Restriction and Verbal Complexes in LFG - A Case Study for Danish

Jürgen Wedekind
Center for Language Technology

Bjarne Ørsnes
Copenhagen Business School

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Jürgen Wedekind*
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Bjarne Ørsnes†
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1 Introduction

In early Lexical-Functional Grammar (LFG) auxiliaries were treated as raising verbs, i.e., verbs associated with an XCOMPlement and a nonthematic subject. On this analysis it was possible to state the morphosyntactic dependencies between the auxiliary and the nonfinite verb as restrictions on the verbal form features of the XCOMPlement. As discussed in a.o. Butt et al. (1996) this approach is crosslinguistically unsatisfactory in as much as it mirrors the surface syntax and leads to different f-structures in cases where the same morphosyntactic content is expressed by either synthetic or analytic means. Instead, Butt et al. (1996) assign a flat f-structure to verbal complexes with the main verb as the top-level predicate, while the morphosyntactic dependencies are accounted for in a separate morphological projection, projected from the c-structure.

Frank and Zaenen (2002) observe not only that this approach requires functional information to be duplicated in the m(orphological)-structure, it is also confronted with problems in analyzing certain long-distance phenomena involving morphological constraints. To overcome these problems they propose a sequenced architecture where the m-structure is projected from the f-structure. However, Frank and Zaenen's approach, though removing the need for a duplication of functional information in the m-structure, requires all possible morphosyntactic embeddings of the auxiliaries and main verbs to be encoded in the lexicon and leads thus to a massive duplication of morphosyntactic information in the lexicon.

Apart from these rather technical issues, we argue in this paper that both projection approaches are theoretically unsatisfactory, since a morphological projection seems to be called for in exactly those cases where the expression of a given morphosyntactic content is syntactic and not morphological. Instead, we propose to analyze verbal complexes without a morphological projection. We develop an approach based on the restriction operator (Kaplan and Wedekind 1993) where the morphosyntactic dependencies are checked in functional terms as dependencies between a c-structure head and an

* CST, Njalsgade 80, 2300 Copenhagen S, Denmark. E-mail: juergen@cst.dk
† Department of Computational Linguistics, Bernhard Bangs Allé 17 B, 2000 Frederiksberg, Denmark. E-mail: boe.id@cbs.dk

ungoverned DEP function while the verbal complex (and consequently the sentence) is assigned a flat f-structure. This approach overcomes the problems inherent to the raising and m-structure approaches. The approach is illustrated for temporal auxiliaries, passives and modal constructions in Danish.

2 Previous Approaches to Verbal Complexes in LFG

In traditional LFG, auxiliaries have been treated as main verbs which introduce their own predicates (Kaplan and Bresnan 1982, Falk 1984). In particular, they were analyzed as (a special subclass of) raising verbs that are—though marked with the AUX feature—in other respects identical to raising verbs in that their predicates subcategorize for a nonthematic subject and a verbal complement (XCOMPlement). Since the embedding on the f-structure mirrors the embedding of the auxiliaries in the c-structure, the advantage of this analysis is that the morphosyntactic dependencies between the auxiliaries and the nonfinite verb can be encoded straightforwardly by appropriately restricting the verbal form features of the embedded XCOMPlements. For a brief illustration of the relatively straightforward modeling of the morphosyntactic dependencies that the raising approach permits let us consider the simple English sentence in (1)

(1) John will work

and the (oversimplified) entries of *work* and the future tense auxiliary *will* in (2).[1]

(2) a. will V $(\uparrow \text{PRED}) = \text{'FUT}\langle(\uparrow \text{XCOMP})\rangle(\uparrow \text{SUBJ})\text{'}$
$(\uparrow \text{SUBJ}) = (\uparrow \text{XCOMP SUBJ})$
$(\uparrow \text{TENSE}) = \text{FUT}$
$(\uparrow \text{VFORM TYPE AUX}) = \text{TENSE}$
$(\uparrow \text{VFORM FORM}) = \text{FIN}$
$(\uparrow \text{XCOMP VFORM FORM}) =_c \text{INF}$
$(\uparrow \text{XCOMP VFORM TYPE}) = \text{MAIN}$

b. work V $(\uparrow \text{PRED}) = \text{'WORK}\langle(\uparrow \text{SUBJ})\rangle\text{'}$
$(\uparrow \text{VFORM TYPE}) = \text{MAIN}$
$(\uparrow \text{VFORM FORM}) = \text{INF}$

The entry (2a) indicates that *will* is a finite form of the tense auxiliary that contributes the (simple) future tense information, given the verb form of the subcategorized XCOMP is an infinitive form of a main verb, as in case of *work* in (2b). The c- and f-structure that sentence (1) gets assigned under the traditional raising analysis is shown in Figure 1.

It has long been recognized, however, that this f-structure representation mirrors the surface syntax and leads to different f-structures in cases where the same morphosyntactic content is expressed by either synthetic or analytic means.

In the context of parallel grammar development, for example, Butt et al. (1996) observe that a raising analysis would provide for the sentences in (3)

(3) a. The driver will have turned the lever

1 We assume here a slightly different system of morphosyntactic features (than the one used in Kaplan and Bresnan 1982) and abstract from other tenses (future perfect) and modal readings.

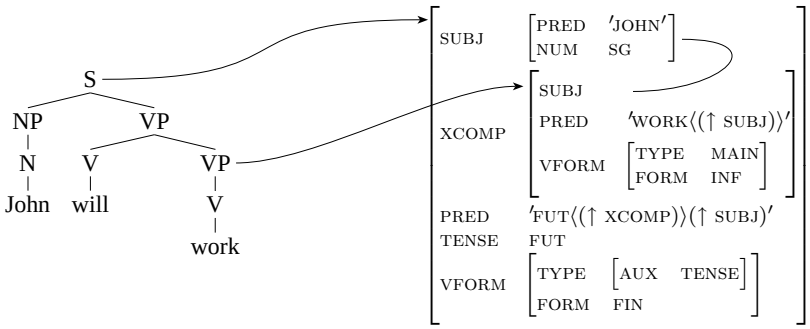

Figure 1
The traditional raising analysis of the sentence *John will work* (together with the relevant structural correspondences).

b. Le conducteur aura tourné le levier

structurally divergent f-structures although the sentences are meaning equivalent and thus expected to obtain equivalent predicate-argument structures. Since future tense is realized in English periphrastically (*will have*), but in French morphologically (*aura*), the f-structure of the French sentence (3b) has one level of embedding less than the structure of the corresponding English sentence (3a). The raising approach thus creates (unnecessary) crosslinguistic problems for parallel grammar development or machine translation, since it provides structurally misaligned analyses for functionally very similar constructions. Similar problems may, of course, also arise language internally, but then affecting language internal descriptive consistency rather than crosslinguistic parallelism. Under a raising analysis, the synthetic and analytic passives in the Scandinavian languages, for example, are associated with different f-structures obscuring the fact that the basic predicate-argument relations are the same.

As a crosslinguistically more adequate alternative, Butt et al. (1996) propose an analysis of the auxiliary complex that provides flat f-structures regardless of whether the tenses are realized morphologically or periphrastically. They analyze auxiliaries as functional categories contributing tense and aspectual information, but no predicate. In order to ensure that the auxiliary complex satisfies the hierarchically organized well-formedness restrictions on the order of the different verb types and forms, they project the multiple XCOMPlement embedding provided by the raising approach simply off of the c-structure into a separate m(orphological)-structure. This requires the original XCOMP to be appropriately renamed, since it is a governable function and thus subject to completeness and coherence tests (which would fail, since auxiliaries are not PRED-bearing anymore).

Morphological structures are related to c-structure nodes by means of the projection μ, just in the same way as c-structure nodes and f-structures are set in correspondence by the projection ϕ. To explicitly identify the structures in the range of multiple projections whose description is being developed by the particular annotations, it is, of course, necessary to explicitly distinguish the projections. This is accomplished by using the symbol $*$ as a variable for the annotated node and the term $\mathcal{M}*$ to denote its mother. With the terms $\mu*$ and $\mu\mathcal{M}*$ it is then possible to refer to the m-structure associated with

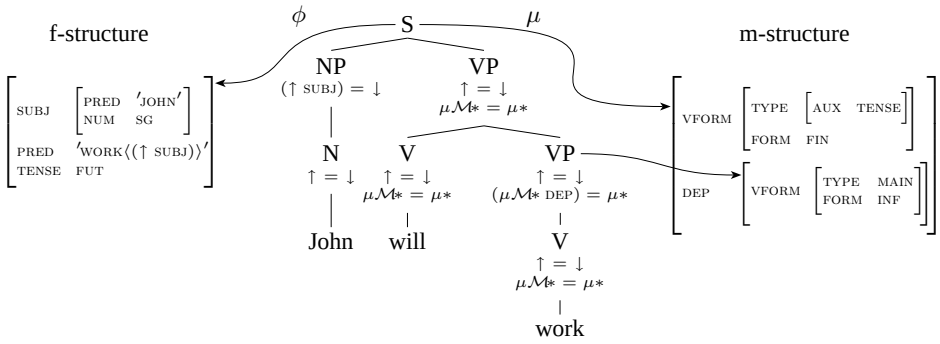

Figure 2
The m-structure analysis of the sentence *John will work* (together with the relevant structural correspondences).

the annotated node and its mother, respectively. Given this more general correspondence architecture (with more than one level of linguistic description involved), the traditional $\downarrow$ and $\uparrow$ metavariables have to be conceived as convenient abbreviations of the more complex expressions $\phi*$ and $\phi\mathcal{M}*$. Continuing with the convenient functional abbreviations, the morphosyntactic dependencies for our example sentence (1) are then encoded in the m-structure approach as follows. As the lexical entries for *will* and *work* in (4) indicate, both the specification of the verbal form features and the constraints on the dependent verb forms are not considered to contribute to the description of the f-structure, but to the one of the m-structure.

(4) a. will V $(\uparrow \text{TENSE}) = \text{FUT}$
$(\mu\mathcal{M}* \text{ VFORM TYPE AUX}) = \text{TENSE}$
$(\mu\mathcal{M}* \text{ VFORM FORM}) = \text{FIN}$
$(\mu\mathcal{M}* \text{ DEP VFORM FORM}) =_c \text{INF}$
$(\mu\mathcal{M}* \text{ DEP VFORM TYPE}) = \text{MAIN}$

b. work V $(\uparrow \text{PRED}) = \text{'WORK}\langle(\uparrow \text{SUBJ})\rangle'$
$(\mu\mathcal{M}* \text{ VFORM TYPE}) = \text{MAIN}$
$(\mu\mathcal{M}* \text{ VFORM FORM}) = \text{INF}$

The embedding on the m-structure is then, as shown in the c-structure of Figure 2, accomplished by additional μ-annotations of the grammar rules. Here, the recursive VP rule produces the desired flat f-structures because of the trivial equation $\uparrow = \downarrow$, while the equation $(\mu\mathcal{M}* \text{ DEP}) = \mu*$ projects the embedded DEPendent m-structures required to test the hierarchically organized well-formedness restrictions.

Frank and Zaenen (2002), however, show that projecting the morphology from the c-structure leads to a duplication of syntactic information in cases where not only morphological information on the verbs, but also on their arguments is assumed to be represented in the m-structure. Since the different arguments of a verb may introduce conflicting values for the different morphological features, the embedding of the f-structure has to be reproduced in the m-structure by some additional non-governable functions (e.g., EXTernal- and INTernal-ARGuments). This causes the m-structure to structurally assimilate the f-structure and thus to unnecessarily copy structural information on predicate-argument dependencies already contained in the f-structure. Moreover, Frank and Zae-

nen (2002) observe that a μ-projection from the c-structure might cause problems when morphological agreement and functional uncertainty interact, as, for example, in object relative clauses in French where the perfect participle agrees (in number and gender) with the relative pronoun (and the embedding noun). Here, both the OBJect and the INT-ARGument function are assigned to the relative pronoun by two independent functional uncertainty expressions, one on the f-structure and the other one on the m-structure. To test the agreement with the embedded perfect participle, both functional uncertainty expressions have to be resolved so that the strings that are chosen from the two regular sets are equal in length. But this synchronization is difficult to accomplish, since f-structures but not m-structures are subject to the general principles of completeness and coherence. The differently constrained resolution spaces of the two functional uncertainty expressions might then (at least without any further constraints) permit the functional uncertainty expression on the m-structure to be resolved to strings other than the ones required to ensure the agreement.

To avoid these problems, they propose a sequenced architecture where the morphological dependencies are projected from the f-structure. Since μ is a function, the hierarchical m-structure can here, of course, not any longer be recursively derived by rules that produce flat f-structures by virtue of the trivial equation $\uparrow = \downarrow$. To account for the various constructions, Frank and Zaenen (2002) are thus forced to (non-recursively) enumerate the possible dependencies in the lexicon. But this requires to disjunctively specify for each nonfinite verb form at which level of embedding it may occur and how it constrains from there the form and type of the dependent verb form on the next level. In order to derive, for example, the English sentences in (5), they would have to assume for the lexical entries of the perfect auxiliary *have* and the perfect participle *worked* that at least two alternative levels of embedding are specified.

(5) a. John may have worked

b. John will have worked

In sentence (5a) *have* is directly embedded under an XCOMPlement (subcategorized by the modal) and requires no DEP embedding, whereas in (5b) it is dependent from a tense auxiliary requiring the usual lexical specifications to be pushed down one extra level. Frank and Zaenen (2002) thus have to assume for *have* an entry like (6a). To ensure that the constraints on the dependent verb forms in (6a) take effect, the (usual) morphological features of *worked* have to be embedded under one, respectively two DEP attributes as shown in (6b).

(6) a. have V $(\uparrow \text{ASPECT}) = \text{PERFECTIVE}$
$\{ (\mu\uparrow \text{VFORM TYPE AUX}) = \text{PERF}$
$(\mu\uparrow \text{VFORM FORM}) = \text{INF}$
$(\mu\uparrow \text{DEP VFORM FORM}) =_c \text{PERFP}$
$|(\mu\uparrow \text{DEP VFORM TYPE AUX}) = \text{PERF}$
$(\mu\uparrow \text{DEP VFORM FORM}) = \text{INF}$
$(\mu\uparrow \text{DEP DEP VFORM FORM}) =_c \text{PERFP} \}$

b. worked V $(\uparrow \text{PRED}) = \text{'WORK}\langle(\uparrow \text{SUBJ})\rangle\text{'}$
$\{\ (\mu\uparrow \text{DEP VFORM TYPE}) = \text{MAIN}$
$(\mu\uparrow \text{DEP VFORM FORM}) = \text{PERFP}$
$|(\mu\uparrow \text{DEP DEP VFORM TYPE}) = \text{MAIN}$
$(\mu\uparrow \text{DEP DEP VFORM FORM}) = \text{PERFP}\ \}$

Although Frank and Zaenen (2002) obviously avoid some of the problems of the original projection approach, their solution is nevertheless not really satisfactory. In order to simulate the effects of a simple recursive rule, they have to specify all possible DEP embeddings of the auxiliaries and (nonfinite) main verbs in the lexicon. In case of a full-form lexicon, this solution thus increases the size of the overall grammar far more drastically than any possible solution that is based on a simple recursive rule.[2] It is in this connection also not really helpful to encode, as they do, the possible embeddings for the numerically predominant and most deeply embeddable main verbs by virtue of functional uncertainty expressions instead of finite disjunctions. This certainly reduces the size of the lexicon, but it increases at the same time the disjunctive solution space much more than actually required, since strictly local dependencies are treated as if they were unbounded.

Only their explicit assumption that a morphological analyzer is employed in the system architecture permits it to circumvent these problems to a certain extent. For the nonfinite main verb forms then the encoding of the possible embeddings can be moved to the appropriate morphological tags (e.g., the one for perfect participle morphemes) provided by the morphological analyzer. Since this does not work for alternative architectures based on full-form lexicons (like our's), their approach can hardly be considered as a theoretically satisfying general solution.

As an alternative to the projection approaches that avoids the problems already mentioned as yet we propose here an analysis that provides flat f-structures for auxiliary constructions without leaving the usual functional level of linguistic description. We are thus not compelled to stipulate an additional morphological projection to establish the desired crosslinguistic parallelism. Our approach that we will illustrate by providing an analysis of the Danish verbal complex, including complex tenses, passives and modals, exploits instead of a projection the restriction operator introduced by Kaplan and Wedekind (1993) and Wedekind and Kaplan (1993).

The restriction operator is a formal device that permits it to ignore information from an f-structure if this information is assumed to be irrelevant for the predicate-argument structure and thus for the semantic interpretation of a sentence. Informally, the restriction of a given f-structure f with respect to an attribute F (notated by f/F) is the f-structure that results from removing F and its value from f. The restriction of the f-structure f in (7a) by SUBJ, for example, is the f-structure in (7b).

2 Moreover, since they generate the embeddings not there where they are actually required, namely in the verb complex, the alternative embeddings encoded in the entries of the nonfinite main verb forms also have to be evaluated when constructions without dependent verb forms are processed, like, for example, infinitival complements as in the sentence *John tries to work* (vs. *John will work*).

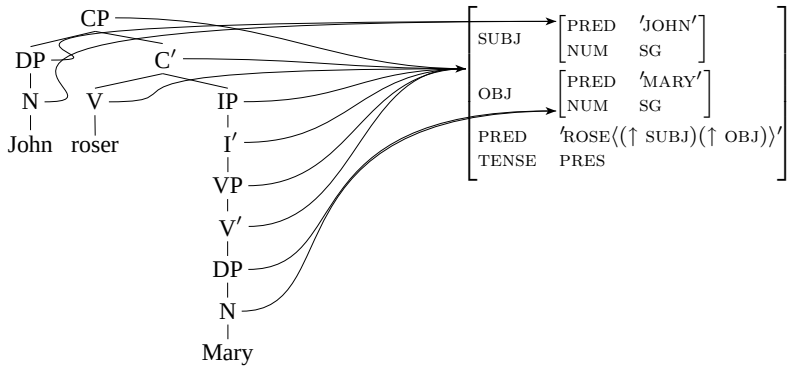

Figure 3
The c- and f-structure of the sentence *John roser Mary* (John praises Mary) and their structural correspondence.

(7) a.
$$f = \begin{bmatrix} \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{'}\textsc{john}\text{'} \\ \textsc{num} & \textsc{sg} \end{bmatrix} \\ \textsc{pred} & \text{'}\textsc{arbejde}\langle(\uparrow \textsc{subj})\rangle\text{'} \\ \textsc{tense} & \textsc{pres} \end{bmatrix}$$

b.
$$f/\textsc{subj} = \begin{bmatrix} \textsc{pred} & \text{'}\textsc{arbejde}\langle(\uparrow \textsc{subj})\rangle\text{'} \\ \textsc{tense} & \textsc{pres} \end{bmatrix}$$

In particular, restriction allows it to express that two f-structures only partially agree. The statement $f/\textsc{f} = g/\textsc{f}$, for example, asserts that f and g agree with respect to all attributes and values other than F (and its values). Note furthermore that $(f/\textsc{f})/\textsc{f} = f/\textsc{f}$ and $(f/\textsc{f})/\textsc{g} = (f/\textsc{g})/\textsc{f}$ and that $f/\textsc{f}$ always subsumes f.

For the illustration of our approach, then, we assume for Danish a rather traditional endocentric, X-bar oriented phrasal structure. The basic structure is illustrated by the example depicted in Figure 3. Since Danish is a V2 language, sentences are assumed to be a projection of the functional category C (complementizer). In main clauses the finite verb appears in C position and initial (topicalized) constituents fill the specifier position of CP. If there is no inversion the subject is initial and appears in CP's specifier position. In case of inversion or in subordinate clauses the subject appears in specifier position of IP. Sentence adverbials, like, for example, negation, are dominated by I′. Since unstressed pronominal objects in main clauses appear in front of sentence adverbials, I′ permits them to appear in front of the adverbials.[3] If there is no object-shift, all possible verbal arguments and subsequent adjuncts are derived by the V′ rule.

3 The sentences (a–c) illustrate that object-shift is obligatory if the pronominal object is unstressed.
a. Jeg ser ikke bussen
I see not the-bus
b. Jeg ser den ikke
I see it not
c. *Jeg ser ikke den
I see not it

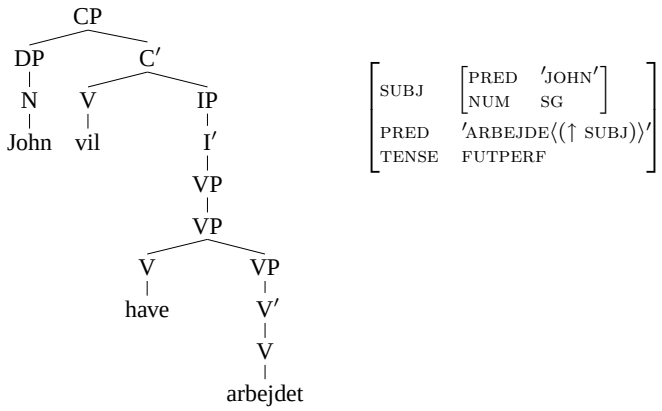

Figure 4
The c- and f-structure of sentence (8).

3 Temporal Auxiliaries

The analysis that we assume here for the complex tenses in Danish is in line with the unified analysis of (tense) auxiliaries in English, French and German proposed by Butt et al. (1996, 1999). They produce flat f-structures by treating auxiliaries as functional, and thus non-PRED-bearing categories and provide complex tense values, like, for example, FUTPERF, based on a system of constraints on the combinations of auxiliaries and main verbs instead of just collecting the morphological features of the auxiliaries and verbs of a complex (analytical) tense form (as, for example, Nordlinger and Bresnan (1996)). For the sentence (8)

(8) John vil have arbejdet
John will have worked

we thus get the c-structure and f-structure in Figure 4.

The Danish (tense) auxiliary system is quite similar to the English one, but it additionally exhibits auxiliary selection for the perfective auxiliary: verbs select either *have* (*have*) or *være* (*be*). Altogether we have to distinguish two synthetic and six analytic tense forms.

(9) (a) Present tense: synthetic
John arbejder
John works

(b) Past tense: synthetic
John arbejdede
John worked

(c) Present Perfect: perfect auxiliary in present tense followed by perfect participle form
John har arbejdet
John has worked

(d) Past Perfect: perfect auxiliary in past tense followed by perfect participle form
John havde arbejdet
John had worked

(e) Future: present tense of *ville* followed by infinitive form (but not of a perfect auxiliary)
John vil arbejde
John will work

(f) Future Perfect: present tense of *ville* followed by infinitive form of perfect auxiliary followed by perfect participle form
John vil have arbejdet
John will have worked

(g) Conditional: past tense of *ville* followed by infinitive form (but not of a perfect auxiliary)
John ville arbejde
John would work

(h) Conditional Perfect: past tense of *ville* followed by infinitive form of perfect auxiliary followed by perfect participle form
John ville have arbejdet
John would have worked

Since Danish does not allow scrambling of the auxiliaries and permits at least in complex forms only nexus adverbials to appear between the finite form and the nonfinite forms, we can—similar to English—derive the nonfinite forms with the recursive VP rule in (10). The finite form is—as the c-structure of Figure 4 illustrates—the head of C′ and the adverbial phrase is considered to be adjoined to I′.

(10) VP → V VP

In order to ensure that each auxiliary and modal can only be followed by a verb of the right type and form we use—similar to almost all other approaches—a system of morphosyntactic features whose relevant parts are given in (11).

(11)
$$\text{VFORM}\left[\begin{array}{ll}\text{TYPE} & \left\{\begin{array}{ll}\text{MAIN} & \\ \text{AUX} & \left\{\begin{array}{l}\text{TENSE}\\ \text{PERF}\\ \text{PASS}\end{array}\right.\\ \text{MOD} & \left\{\begin{array}{l}\text{ROOT}\\ \text{EPIST}\end{array}\right.\end{array}\right.\\ \text{FORM} & \left\{\begin{array}{l}\text{FIN}\\ \text{INF}\\ \text{PERFP}\\ \text{PASSP}\end{array}\right.\\ \text{AUX–SEL} & \left\{\begin{array}{l}\text{HAVE}\\ \text{BE}\end{array}\right.\\ \text{PASSIVIZE} & \left\{\begin{array}{l}\text{YES}\\ \text{NO}\end{array}\right.\end{array}\right.$$

This (rather informal) feature declaration indicates that each verb has a VFORM feature whose value specifies the verb type, its form, which auxiliary it selects and whether it passivizes. We distinguish here tense, perfect and passive auxiliaries and root and epistemic modals. Since our present purposes do not require a further subclassification of the main verbs, we consider MAIN as an atomic value. We further distinguish (here) four different forms, namely finite forms, infinitives, perfect participles and passive participles.

Using restriction we can then state the hierarchically organized morphosyntactic well-formedness restrictions on the order of the different verb types and forms similarly easy as in the raising approach. The only difference is that tense and perfect (as well as passive) auxiliaries do not introduce predicates and that the structural hierarchy is established by the non-governable DEP function instead of XCOMP. We thus state the hierarchical DEPendencies and the constraints on them as ordinary functional specifications instead of projecting them off of the c-structure as morphological specifications. For present perfect, for example, this is illustrated by the lexical entries in (12). In order to introduce the tense value PRESPERF, the tense auxiliary *har* is constrained to combine with a DEPendent perfect participle verb form that selects HAVE, as, for example, *arbejdet*.

(12) a. har V $(\uparrow \text{TENSE}) = \text{PRESPERF}$
$(\uparrow \text{VFORM TYPE AUX}) = \text{TENSE}$
$(\uparrow \text{VFORM FORM}) = \text{FIN}$
$(\uparrow \text{DEP VFORM FORM}) =_c \text{PERFP}$
$(\uparrow \text{DEP VFORM AUX–SEL}) = \text{HAVE}$

b. arbejdet V $(\uparrow \text{PRED}) = \text{'ARBEJDE}\langle(\uparrow \text{SUBJ})\rangle'$
$(\uparrow \text{VFORM TYPE}) = \text{MAIN}$
$(\uparrow \text{VFORM FORM}) = \text{PERFP}$
$(\uparrow \text{VFORM AUX–SEL}) = \text{HAVE}$

The flat f-structure analysis of the complex tense forms is then obtained by simply restricting off the information on the morphological dependencies. This requires to slightly refine the CP and the VP rule as in (13).

(13) a. CP → (DP) C′
$(\uparrow \text{SUBJ}) = \downarrow$ $\uparrow = \downarrow/\text{DEP}/\text{VFORM}$
$(\uparrow \text{TENSE})$

b. VP → (V) VP
$\uparrow = \downarrow$ $(\uparrow \text{DEP}) = \downarrow$
$(\downarrow \text{VFORM FORM}) \neq \text{FIN}$ $(\uparrow \text{VFORM})$
$\uparrow/\text{DEP}/\text{VFORM} = \downarrow/\text{DEP}/\text{VFORM}$

The VP rule can only be applied if there is already a verb form (enforced by the constraint $(\uparrow \text{VFORM})$). Since we are at the moment only concerned with tense and perfect auxiliaries, the first application of the VP rule requires the finite verb (dominated by C′) to be a tense auxiliary. This results from the rule (14)

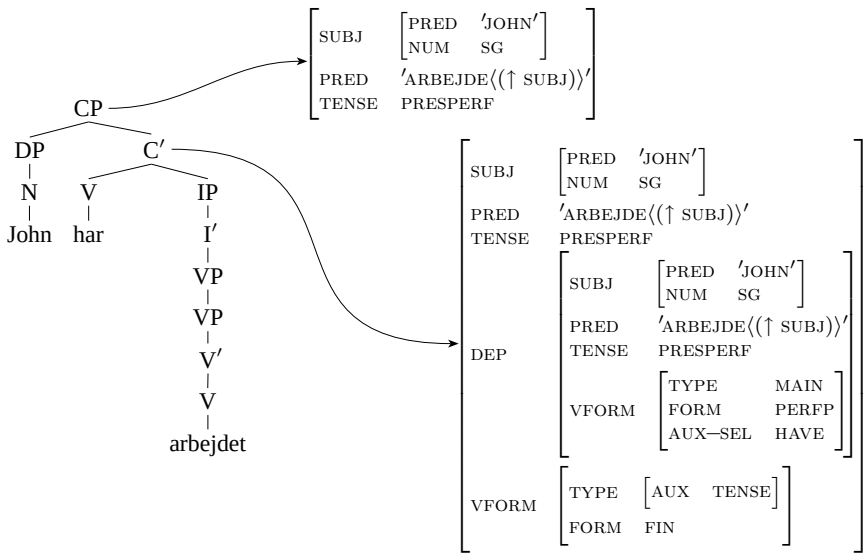

Figure 5
The c-structure of the sentence *John har arbejdet* and the f-structures related to the CP and the C′ node.

(14) VP → V′
$\uparrow = \downarrow$
$(\uparrow \text{VFORM TYPE}) =_c \text{MAIN}$

that is used to leave the recursively constructed auxiliary complex. Rule (14) requires the f-structure associated with V′ to contain a predicate of a main verb. So, if there were already a finite main verb and rule (13b) is applied at least once, then—under a flat analysis—the semantic form of the DEPendent main verb required by rule (14) would cause a unification failure. Hence, the finite form must be an auxiliary when rule (13b) is applied. Moreover, the first application of the VP rule (13b) can only derive the dependent VP, since the verb is constrained to be nonfinite. Further applications of the rule (13b) then require the verb position to be filled by a nonfinite verb form, preventing the grammar from recursively generating non-branching VP chains. The annotation $\uparrow/\text{DEP}/\text{VFORM} = \downarrow/\text{DEP}/\text{VFORM}$ then expresses that the f-structure associated with the mother agrees with the one of the dependent daughter except for the information on the dependent structures and the particular verbal forms. This causes the information that is relevant for the f-structure of the sentence (assigned to the c-structure root) to be percolated upwards. The C′ annotation of the CP rule finally restricts the information on the dependent verbal forms off of the f-structure that is assigned to C′ and thus to the c-structure root CP. The example in Figure 5 illustrates the effects of the restriction annotations by showing not only the f-structure that is assigned to the root, but also the structure from which it is obtained by restriction, namely the one that is assigned to C′.

Since present and past perfect and future and conditional tenses differ only with respect to the tense form of the auxiliary, we can complete the description of our analysis of the complex Danish tense forms by considering the lexical entries of the auxiliaries that are involved in the future tense forms. For perfect participles which select HAVE

these are the ones in (15). Entry (15a) also applies to participles which select *være*.

(15) a. vil V $(\uparrow \text{VFORM TYPE AUX}) = \text{TENSE}$
$(\uparrow \text{VFORM FORM}) = \text{FIN}$
$(\uparrow \text{DEP VFORM FORM}) =_c \text{INF}$
$\{\ (\uparrow \text{TENSE}) = \text{FUT}$
$(\uparrow \text{DEP VFORM TYPE AUX}) \neq \text{PERF}$
$|(\uparrow \text{TENSE}) = \text{FUTPERF}$
$(\uparrow \text{DEP VFORM TYPE AUX}) = \text{PERF}\ \}$

b. have V $(\uparrow \text{ASPECT}) = \text{PERFECTIVE}$
$(\uparrow \text{VFORM TYPE AUX}) = \text{PERF}$
$(\uparrow \text{VFORM FORM}) = \text{INF}$
$(\uparrow \text{DEP VFORM FORM}) =_c \text{PERFP}$
$(\uparrow \text{DEP VFORM AUX–SEL}) = \text{HAVE}$

The complex future tense forms are constructed with the present tense form of *ville*. The finite form *vil* requires a DEPendent infinitive verb form. Depending on whether the infinitive form of this DEPendent form is a perfect auxiliary or not, the tense is either future perfect or future. If this form is a perfect auxiliary, like, for example, *have*, it requires, as any other form of the perfective auxiliaries, a DEPendent perfect participle form, for example *arbejdet* that selects HAVE (cf. (12b)). The infinitive forms of the perfect auxiliaries also introduce aspectual information. This is required for nonfinite clauses, but not for finite clauses because of the perfective tense values. For finite clauses we then eliminate this redundancy by restricting aspectual information off at the IP daughter of the rule (16).

(16) $\text{C}' \rightarrow$ V (IP)
$\uparrow = \downarrow$ $\uparrow = \downarrow/\text{ASPECT}$

4 Passive Verbal Structures

Like Norwegian and Swedish, Danish has two passive forms: a morphological passive that is formed by adding *s* to the verb and a periphrastic passive that involves—similar to English—a finite or nonfinite form of the passive auxiliary *blive* (*be*) and a passive participle. Examples of both forms are given in (17).

(17) a. John roses af Mary
John is-praised by Mary

b. John bliver rost af Mary
John is praised by Mary

Although there are semantic, contextual and lexical restrictions on the use of these two passive forms (see, for example, Engdahl 1999), these differences do not justify a raising analysis of the passive auxiliary. Such an analysis would not capture the functional similarity between the two passive forms. We therefore prefer an analysis similar to the tense auxiliaries where the main verb contributes the top-level PREDicate value.

Apart from very few past tense forms, the *s*-passive is mainly used in present tense and the infinitive in Danish. An example is the verb *roses* whose lexical entry is shown in (18).

(18) roses V $\{ (\uparrow \text{PRED}) = \text{'ROSE}\langle(\uparrow \text{SUBJ})(\uparrow \text{OBL–AGT})\rangle' \mid (\uparrow \text{PRED}) = \text{'ROSE}\langle(\uparrow \text{SUBJ})\rangle' \}$
$(\uparrow \text{PASS}) = \text{MORPH}$
$(\uparrow \text{VFORM TYPE}) = \text{MAIN}$
$\{ (\uparrow \text{TENSE}) = \text{PRES} \mid (\uparrow \text{VFORM FORM}) = \text{FIN} \mid (\uparrow \text{VFORM FORM}) = \text{INF} \}$

If we assume that the lexicon contains only inflected forms, then the *s*-passive requires no further attention from a syntactic point of view. Sentence (17a) thus is associated with the f-structure in (19).

(19)
$$\begin{bmatrix} \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{'JOHN'} \\ \text{NUM} & \text{SG} \end{bmatrix} \\ \text{OBL–AGT} & \begin{bmatrix} \text{PRED} & \text{'MARY'} \\ \text{NUM} & \text{SG} \\ \text{PCASE} & \text{AF} \end{bmatrix} \\ \text{PRED} & \text{'ROSE}\langle(\uparrow \text{SUBJ})(\uparrow \text{OBL–AGT})\rangle' \\ \text{TENSE} & \text{PRES} \\ \text{PASS} & \text{MORPH} \end{bmatrix}$$

Periphrastic passive forms consist of a finite, infinitive or perfect participle form of the passive auxiliary *blive* and a dependent passive participle form. On the basis of the rules that we already presented we thus easily obtain a flat analysis of the analytic passive by assuming for the different forms of the passive auxiliary lexical entries which are similar to the ones for the tense auxiliaries. The entry for the present tense form of *blive*, for example, is given in (20).

(20) bliver V $(\uparrow \text{PASS}) = \text{PERIPH}$
$(\uparrow \text{TENSE}) = \text{PRES}$
$(\uparrow \text{VFORM TYPE AUX}) = \text{PASS}$
$(\uparrow \text{VFORM FORM}) = \text{FIN}$
$(\uparrow \text{DEP VFORM FORM}) =_c \text{PASSP}$

Under the usual assumption that passive participle verb forms are contained in the lexicon we could already stop here and complete this section with a sample f-structure of a sentence containing an analytic passive form. However, in our grammar we followed a suggestion by John Maxwell and encoded passivization syntactically. Passive participle forms are thus not contained in the lexicon. The reason for adopting this strategy was rather practical. Our Danish grammar currently contains a full-form lexicon that was automatically extracted from a lexical database. Here, the use of syntactic passivization rules turned out to be very useful, since we could not only simplify the extraction process, but also reduce the size of the lexicon by the number of passive participle alternatives.

Traditional LFG accomplishes passivization by lexical rules that produce passive form alternatives if they are applied to the functional specifications of verbs that are able to passivize. For English transitive verbs, for example, this is the rule in (21).

(21) PASS(SCHEMATA) = SCHEMATA
$(\uparrow \text{VFORM FORM}) = \text{PASSP}$
$(\uparrow \text{OBJ}) \rightarrow (\uparrow \text{SUBJ})$
$\{ (\uparrow \text{SUBJ}) \rightarrow (\uparrow \text{OBL–AGT})$
$\mid (\uparrow \text{SUBJ}) \rightarrow \text{NULL} \}$

Syntactic passivization, on the other hand, is performed in the rule component, namely at that position where passive participles can occur. This is the verbal head position of the V′ rule. The V′ rule is usually used to derive the main verb of a (complex) verbal complex, the arguments of the main verb and the subsequent adjuncts. A simplified version that is sufficient for our present purposes is the rule depicted in (22) that allows us to illustrate passivization for transitive verbs.

(22) V′ → (V) (DP) (PP)
$\{ (\downarrow \text{VFORM TYPE}) =_c \text{MAIN}$ $(\uparrow \text{OBJ}) = \downarrow$ $\{ (\uparrow \text{OBL}) = \downarrow$
$\uparrow = \downarrow$ $\mid (\uparrow \text{OBL–AGT}) = \downarrow$
$\mid (\downarrow \text{VFORM PASSIVIZE}) =_c \text{YES}$ $(\downarrow \text{PCASE}) =_c \text{AF} \}$
$\downarrow/\text{SUBJ}/\text{OBJ}/\text{VFORM} = \uparrow/\text{SUBJ}/\text{OBL–AGT}/\text{VFORM}$
$(\downarrow \text{OBJ}) = (\uparrow \text{SUBJ})$
$(\downarrow \text{SUBJ}) = (\uparrow \text{OBL–AGT})$
$\{(\uparrow \text{OBL–AGT}) = \text{NULL}\}$
$(\uparrow \text{VFORM TYPE}) = \text{MAIN}$
$(\uparrow \text{VFORM FORM}) = \text{PASSP} \}$

Passivization is then accomplished by this rule as follows. First, it is required that the verbal head position is filled by a (perfect participle form of a transitive) verb that passivizes. The restriction annotation then states that the f-structure associated with the verb agrees with the one assigned to V′ except for the subject, object and the verb form features. Similar to lexical passivization, the subject of the V′ f-structure is identified with the original object and the OBL–AGT with the original subject. For agent-less passives this new OBL–AGT can optionally become NULL. Finally, the f-structure assigned to V′ gets the VFORM features of a passive participle verb form.

For sentence (17b) then we get the c- and f-structure depicted in Figure 6. To illustrate the effects of the passivization annotation we depicted also the f-structures associated with the V and V′ node. As the f-structures of the sentences (17a) and (17b) illustrate, our grammar provides similar f-structures for analytic and synthetic passive forms. We do, however, keep the passive feature as a trigger for the slightly different interpretation of the two forms.[4]

5 Modals

Modals are treated as verbs that introduce a PREDicate subcategorizing for an XCOMPlement that is functionally controlled by the subject. The Danish modal verb system includes as the main representatives *ville, kunne, måtte* and *skulle*. Since the Danish system is almost identical to the Norwegian system, we observe the same systematic ambiguity between a one-place epistemic reading and a two-place root reading that Dyvik (1999)

4 Passivization can, of course, also be performed syntactically if a morphological analyzer is used. This simply requires to extend the sublexical verb rule such that it alternatively permits passivization as in our V′ rule if a morphological passive feature (*-s* or passive participle form) is present.

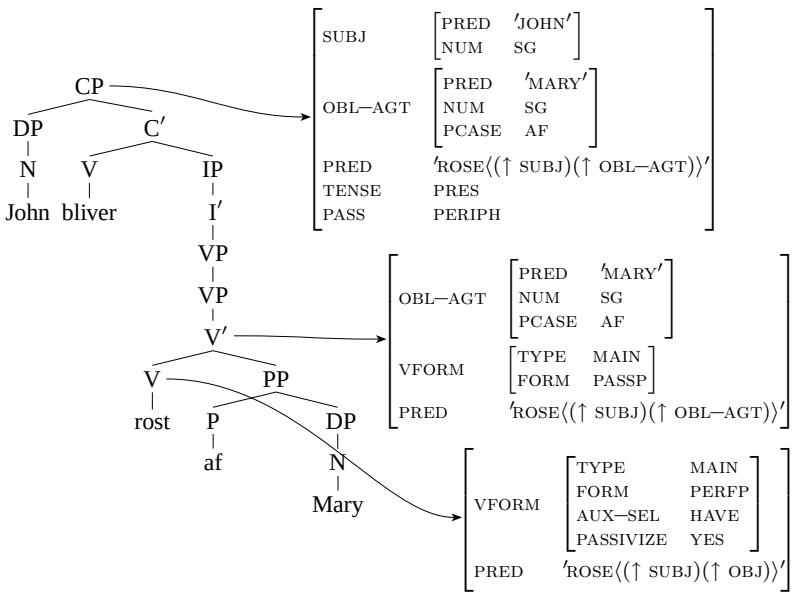

Figure 6
The c- and f-structure of sentence (17b) with the f-structures assigned to the V and the V′ node.

stated for Norwegian. The corresponding examples are given in (23).

(23) a. John kan dreje håndtaget
John may/is able to$_{\text{pres}}$ *turn*$_{\text{inf}}$ *the-lever*

b. John må dreje håndtaget
John must/is obliged to$_{\text{pres}}$ *turn*$_{\text{inf}}$ *the-lever*

c. John skal dreje håndtaget
John is said to/has to$_{\text{pres}}$ *turn*$_{\text{inf}}$ *the-lever*

d. John vil dreje håndtaget
John will/wants to$_{\text{pres}}$ *turn*$_{\text{inf}}$ *the-lever*

As indicated above, we follow Dyvik in making a main distinction between the epistemic and the root reading of the modals. However, in case of the modal verb *kunne* it turns out that Danish grammaticalizes a three-way modal distinction between an epistemic reading, a deontic reading and a dynamic reading. The distinction can be exemplified by (24) below which allows for the three readings in (25). Generally the root reading is vague as to the difference between a deontic and a dynamic reading, but in case of *kunne* the readings are syntactically distinguished in combination with passive complements.

(24) John kan operere
John can operate

(25) a. John kan (være ved at) operere (epistemic)
John may (*be busy*) *operating*

b. John kan (godt) operere (dynamic)
John is (*very well*) *able to operate*

c. John kan operere (i stedet for) (deontic)
John can operate (*instead*)

We will return to a more thorough discussion of these readings below.

For *kunne* the root reading corresponds to 'be able to', while under the epistemic reading it translates as 'may', 'have the possibility to' or 'be likely to'. The root interpretation of *skulle* is in English expressed by 'must' or 'have to', while the epistemic reading corresponds to 'be said to'. For *måtte* the root reading corresponds to 'be allowed to' or 'be obliged to'; the epistemic reading to 'be bound to'. Only *ville* is an exception. It has a volitional root reading 'have the will to' or 'want', but no proper epistemic reading. This reading is in some sense blocked, since its finite forms are used for the future tenses (i.e., they are already part of the tense system). Under the epistemic interpretation of the modals the subject is a nonthematic argument, whereas the predicates of the root readings subcategorize for a thematic subject.

Modals require a dependent infinitive verb form. Ignoring for the moment the distinction between epistemic and root modals, we observe that there are no further syntactic type restrictions; they can combine not only with active main verbs as in (23), but also with modals (26a), perfect (26b) and passive (26c) auxiliaries and *s*-passive forms (26d). (Tense auxiliaries occur only in finite form.)

(26) a. John skal kunne komme
John must$_{\text{pres}}$ *be able to*$_{\text{inf}}$ *come*$_{\text{inf}}$

b. John må have set det
John must$_{\text{pres}}$ *have*$_{\text{inf}}$ *seen*$_{\text{perfp}}$ *it*

c. John kan blive valgt
John may$_{\text{pres}}$ *be*$_{\text{inf}}$ *elected*$_{\text{passp}}$

d. John kan vælges
John may$_{\text{pres}}$ *be-elected*$_{\text{inf}}$

Since modals have infinitive forms, it is (in principle) syntactically possible to embed arbitrarily many modals under each other, although, in practice, the number of the embedded modals is certainly bounded by human performance limitations. A more complex example is given in (27).

(27) John må skulle kunne gøre det
John may$_{\text{pres}}$ *have to*$_{\text{inf}}$ *be able to*$_{\text{inf}}$ *do*$_{\text{inf}}$ *it*

Since Danish modals have perfect participle forms too, also tense (28a) and perfect (28b) auxiliaries can combine with them.

(28) a. John har skullet vaske bilen
John has$_{\text{presperf}}$ *had to*$_{\text{perfp}}$ *wash*$_{\text{inf}}$ *the-car*

b. John må have villet gøre det
John must$_{\text{pres}}$ *have*$_{\text{inf}}$ *wanted to*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*

Because of the relatively unconstrained position and the in principle unbounded number of modals in the VP, we will incorporate modals in our analysis by allowing the VP rule to derive auxiliaries and modals in any order. This simply requires the VP daughter of rule (13b) to alternatively introduce an XCOMP as in (29).

(29) VP → (V) VP
$\uparrow = \downarrow$ $(\uparrow \text{DEP}) = \downarrow$
$(\downarrow \text{VFORM FORM}) \neq \text{FIN}$ $(\uparrow \text{VFORM})$
$\{\ \uparrow/\text{DEP}/\text{VFORM} = \downarrow/\text{DEP}/\text{VFORM}$
$\mid (\uparrow \text{XCOMP}) = \downarrow/\text{DEP}/\text{VFORM}$
$(\downarrow \text{VFORM FORM}) =_c \text{INF}\ \}$

Unlike auxiliaries where the form of the dependent verb varies depending on the type and the form of the auxiliary, modals always require an infinitive verb form regardless of their form and their type. Since we thus do not have to access the form/type information, we can encode this constraint directly at the XCOMP daughter of the VP rule instead of attaching it to the lexical entries of the modals.[5]

Since we postponed the subtype distinction of the modals when we considered the possible combinations of the modals, it finally remains to be investigated whether and how the type of both the embedding and the embedded verb constrains the interpretation of the modals. First, we work along the principles in (30) that Dyvik (1999) observed for Norwegian before we deal with the influence of passive forms that is not treated by Dyvik (1999).

(30) (i) A modal following a root modal is always given a root interpretation.

(ii) A modal following an epistemic modal always has the root reading unless the embedded modal takes a perfective complement.

(iii) Whenever a modal is the dependent verb of a perfect or perfective tense auxiliary, only the root reading of the modal verb is accepted.

(iv) A modal is always epistemic when it takes a perfective complement.

As the examples in (31) illustrate, principle (30i) seems to hold for Danish as well. Under the root interpretation of the first modal only the root reading of the embedded modal is possible.

(31) a. John skal kunne komme
John has to$_{\text{pres}}$ *be able to*$_{\text{inf}}$ *come*$_{\text{inf}}$

b. John skal måtte komme
John has to$_{\text{pres}}$ *be allowed to*$_{\text{inf}}$ *come*$_{\text{inf}}$

5 For languages which differ from Danish in that they also posses main verbs subcategorizing for infinitival complements without infinitive marker, the additional annotation $(\uparrow \text{VFORM TYPE MOD})$ at the XCOMP daughter is required to constrain the verbal head of the matrix to be a modal.

If two (distinct) modals are combined then the epistemic interpretation of the first modal permits only the root interpretation of the embedded one (32).

(32) a. John må skulle ordne det
John may$_{\text{pres}}$ *have to*$_{\text{inf}}$ *take care of*$_{\text{inf}}$ *it*

b. Man skulle kunne dø af det
One might$_{\text{past}}$ *possibly*$_{\text{inf}}$ *die*$_{\text{inf}}$ *from it*

c. Man måtte kunne dø af det
One might$_{\text{past}}$ *possibly*$_{\text{inf}}$ *die*$_{\text{inf}}$ *from it*

Even though the examples in (32b,c) may also be translated as 'one may possibly die from it', we analyze it as an instance of a root modality, for example, with a dispositional reading: one has the disposition that one can die from it. These examples differ from the more obvious readings of the root modality in that the subject argument in (32b) and (32c) is an experiencer rather than an agent. We will return to this issue in the discussion of the passives below.

In accordance with principle (30iii) a modal occurring in a complex tense form has only the root reading (33). For *kunne*, we observe here the same ambiguity between a dynamic and a deontic reading as in (32b,c).

(33) a. John har kunnet gøre det
John has$_{\text{presperf}}$ *been able to*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*

b. John vil skulle gøre det
John will$_{\text{fut}}$ *have to*$_{\text{inf}}$ *do*$_{\text{inf}}$ *it*

c. John vil kunne gøre det
John will$_{\text{fut}}$ *be able to*$_{\text{inf}}$ *do*$_{\text{inf}}$ *it*

d. John ville have kunnet gøre det
John could$_{\text{condperf}}$ *have*$_{\text{inf}}$ *possibly*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*

Dyvik's last principle (30iv) does not seem to hold for Danish. If a modal takes a perfective complement we still observe the systematic ambiguity of the modals as illustrated in (34).

(34) a. Eleverne skal have læst stoffet før eksamen
The-pupils may$_{\text{pres}}$ *have*$_{\text{inf}}$ *read*$_{\text{perfp}}$ *the-material before the-exam*
The-pupils must$_{\text{pres}}$ *have*$_{\text{inf}}$ *read*$_{\text{perfp}}$ *the-material before the-exam*

b. Eleverne må gerne have læst stoffet (root)
The-pupils are allowed to$_{\text{pres}}$ *preferably*$_{\text{adv}}$ *have*$_{\text{inf}}$ *read*$_{\text{perfp}}$ *the-material*

Eleverne må vel have læst stoffet (epistemic)
The-pupils may$_{\text{pres}}$ *possibly*$_{\text{adv}}$ *have*$_{\text{inf}}$ *read*$_{\text{perfp}}$ *the-material*

For the effect of the passive forms on the interpretation we can rely on several investigations, among them Engdahl (1999). They all agree on the following systematic interaction: whenever a modal takes a passive complement then the *blive*-passive permits only the epistemic reading of the modal and the *s*-passive only the root reading. Some examples of modals with passive complements are given in (35).

(35) a. Kagen kan blive spist
The-cake may$_{\text{pres}}$ *be*$_{\text{inf}}$ *eaten*$_{\text{passp}}$

b. Kagen kan spises
The-cake can$_{\text{pres}}$ *be-eaten*$_{\text{inf}}$
'The cake is edible'

c. Kagen skal blive spist
The-cake will$_{\text{pres}}$ *be*$_{\text{inf}}$ *eaten*$_{\text{passp}}$

d. Kagen skal spises
The-cake has to$_{\text{pres}}$ *be-eaten*$_{\text{inf}}$

e. Kagen vil blive spist
The-cake will$_{\text{fut}}$ *be*$_{\text{inf}}$ *eaten*$_{\text{passp}}$

f. Kagen vil spises (forces a non-sensical reading)
The-cake wants to$_{\text{pres}}$ *be-eaten*$_{\text{inf}}$

g. Kagen må blive spist
The-cake may$_{\text{pres}}$ *be*$_{\text{inf}}$ *eaten*$_{\text{passp}}$

h. Kagen må spises
The-cake can$_{\text{pres}}$ *be-eaten*$_{\text{inf}}$

However, the picture turns out to be somewhat more complicated. Note that the generalization about the passive form and the interpretation of the modals interacts with Dyvik's principle (30iii). According to principle (30iii), a perfect participle of a modal only permits the root reading, so we would predict that a perfect participle of a modal verb does not allow a complement with a *blive*-passive, since a *blive*-passive forces an epistemic reading. Corpus searches show that this prediction is borne out for the verbs *skulle* and *måtte*, but not for the verb *kunne*. Actually there are several instances of *kunne* combining with a *blive*-passive:[6]

(36) a. Adskillige patienter har kunnet blive opereret
Several patients have could become operated
'It has been possible to operate several patients'

6 We have used the following corpora: korpus2000 (WWW.DSL.DK) and Danish web-pages searched through GOOGLE.

b. ... der ikke har kunnet blive omskolet
... who not have had the possibility to be retrained
'... whom it has not been possible to retrain'

c. Alle har kunnet blive ansat
Everyone has had the possibility to be employed
'It has been possible to employ everyone'

Interestingly, the examples cannot be interpreted as epistemic modality. The combination with a *blive*-passive rather seems to favour a deontic interpretation, while the combination with an *s*-passive a dynamic interpretation, cf. (37).

(37) Patienten har kunnet opereres
The-patient has been able to be-operated
'The patient could be cured by means of operation'

The question is, however, whether this *deontic* reading of the modal *kunne* is indeed associated with a thematic subject. In some respects the deontic reading seems to pattern with the epistemic reading, in others it seems to pattern with the root reading. Dyvik's analysis is motivated by the fact that epistemic modals allow for expletive subjects:

(38) Der kan komme nogen
There can come somebody
'Somebody may come'

This argument is, however, weakened by the fact that deontic interpretations are also available in contexts with expletive subjects, cf. example (39) below and the possible readings in (40).

(39) Der skal komme nogen
There shall come somebody

(40) a. Somebody is said to come (epistemic)

b. Somebody has to come (deontic)

Thus, the possibility of expletive subjects seems not to be restricted to epistemic contexts.

An argument in favour of treating the deontic reading as a reading involving a two-place predicate is that the deontic reading allows for paraphrases containing a *for*-PP. For (41) below, which is ambiguous between a deontic and a dynamic reading

(41) John kan tale tysk
John can speak German

the possible paraphrases are shown in (42).

(42) a. John is able to speak German (dynamic)

b. John is allowed to speak German (deontic)

It is allowed for John to speak German

These paraphrases suggest that the deontic reading patterns with the dynamic reading and provide an argument in favour of treating both as instances of the *root* modality. However, the different readings only have to be resolved when *kunne* combines with passive complements (cf. (36) and (37)).

These considerations boil down to a number of morphosyntactic constraints on the interpretation of modals. Only finite forms, i.e., present and past tense forms, exhibit the systematic ambiguity between an epistemic and a root interpretation, while nonfinite forms, i.e., infinitives and perfect participles, always have solely the root reading (comprising both the dynamic and the deontic reading). Moreover, if we ignore *kunne* for the moment then *blive*-passive complements exclude the root interpretation and *s*-passive complements the epistemic reading. These facts can easily be taken into account by simply assuming for the finite and the nonfinite forms different lexical specifications, like, for example, the ones for the present tense and perfect participle forms of *måtte* in (43a,b).

(43) a. må V
$$
\begin{array}{l}
(\uparrow \textsc{tense}) = \textsc{pres} \\
(\uparrow \textsc{vform form}) = \textsc{fin} \\
\{\ (\uparrow \textsc{pred}) = \text{'}\textsc{måtte}\langle(\uparrow \textsc{xcomp})\rangle(\uparrow \textsc{subj})\text{'} \\
\quad (\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
\quad (\uparrow \textsc{vform type mod}) = \textsc{epist} \\
\quad (\uparrow \textsc{xcomp pass}) \neq \textsc{morph} \\
|\ (\uparrow \textsc{pred}) = \text{'}\textsc{måtte}\langle(\uparrow \textsc{subj})(\uparrow \textsc{xcomp})\rangle\text{'} \\
\quad (\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
\quad (\uparrow \textsc{vform type mod}) = \textsc{root} \\
\quad (\uparrow \textsc{xcomp pass}) \neq \textsc{periph}\ \}
\end{array}
$$

b. måttet V
$$
\begin{array}{l}
(\uparrow \textsc{pred}) = \text{'}\textsc{måtte}\langle(\uparrow \textsc{subj})(\uparrow \textsc{xcomp})\rangle\text{'} \\
(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
(\uparrow \textsc{vform type mod}) = \textsc{root} \\
(\uparrow \textsc{vform form}) = \textsc{perfp} \\
(\uparrow \textsc{vform aux–sel}) = \textsc{have} \\
(\uparrow \textsc{xcomp pass}) \neq \textsc{periph}
\end{array}
$$

We thus follow Dyvik (1999) in assuming that the predicates of the epistemic readings subcategorize for a nonthematic subject, while the root readings have a thematic one. For constraining the interaction between the interpretation of modals and the possible passive forms we use simple inequalities.

For the root readings of the modal verb *kunne*, we observed that *blive*-passive complements force the deontic interpretation and *s*-passive complements the dynamic reading. We thus arrive at the following lexical encoding for the modal verb *kunne*. We consider first the entries for the finite forms illustrated by the present tense form *kan* in (44).

(44) kan V
$$
\begin{array}{l}
(\uparrow \textsc{tense}) = \textsc{pres} \\
(\uparrow \textsc{vform form}) = \textsc{fin} \\
\{\ (\uparrow \textsc{pred}) = \text{'}\textsc{kunne}\langle(\uparrow \textsc{xcomp})\rangle(\uparrow \textsc{subj})\text{'} \\
\quad (\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
\quad (\uparrow \textsc{vform type mod}) = \textsc{epist} \\
\quad (\uparrow \textsc{xcomp pass}) \neq \textsc{morph} \\
|(\uparrow \textsc{pred}) = \text{'}\textsc{kunne}\langle(\uparrow \textsc{subj})(\uparrow \textsc{xcomp})\rangle\text{'} \\
\quad (\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
\quad (\uparrow \textsc{vform type mod}) = \textsc{root} \\
\quad \{\ (\uparrow \textsc{modvalue}) = \textsc{dynamic} \\
\qquad (\uparrow \textsc{xcomp pass}) \neq \textsc{periph} \\
\quad |(\uparrow \textsc{modvalue}) = \textsc{deontic} \\
\qquad (\uparrow \textsc{xcomp pass}) \neq \textsc{morph}\ \}\ \}
\end{array}
$$

The lexical entry shows that the finite form *kan* allows for both an epistemic reading and a root reading where the root reading is ambiguous between a deontic and a dynamic interpretation. If the complement contains a periphrastic passive we get an ambiguity between an epistemic and a deontic reading, and if the complement is a synthetic passive we get a dynamic reading.

The lexical entry for the perfect participle in (45) is similar but lacks the epistemic reading in accordance with Dyvik's principles.

(45) kunnet V
$$
\begin{array}{l}
(\uparrow \textsc{vform form}) = \textsc{perfp} \\
(\uparrow \textsc{vform aux–sel}) = \textsc{have} \\
(\uparrow \textsc{pred}) = \text{'}\textsc{kunne}\langle(\uparrow \textsc{subj})(\uparrow \textsc{xcomp})\rangle\text{'} \\
(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
(\uparrow \textsc{vform type mod}) = \textsc{root} \\
\{\ (\uparrow \textsc{modvalue}) = \textsc{dynamic} \\
\quad (\uparrow \textsc{xcomp pass}) \neq \textsc{periph} \\
|(\uparrow \textsc{modvalue}) = \textsc{deontic} \\
\quad (\uparrow \textsc{xcomp pass}) \neq \textsc{morph}\ \}
\end{array}
$$

Compared to Dyvik's analysis, we thus explicitly assume a deontic and a dynamic reading of the root modal *kunne*, since these readings are systematically distinguished when *kunne* combines with a passive complement.

Finally, we have to consider the epistemic readings of the finite forms of *ville*. Since they have degenerated to tense markers, their entries are slightly different. In (46) we show the one for *vil* where the future tense markers substitute the epistemic reading of the entire modals.

(46) vil V
$$
\begin{array}{l}
\{\ (\uparrow \textsc{vform type aux}) = \textsc{tense} \\
\quad (\uparrow \textsc{vform form}) = \textsc{fin} \\
\quad (\uparrow \textsc{dep vform form}) =_c \textsc{inf} \\
\quad (\uparrow \textsc{pass}) \neq \textsc{morph} \\
\quad \{\ (\uparrow \textsc{tense}) = \textsc{fut} \\
\qquad (\uparrow \textsc{dep vform type aux}) \neq \textsc{perf} \\
\quad |(\uparrow \textsc{tense}) = \textsc{futperf} \\
\qquad (\uparrow \textsc{dep vform type aux}) = \textsc{perf}\ \} \\
|(\uparrow \textsc{pred}) = \text{'}\textsc{ville}\langle(\uparrow \textsc{subj})(\uparrow \textsc{xcomp})\rangle\text{'} \\
\quad (\uparrow \textsc{tense}) = \textsc{pres} \\
\quad (\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \\
\quad (\uparrow \textsc{vform type mod}) = \textsc{root} \\
\quad (\uparrow \textsc{vform form}) = \textsc{fin} \\
\quad (\uparrow \textsc{xcomp pass}) \neq \textsc{periph}\ \}
\end{array}
$$

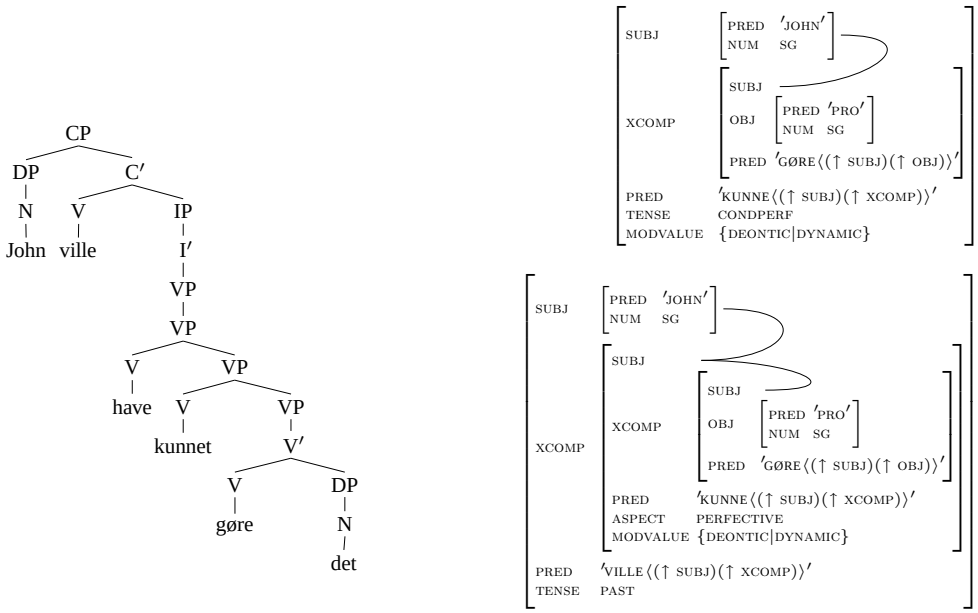

Figure 7
The c- and f-structures of sentence (47).

According to our analysis we then get, for example, for the sentence (33d), repeated here in (47),

(47) John ville have kunnet gøre det
John could$_{\text{condperf}}$ *have*$_{\text{inf}}$ *possibly*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*
John could$_{\text{condperf}}$ *have*$_{\text{inf}}$ *been able to*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*
John wanted to$_{\text{past}}$ *have*$_{\text{inf}}$ *the possibility to*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*
John wanted to$_{\text{past}}$ *have*$_{\text{inf}}$ *been able to*$_{\text{perfp}}$ *do*$_{\text{inf}}$ *it*

altogether four readings. The c-structure and the corresponding f-structures are depicted in Figure 7.

6 Conclusion

We have presented an analysis of the Danish verb complex that provides the desired flat f-structures for auxiliary constructions. Since our restriction-based approach permits us to state and derive the hierarchically organized morphosyntactic well-formedness conditions similarly easy as in the formally quite elegant raising approach, it avoids the space-consuming lexical simulation of the sequenced projection architecture proposed by Frank and Zaenen (2002). Moreover, since our approach operates only on the functional level of representation, the intermodular problems of the parallel projection architecture detected by Frank and Zaenen (2002) cannot occur.

But, apart from these rather technical issues, both projection approaches seem also to be confronted with a more serious conceptual problem resulting from LFG's fundamental assumptions on the modular architecture of the different kinds of linguistic information.

LFG assigns to a sentence a c-structure representing the ordered arrangement of

words and phrases in the sentence and an f-structure representing its underlying predicate-argument structure. F-structures that are related to the c-structures by ϕ-correspondences abstract from the superficial arrangement of words and phrases and are thus assumed to be nearly invariant across languages. Since strings are regarded to be (syntactically) well-formed, if they have valid c-structures that get assigned (well-formed) f-structures, grammaticality is entirely determined on the phrasal and functional level of representation. Structures on other (typically more abstract) levels of representation (e.g., semantic and thematic structures) are then related to the c- or f-structure by multiple correspondences.

According to this rough sketch of LFG's modular specifications of different kinds of linguistic information, one would expect the m-structure to differ from the f-structure in at least two respects. For the sequenced architecture one would expect the m-structure to be somewhat more abstract than the f-structure, since it is projected from the f-structure and thus assumed to abstract from some aspects of the underlying predicate-argument relationships while illuminating other linguistically interesting aspects closer to the meaning representation. With the m-structure located on roughly the same rather than a higher level of abstraction this applies slightly weakened also to the parallel architecture. Moreover, since grammaticality is supposed to be determined solely on the phrasal and functional level of representation, the m-description is expected to be a (syntactically) conservative extension of the f-description. In other than syntactic respects, the extension might, of course, be creative, as, for example, an additional semantic projection that might filter out some of the syntactically well-formed strings for purely semantic reasons.

Already the arguments of the authors, then, suffice to see that for both projection approaches exactly the opposite seems to hold. (This fortunately protects our argumentation from entering a complicated and difficult discussion on the explication of the linguistic notion of abstractness.) The f-structure is in both cases more abstract than the m-structure, since it abstracts—as intended by the authors—from the hierarchically organized morphological dependencies encoded in the m-structure. The extensions are in both cases also not syntactically conservative. The whole purpose of the μ-projection is to test the hierarchically organized morphosyntactic well-formedness conditions and to filter out those strings as syntactically ill-formed which violate them. Other than syntactic reasons to mark strings as ill-formed have to be ruled out, since strings that get assigned valid c-structures are morphologically well-formed.

Within LFG's multiple projection architecture, both μ-projections can thus not seriously be considered as representing linguistically motivated, independent and hence legitimate levels of representation. The projections are rather misused to carry out some simple computations which are necessary to determine grammaticality, but not worth or desired to appear in the f-structure.

The restriction approach on the other hand gets along without stipulating these note sheets to represent linguistically interesting and illuminating structures. And it makes it possible to carry out those computations when the f-structure of the entire sentence is computed from the f-structures of its constituents. Hence, it computes the morphological dependencies before the sentence gets assigned its f-structure. The restriction approach thus retains morphosyntactic dependencies—as usually assumed—on a less

abstract level of representation and permits grammaticality—as in usual LFG—to be determined on the phrasal and functional level of representation.

A final note about the basic formal properties of the approaches. For traditional LFG grammars (satisfying the Nonbranching Dominance Condition) the parsing problem is decidable, since a grammar can assign to a string only a finite number of valid derivations which guarantees the composition of the (decidable) context-free parsing and the (decidable) constraint satisfaction problem to be finitely bounded by the sentence length. Because of the decidability of the satisfiability problem for descriptions containing projection and/or restriction constraints, decidability of the parsing problem follows for all these extensions too.

With respect to generation, however, the matter is different. We have seen that the restriction operator permits it to remove information when this information is assumed to be irrelevant for the f-structures finally assigned to the sentences. Thereby, it produces floating structures that are not considered to be part of the actual f-structures. Since the inputs to the generator do not include the floating structures produced by restriction, generation is here affected by the same problems as they arise in projection architectures. These assume only the f-structures, but not the complete f- and m-structure configurations derived by the grammar to be given to the generator and depend thus also on the assumption that the inputs to the generator are underspecified.

Unfortunately, the problem of whether or not there are any strings associated with an underspecified input structure had been shown to be undecidable in general (see, for example, Wedekind 1999). Since there is in general no structural relation between the (underspecified) inputs and the fully specified structures, it is in principle possible to restrict/project off structures whose size is not bounded by the size of the actual input f-structures. And this permits the computation of some in general undecidable problems to be encoded in the structures restricted/projected off the f-structures.

However, for auxiliary constructions we have seen that the depth of the required DEP embeddings is always finitely bounded (up to three or four, depending on the language), so that at least for grammars analyzing those particular constructions by restriction or projection decidability of the generation problem can still be established.

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