the finite verb as functionally incomplete by (9), the constraint (8) for a functionally complete, maximal sentence structure and the specification of functional categories as functionally licensing elements in (7), we mirror the 'Functional Licensing Condition' in (4). The finite verb

[5] The concept of functional categories has been applied to an analysis of V2 in Netter(1992). We do not take into account this analysis here because, on our view, it bears rather unorthodox characteristics. Among them is the appearance of X^0 categories on the SUBCAT list and the divergence from assumptions about inherent properties of functional categories, which are widely held to subcategorize for only one complement.

[6] Functional Complementation:
In a lexical category of the type *func-cat* the value of its MAJOR attribute is token identical with the MAJOR value of its complement. ([Net94]:15)

[7] Functional Completeness Constraint:
Every maximal projection is marked as functionally complete in its MINOR feature. ([Net94]:15)

final structure is now required to be closed by e.g. a complementizer projection.[8] If no complementizer is present, as in main clauses, the VP projection of the finite verb in final position does not yet satisfy (8). According to [Hai], the only way to produce a wellformed structure is by realizing the finite verb in a derived functional head position, where it takes the VP that contains its trace as its complement, thereby fulfilling the constraint (8) on functionally complete maximal phrases. The formal definition of this local dependency relation, holding between the verb trace in the final VP position and the antecedent verb in the functional head position, is the main topic of the next Section.

3 The Representation of V2 in HPSG

3.1 The Lexical Rule Analysis of V2

Kiss/Wesche(1991) [K/W], inspired by an analysis in categorial grammar [Hep], proposed an analysis of V2 by a lexical rule, further refined in [Kiss].[9] It takes as input the structure of the finite verb as it is defined for the sentence final position and derives an output structure that defines the finite verb which occupies the sentence initial position. In (10) we state a revised version of [K/W]'s lexical rule, which integrates the functional concepts of [Net94] which were shown above to allow a natural translation of the V2 analysis in [Hai]. This enriched version (10) will be argued to be empirically superior to the original formulation of the lexical rule in [K/W].

The rule specifies the verb figuring in initial position as a functional category type, i.e. as functionally complete and sharing its MAJOR value with its single complement. The representation of the local dependency holding between the verb in initial position and its trace in final position is rendered by the introduction of the new non-local attribute DSL (double-slash), which gets instantiated as an inherited value (INH) in the traditional way by the definition of a trace of category X^0 in the final VP position,[10] and gets bound (TO-BIND) by the verb in initial sentence position. Note that the value of DSL, tagged $\boxed{3}$, is coindexed with the LOCal value of the input structure of the lexical rule. It is thereby ensured – via the non-local dependency mechanism in HPSG – that the lexically determined syntactic and semantic properties of the verb (subcategorization, content definition, categorial features, etc.), stated in the input structure, are correctly instantiated by the trace in the head position of the VP, where e.g. the complementation requirements and content information must be processed. This aspect of 'carrying over' parts of the input structure for the definition of the dependency relation in the verb initial structure will be discussed in more detail shortly.

(10) Lexical Rule for V2: (revised from [K/W], [Kiss], fn. 11)

$$\begin{bmatrix} \text{LOC}\ \boxed{3} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD}\ \boxed{1} \begin{bmatrix} \text{MAJ}\ \boxed{4}\ \textit{verb} \\ \text{MIN} \begin{bmatrix} \text{FC}\ - \\ \text{VF}\ \textit{fin} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \text{CONT}\ \boxed{2} \end{bmatrix} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{LOC} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD} \begin{bmatrix} \text{MAJ}\ \boxed{4} \\ \text{MIN} \begin{bmatrix} \text{FC}\ + \\ \text{VF}\ \textit{fin} \end{bmatrix} \end{bmatrix} \\ \text{SBC} < \begin{bmatrix} \text{LOC} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD}\ \boxed{1} \end{bmatrix} \end{bmatrix} \\ \text{NLOC} \begin{bmatrix} \text{INH} \begin{bmatrix} \text{DSL}\ \{\boxed{3}\} \end{bmatrix} \end{bmatrix} \end{bmatrix} > \end{bmatrix} \\ \text{CONT}\ \boxed{2} \end{bmatrix} \\ \text{NLOC} \begin{bmatrix} \text{TO-BIND} \begin{bmatrix} \text{DSL}\ \{\boxed{3}\} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

By introducing the functional concepts of [Net94] into the original definition of the Lexical Rule in [K/W], this revised analysis avoids some shortcomings of the original definition.[11] Without functional notions,

[8] There are some open problems to be discussed for the generalization (4) as regards infinite complements (see [Fra]).

[9] We will continue to refer to the analysis as [K/W] here, while taking into account the amendments in [Kiss].

[10] Trace of category X^0:

$$\begin{bmatrix} \text{PHON}\ <> \\ \text{SYNSEM} \begin{bmatrix} \text{LOC}\ \boxed{1} \\ \text{NON-LOC}\ [\text{INH}\ [\text{DSL}\ \{\boxed{1}\}]] \end{bmatrix} \end{bmatrix}$$

no distinction could be made between verb final and verb initial structures in terms of HEAD, CAT or NONLOC features. It was therefore not possible to define constraints for V2 structure in matrix sentences (11.a), or verb final position in complementizer-introduced sentences (11.b). By contrast, with (10) the obligatoriness of V2 in main clauses (11.a) is ensured by Netter's constraint on functionally complete maximal phrases (8), and the complementarity of complementizer and V2 in embedded clauses in (11.b) is covered by the definition of functional categories (7), which subcategorize for functionally incomplete complements.

(11) a. * Peter nach Hause kommt.
b. * daß Peter kommt nach Hause.
c. * Max$_j$ kennt$_i$ e_j glaubt, daß Susanne Fritz e_i.

But, contrary to the claim in [K/W], the locality of the V2 dependency (11.c) cannot be ensured – not even by the revised lexical rule in (10). The 'raised' verb in initial position *can* bind a DSL value defined by a verb trace in embedded sentences, as in (11.c). So the locality of the V2 dependency has to be accounted for independently by general locality constraints on nonlocal dependencies.

An important advantage of the use of functional notions is that linear precedence constraints defining the order of head and complements can be formulated in a much more general way. In German, functional categories (FC +) (complementizer, initial finite verb and determiner) select their complement to the right, lexical categories (FC −) bearing positive verbal features (verbs and adjectives) select their complements to the left, those bearing negative verbal features (nouns and prepositions), to the right (see [Hai]). By contrast, in [K/W] linear precedence constraints must be defined be referring to the nonlocal feature DSL.

The V2 Dependency Relation If we have a closer look at the lexical rule (10) we notice that the input and output structures, if applied to full-fledged lexicon entries, differ significantly in their LOCal values. The SUBCAT and MINOR values, as well as the properties defining the projection of CONTent differ substantially. By coindexation of the verb final's LOCal value ($\boxed{3}$) and the DSL value of the 'raised' verb, the same differences hold between the LOCal value of the 'antecedent' in initial position and the verb 'trace' in the final VP position. For the representation of the V2 dependency relation holding between the verbal antecedent and the verb trace this has important consequences. In contrast to the analysis of nonlocal dependencies involving maximal phrases, where antecedent and trace share their LOCal features (see [P/S]), antecedent and trace in the V2 dependency *cannot* share their LOCal features. It is impossible, on principled grounds, to define the TO-BIND DSL value of the 'antecedent' verb structure *by its own force*, i.e. by its *own* LOCal value. Instead, the LOCal values of antecedent and trace are held completely independent from each other, while the DSL value gets defined – by application of the lexical rule – by the 'original' verb structure.
If then, for the analysis of a V2 sentence, we use the 'derived' verbal entry in isolation, we observe that antecedent and trace in the V2 dependency relation differ in their categorial status, being characterized as a functional vs. lexical category type, respectively. Identification of the LOCal values of antecedent and trace being prohibited, nothing in the lexical structure of the antecedent verb indicates that the LOCal value of the trace it binds in its DSL attribute is the trace it is *itself* the antecedent of.[12] Thus, following the lexical rule approach to V2, we are confronted with a phenomenon which was shown to be problematic for GB analyses of V2 in Section 1: The dependency relation in terms of "shared information structure", holding between antecedent and trace, cannot be characterized by identical categorial status,

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[11] Lexical Rule for V2: ([Kiss]:144)

$$\left[\text{LOC}\ \boxed{3}\ \begin{bmatrix}\text{CAT}\ [\text{HEAD}\ \boxed{1}[\text{VFORM}\ \textit{fin}]]\\ \text{CONT}\ \boxed{2}\end{bmatrix}\right] \Rightarrow \begin{bmatrix}\text{LOC}\ \begin{bmatrix}\text{CAT}\ \begin{bmatrix}\text{HEAD}\ \boxed{1}\\ \text{SBC} < \begin{bmatrix}\text{LOC}\ [\text{CAT}\ [\text{HEAD}\ \boxed{1}]]\\ \text{NLOC}\ [\text{INH}\ [\text{DSL}\ \{\boxed{3}\}]]\end{bmatrix} >\end{bmatrix}\\ \text{CONT}\ \boxed{2}\end{bmatrix}\\ \text{NLOC}\ [\text{TO-BIND}\ [\text{DSL}\ \{\boxed{3}\}]]\end{bmatrix}$$

[12] This is finally the reason why the analysis does not get hold of the locality restriction on V2.

nor by identical LOCal information structure.[13]

3.2 The Underspecification Analysis of V2

In the following we develop an alternative analysis of V2 in HPSG which maximizes the amount of shared information between antecedent and trace in the V2 dependency relation. The analysis is largely inspired by the analysis of [Hai], who subscribes to a one-level representation view in taking 'movement' as a metaphor for nonlocal dependencies holding at *one* single level of representation, namely S-structure. Therefore, verb initial and verb final structures are to be regarded as independent structural alternatives the finite verb may appear in. If we take over this conception, it is not possible – as does the lexical rule approach – to give a definition of the verb trace by referring to the verb structure as defined for verb final sentences. We will therefore develop an analysis of V2 by underspecification which takes seriously the idea of 'alternative realization' of the finite verb in different structural positions and which identifies antecedent and trace in the V2 dependency relation by (enriched) head attributes. A distinction is made between dependency relations for phrasal categories, where antecedent and trace share LOCal values, and dependency relations holding between nonphrasal categories, where antecedent and trace share HEAD values. The underspecification analysis can be considered a solution to the GB theoretic representation problem of head movement discussed in Section 1.1. Furthermore, the analysis makes interesting predictions as regards the locality of V2 and the ungrammaticality of V2 in embedded wh-clauses.

3.2.1 The Underspecification Problem

The idea of underspecification is to state one underspecified lexical entry for the finite verb, which can be alternatively realized in sentence initial position as a functional category in the V2 dependency relation or as a lexical category in sentence final position. We face two problems here.

Subcategorization and content properties If we try to define lexical and functional category types *lex-cat* and *func-cat* for the verb in final and initial position, respectively, to be subtypes of one common abstract category type *cat* – the *underspecified* category type which will be used to define the finite verb in the lexicon – we are confronted with differing subcategorization requirements of the two subtypes: The subcategorized arguments of the verb, as well as the mapping of the arguments' content to the content of the verb are lexically determined and therefore have to be stated in the lexicon entry for the abstract category type *cat*. Whereas *lex-cat* will appropriately inherit the SUBCAT and CONTent values, the functional category type does not: as seen in (10), the verb initial structure takes a single VP complement, which is not defined to map its CONTent value to an argument role of the verb's CONTent.

The V2 dependency relation Ignoring these problems for a moment, we face another one if we try to further distinguish two subtypes of *func-cat*, *prim-func-cat* for 'ordinary' functional categories like complementizers, and *sec-func-cat* for the derivational functional category type, the finite verb in V2 position. For *sec-func-cat* we have to define the DSL value to be bound, which in turn will define the LOCal value of the trace in the final VP position. As discussed, we cannot define the DSL value by

[13] Given our observations, we may even argue that the lexical rule (10) can be characterized as a feature-structure transforming operation, which is in some sense comparable to a multi-level of representation view in the GB framework, where move-α is understood as a relation holding between two levels of representation. Comparably, in the HPSG analysis the lexical rule applies to the lexical entry of a finite verb, appropriate to create a verb final sentence structure, to produce a new lexical entry, which is independently used to build a verb initial structure. While for the GB movement analysis the dependency relation holding between antecedent and trace in the V2 structure was argued to relate syntactic items characterized by conflicting categorial properties, in the HPSG analysis of V2 by lexical rule – avoiding this formal inconsistency – there is *no* shared information structure between antecedent and trace.

coindexation with the LOCal value of *sec-func-cat itself*, and – given the underspecification approach – we cannot refer to the LOCal value which will be defined for the verb final type *lex-cat*.[14]

3.2.2 Head feature SUBCAT and Valence Instantiation

Our first problem can be solved by a minor revision: Following [P/S], we break up the SUBCAT list in valence attributes SUBJ, COMPS, etc. Yet, we will keep the original SUBCAT attribute as a HEAD feature.[15] The underspecified category type *cat* for lexical elements (LEX +) is stated in (12).

$$(12)\quad \left[\begin{array}{ll} \text{LOC} & \left[\begin{array}{ll} \text{CAT} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \text{MAJ} & \textit{major} \\ \text{MIN} & \textit{minor} \\ \text{SUBCAT} & \langle \text{NP}_{\boxed{x}}, \ldots \rangle \end{array}\right] \\ \text{LEX} & + \end{array}\right] \\ \text{CONT} & \left[\begin{array}{ll} \text{REL} & \textit{relation} \\ \text{ARGx} & \boxed{x} \end{array}\right] \end{array}\right] \end{array}\right]_{cat}$$

The lexically determined subcategorization and content projection properties are defined by the HEAD attribute SUBCAT and the CONTent value. By the definition of the Valence Instantiation Principle (VIP) (13), categories of type *lex-cat* instantiate their valence features by coindexation with the SUBCAT attribute, which reflects the fact that their complement selection properties are lexically determined. The complementation properties of functional categories are invariant. Accordingly, (13.b) defines COMPS independently from the SUBCAT value, and sets SUBJ to the empty list. Yet, the content projection is defined identically for lexical and functional categories by the abstract category type *cat*.

(13) **Valence Instantiation Principle (VIP)**

(a) Lexical categories *lex-cat*

$$\left[\begin{array}{ll} \text{LOC} & \left[\begin{array}{ll} \text{CAT} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \text{SUBCAT} & \textit{app}(\langle \boxed{1} \rangle, \boxed{2}) \end{array}\right] \\ \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \boxed{2} \\ \text{EXT} & - \end{array}\right] \end{array}\right] \end{array}\right]_{lex-cat}$$

(b) Functional categories *func-cat*

$$\left[\begin{array}{ll} \text{LOC} & \left[\begin{array}{ll} \text{CAT} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \text{MAJ} & \boxed{1}\ \textit{major} \\ \text{SUBCAT} & \textit{list} \end{array}\right] \\ \text{SUBJ} & \langle\rangle \\ \text{COMPS} & \langle [..\text{MAJ}\ \boxed{1}] \rangle \\ \text{EXT} & + \end{array}\right] \end{array}\right] \end{array}\right]_{func-cat}$$

The new binary attribute EXT (extended projection) marks the lexical and functional category types, respectively, as non-extended and extended projections, in the spirit of [Grim]. In a binary branching VP structure, by the Principle of Extended Projections (PEP) (14), every head projection of *lex-cat* is marked as non-extended projection. The use of the EXTended attribute will be discussed shortly.

(14) **Principle of Extended Projection (PEP)**
The EXT(ended) value of a phrase is identical to the EXT(ended) value of its HEAD-DTR.

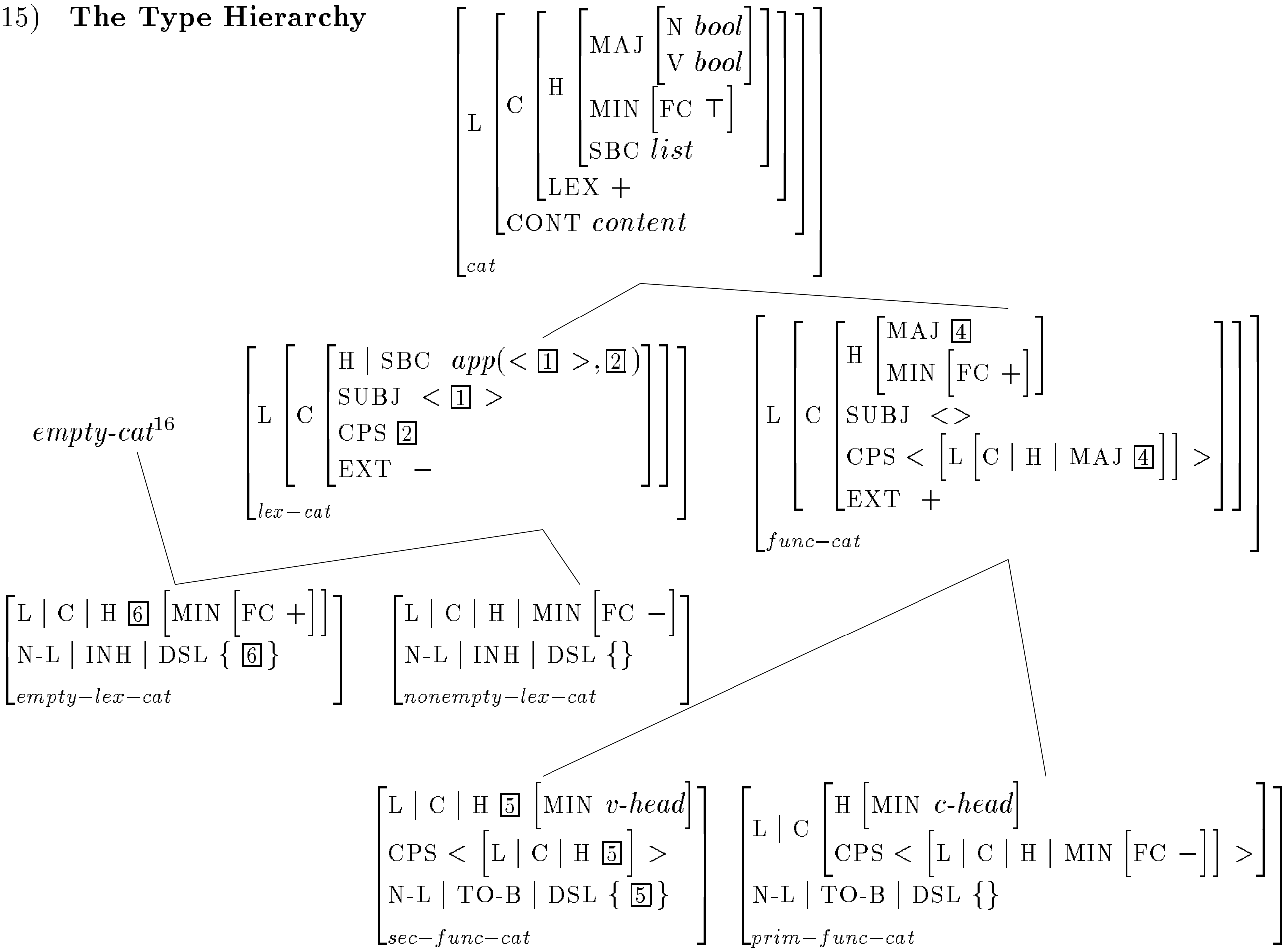
3.2.3 The Type Hierarchy

We can now state the type hierarchy (15), which defines the underspecified category type *cat* – the type of the finite verb's lexicon entry – to specialize to increasingly specified lexical and functional subtypes.

[14] If on the other hand we left DSL undefined, the LOCal value of the trace could take arbitrary values for the SUBCAT and CONTent attributes, resulting in completely ungrammatical sentences.

[15] The use of a head feature SUBCAT has been proposed in [F/R] for the analysis of quantifier scope, and it is independently needed for the HPSG binding theory.

(15) **The Type Hierarchy**



The type *cat* is defined as underspecified ($\top$) for functional completeness. FC is set to + in *func-cat*, which differs from (7) in specifying SUBJ as the empty list by application of VIP (b) and does not require an f-incomplete complement. The latter constraint is now stated in *prim-func-cat*, which is restricted to complementizer head features in MINor. The V2 dependency relation is defined in *func-cat*'s subtype *sec-func-cat*, which identifies its HEAD value with the HEAD value of its complement, as well as the DSL value that it binds. With our new definition of X^0-category traces (see fn.16) the HEAD value of the verb initial structure, $\boxed{5}$, by coindexation with the DSL value, gets identified with the HEAD value of the complement and satisfies the additional coindexing constraint between the functional categories' and its complement's HEAD features. The identification of the full HEAD information between antecedent and trace characterizes the latter as an f-complete (FC +) lexical category *empty-lex-cat*. In terms of the functional licensing condition (4), the specification of the verb trace as f-complete, i.e. functionally licensed, is to be understood as follows: The finite verb in VP final position is not functionally licensed by its own force (see *nonempty-lex-cat*); the VP projection requires an independent functional head in order to satisfy (4) [or (8)]. The verb trace, however, by identifying it's HEAD structure with the INH DSL value (see *empty-lex-cat*), forces the realization of its overt antecedent, which can only occupy a higher, functional head position (for locality see below). This antecedent, as an instance of *func-cat*, performs functional licensing of the finite VP that contains its own trace. The dependency relation between the functional head and the verb trace being an integral part of the definition of the verb trace, the trace can be characterized as necessarily functionally licensed, i.e. f-complete, by the functionally complete

[16] $$\begin{bmatrix} \text{PHON} & \langle\rangle \\ \text{SYNSEM} & \begin{bmatrix} \text{LOC}\,[\text{CAT}\,[\text{HEAD}\ \boxed{1}]] \\ \text{NON-LOC}\,[\text{INH}\,[\text{DSL}\ \{\boxed{1}\}]] \\ _{empty-cat} \end{bmatrix} \end{bmatrix}$$

antecedent it is identified with by HEAD coindexation.

Our underspecification analysis of V2 covers the topological data correctly: In main clauses the V2 structure is forced, since *nonempty-lex-cat* cannot satisfy (8), so (11.a) is ruled out. Complementizer introduced V2 structures (11.b) are ruled out by *prim-func-cat* requiring an f-incomplete complement. The locality of the V2 dependency is covered by the identification of the HEAD features of the functional head and its complement in *sec-func-cat*: The verb in initial position requires its complement to be f-complete. This condition is satisfied in (16), but not in (17). It may be suspected that, still, (18) could come out grammatical. Yet, here we would have a violation of the NFP: a verb initial structure *sec-func-cat* has to bind a DSL value which is identical to its own HEAD value. As soon as the verb is realized as *sec-func-cat*, the DSL value is bound and DSL set to *empty*. For the 'higher' verb in (18) there would be no DSL value to be bound, since we cannot assume *two* verb traces heading the VP.

(16) Glaubt$_i$ [Peter [daß Max Maria kennt] e$_i$].
(17) * Kennt$_j$ [Peter daß [Maria Fritz e$_j$] glaubt].
(18) * Kennt kennt Peter Maria.

Finally, the precedence constraints defining the order of head and complements can be defined in a general way. Instead of the functional completeness attribute referred to in Section 3.2.1, we could refer to the types *lex-cat* and *func-cat* if we assumed a flat VP structure. Since we assume binary branching, we do not refer to this type distinction – defined only at the lexical level (LEX +) – but to the notion of extended projections EXT ±, governed by PEP (14).

(19) a. $\mathrm{H}\left[\mathrm{LOC} \mid \mathrm{CAT} \mid \mathrm{EXT}\ +\right] > \mathrm{C}$

b. $\mathrm{C} > \mathrm{H}\left[\mathrm{LOC} \mid \mathrm{CAT}\begin{bmatrix}\mathrm{HEAD} \mid \mathrm{MAJ} \mid \mathrm{V}\ + \\ \mathrm{EXT}\ -\end{bmatrix}\right]$

c. $\mathrm{H}\left[\mathrm{LOC} \mid \mathrm{CAT}\begin{bmatrix}\mathrm{HEAD} \mid \mathrm{MAJ} \mid \mathrm{V}\ - \\ \mathrm{EXT}\ -\end{bmatrix}\right] > \mathrm{C}$

We end up with a characterization of the traditional functional and lexical verbal categories in terms of category types and HEAD feature specifications in (20). By restricting shared information in the V2 dependency relation to HEAD features, we avoid the formal representation problem of V2 movement, which was shown to arise from the conception of atomic category labels in the traditional GB framework.

(20) $\mathrm{C}^0 \approx \textit{func-cat}$ $\begin{bmatrix}\mathrm{MAJ} & \textit{verb} \\ \mathrm{MIN} & \begin{bmatrix}\mathrm{CFORM} & \textit{cform} \\ \mathrm{FCOMPL} & +\end{bmatrix}\end{bmatrix}$ $\quad \mathrm{I}^0 \approx \textit{func-cat}$ $\begin{bmatrix}\mathrm{MAJ} & \textit{verb} \\ \mathrm{MIN} & \begin{bmatrix}\mathrm{VFORM} & \mathrm{fin} \\ \mathrm{FCOMPL} & +\end{bmatrix}\end{bmatrix}$ $\quad \mathrm{V}^0 \approx \textit{lex-cat}$ $\begin{bmatrix}\mathrm{MAJ} & \textit{verb} \\ \mathrm{MIN} & \begin{bmatrix}\mathrm{VFORM} & \textit{vform} \\ \mathrm{FCOMPL} & \top\end{bmatrix}\end{bmatrix}$

3.2.4 Underspecification and the Syntax-Semantics Interface

In the beginning we mentioned that the underspecification analysis makes interesting predictions for the ungrammaticality of V2 in embedded wh-clauses. Before we can go into these details, some remarks about the semantics interface are in order. According to the semantics principle of [P/S] the content of the verb in initial position projects to the phrasal level, while the content of its VP complement will not. Thus the lexical rule (10) has to be adjusted: The content of the verb in functional position has to be defined by the content of its VP complement in order to guarantee the projection of adverbial semantics to the sentential level.[17] The underspecification analysis makes use of a syntax-semantics interface for UDRS construction in HPSG, described in [F/R], which is based on a revised semantics principle. The CONTent attribute is defined to represent Underspecified Discourse Representation Structures (UDRS), developed by [Rey]. By revision of the semantics principle, the content information is not projected from *one* of

[17] Our attention was drawn to this problem by an anonymous reviewer, pointing out that our original definition of semantics projection for functional heads didn't cope with VP adjuncts.

the daughters, but is defined as the *union* of the sets of conditions of the daughters. In our analysis the semantic conditions of the verb in initial position are introduced at the functional head position, while the arguments of the verb are instantiated and semantically evaluated in the VP complement (via the head attribute SUBCAT and VIP clauses). The semantic conditions stemming from the 'fronted' verb and its VP complement, eventually modified by VP adjuncts, get unioned by the semantics principle.[18] Now we can give hints at why – given appropriate assumptions about the semantics of sentential complementation – V2 in embedded wh-clauses is predicted to be ungrammatical by the underspecification analysis. We may assume that for embedded sentences the functional head introduces a propositional discourse referent, with the embedding verb imposing corresponding restrictions on the (propositional) type of its sentential complement. If in the syntax-semantics interface the introduction of the propositional discourse referent has to be effected by the functional head of the embedded sentence, we cannot, for principled reasons, realize the finite verb in V2 position as in (21.b): The finite verb, being stated in the lexicon as the abstract category type *cat* cannot be defined to introduce a propositional discourse referent in its CONTent, since the very same semantic conditions would then be introduced by the finite verb in final position in complementizer-introduced sentences. On the other hand, given the type hierarchy, we cannot *redefine* the CONTent value of the subtype *sec-func-cat* to introduce a propositional discourse referent. Thus in (21.a), in order to satisfy the propositional selection conditions of the embedding verb, we have to assume an empty complementizer of type *prim-func-cat* to define the appropriate semantic conditions, which – given the complementarity of complementizer and V2 – predicts (21.b).

(21) a. Max weiß nicht, wem $\emptyset$ er sein Fahrrad ausgeliehen hat.
b. * Max weiß nicht, wem hat er sein Fahrrad ausgeliehen.

4 Conclusion

We came up with an analysis of V2 in HPSG that can be understood as a direct transposition of the GB analysis in [Hai], which is characterized by the assumption of an underspecified functional category in sentence structure and a one-level representation view. One of our results is the clarification of the formal characterization of 'head movement': The constraint on categorial identity of antecedent and trace – shown to be problematic in Sections 1.1 and 3.1 – has been weakened to the identity of (enriched) HEAD attributes for X^0-categories, as opposed to LOCal attributes for maximal phrases. The differing functional and complementation properties of antecedent and trace in the V2 dependency relation are governed by the VIP clauses (13). We established a complex feature and category type specification for functional and functionally marked verbal categories, which dispenses with the atomic category labels traditionally used in the GB framework. The underspecification analysis bears two interesting features: By constraining antecedent and trace to share (enriched) HEAD values in the V2 dependency relation, we get hold of the locality restriction of the V2 dependency not covered by the lexical rule approach. By defining the finite verb as the underspecified category type *cat* in the lexicon – with appropriate assumptions about the semantics of sentential complementation – we predict the ungrammaticality of V2 in embedded wh-clauses.

[18] For VP adjuncts, appropriate scoping constraints are defined by subordination relations between UDRS labels.

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