

# Developing a Danish grammar in the GRASP project: A construction-based approach to topology and extraction in Danish

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## Abstract

This paper presents work carried out in the GRASP (GRAMmar SPecifications for Danish) project to develop and implement a grammar of Danish within a construction-based framework. The grammar builds on an approach in which standard generalisations about dependency relations interact with constraints on topology and extraction in the definition of a hierarchy of construction types of non-trivial coverage. Thus, this work addresses two of the most discussed topics in the literature on Danish syntax – topology and extraction – in the framework of constraint-based linguistic theory. It breaks new ground by providing an (implemented) HPSG account of Danish of reasonable coverage, at the same time as providing an interesting testbed for a construction-oriented HPSG approach.

The approach described has been implemented in the LKB system.

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## 1 Introduction

GRASP is a project running at the Center for Sprogteknologi (Centre for Language Technology) in Copenhagen, the aim of which is to develop formal specifications and implementations covering central aspects of the Danish language. The project is currently working within the two different theoretical frameworks provided by HPSG on the one hand, and LFG on the other.

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This paper focusses on the results achieved so far in the HPSG-oriented part of the project, in which we have developed a grammar of Danish based on the construction-based view of grammar recently arisen within HPSG theory [14].

The grammar builds on an approach in which standard generalisations about dependency relations interact with constraints on topology and extraction in the definition of a hierarchy of construction types of non-trivial coverage. More specifically, constituent order patterns well-known from field grammar analyses of Scandinavian languages are recast in terms of a hierarchy of constituent order types allowing for a succinct distinction between main and subordinate clauses on the one hand, and declarative and interrogative clauses on the other. Furthermore, different kinds of extracted phrases are distinguished: this provides the basis for an account of topicalised constructions and various relative clause types. The constraint system set up also allows for multiple gap examples.

Thus, this work addresses two of the most discussed topics in the literature on Danish syntax – topology and extraction – in the framework of constraint-based linguistic theory. It breaks new ground by providing an (implemented) HPSG account of Danish of reasonable coverage, at the same time as providing an interesting testbed for a construction-oriented HPSG approach.

The grammar has been implemented in the LKB system [4]. LKB is a typed-based system, where not only lexical and syntactic features, but also grammatical phrases and clauses are defined as types. To give an impression of the coverage of our implementation, the GRASP grammar consists of 183 types, 48 of which are phrasal and clausal types equivalent to grammar rules. In addition to basic grammar phrases such as head-complement, head-specifier and a few types of head-adjunct phrases, these cover an interesting subset of clausal types as explained in the following sections. The grammar has not yet been evaluated extensively, the main obstacle being the currently limited coverage of lexical types. In the tests carried out so far, the system performs with a speed of 30.53 CPU msec per word.

## 2 Topology and Clause Types in Danish

Field schemata have often been assumed necessary to account for the topology in languages exhibiting topological properties diverging from those found in English, e.g. German, Swedish and Danish, cf. [10] and [9]. In these accounts, instead of applying to local constituents in phrase structures, a separate domain is assumed to which precedence statements based on field schemata can be applied, cf. [5]. Importantly, constituents are linearised in this domain enabling precedence statements referring beyond local constituents. Here an account is presented which claims that Danish topology and the relation between topology and clause type can be accounted for without such a separate linearised domain. The present account is based on a hierarchy of construc-

tions with the two dimensions headedness and clausality, cf. [15] and [8]. In the headedness dimension, a marking feature encodes topology information in a subset of phrase types. The clausality dimension specifies clause types. A number of constructions are subsumed by both dimensions relating topology and clause type. This allows for a straightforward account of the relation between topological properties such as subject-main verb inversion and adverb placement, and different clause types such as declaratives, interrogatives, main clauses, subclauses and topicalised clauses<sup>3</sup>.

### 2.1 Data

The examples in (1) illustrate how constituent order and clause type interact.

- (1) a. *Kvinden ser også manden.*  
 (Woman-the sees also man-the.)  
 ‘The woman also sees the man.’
- b. *(fordi) kvinden også ser manden.*  
 ((because) woman-the also sees man-the.)  
 ‘(because) the woman also sees the man.’
- c. *Hopper manden?*  
 (Jumps man-the?)  
 ‘Does the man jump?’
- d. *Senere hopper manden.*  
 (Later jumps man-the.)  
 ‘Later the man jumps.’

(1a) and (1b) show how adverb placement and the main vs. subclause distinction are interdependent. So-called “nexus” adverbs, or central adverbs, are placed in postverbal position in main clauses, and in preverbal position in subclauses. Similarly, (1c) and (1d) show that subject-main verb inversion is found in either interrogatives or declarative topicalised clauses, depending on whether or not a constituent appears preverbally<sup>4</sup>.

### 2.2 Marking and Topology

To account for the data a modified notion of marking is adopted, cf. [13]. Here the marking values reflect a reinterpretation of the field schema. Marking is

<sup>3</sup> Wh-interrogatives and imperatives are not dealt with in this paper.

<sup>4</sup> It should be noted that inversion is also found in conditionals as in

*Ser kvinden manden, hopper han.*

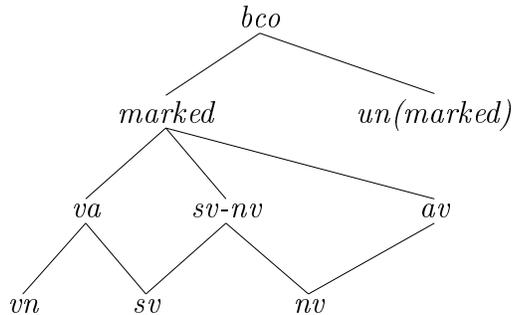
(Sees woman-the man-the, jumps he.)

‘If the woman sees the man, he will jump.’

Such constructions are obvious counterexamples to the observation that verb-initial inverted clauses are always interrogatives, and remain to be dealt with.

used to mark the “nexus field” in constituent structure in order to ensure that certain constituents appear outside it, whereas others appear inside it, e.g. nexus adverbs and inverted subjects are positioned inside<sup>5</sup>. A non-inverted subject and complements constitute nexus boundaries. The BCOMARK value (Basic Constituent Order Marking) is structure shared between the non-head constituent and the mother in phrasal constructions. The value of BCOMARK is of type *bco*, subtyped as in (2).

(2)



An inverted subject (examples (1c) and (1d)) and nexus adverbs (examples (1a) and (1b)) appear in the nexus field, and they mark constructions with values that are subtypes of *marked*. The inverted subject marks a construction as BCOMARK*vn*, a preverbal adverb as BCOMARK*av*, and a postverbal adverb as BCOMARK*va*. Non-inverted subjects and complements mark a construction as BCOMARK*unmarked*, they appear outside the nexus field<sup>6</sup>.

Marking values change values throughout a construction. This means that on the top node of a construction, no record of lower level markings is kept. As it is the markings inside the nexus field that are interesting from the point of view of clause type, a second feature is needed, the BCO*bco* feature (Basic Constituent Order). BCO is an attribute of *head*, also with values of type *bco*. It is used to specify, on a verbal head, the actual topological information pertaining to the entire construction in which it occurs. The BCO value of the head daughter is constrained by the non-head daughter in a construction. An inverted subject constrains the head’s BCO value to *vn*, a maximal type indicating inverted constituent order. Non-inverted subjects constrain the head’s BCO value to *sv-nv*, an underspecified type indicating subject-verb order, but underspecified wrt. whether the subject is in the nexus field or not according to field schema analysis. The underspecification is resolved by the position of nexus adverbs, as they, depending on their position, constrain the head’s BCO value to *va* or *av*. This means that BCO*va* constrained heads

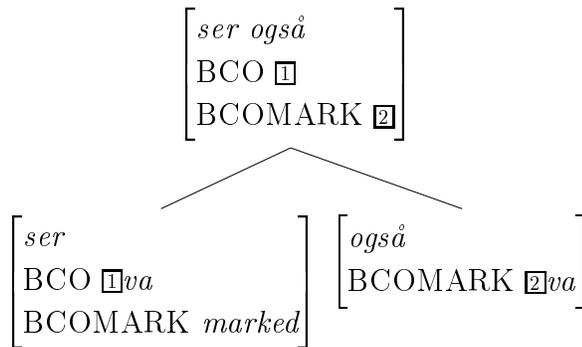
<sup>5</sup> Future research will investigate how this marking constrains the occurrence of “light” and negated objects which also occur in the nexus field.

<sup>6</sup> It should be noted that the subject in a declarative subclause marks a construction as BCOMARK*unmarked*, even though it appears in the nexus field in traditional field schema analyses.

resolve to  $BCO_{sv}$ , the common subtype of  $sv-nv$  and  $va$ , indicating non-nexus subject-verb order.  $BCO_{av}$  constrained heads, on the other hand, resolve to  $BCO_{nv}$ , the common subtype of  $sv-nv$  and  $av$ , indicating nexus subject-verb order.

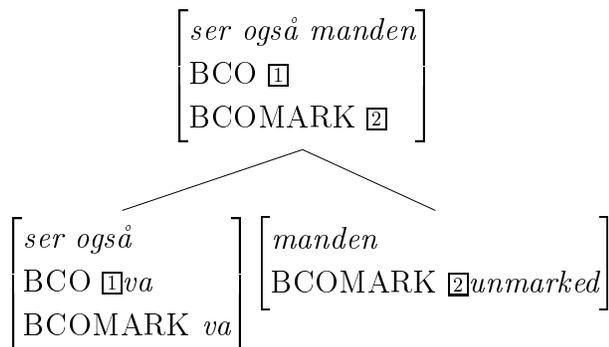
BCOMARK and BCO constrain the basic constituent order in (1a) as shown in (3) through (5). (3) is an example of a head-adjunct construction. The verb is lexically underspecified wrt. BCO and BCOMARK. Its BCO value is constrained to  $va$  in a construction type, the *hd-nexadjunct-non-cl* type, and its BCOMARK value is constrained to *marked* in the same type ensuring that the adverb appears inside the nexus field. The value of BCO is structure shared by the head daughter and the mother, as BCO is a head feature. The marking feature BCOMARK, on the other hand, is structure shared between the non-head daughter and the mother.

(3)



In (4) a complement is attached. A complement marks the boundary of the nexus field, and the BCOMARK value passed on from the complement daughter to the mother is *unmarked*. A complement does not constrain the BCO and BCOMARK values of the head daughter, the former value being passed on via the Head Feature Principle to the mother which remains  $BCO_{va}$ .

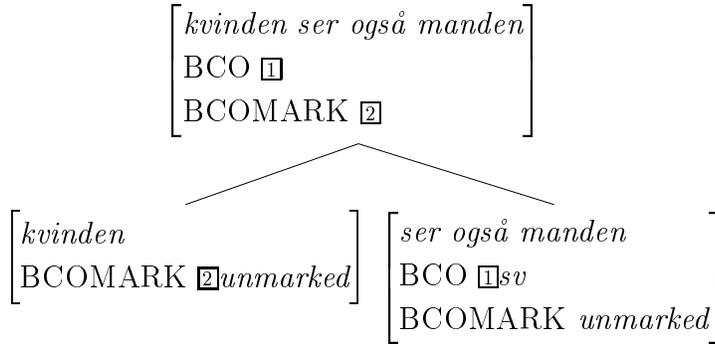
(4)



Finally, in (5) a subject is attached. A subject also marks the boundary of the nexus field, and  $BCOMARK_{unmarked}$  is passed on from the subject daughter to the mother. The head daughter is constrained to  $BCO_{sv-nv}$  in a construction type, the *subj-hd-ph* type, and as the head daughter is  $BCO_{va}$ , the values resolve to  $BCO_{sv}$ , the only common subtype of  $sv-nv$  and  $va$ . This

means that the subject is a non-nexus subject. In this way the postverbal adverb resolves the underspecification presented by a preverbal subject.

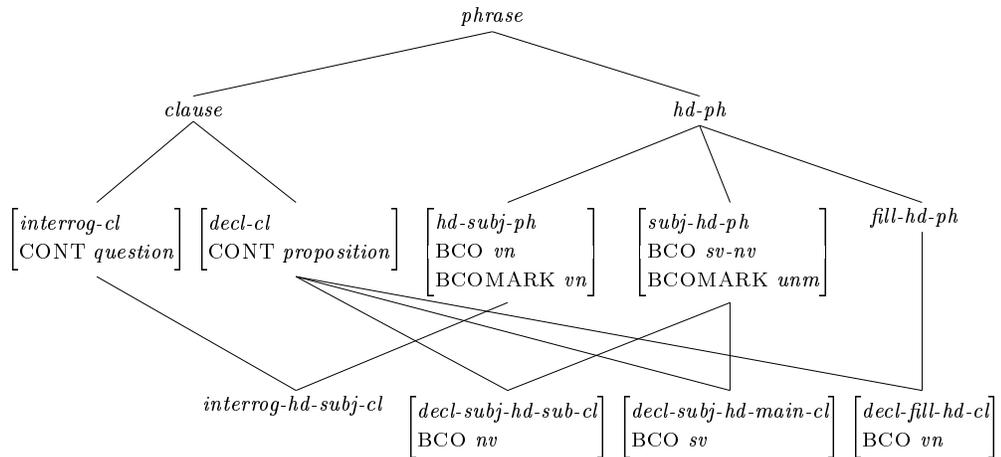
(5)



### 2.3 Topology and Clause Types

The constraints wrt. topological properties on the various phrase types as explained in 2.2 are related to clause types as shown in (6), where also the topological constraints on phrase types are shown.

(6)



In the *interrog-hd-subj-cl* type the interrogative clause type and the constituent order *vn*, i.e. subject-main verb inversion, are related, cf. example (1c). In the *decl-subj-hd-sub-cl* type the declarative subclause type and the constituent order *nv*, i.e. nexus subject-verb order, are related, cf. example (1b), whereas in the *decl-subj-hd-main-cl* type the declarative main clause type and the constituent order *sv*, i.e. non-nexus subject-verb order, are related, cf. example (1a). Finally, in the *decl-fill-hd-cl* the declarative topicalised clause type and the constituent order *vn*, i.e. verb-inverted nexus subject order, are related, cf. example (1d). The construction exemplified in (5) is a *decl-subj-hd-main-cl*, as the postverbal adverb constrains the underspecification of the preverbal subject to *sv*.

### 3 Extraction

Extraction is an important phenomenon to be dealt with in a grammar of Danish, as topicalisation is quite a frequent construction in spoken as well as written language. A treatment of the complete range of constructions for which extraction is relevant, must take into account the interesting fact that Danish, and Scandinavian languages in general, allow extraction out of relative clauses (see [6]), and consequently sentences displaying multiple gaps as discussed in more detail in Section 3.1.

The following are examples of the constructions we will be dealing with in this section. All of them presuppose a treatment of extraction<sup>7</sup>.

- (7) a. *Ham<sub>i</sub> siger kvinden hun tror hun har set <sub>-i</sub>.*  
(Him says the-woman she thinks she has seen.)
- b. *Ham<sub>i</sub> er der ikke nogen<sub>j</sub> der<sub>j</sub> vil bo sammen med <sub>-i</sub>.*  
(Him is there noone who will live together with.)
- c. *Jeg kender ham<sub>i</sub> som<sub>i</sub>/\*der<sub>i</sub> hun bor sammen med <sub>-i</sub>.*  
(I know him who/that she lives together with.)
- d. *Jeg kender en<sub>i</sub> (som<sub>i</sub> <sub>-i</sub>)/der<sub>i</sub> vil købe sofaen.*  
(I know one who/that will buy the-sofa.)
- e. *Jeg kender ham<sub>i</sub> hun bor sammen med <sub>-i</sub>.*  
(I know him she lives together with.)

Thus, we want the grammar to account for examples of topicalisation with or without multiple gaps, as in (7a) and (7b) respectively; *som*-relative clauses and resumptive *der* clauses, as in (7c) and (7d); and bare relatives as in (7e).

Our treatment of extraction builds in short on a proposal by Bouma *et al* [3], where a type *gap-ss* is used to establish a sharing of values between the local features of the extracted constituent and an element of the SLASH list. In Section 3.2, we shall see that to account for the different types of extraction site, three different extracted phrases are distinguished corresponding to complement, subject and adjunct extraction. The hierarchy of Danish clause types is then extended in Section 3.3 with the relative construction types we are interested in<sup>8</sup>.

To anticipate the conclusion, we find that also with respect to extraction, a construction-oriented approach following Sag (97) [15] constitutes a framework rich enough to provide for the variation found in specific constructions without abandoning the rigour of general formal principles.

<sup>7</sup> Gaps are indicated in the examples for illustrative purposes although our treatment does not use gaps in the constituent structures.

<sup>8</sup> Extraction is also relevant to the treatment of wh-interrogative clauses, which, however, are not dealt with here.

### 3.1 Multiple extractions in Danish relative clauses

In Danish, various constituent types can be extracted and topicalised, including sentence adjuncts, NPs with complement as well as subject function, even infinitival verbal forms. As mentioned in Section 2, topicalised sentences are characterised by inverted subject verb constituent order (BCO $_{vn}$ ). As already noted, Danish allows for extraction out of relative clauses. The following is an authentic example. A and B are two people having a conversation:

- (8) A: *Det fungerer godt.* (It works okay.)  
 B: *Det<sub>i</sub> tror jeg der er [nogle familier]<sub>j</sub> det ikke ville gøre <sub>-i</sub> i <sub>-j</sub>*  
 (That I think there are some families it wouldn't for.)

Although complex examples such as (8) are possible (and indeed produced maybe contrary to native speakers' possibly negative grammatical judgements) this is not to say that extraction in Danish is completely unconstrained: various proposals have in fact been made in the literature concerning syntactic constraints on extraction in Scandinavian languages.

One such constraint has been proposed by Allwood [1], who claims that extraction out of relative clauses is not possible unless the relative pronoun has subject function. Thus, extraction is possible in (9a) but not in (9b):

- (9) a. *Børn<sub>i</sub> kender jeg mange forretninger<sub>j</sub> som<sub>j</sub> <sub>-j</sub> sælger is til <sub>-i</sub>.*  
 (Children I know many shops which sell icecream to.)  
 b. *?Børn<sub>i</sub> kender jeg mange slags is<sub>j</sub> som<sub>j</sub> forretninger sælger <sub>-j</sub> til <sub>i</sub>.*  
 (Children I know many types of icecream which shops sell to.)

Allwood's subject restriction has been questioned, e.g. by Andersson [2], who claims that given the right semantic and pragmatic context, counterexamples overriding it can be constructed, as e.g. (10) (adapted from Andersson):

- (10) *Selv småbørn<sub>i</sub> er der utrolig meget<sub>j</sub> man kan lære <sub>-i</sub> at gøre <sub>-j</sub>.*  
 (lit: Even small children is there an awful lot one can teach to do.) 'There is an awful lot you can teach even small children how to do.'

In the same collection, Erteschik-Shir [7] proposes a pragmatic constraint according to which "an NP can be extracted out of a clause iff the clause may be interpreted as dominant." (p.177)

From the tests Erteschik-Shir uses, it would seem that being dominant is equivalent to belonging to the focus of the sentence, i.e. that part of the sentence contributing discourse-new information. If this is true, Erteschik-Shir's hypothesis would harmonise with an observation made by Knud Lambrecht<sup>9</sup> that our examples of Danish multiple extractions all seem to belong to the presentational relative construction type [11] (a type of existential construction according to others, e.g. [12]). It is in fact characteristic of presentational relative constructions, contrary to modifying relative clauses, that the relative introduces focal information. We shall not pursue this point any further here,

<sup>9</sup> Oral communication.

but only note that the examples of multiple gaps mentioned in this paper fall nicely into the presentational relative category. They all display the pattern ‘NP[*extracted*] *er der* NP[*indef*] rel-clause’. More investigation is needed, however, to establish a typology of Danish presentational relatives, and to test the hypothesis that this kind of construction allows for more extraction freedom than others, and in particular that Allwood’s subject constraint can be overridden precisely in these constructions.

In conclusion, it may be possible to specify grammatical contexts in which Allwood’s subject constraint can be overridden, and presentational relative clauses seem a good example of such a context. However, in the general case counterexamples to Allwood’s constraint are hard to construct and understand. Furthermore, a distinction between subject and non-subject extraction also seems relevant to account for the ungrammaticality of a sentence like (11a).

- (11) a. \**Peter ved jeg at kommer.* (lit: Peter I know that/when is coming.)  
 b. *Peter ved jeg at du har mødt.* (lit: Peter I know that/how you have met.)

Here, the constraint is that subject extraction is ungrammatical in embedded clauses introduced by a complementiser, whilst complement extraction is perfectly acceptable (11b). To sum up, the syntactic distinction between subject and non-subject extraction seems necessary to explain why subject and non-subject gaps behave differently at least in certain grammatical contexts. In what follows, this distinction is captured easily by way of different extraction constructions.

### 3.2 Formalisation

Our formalisation builds on the use of the familiar SLASH feature – a list-valued feature in our implementation<sup>10</sup> – to record constituents extracted from their local site. A feature of type *gap-ss*, in which LOCAL is structure shared with SLASH, is used to represent extracted arguments (subject or complements) on the lexical head’s SUBJ or COMPS list, as done by Bouma *et al.* in [3]. In Bouma *et al.*’s proposal, elements of type *gap-ss* are subtracted from the list of complements of a lexical head by means of lexical constraints. We have instead chosen to introduce *gap-ss* elements by means of phrasal types.

The type *gap-ss* appears in two unary phrase types accounting for subject and complement extraction, respectively. In (12) below, we show the type for subject extraction. Besides positing a gap on the SUBJ list of the head daughter, the type allows the daughter node itself to be slashed, thus permitting an analysis of multiple extraction. In contrast, the head daughter’s SLASH is constrained to be empty in the type for complement extraction (not shown

<sup>10</sup>The actual type is a difference list, which takes the attributes LIST and LAST. These are roughly the same as the more customary FIRST and REST.

here).

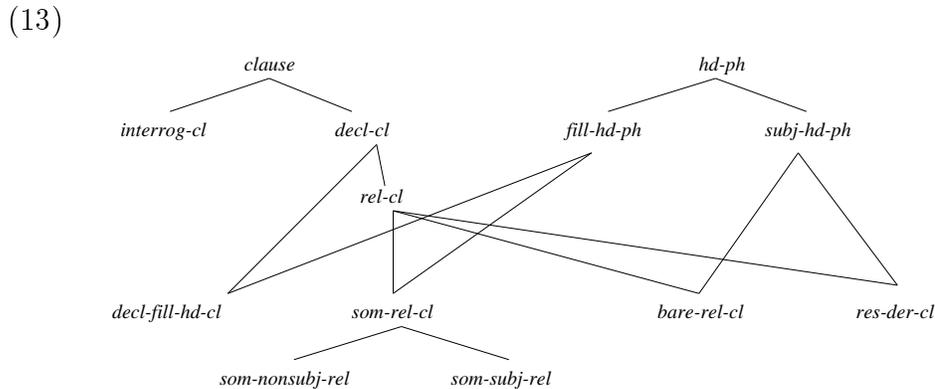
$$(12) \left[ \begin{array}{l} \textit{hd-extracted-subj-ph} \\ \text{SYNSEM} \left[ \begin{array}{l} \text{LOC | CAT} \left[ \begin{array}{l} \text{COMPS } \langle \rangle \\ \text{SUBJ } \langle \rangle \end{array} \right] \\ \text{NON-LOC | SLASH} \left[ \begin{array}{l} \text{LIST } \boxed{1} \\ \text{LAST } \boxed{2} \end{array} \right] \end{array} \right] \\ \text{HD-DTR | SYNSEM} \left[ \begin{array}{l} \text{LOC | CAT} \left[ \begin{array}{l} \text{COMPS } \langle \rangle \\ \text{SUBJ } \langle \langle \textit{gap-ss} \\ \text{NON-LOC | SLASH } \boxed{1} \rangle \rangle \end{array} \right] \\ \text{NON-LOC | SLASH | LIST } \boxed{2} \end{array} \right] \end{array} \right] \end{array} \right]$$

Another difference with respect to Bouma *et al.*'s proposal, is the fact that we do not treat adjuncts as dependents of lexical heads. Therefore, adjunct extraction is accounted for by a different unary type, where *gap-ss* does not play a role, and an adjunct of the right type<sup>11</sup> is added onto the SLASH list of the mother node.

The SLASH values that appear in the extracted types are threaded in the relevant phrases (an alternative approach would be lexical amalgamation, which, however, is not part of the present implementation), to be bound off in the *filler-hd-ph* type. Here again, care is taken that more than one filler can occur in the same sentence, and that they occur in the right order (crossing dependencies are not supported yet).

### 3.3 Construction types

With a treatment of extraction in place, the hierarchy of construction types can be extended to comprise the clause types in (13) to account for the relative clause types we want the grammar to cover.



As already shown, topicalised clauses (*decl-filler-hd-cl*) are a type of declarative clause and filler-head phrase. Relative clauses are also declarative clauses, further constrained by the fact that they modify a nominal, and are grouped into three types. *Som*-relatives are filler-head phrases: the relative pronoun is the filler, and shares its REL value with the INDEX value of the modified

<sup>11</sup> Danish adverbs can be grouped into different classes depending on where in the sentence they can occur.

Construction	Constraints
<i>rel-cl</i>	$\left[ \text{HD} \left[ \begin{array}{l} \text{BCO } sv \\ \text{MOD} \left[ \text{HEAD } noun \right] \end{array} \right] \right]$
<i>som-rel-cl</i>	$\left[ \begin{array}{l} \text{HD} \left[ \text{MOD NP} \square \right] \\ \text{NON-HD} \left[ \begin{array}{l} rel-pron \\ \text{REL} \langle \square \rangle \end{array} \right] \end{array} \right]$
<i>som-subj-rel</i>	$[\text{HD } hd-extracted-subj-ph]$
<i>som-nonsubj-rel</i>	$[\text{HD } bare-rel-cl]$
<i>bare-rel-cl</i>	$\left[ \text{HD} \left[ \begin{array}{l} \text{MOD NP} \square \\ \text{SLASH}   \text{FIRST}   \text{INDEX} \langle \square \rangle \end{array} \right] \right]$
<i>res-der-cl</i>	$\left[ \begin{array}{l} \text{HD} \left[ \text{MOD NP} \square \right] \\ \text{NON-HD} \left[ \begin{array}{l} res-pron \\ \text{REL} \langle \square \rangle \end{array} \right] \end{array} \right]$

Fig. 1. Relative clause constraints

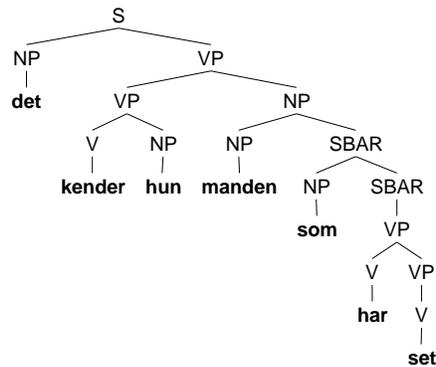
noun. Bare relatives, on the other hand, are subject-head phrases: due to the absence of a relative pronoun, the INDEX value of the noun they modify is structure shared directly with the INDEX value of the first element on their SLASH list. Finally, the so-called resumptive *der*-clause, where the pronoun *der* is always used with subject function, is also a subject-head phrase. We claim that the pronoun in this case does not represent an extracted subject, although other complements may well be extracted from a resumptive *der*-clause. Therefore, no subject gap is posited, see example (7d). Evidence of this is provided in example (14):

- (14) *Den film er der ikke nogen som/\*der jeg tror gider se igen.*  
 (That film there is noone who/that I think wants to see again.)

The constraints at work in the various relative clause types are formalised in Figure 1.

To conclude this section on extraction and Danish relative clauses, and to show how various construction types interact with each other in the analysis of a single example, we show in Figure 2 the parse tree produced by the LKB system for the multiple gap example *det kender hun manden som har set* (that, she knows the man who has seen).

The topmost S node is of type *decl-fill-hd-cl*, the higher SBAR is a *som-subj-rel*, the lower SBAR a *hd-extracted-subj-ph*, and finally the lowest VP is



(lit: that knows she the-man who has seen.)

Fig. 2. LKB parse tree

a *hd-extracted-comp-ph*. As for extraction, looking at the tree bottom-up, the first element on the SLASH list is introduced on the lowest VP node, and passed all the way up to the highest VP node to be bound to the LOCAL value of the topicalised NP. The second element is introduced on the lower SBAR node to be bound to the LOCAL value of the relative *som*.

## 4 Conclusion

We hope to have shown that the constraints on topology and extraction relevant to Danish grammar can be expressed clearly and economically in a construction-oriented approach. The implementation described here covers a number of Danish construction types of non-trivial complexity so far. However, expanding the size of the implementation is an ongoing process and we aim to achieve a coverage large enough for the implementation to provide a good starting point for future applications. In the immediate future, we would like to deal with other clause types such as imperatives, conditionals and wh-interrogatives. Also, we would like to extend the coverage to light objects and negated constituents which in Danish are positioned in the nexus field. The addition of other unbounded dependency constructions such as clefts are also planned. Further research is also needed to study the issue of extraction in presentational relative clauses, and to set up a typology of this interesting construction for Danish.

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