Extraposition via Complex Domain Formation*

Andreas Kathol and Carl Pollard
Dept. of Linguistics
1712 Neil Ave.
Ohio State University
Columbus, OH 43210, USA
{kathol,pollard}@ling.ohio-state.edu

Abstract

We propose a novel approach to extraposition in German within an alternative conception of syntax in which syntactic structure and linear order are mediated not via encodings of hierarchical relations but instead via order domains. At the heart of our proposal is a new kind of domain formation which affords analyses of extraposition constructions that are linguistically more adequate than those previously suggested in the literature.

1 Linearization without phrase structure

Recent years have seen proposals for the elimination of the phrase structure component in syntax in favor of levels of representation encompassing possibly nonconcatenative modes of serialization (Dowty, In press; Reape, 1993; Reape, 1994; Pollard et al., 1993). Instead of deriving the string representation from the yield of the tree encoding the syntactic structure of that sentence (as, for instance in GPSG, LFG, and—as far as the relationship between S-structure and PF, discounting operations at PF, is concerned—GB), these proposals suggest deriving the sentential string via a recursive process that operates directly on encodings of the constituent order of the subconstituents of the sentence. In Reape's proposal, which constitutes an extension of HPSG (Pollard and Sag, 1994), this information is contained in "(Word) Order Domains". On the other hand, the way that the surface representation is put together, i.e. the categories that have contributed to the ultimate string and the grammatical dependency relations (head-argument, head-adjunct, etc.) holding among them, will be called the "composition structure" of that sentence, represented below by means of unordered trees.

As an example, consider how a German V1 sentence, e.g. a question or conditional clause, is derived in such a system.[1]

(1) Las Karl das Buch
read Karl the book
E.g.: 'Did Karl read the book?'

The representation in Figure 1 involves a number of order domains along the head projection of the clause ([1]–[3]). Each time two categories are combined, a new domain is formed from the domains of the daughters of that node, given as a list value for the feature DOM. While the nodes in the derivation correspond to *signs* in the HPSG sort hierarchy (Pollard and Sag, 1994), the elements in the order domains, which we will refer to as *domain objects*, will minimally contain categorial and phonological information (the latter given in italics within angled brackets). The value of the DOM attribute thus consists of a list of domain objects. Ordering is achieved via linear precedence (LP) statements.

In Reape's approach, there are in essence two ways in which a sign's DOM value can be integrated into that of its mother. When combining with its verbal head, a nominal argument such as *das Buch* in Figure 1 in general gives rise to a *single* domain element, which is "opaque" in the sense that adjacency relations holding within it cannot be disturbed by subsequent intervention of other domain objects. In contrast, some constituents contribute the contents of their order domains wholesale into the mother's domain. Thus, in Figure 1, both elements of the VP ([2]) domain become part of the higher clausal ([1]) domain. As a result, order domains allow elements that are not sisters in composition structure to be linearly ordered with respect to each other, contrary

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[1]In Kathol and Pollard (1995), we argue for dispensing with binary-valued features such as INV(ERTED) or EXTRA(POSED) in favor of a multi-valued single feature TOPO(LOGY) which imposes a partition on the set of domain elements of a clause according to membership in Topological Fields (see also Kathol (In progress)). Since nothing in the present proposal hinges on this detail, we keep with the more common binary features.

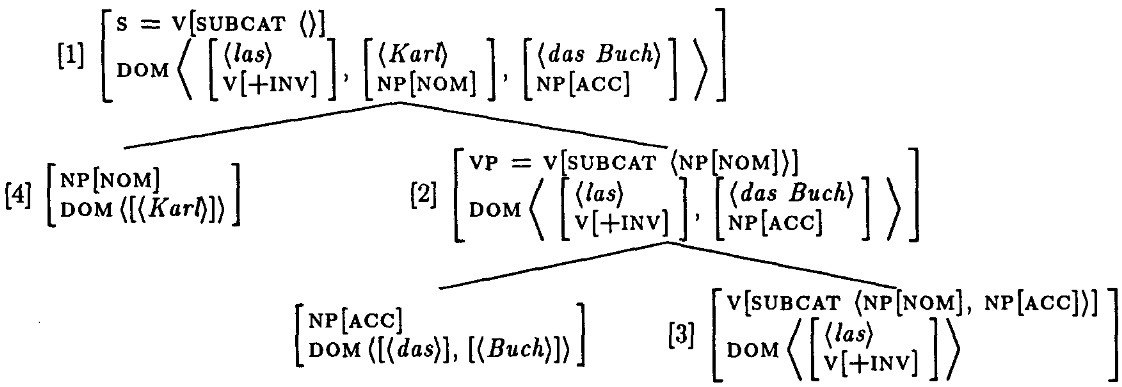

Figure 1: Derivation of V1 clause using order domains

to ordinary HPSG, but in the spirit of "liberation" metarules (Zwicky, 1986).

With Reape we assume that one crucial mechanism in the second type of order domain formation is the *shuffle* relation (Reape's *sequence union*), which holds of n lists L_1, ..., L_{n-1}, L_n, iff L_n consists of the elements of the first n-1 lists interleaved in such a way that the relative order among the original members of L_1 through L_{n-1}, respectively, is preserved in L_n. As a consequence, any precedence (but not adjacency) relations holding of domain elements in one domain are also required to hold of those elements in all other order domains that they are members of, which amounts to a monotonicity constraint on deriving linear order. Hence, if [1] in Figure 1 were to be expanded in the subsequent derivation into a larger domain (for instance by the addition of a sentential adverb), the relative order of subject and object in that domain could not be reversed within the new domain.

The data structure proposed for domains in Reape (1993) is that of a list of objects of type *sign*. However, it has been argued (Pollard et al., 1993) that signs contain more information than is desirable for elements of a domain. Thus, a sign encodes its internal composition structure via its DAUGHTERS attribute, while its linear composition is available as the value of DOM. Yet, there are no known LP constraints in any language that make reference to these types of information. We therefore propose an impoverished data structure for elements of order domains which only consists of categorial and semantic information (viz. the value of SYNSEM (Pollard and Sag, 1994)) and a phonological representation. This means that whenever a constituent is added to a domain as a single element, its information content will be condensed to categorial and phonological information.[2] The latter is constrained to be the concatenation of the PHONOLOGY values of the domain elements in the corresponding sign's order domain. We will refer to the relation between a sign S and its representation as a single domain object O as the *compaction*, given informally in (2):[3]

(2) compaction($\boxed{1}$,$\boxed{2}$) ≡

$$\boxed{1}: \begin{bmatrix} \textit{sign} \\ \text{SYNSEM}\ \boxed{3} \\ \text{DOM}\ \langle[\text{PHON}\ \boxed{4}],\ldots,[\text{PHON}\ \boxed{n}]\rangle \end{bmatrix}$$
$$\wedge\ \boxed{2}: \begin{bmatrix} \textit{dom-obj} \\ \text{SYNSEM}\ \boxed{3} \\ \text{PHON}\ \boxed{4} \circ \ldots \circ \boxed{n} \end{bmatrix}$$

To express this more formally, let us now define an auxiliary relation, $join_F$, which holds of two lists L_1 and L_2 only if L_2 is the concatenation of values for the feature F of the elements in L_1 in the same order:[4]

(3) $\text{join}_F(\boxed{1},\boxed{2}) \equiv$

$$(\boxed{1} : \langle\rangle \wedge \boxed{2} : \langle\rangle)$$
$$\vee\ (\text{cons}([F\ (\boxed{3})], \boxed{4}, \boxed{1})$$
$$\wedge\ \text{join}_F(\boxed{4},\boxed{5})$$
$$\wedge\ \text{append}(\boxed{3},\boxed{5},\boxed{2})\ )$$

This allows us to define *compaction* more precisely as in (4):

(4) compaction($\boxed{1}$,$\boxed{2}$) ≡

$$\boxed{1}: \begin{bmatrix} \textit{sign} \\ \text{SYNSEM}\ \boxed{3} \\ \text{DOM}\ \boxed{4} \end{bmatrix}$$
$$\wedge\ \boxed{2}: \begin{bmatrix} \textit{dom-obj} \\ \text{SYNSEM}\ \boxed{3} \\ \text{PHON}\ \boxed{5} \end{bmatrix}$$
$$\wedge\ \text{join}_{PHON}(\boxed{4},\boxed{5})$$

[2]For expository convenience, semantic information is systematically ignored in this paper.

[3]Here, "∘" is a convenient functional notation for the append relation.

[4]Here *cons* is the relational analogue of the LISP function cons; i.e. *cons* holds among some element E and two lists L_1 and L_2 only if the insertion of E at the beginning of L_1 yields L_2.

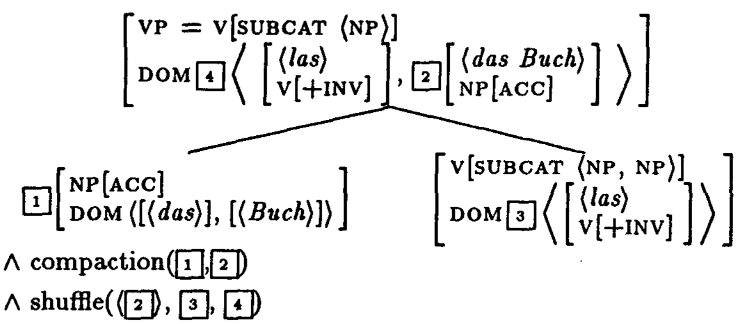

Figure 2: Domain formation using *compaction* and *shuffle*

Given *compaction* and the earlier *shuffle* relation, the construction of the intermediate VP domain can be thought of as involving an instance of the Head-Complement Schema (Pollard and Sag, 1994), augmented with the relevant relational constraints on domain formation, as shown in Figure 2.

2 Extraposition via Order Domains

Order domains provide a natural framework for order variation and discontinuous constituency. One of the areas in which this approach has found a natural application is extraposition of various kinds of constituents. Reape (1994) proposes the binary-valued feature EXTRA to order an extraposed VP last in the domain of the clause, using the LP statement in (5):

(5) [−EXTRA] ≺ [+EXTRA]

Similarly, Nerbonne (1994) uses this feature to account for instance for extrapositions of relative clauses from NPs such as (6); the composition structure proposed by Nerbonne for (6) is given in Figure 3.

(6) einen Hund füttern [der Hunger hat]
a dog feed that hunger has
'feed a dog that is hungry'

The structure in Figure 3 also illustrates the feature UNIONED, which Reape and Nerbonne assume to play a role in domain formation process. Thus, a constituent marked [UNIONED +] requires that the contents of its domain be shuffled into the domain of a higher constituent that it becomes part of (i.e. it is *domain-unioned*). For instance, in Figure 3, the [UNIONED +] specification on the higher NP occasions the VP domain to comprise not only the verb, but also both domain objects of the NP. Conversely, a [UNIONED −] marking in Reape's and Nerbonne's system effects the insertion of a single domain object, corresponding to the constituent thus specified. Therefore, in Figure 3, the internal structure of the relative clause domain becomes opaque once it becomes part of the higher NP domain.

3 Shortcomings of Nerbonne's analysis

One problematic aspect of Nerbonne's proposal concerns the fact that on his account, the extraposability of relative clauses is directly linked to the Head-Adjunct Schema that inter alia licenses the combination of nominals with relative clauses. However, whether a clause can be extraposed is independent of its adjunct/complement status within the NP. Thus, (7) illustrates the extraposition of a complement clause (Keller, 1994):

(7) Planck hat die Entdeckung gemacht
Planck has the discovery made
[daß Licht Teilchennatur hat].
that light particle.nature has
'Planck made the discovery
that light has a particle nature.'

The same also holds for other kinds of extraposable constituents, such as VPs and PPs. On Nerbonne's analysis, the extraposability of complements has to be encoded separately in the schema that licenses head-complement structures. This misses the generalization that extraposability of some element is tied directly to the final occurrence within the constituent it is dislocated from.[5] Therefore, extraposability should be tied to the *linear* properties of the constituent in question, not to its grammatical function.

A different kind of problem arises in the case of extractions from prepositional phrases, as for instance in (8):

(8) an einen Hund denken [der Hunger hat]
of a dog think that hunger has
'think of a dog that is hungry'

On the one hand, there has to be a domain object for *an einen Hund* in the clausal domain because this

[5] Note that final occurrence is a necessary, but not sufficient condition. As is noted for instance in Keller (1994), NP complements (e.g. postnominal genitives) cannot be extraposed out of NPs despite their final occurrence. We attribute this fact to a general constraint against extraposed NPs in clauses, except for adverbial accusative NPs denoting time intervals.

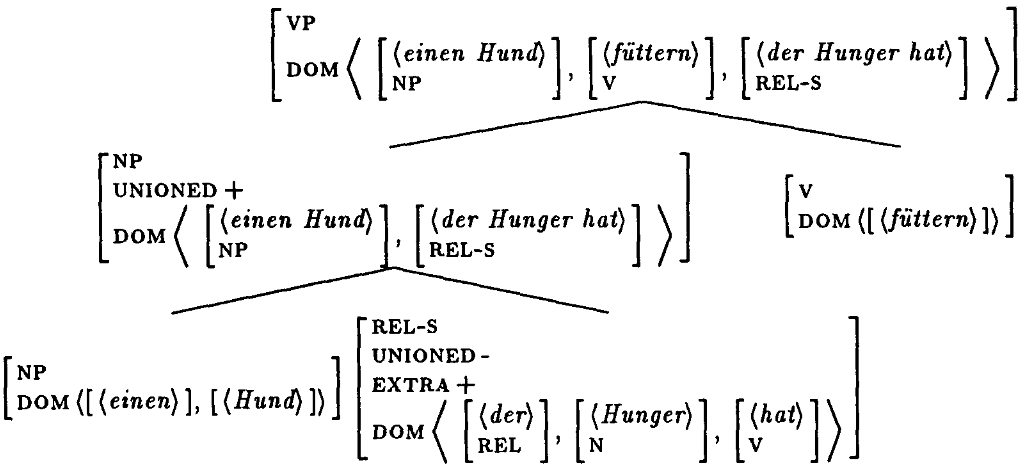

Figure 3: Extraposition of relative clause in Nerbonne 1994

element is subject to the same variations in linear order as PPs in general. On the other hand, the attachment site of the preposition will have to be higher than the relative clause because clearly, the relative clause modifies the nominal, but *not* the PP.

As a potential solution one may propose to have the preposition directly be "integrated" (phonologically and in terms of SYNSEM information) into the NP domain object corresponding to *einen Hund*. However, this would violate an implicit assumption made in order domain-based approaches to linearization to the effect that domain objects are inalterable. Hence, the only legitimate operations involve adding elements to an order domain or compacting that domain to form a new domain object, but crucially, operations that nonmonotonically change existing domain objects within a domain are prohibited.

4 Partial compaction

In this section, we present an alternative to Nerbonne's analysis based on an extension of the possibilities for domain formation. In particular, we propose that besides total compaction and domain union, there is a third possibility, which we will call *partial compaction*. In fact, as will become clear below, total compaction and partial compatcion are not distinct possibilities; rather, the former is a subcase of the latter.

Intuitively, partial compaction allows designated domain objects to be "liberated" into a higher domain, while the remaining elements of the source domain are compacted into a single domain object. To see how this improves the analysis of extraposition, consider the alternative analysis for the example in (6), given in Figure 4.

As shown in Figure 4, we assume that the order domain within NPs (or PPs) is essentially flat, and moreover, that domain objects for NP-internal prenominal constituents are prepended to the domain of the nominal projection so that the linear string is isomorphic to the yield of the usual right-branching analysis trees for NPs. Adjuncts and complements, on the other hand, follow the nominal head by virtue of their [+EXTRA] specification, which also renders them extraposable. If the NP combines with a verbal head, it may be partially compacted. In that case, the relative clause's domain object ([3]) is inserted into the domain of the VP together with the domain object consisting of the same SYNSEM value as the original NP and that NP's phonology minus the phonology of the relative clause ([2]). By virtue of its [EXTRA +] marking, the domain object of the relative clause is now ordered last in the higher VP domain, while the remnant NP is ordered along the same lines as NPs in general.

One important aspect to note is that on this approach, the inalterability condition on domain objects is not violated. Thus, the domain object of the relative clause ([3]) in the NP domain is token-identical to the one in the VP domain. Moreover, the integrity of the remaining NP's domain object is not affected as—unlike in Nerbonne's analysis—there is no corresponding domain object in the domain of the NP before the latter is licensed as the complement of the verb *füttern*.

In order to allow for the possibility of partially compacting a domain by replacing the *compaction* relation of (4) by the *p-compaction* relation, which is defined as follows:

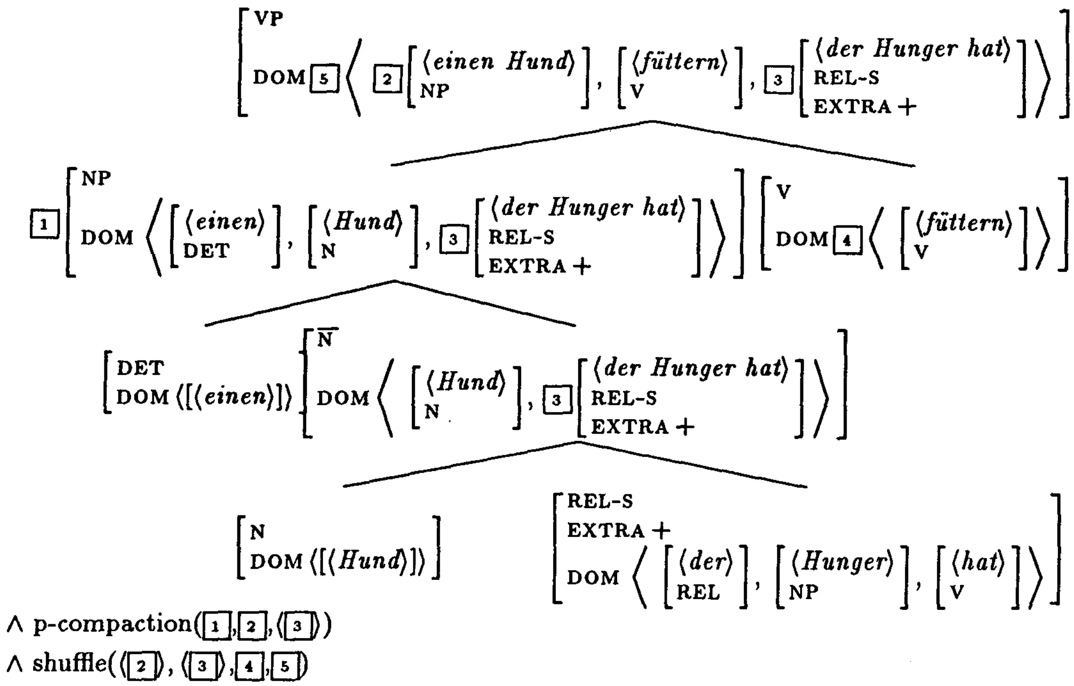

Figure 4: Extraposition via partial compaction

(9) p-compaction($\boxed{1}$,$\boxed{2}$,$\boxed{3}$) ≡

$$\boxed{1}: \begin{bmatrix} \textit{sign} \\ \text{SYNSEM}\ \boxed{4} \\ \text{DOM}\ \boxed{6} \end{bmatrix}$$

$$\wedge\quad \boxed{2}: \begin{bmatrix} \textit{dom-obj} \\ \text{SYNSEM}\ \boxed{4} \\ \text{PHON}\ \boxed{7} \end{bmatrix}$$

$$\wedge\quad \text{shuffle}(\boxed{5},\boxed{3},\boxed{6})$$

$$\wedge\quad \text{join}_{PHON}(\boxed{5},\boxed{7})$$

Intuitively, the ***p-compaction*** relation holds of a sign S ($\boxed{1}$), domain object O ($\boxed{2}$), and a list of domain objects L ($\boxed{3}$) only if O is the compaction of S with L being a list of domain objects "liberated" from the S's order domain. This relation is invoked for instance by the schema combining a head (H) with a complement (C):

(10) [M:] [DOM $\boxed{5}$]

[H:] [DOM $\boxed{4}$] [C:] $\boxed{1}$

$$\wedge\ \text{p-compaction}(\boxed{1},\boxed{2},\boxed{3})$$

$$\wedge\ \text{shuffle}(\langle\boxed{2}\rangle,\boxed{3},\boxed{4},\boxed{5})$$

$$\wedge\ \boxed{3}: \textit{list}\ (\ [\text{SYNSEM}\,[\text{EXTRA}\,+]])$$

$$\wedge\ (\boxed{3}: \langle\rangle \vee \boxed{2}: \begin{bmatrix} \text{SYNSEM}\ \neg \begin{bmatrix} \text{HEAD}\ \textit{verb} \\ \text{SUBCAT}\ \langle\rangle \end{bmatrix} \end{bmatrix})$$

The third constraint associated with the Head-Complement Schema ensures that only those elements that are marked as [EXTRA +]) within the smaller constituent can be passed into the higher domain, while the last one prevents extraposition out of clauses (cf. Ross' Right Roof Constraint (Ross, 1967)).

This approach is superior to Nerbonne's, as the extraposability of an item is correlated only with its linear properties (right-peripheral occurrence in a domain via [EXTRA +]), but not with its status as adjunct or complement. Our approach also makes the correct prediction that extraposition is only possible if the extraposed element is already final in the extraposition source.[6] In this sense, extraposition is subject to a monotonicity condition to the effect that the element in question has to occur in the same linear relationship in the smaller and the larger domains, viz. right-peripherally (modulo other extraposed constituents). This aspect clearly favors our approach over alternative proposals that treat extraposition in terms of a NONLOCAL dependency (Keller, 1994). In approaches of that kind, there is nothing, for example, to block extraposition of prenominal elements.

Our approach allows an obvious extension to the case of extraposition from PPs which are problematic for Nerbonne's analysis. Prepositions are prepended to the domain of NPs in the same way

[6]It should be pointed out that we do *not* make the assumption, often made in transformational grammar, that cases in which a complement (of a verb) can only occur extraposed necessitates the existence of an underlying non-extraposed structure that is never overtly realized.

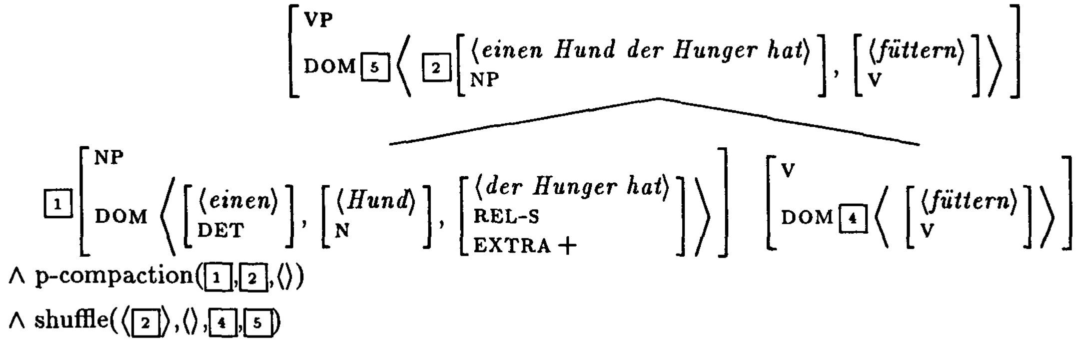

Figure 5: Total compaction as a special case of compaction

that determiners are to $\overline{\mathrm{N}}$ domains.

Along similar lines, note that extrapositions from topicalized constituents, noted by Nerbonne as a challenge for his proposal, do not pose a problem for our account.

(11) Eine Dame ist an der Tür
a lady is at the door
[die Sie sprechen will].
who you speak wants
'A lady is at the door
who wants to talk to you.'

If we assume, following Kathol (In progress), that topicalized constituents are part of the same clausal domain as the rest of the sentence,[7] then an extraposed domain object, inherited via partial compaction from the topic, will automatically have to occur clause-finally, just as in the case of extraposition from regular complements.

So far, we have only considered the case in which the extraposed constituent is inherited by the higher order domain. However, the definition of the *p-compaction* relation in (12) also holds in the case where the list of liberated domain objects is empty, which amounts to the total compaction of the sign in question. As a result, we can regard total compaction as a special case of the *p-compaction* relation in general. This means that as an alternative linearization of (6), we can also have the extrapositionless analysis in Figure 5.

Therefore, there is no longer a need for the UNIONED feature for extraposition. This means that we can have a stronger theory as constraints on extraposability will be result of general conditions on the syntactic licensing schema (e.g. the Right Roof Constraint in (10)). But this means that whether or not something can be extraposed has been rendered exempt from lexical variation in principle—unlike in Reape's system where extraposability is a matter of lexical selection.

Moreover, while Reape employs this feature for the linearization of nonfinite complementation, it can be shown that the Argument Composition approach of Hinrichs & Nakazawa (Hinrichs and Nakazawa, 1994), among many others, is linguistically superior (Kathol, In progress). As a result, we can dispense with the UNIONED feature altogether and instead derive linearization conditions from general principles of syntactic combination that are not subject to lexical variation.

5 Conclusion

We have argued for an approach to extraposition from smaller constituents that pays specific attention to the *linear* properties of the extraposition source.[8] To this end, we have proposed a more fine-grained typology of ways in which an order domain can be formed from smaller constituents. Crucially, we use relational constraints to define the interdependencies; hence our approach fits squarely into the paradigm in which grammars are viewed as sets of relational dependencies that has been advocated for instance in Dörre et al. (1992). Since the relational perspective also lies at the heart of computational formalisms such as CUF (Dörre and Eisele, 1991), the ideas presented here are expected to carry over into practical systems rather straightforwardly. We leave this task for future work.

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[7] I.e. the initial placement of a preverbal constituent in a verb-second clause is a consequence of LP constraints within a *flat* clausal order domain.

[8] For similar ideas regarding English, see Stucky (1987).

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