Empirical Issues in Syntax and Semantics 5
O. Bonami & P. Cabredo Hofherr (eds.) 2004, pp. 27–44
http://www.cssp.cnrs.fr/eiss5

Structure-Preserving Extraction without Traces

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1 Introduction

In this paper I present a trace-free analysis of unbounded dependency constructions (UDCs) couched in the HPSG framework. The approach described here differs from previous trace-free HPSG accounts of UDCs in two significant ways. First, unlike the analysis in Pollard and Sag (1994), it handles extraction uniformly from both root and embedded clauses alike, regardless of the grammatical function of the gap. Secondly, unlike the analysis in Bouma *et al.* (2001), it in principle permits extraction of any non-head constituent, whether or not that constituent is present on the valence list of some lexical head.

The benefits of the first distinguishing property have been discussed at length elsewhere (Hukari and Levine 1995; Bouma *et al.* 2001), so I do not belabor the point here. The benefits of the second property, however, have been less recognised (but see Levine (2003)) and even denied (Bouma *et al.* 2001), so I spend some time examining them below (section 3).

The presentation is organised as follows. First, in section 2, I review the proposal in Bouma *et al.* (2001) (hereafter BMS), focussing on their treatment of adjunct extraction. Then, in section 3, I present some data from English that appears problematic for the BMS approach to adjunct extraction. In section 4, I present an analysis of UDCs which is fully compatible with the problematic data discussed in section 3, and conclude the section with a short demonstration of how it one can use this theory to characterise morphosyntactic reflexes of extraction in Chamorro. Finally, in section 5, I discuss the prospects for certain extensions to the current analysis.

2 Bouma, Malouf, and Sag (2001)

In essence, the heart of the BMS account of UDCs is the postulation of a series of three kinds of head-borne lists, where each kind of list expresses a distinct relation that a head bears to other elements in its projections. We can call these three relations the *argument structure* of a head, its *dependency structure*, and its *valence*.

Of the three relations, argument structure is taken to be the most primitive; the argument structure of a head is given by its lexical entry, where it is encoded as the list-value of the *category* feature ARG-ST.

*The ideas presented here would be worse without the criticism and other kind advice of Danièle Godard, Rich Janda, Bob Levine, Vanessa Metcalf, Carl Pollard, and especially Detmar Meurers. I alone am responsible for anything untrue, invalid, or otherwise offensive.

An ARG-ST list, roughly speaking, contains the SYNSEM values of a word's semantic arguments. It is to this level of structure that HPSG's binding theory applies.[1]

As is by now standard, a lexical head's SUBJ and COMPS (and SPR) features represent its valence, and so drive its projections' selection of any realised arguments. For example, in a head-complement phrase any elements on the head-daughter's COMPS list must be realised as sisters to that head.

The argument structure of a word determines in large part its valence, and it is as a sort of intermediary between these two levels that BMS introduce the novel level of dependency structure. The list-valued *category* feature DEPS, present on words, represents this level.

As noted above, the argument structure of a word determines its valence to quite a large extent. However, the BMS analysis of adjunct extraction crucially supposes that the extent of this determination is somewhat less than usually assumed.

In particular, serving as middleman between ARG-ST and valence lists, not only does the DEPS list of a verb include all of its arguments, but furthermore it may also include an arbitrary number of modifiers.

BMS's constraint Argument Structure Extension permits this as follows:

(1) Argument Structure Extension:

$$\begin{bmatrix} \textit{word} \\ \text{HEAD} \;\; \textit{verb} \end{bmatrix} \rightarrow \begin{bmatrix} \text{HEAD} & \boxed{2} \\ \text{DEPS} & \boxed{1} \oplus \textit{list}\left(\left[\text{MOD}|\text{HEAD} \;\; \boxed{2}\right]\right) \\ \text{ARG-ST} & \boxed{1} \end{bmatrix}$$

This constraint states that the DEPS list of a verb is its ARG-ST list prefixed to a (perhaps empty) list of modifiers.

Consistent with the above constraint, for example, both descriptions below describe legitimate transitive verbs; the first is a transitive verb without any dependent modifiers, and the second is one with a single dependent modifier:

(2) Two transitive verbs:

a. The verb *tied*, as in *Kim tied her shoes*.

$$\begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{DEPS} & \left\langle \boxed{1}\text{NP}, \boxed{2}\text{NP} \right\rangle \\ \text{ARG-ST} & \left\langle \boxed{1}, \boxed{2} \right\rangle \end{bmatrix}$$

b. The verb *tied*, as in *Kim tied her shoes with one hand*.

[1] As Danièle Godard has pointed out (p.c.), given that HPSG's binding theory is formulated in terms of ARG-ST elements, ARG-ST lists must also contain expletive arguments playing no semantic role, at least when such elements control the agreement features of anaphors. For instance, in the French example below (i), the expletive impersonal subject clitic *il* controls the agreement features of the third person reflexive clitic *se*.

(i) Il ne s'est trouvé que nous d'heureux.
It NE SE found only us happy
'Only we turned out happy.'

This detail of ARG-ST values, however, plays no part in the discussion in this paper.

$$\begin{bmatrix} \text{HEAD} & \boxed{3}\,\textit{verb} \\ \text{DEPS} & \left\langle \boxed{1}\,\text{NP}, \boxed{2}\,\text{NP}, \left[\text{MOD}|\text{HEAD}\ \boxed{3}\right] \right\rangle \\ \text{ARG-ST} & \left\langle \boxed{1}, \boxed{2} \right\rangle \end{bmatrix}$$

As a consequence of their differing dependency structures, these two verbs should potentially head differently structured verb phrases. BMS accomplish this by determining the valence of a head from its DEPS value with the following constraint on words' SUBJ and COMPS lists, which they name Argument Realization (3, below). (The type *gap_ss* mentioned in (3) is a subtype of *synsem* object disjoint to *canonical_ss*, where only *canonical_ss* is an appropriate value for a sign's SYNSEM attribute.)

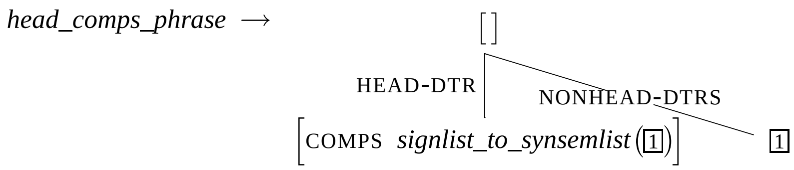
(3) Argument Realization:

$$\textit{word} \longrightarrow \begin{bmatrix} \text{SUBJ} & \boxed{1} \\ \text{COMPS} & \boxed{2} \ominus \textit{list}(\textit{gap\_ss}) \\ \text{DEPS} & \boxed{1} \oplus \boxed{2} \end{bmatrix}$$

This Argument Realization constraint (along with the assumption that all verbs have a singleton SUBJ list) ensures that a verb's subject will be the first element on its DEPS list, and any COMPS list elements will be elements of the rest of the DEPS list.

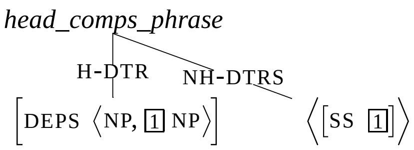
Assuming the DEPS lists in the above (2) descriptions contain no *gap_ss* elements, and a head-complement schema as follows, then each of the verbs in (2a,b) can head only the structures in (5a) and (5b) respectively.

(4) Head-complement schema:[2]

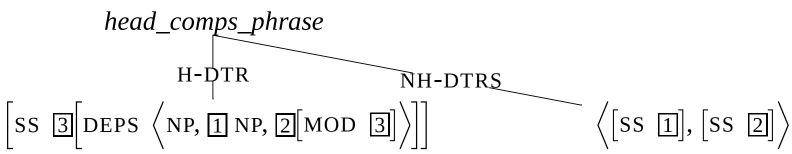


(5) Two head-complement phrases:

a. transitive verb with its direct object



b. transitive verb with its direct object and a modifier



[2]This schema's formulation presupposes a valence principle (or some set of valence principles) that ensures *head_comps_phrases* are COMPS <>.

On the other hand, suppose one extends the description in (2b) as in (6a) or as in (6b). One obtains descriptions of verbs which cannot head the VP in (5b), since neither non-head daughter in (5b) can have a SYNSEM value of type *gap_ss*.[3]

(6) Two extensions of a verb with a direct object and modifier:

a. The verb *tied*, as in *Her left shoe, Kim tied with one hand*.

$$\begin{bmatrix} \text{HEAD} & \boxed{3}\ \textit{verb} \\ \text{DEPS} & \left\langle \text{NP, NP}[\textit{gap\_ss}], \begin{bmatrix} \textit{canonical\_ss} \\ \text{MOD}|\text{HEAD}\ \boxed{3} \end{bmatrix} \right\rangle \end{bmatrix}$$

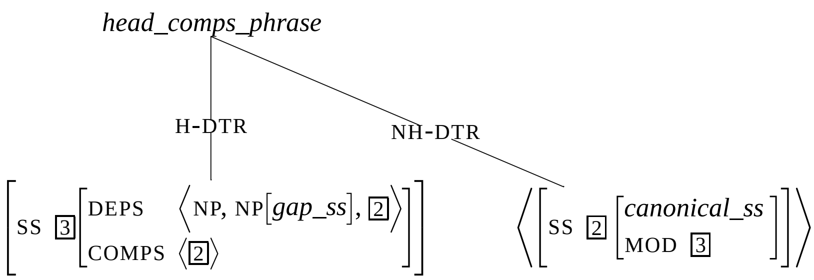
b. The verb *tied*, as in *With her right hand, Kim tied her left shoe*.

$$\begin{bmatrix} \text{HEAD} & \boxed{3}\ \textit{verb} \\ \text{DEPS} & \left\langle \text{NP, NP}[\textit{canonical\_ss}], \begin{bmatrix} \textit{gap\_ss} \\ \text{MOD}|\text{HEAD}\ \boxed{3} \end{bmatrix} \right\rangle \end{bmatrix}$$

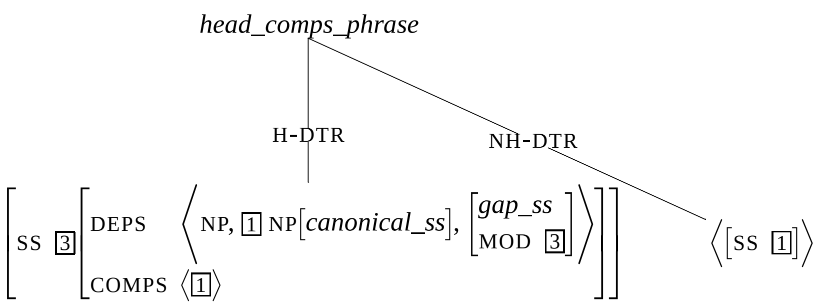
Nonetheless, the verbs in (6a,b) can respectively head the VPs in (7a,b) since (consistent with Argument Realization) their COMPS lists need not include any *gap_ss* dependent.

(7) Two head-complement structures with gaps:

a. head-complement phrase with a gapped direct object



b. head-complement phrase with a gapped modifier



One may obtain an illustration of how BMS model extraction by comparing the descriptions of the heads of the distinct VPs in (5b), (7a), and (7b), and then noting that each of them extends the description in (2b); the fact that a verb's dependent may be extracted is modelled by the fact that such a dependent may be a *gap_ss*, and hence absent from the COMPS list and not realised as a complement-sister. (We ignore BMS's analysis of subject extraction here.)

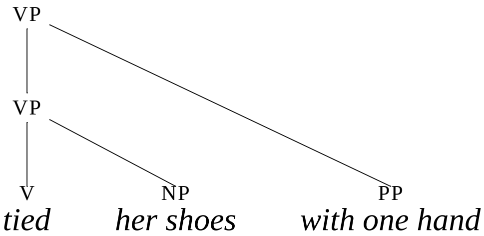
[3] We elide ARG-ST from now on, since it plays no further part in the discussion.

In particular, with respect to the extraction of adjuncts, comparison of the head-daughter's COMPS list in (7a) with the head-daughter's COMPS list in (7b) reveals how BMS's proposal handles the extraction of modifying adjuncts—by analysing it as complement extraction.

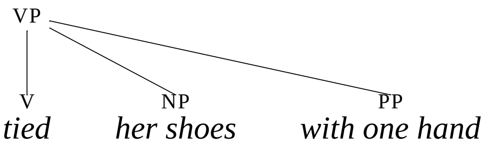
This, of course, requires that they treat extractable modifiers as phrase-structural complements, not as adjuncts. That is, rather than analysing modified VPs like *tied her shoes with one hand* as a head-adjunct structure, as in (8a), BMS assume that such VPs have the flat constituent structure in (8b).[4]

(8) Two conceivable structures for a modified VP:

a. adjoined modifier



b. modifier as complement



In the next section, we present evidence that this structural consequence may be problematic.

3 Verbal Anaphora and Constituency

As established in the previous section, BMS commit to a flat-VP analysis of sentences like (9a).

(9) a. Kim tied her shoes with one hand.
b. With which hand did Kim tie her shoes?
c. With just her left hand, I doubt that Kim will be able to tie both her shoes.

Examples (9b) and (9c) show that *with one hand* in (9a) is, in fact, extractable and hence treated as a complement by BMS.[5]

But given this flat analysis of the constituent structure of VPs in examples like (9), it is difficult to see how they can provide two of the interpretations of (10) below.

[4] See Bouma (2003) for the details of how they manage to ensure correct semantic scope for multiple modifiers, and see Levine (2003) for detailed discussion of problems with such an approach.

[5] One might question whether the ostensibly extracted phrase in (9c) is truly extracted. Instead, one might suppose that *with just her left hand* is an *in situ* modifier of the matrix clause, with an interpretation something like that of the absolutive *supposing that Kim employs just her left hand*. I do not address such a possibility in the main text.

However, proponents of such a view will need to contend with the fact that putative matrix modifiers like *with just her left hand* in (9c) have an instrumental reading just in case there is a verb in the sentence that admits instrumental modifiers.

(i) Supposing that Kim employs just her left hand, I doubt that Kim will be able to tie both her shoes.

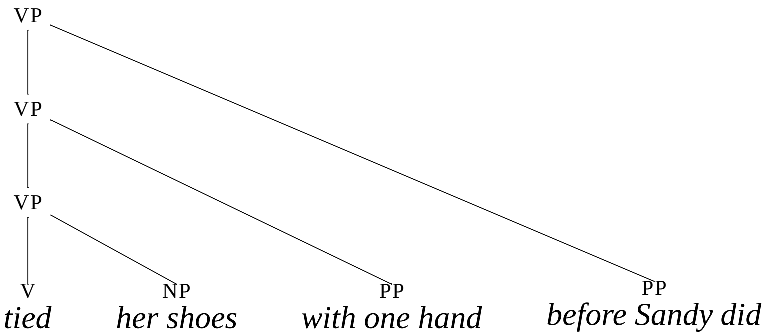
(10) Kim tied her shoes with one hand before Sandy did.

Any analysis that treats the structure of iterated modification like that in (10) in terms of nested adjunctions will have little problem handling the readings of (10) paraphrased in (11):

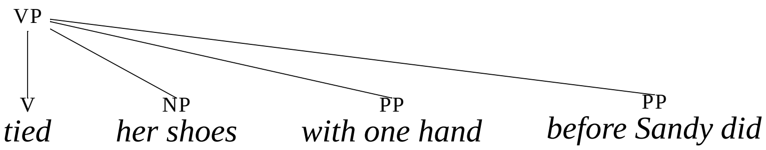
(11) a. Kim tied her shoes single-handedly before Sandy tied her shoes single-handedly.
b. Kim tied her shoes single-handedly before Sandy tied her shoes (at all).

That is, if (10) has the structure in (12a), below, then there are constituents—*tied her shoes with one hand* and *tied her shoes*—to serve as potential antecedents for the anaphoric pro-verb *did*, yielding the readings in (11).

(12) Two conceivable structures for a doubly modified VP:
a. adjoined modifiers



b. modifiers as complements



On the BMS analysis, however, the structure of (10) is the flat structure in (12b), and neither *tied her shoes with one hand* nor *tied her shoes* is a constituent. That is, no antecedent linguistic expression has the meaning borne by *did* under the interpretations given in (11).

One might question whether such examples constitute a true problem for the BMS account, since their status as counterexamples to flat modificational structures rests on the assumption that *did* requires a linguistic antecedent.[6]

That is, (i) is a sufficient paraphrase of one reading of (9c) because the *with*-phrase in (9c) has an instrumental reading. And, on the other hand, (iii) seems to fail as a sufficient paraphrase of any reasonable reading of (ii) precisely because the *with*-phrase in (ii) lacks an instrumental reading.

(ii) With just her left hand, I doubt Kim enjoys baseball.

(iii) Supposing that Kim employs just her left hand, I doubt Kim enjoys baseball.

Those supporting an analysis of (9c) wherein the *with*-phrase is exclusively a matrix modifier will require some explanation of why (iii) is a such poor paraphrase of (ii). My assumption that such material fills a gap in the subordinate clause provides an immediate explanation for this correspondence between instrumental readings and instrument-appropriate subordinate predicates.

[6] Miller (1992:Chapter 3) develops an HPSG treatment of English auxiliaries as VP anaphors which features an account of the pseudogapping phenomenon exhibited by examples like (i), below.

With respect to this question, however, the contrast in acceptability of the response in (13a) compared to the response in (13b) suggests that *did* is indeed a pro-verb that is happiest when it has an antecedent sign whose meaning it depends on.

(13) a. **A:** Hey, the door is locked.
B: I know. *I did.
b. **A:** Hey, someone locked the door.
B: I know. I did.

In the next section, we will present an analysis of UDCs that preserves the nested constituency of examples like (10).

4 Structure-Preserving Extraction

In this section I propose a trace-free theory of UDCs that in principle permits extraction of any non-head constituent, regardless of whether that constituent is the valent of any lexical head. Hence, in particular, the theory presented here can license extraction of true adjuncts, without reanalysing them as modifying complements.

The section is organised into the following parts: Section 4.1 introduces the primitive entities used by the theory, and illustrates how they permit the theory to license gapped phrases. Section 4.2 illustrates how these primitives can be used to characterise various sorts of phrase. Section 4.3 describes how information about the presence of a gapped phrase is piped up through phrase-structures to phrases properly containing the gapped phrase, as appropriate, via the familiar set-valued feature SLASH. Section 4.4 describes how the upward percolation of SLASH elements may be halted through the use of constraints pertaining to particular phrasal types, and reliance on the peculiar fact that the projections of most parts of speech never fail to pass their entire SLASH values up to an immediately dominating phrase. Finally, in section 4.5, we briefly discuss how the theory presented here can accomodate the morphological registration of gap-binding domains in Chamorro.

4.1 Dependents, Gaps, and Non-Head Daughters

The heart of the present proposal is the primitive assumption that phrases (and not words) have dependents. Each dependent is in one of two possible states: *realised* or *unrealised*. A realised dependent is, by definition, a non-head daughter of the phrase it depends on. An unrealised dependent, on the other hand, is not, and (again by definition) constitutes a gap in the phrase it depends on. The two head-adjunct phrases below exemplify how a phrase with a dependent in either of these states is described.[7]

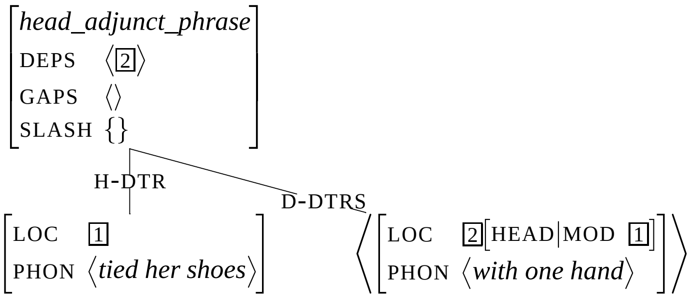
(i) I'm sure I would like him to eat fruit more than I would cookies.

Absent an account like Miller's, such examples would be ostensible counterexamples to the assumption that *did* requires a linguistic antecedent in examples like (10).

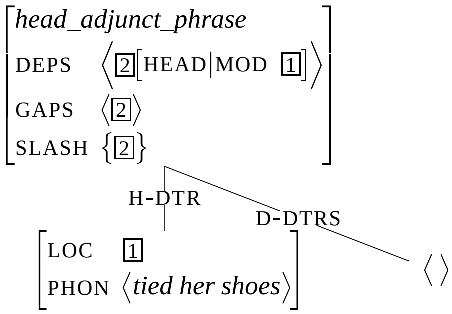
[7] D-DTRS is a feature of phrases whose value is the list of non-head (i.e. dependent) daughters of that phrase. That is, D-DTRS is simply another name for the N(ON)H(EAD)-DTRS feature.

(14) head-adjunct phrases:

a. head-adjunct phrase with a realised dependent



b. head-adjunct phrase with an unrealised dependent



As is apparent from the descriptions in (14), my analysis assumes two new features of phrases: DEPS and GAPS. The DEPS value of a phrase is a list of *local* objects called the *dependents* of that phrase, and the GAPS value of a phrase is likewise a list of *local* objects.

The following constraint ensures that the GAPS of a phrase are precisely its unrealised dependents:

(15) definition of GAPS:[8]

$$\textit{phrase} \longrightarrow \begin{bmatrix} \text{DEPS} & \boxed{1} \bigcirc \textit{signlist\_to\_local\_list}(\boxed{2}) \\ \text{GAPS} & \boxed{1} \\ \text{D-DTRS} & \boxed{2} \end{bmatrix}$$

This constraint states that one can obtain the list of dependents of any phrase by shuffling the list of its gaps with the list of LOCAL values of its non-head daughters.

One can verify that both head-adjunct phrases described in (14) satisfy this constraint. In one, the sole dependent is realised, and hence the head-adjunct phrase has no gaps. In the other, the sole dependent is unrealised, and hence the head-adjunct phrase has a single gap, represented as the sole element of its GAPS value.

The two head-adjunct structures in (14) also illustrate what is probably the most salient difference between the function of the DEPS feature assumed by BMS, and the homonymous feature assumed here. For BMS, DEPS mediates the relationship between a lexical head's argument structure and its

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[8] ◯ stands for the *shuffle* relation defined in Kathol (1995:p. 88). Informally, shuffling two lists is like shuffling two decks of cards (just once). The function *signlist_to_loc_list* takes a list of signs and returns the list of LOCAL values of those signs.

valence, whereas here the phrasal feature named DEPS mediates the relationship that holds between (on the one hand) the sorts of non-heads that distinguish some particular sort of phrase (e.g., having an adjunct non-head is distinctive of head-adjunct phrases) and (on the other) the non-heads which happen to be realised as daughters of any particular instance of that sort of phrase (e.g. adjunct-daughters).

4.2 Phrasal Schemata

With these features in hand, we can now characterise various sorts of phrase in terms of their dependents.

For example, to license the two phrases in (14), the following head-adjunct schema will suffice:

(16) Head-Adjunct Schema:

$$\textit{head\_adjunct\_phrase} \longrightarrow \begin{array}{c} \left[\text{DEPS}\ \left\langle \left[\text{CAT}|\text{HEAD}|\text{MOD}\ \boxed{1}\right] \right\rangle\right] \\ \Big|\ \text{H-DTR} \\ \left[\text{SS}|\text{LOC}\ \boxed{1}\right] \end{array}$$

According to this constraint, a *head_adjunct_phrase* is a phrase whose sole dependent's MOD element is identical to the LOCAL value of its head daughter. The reader may verify that both examples in (14) are instances of this schema, one with a realised dependent, and the other with an unrealised one.

Any other sort of phrase may be defined analogously, by constraining what shape its dependents must take via constraints on its DEPS feature, and by parameterising such constraints to the value of the relevant feature of the phrase's head-daughter. For example, assuming that DEPS values are always non-empty lists, the following constraint suffices for a head-subject schema:

(17) Head-Subject Schema:

$$\textit{head\_subject\_phrase} \longrightarrow \begin{array}{c} \begin{bmatrix} \text{SS}|\text{LOC}|\text{CAT}|\text{SUBJ} & \langle\rangle \\ \text{DEPS} & \boxed{1} \end{bmatrix} \\ \Big|\ \text{H-DTR} \\ \left[\text{SS}|\text{LOC}|\text{CAT}|\text{SUBJ}\ \boxed{1}\right] \end{array}$$

As the reader may verify, due to the constraint in (15) the identity enforced by the above schema between the head-daughter's SUBJ value and the *head_subject_phrase*'s DEPS value ensures that the subject of any such phrase will either be realised (and hence the non-head daughter) or unrealised (and hence the sole element of the *head_subject_phrase*'s GAPS value).

Likewise, the following constraint serves as a head-complement schema:

(18) Head-Complement Schema:

$$\textit{head\_complement\_phrase} \longrightarrow \begin{array}{c} \begin{bmatrix} \text{SS}|\text{LOC}|\text{CAT}|\text{COMPS} & \langle\rangle \\ \text{DEPS} & \boxed{1} \end{bmatrix} \\ \Big|\ \text{H-DTR} \\ \left[\text{SS}|\text{LOC}|\text{CAT}|\text{COMPS}\ \boxed{1}\right] \end{array}$$

One detail of these schemata (in particular the head-complement schema) which may have surprised those readers familiar with previous HPSG accounts of missing object (MO) constructions (such as *tough* constructions), is the fact that valence lists (e.g. the COMPS list) are here taken to be lists of *local* objects, rather than *synsem* objects. Thus, on the present analysis, lexical heads cannot select via their valence lists for valents bearing some particular SLASH value (since SLASH is not a *local* feature, but rather a *non_local* one). This assumption, that SLASH information is absent from valence list elements both poses a descriptive challenge and possesses explanatory power. To see this, however, a brief review of the standard HPSG analysis of *tough* constructions is in order.

Previous HPSG analyses of *tough* constructions (e.g. Pollard and Sag (1994)) have assumed that MO predicates like *easy*, which bind a SLASH element of one of their complements and co-index said SLASH element with their subject, have a lexical entry as in (19):

(19) A schematic representation of a *tough* adjective's traditional lexical entry:

$$\begin{bmatrix} \textit{word} & \\ \text{SUBJ} & \left\langle \text{NP}\left[\text{INDEX } \boxed{1}\right]\right\rangle \\ \text{COMPS} & \left\langle \ldots, \text{VP}\left[\text{SLASH } \left\{\boxed{2}\ \text{NP}\left[\text{INDEX } \boxed{1}\right]\right\}\right], \ldots\right\rangle \\ \text{TO-BIND} & \left\{\boxed{2}\right\} \end{bmatrix}$$

Analyses which assume lexical entries like the one above depend on the fact that a head's complements' SLASH values are accessible via the COMPS list, in order to ensure that the MO predicate's TO-BIND value binds a SLASH element from the correct complement (here, the specified VP complement).

What such previous analyses have failed to explain, however, is the fact that there appear to exist no MO predicates which bind a SLASH element of any non-verbal complement. That is, if lexical heads had access to their complements' SLASH specifications, one would expect to encounter MO predicates just like the one above, but which bind a SLASH element on some PP complement (say) instead of a VP complement. But no such MO predicates seem to exist.

For example, there is no *tough*-type adjective in English that behaves like the hypothetical adjective *creasy* in (20b), below.

(20) a. Kim is easy/tough/good [for Sandy] [to love __].

b. Kim is creasy [for __] [to love Sandy]

In fact, it appears to be the case that (in English, at least) for any phrase wherein a daughter's SLASH value fails to be inherited, the daughter bearing the bound (i.e. uninherited) SLASH value is an infinitival or finite verbal projection.

If one depends on this generalisation, then, the lexical entry in (19) is redundant. That is, provided that the lexical item described has a non-empty TO-BIND value, we already know that a particular one of its complements bears a SLASH value which gets bound—namely, the infinitival (or finite) one.

In section 4.4.1 we explain how relying on this generalisation removes the apparent difficulty raised by assuming that the objects of valence are *local* values.

4.3 SLASH Inheritance

Thus far, the discussion has only covered how we license phrases which are gapped (i.e. which have an unrealised dependent); I have not yet indicated how phrases containing a gapped phrase get distinguished from those which do not. That is, I have not yet explained how one can force the distribution of the sentence [*Sandy loves* _] to differ from the distribution of the sentence [*Sandy loves Kim*], due to the fact that the first contains a gapped VP whereas the second does not.

I now turn to this question.

As is familiar from other HPSG theories of UDCs (e.g. Pollard and Sag (1994)), we assume that phrases bear a set-valued feature called SLASH, where each element of a phrase *P*'s SLASH value corresponds to some gap in a phrase dominated by *P*.[9] In the usual case, we cause the SLASH value of a phrase to be the union of the SLASH values of its daughters. Furthermore, we assume that phrases bear a set-valued feature TO-BIND, which we use to prevent SLASH values from being inherited at appropriate points in a sign's phrase-structure.

Specifically, the SLASH value of a phrase is defined as follows:

First, it is necessary to ensure that gapped phrases (i.e. those with an unrealised dependent) bear SLASH elements corresponding to their gaps:

(21) GAPS-to-SLASH constraint:

$$\textit{phrase} \quad \longrightarrow \quad \begin{bmatrix} \text{SLASH} & \boxed{S} \\ \text{GAPS} & \boxed{1} \end{bmatrix} \wedge \textit{list\_to\_set}(\boxed{1}) \subseteq \boxed{S}$$

This constraint simply requires that the set-analogue of a phrase's GAPS list be a subset of its SLASH value. Recall that a phrase's GAPS value is nonempty iff it has an unrealised dependent, due to the constraint definining GAPS (15). Thus, the present constraint (21) requires a phrase's unrealised dependents to be elements of its SLASH set.

Then, we ensure that the SLASH values of a phrase's daughters contribute appropriately to its own SLASH value:

(22) SLASH Inheritance constraint (*prose version*):

> The union of the SLASH values of a phrase's daughters with the set-analogue of its GAPS value is the disjoint union of the SLASH value of that phrase with its head-daughter's TO-BIND value.

(23) SLASH Inheritance constraint (*AVM version*):

$$\textit{phrase} \longrightarrow \begin{bmatrix} \text{SLASH} & \boxed{S} \\ \text{H-DTR} & \boxed{1}\begin{bmatrix} \text{TO-BIND} & \boxed{B} \end{bmatrix} \\ \text{D-DTRS} & \boxed{2} \\ \text{GAPS} & \boxed{G} \end{bmatrix} \wedge \textit{list\_to\_set}(\boxed{G}) \cup \textit{collect\_slashes}(\boxed{1} \oplus \boxed{2}) \doteq \boxed{S} \uplus \boxed{B}$$

[9] We further assume phrases are the *only* sort of sign defined for SLASH. In particular, we assume that *words* are not defined for this feature.

This constraint is quite a mouthful. Informally, it says that the SLASH value of a phrase is the largest set containing just its GAPS elements, the SLASH elements of its daughters, but minus any TO-BIND elements on its head-daughter. Furthermore, it requires that any TO-BIND element of *P*'s head-daughter be either one of *P*'s GAP elements or a SLASH element of one of *P*'s daughters.

This constraint (together with the GAPS-to-SLASH constraint above and the assumption that TO-BIND values are at-most-singleton) ensures several things:

- A phrase whose head-daughter has an empty TO-BIND value will inherit all the SLASH values of its daughters.
- A *local* object *B* is the TO-BIND element of *P*'s head-daughter only if *B* is an element of the SLASH value of one of *P*'s daughters. This ensures that forcing a phrase's head-daughter to bear a non-empty TO-BIND value will cause that phrase to have some slashed daughter.
- If *S* is an element of the SLASH value of a daughter of *P*, then *S* is absent from the SLASH value of *P* iff *S* is the TO-BIND element of *P*'s head-daughter. This ensures that forcing a phrase's head-daughter to bear a non-empty TO-BIND value will effect a reduction in the slashes inherited by that phrase.

Thus, we are now in the position where (i) if we want a phrase to inherit all its daughters' SLASH elements, we must ensure that the head of that phrase has an empty TO-BIND value, and where (ii) if we want a phrase to fail to inherit some SLASH element from one of its daughters, then we must ensure that the head of that phrase has a non-empty TO-BIND value.

One way to accomplish this is to do so on a per schema basis.

4.4 SLASH-Binding Constructions

There are at least two sorts of constructions where it is conceivable that one would want to ensure that some SLASH value fails to get inherited from a daughter: head-complement phrases headed by a *tough*-adjective, and head-filler structures (such as WH-relative clauses, constituent questions, etc.).[10]

We will discuss both of these in turn, beginning with *tough*-constructions.

4.4.1 *Tough*-Constructions

In a head-complement phrase, we permit the lexical entry of the head to determine what sort of TO-BIND value the head has.[11] Predicates like *hard* as in *hard for the cops to figure out that Kim vandalised _ last year* are lexically specified with non-empty TO-BIND values, whereas other lexical items (e.g. *eager* as in *eager for it to rain*) are lexically specified as bearing empty TO-BIND values.

[10] English bare relatives constitute a case of gap-binding that is subsumed by neither of the two cases considered here in any obvious way. Space considerations, however, preclude their discussion.

[11] In this respect our treatment is identical to the treatment of *tough*-constructions presented in Pollard and Sag (1994:166–171).

(24) partial lexical entries for *hard* and *eager*:

a. *hard*, (a *tough*-adjective)

$$\begin{bmatrix} \textit{word} & \\ \text{SUBJ} & \left\langle \text{NP}\left[\text{INDEX } \boxed{1}\right] \right\rangle \\ \text{COMPS} & \left\langle \text{PP}\left[\textit{for}\right], \text{VP} \right\rangle \\ \text{TO-BIND} & \left\{ \text{NP}\left[\text{INDEX } \boxed{1}\right] \right\} \end{bmatrix}$$

b. *eager*, (not a *tough*-adjective)

$$\begin{bmatrix} \textit{word} & \\ \text{SUBJ} & \left\langle \text{NP} \right\rangle \\ \text{COMPS} & \left\langle \text{PP}\left[\textit{for}\right], \text{VP} \right\rangle \\ \text{TO-BIND} & \left\{ \right\} \end{bmatrix}$$

The lexical entry above in (24a) and the constraints on SLASH values defined in (21–23) are sufficient to ensure that one of the complements of the *tough*-adjective *hard* has a non-empty SLASH value.

To see this, suppose that *hard*, as described above in (24a), heads a head-complement phrase. Call that phrase *P*, and let *b* be the sole TO-BIND element of *hard*. Then, consider the SLASH Inheritance constraint (23). We know that the disjoint union of *P*'s SLASH value with $\{b\}$ is defined. Hence we know that *b* is either (i) an element of *P*'s GAPS list or (ii) an element of the SLASH value of one of *P*'s daughters. But case (i) is impossible: *b* is not in *P*'s SLASH value (since the disjoint union mentioned above is defined) and hence, by the GAPS-to-SLASH constraint, *b* can't be in *P*'s GAPS list. So *b* is a SLASH element of one of *P*'s daughters. (That is, we know that case (ii) holds.) And, since the head-daughter is a word, we know that *b* is a SLASH element of one of the complement-daughters.

However, which of the complements bears a SLASH value containing *b* is still not determined. This due to the fact that, in contrast to the more traditional analysis of *tough*-adjectives given in (19) wherein the *tough* predicate is lexically specified as selecting a slashed *synsem* valent, the present analysis assumes that the objects of valence are *local* objects, bearing no information regarding the SLASH values of the signs to which they belong.

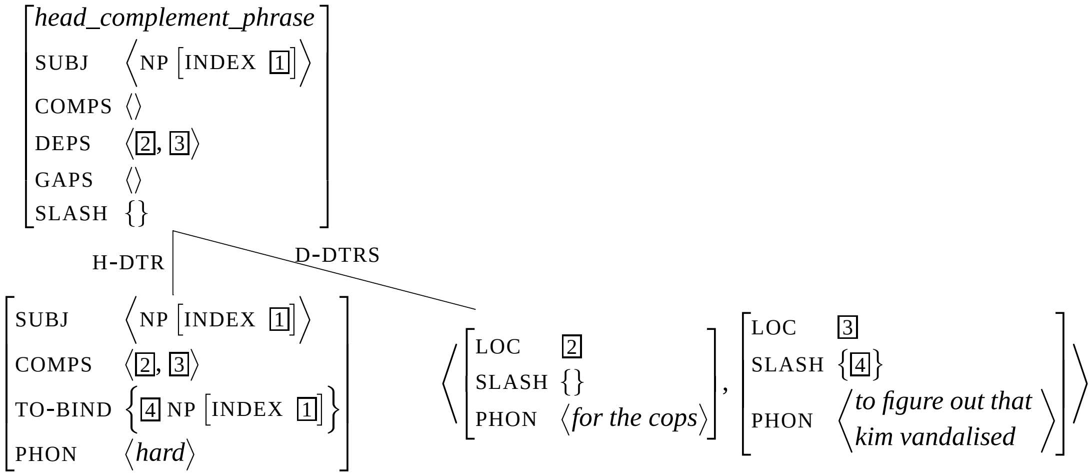
Nonetheless, there is a non-lexical way of ensuring that the TO-BIND element of the lexical entry in (24a) is an element of the correct complement-daughter's SLASH value. Namely, the generalisation that whenever a phrase fails to inherit a SLASH element from one of its daughters, that daughter is a verbal projection.

I will not formulate here a constraint that expresses this generalisation, but provided with one the present theory disallows example (25b), where the wrong complement of a *tough*-adjective is slashed, and ensures the following structure in (26) for the bracketed head-complement phrase in (25a).

(25) a. That statue will be [hard for the cops to figure out that Kim vandalised] (since she did so in invisible ink).

b. * Those cops will be [hard for __ to figure out that Kim vandalised that statue].

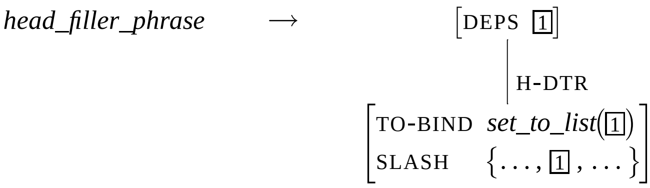
(26) example of a licensed *tough*-construction:



4.4.2 Head-Filler Phrases

Clearly, a head-filler phrase should bind a SLASH element on its head-daughter. The following schema will ensure this:

(27) Head-Filler phrase schema:[12]



This schema requires that its sole dependent has a LOCAL value identical to some SLASH element on the head-daughter.[13] Furthermore, since the schema further requires this *local* object to be the head-daughter's TO-BIND value, the SLASH value of the head-filler phrase will not inherit it.

It is worth noting also that this constraint forces the dependent to be realised as a daughter; its LOCAL value is token-identical to the TO-BIND value of the head-daughter, and hence must be absent from the SLASH value of the head-filler phrase. Hence, by the GAPS-to-SLASH constraint, it must also be absent from the head-filler phrase's GAPS list.

4.5 Morphological Registration of Gap-Binding Domains in Chamorro

Chamorro is a VSO Austronesian language spoken on the Mariana Islands in the western Pacific.

It is one of a number of languages including French, Irish, Icelandic, and Palauan in which a clause may exhibit distinctive morphosyntax when it dominates a slashed phrase but not the phrase within

[12] Note that since TO-BIND values are at-most singleton, the functional relation *set_to_list* need only map the empty set to the empty list, and singleton sets to singleton lists.

[13] There must be exactly one dependent, since DEPS must be nonempty, and TO-BIND is at-most singleton.

which that slash element becomes bound.[14] Of such languages, Chamorro is particularly interesting due to the relative sensitivity to the grammatical function of the conditioning slashed constituent exhibited by such morphosyntactic reflexes.

In Chamorro the morphological paradigms appropriate for the lexical head of a slashed finite clause are determined by which one of its dependents it inherits its SLASH element from.[15] There appear to be at least five different cases to consider, determined by whether the slashed dependent is the subject, direct object, indirect object, or one of two classes of modifier. In this section, I demonstrate how the present analysis of unbounded dependencies can be adapted to characterise the first of these cases, wherein a verb inherits a SLASH element from its subject.

The examples below in (28) illustrate how slashed subjects are morphologically registered. The head verb in example (28a) exhibits the morphology appropriate for a verb whose projections have no slashed dependents, whereas in example (28b) the head verb exhibits the infix *-um-*, which is the morphology distinctive of finite verbs with a slashed subject.[16,17]

(28) a. Ha-fa'gasi si Henry i kareta ni häpbun
AGR(2.SG.RT)-wash UNM Henry the car OBL soap
'Henry washed the car with soap.'

b. Hayi f*um*a'gasi _ i kareta
who? AGR(WH.SBJ).wash GAP the car
'Who washed the car?'

Of course under the present analysis, only realised subjects can technically be slashed (i.e. bear nonempty SLASH values), since unrealised subjects are merely *local* objects. Therefore, to remain faithful to our ontology, a better description than that in the previous paragraph of the head verb in (28b) would be to say that it bears the morphology distinctive of a verb which is the lexical head of a head-subject phrase whose SLASH set properly subsumes its head-daughter's.[18]

The next pair of examples, in (29), demonstrate that this description is indeed accurate; not only do subjects which are gaps themselves (as in (28b)) trigger *-um-* infixation, but so do realised subjects with non-empty SLASH values (like the matrix subject in (29b)). That is, taken together, the examples in (28) and (29) demonstrate that *-um-* infixation on a verb reflects the fact that its subject contributes a SLASH element to its clause.[19]

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[14]See Hukari and Levine (1995) for a survey of this phenomenon in a number of languages.

[15]The analysis given here is based on the facts of Chamorro as presented in Chung (1998).

[16]In the interest of expediting the discussion, this statement glosses over the fact that it is only verbs which are realis and transitive (as *fa'gasi* 'wash' is in examples (28a,b)) whose morphology reflects the presence of a slashed subject.

[17]The Chamorro examples and glosses in (28–29) are taken from Chung and Georgopolous (1988:252–3, 259). The gloss RT indicates *realis and transitive*, while RI indicates *realis and intransitive*. The case marker *si* marks the so-called *unmarked* case, appropriate for subjects and direct objects, and glossed as UNM. The case marker *ni* marks oblique arguments.

[18]For ease of exposition, we pass over the problems associated with talking about head-subject structures in a VSO language.

[19]N.B.: The non-subject argument of the verb *malägu'* 'want' is not a direct object. Hence, its extraction in example (29b) triggers oblique WH-agreement on the lexical head of the subordinate clause.

(29) a. Ha-istotba yu' [na malägu' i lahi-hu kareta]
AGR(3.SG.RT)-disturb me AGR(SG.RI).want the son-my car
'That my son wants the car bothers me.'

b. hafa *um*istotba hao [ni malago'-ña i lahi-mu __]
what? AGR(WH.SBJ).disturb you AGR(WH.OBL).want-3.SG the son-your GAP
'What does it bother you that your son wants? (*Lit.* What [[that your son wants __] bothers you]?)'

Before moving on to its analysis, there is one final aspect of this phenomenon that deserves mention. Whereas the paradigm the verb in (28b) instantiates is the only grammatical one (given that its subject is a gap), the morphology exhibited by the matrix verb in (29b) is not the only grammatical option in the case when a verb's subject properly contains a gap.[20] In the latter case, -*um*- infixation is optional; the alternative paradigm is the one exhibited by verbs heading only unslashed projections, as in (29a) (although Chung (1994) reports that acceptability of this alternative is irretrievably marred when the filler is nonreferential). This optionality is included in the analysis, to which I now turn.

We assume that verbal HEAD objects in Chamorro bear a boolean-valued feature SLASHED-SUBJ, where verbs with the morphology distinctive of a slashed subject are lexically specified as [HEAD|SLASHED-SUBJ +] and all others are [HEAD|SLASHED-SUBJ −]. The proper distribution of [SLASHED-SUBJ +] verbs can now be guaranteed as follows.

First, we require that when a head-subject phrase's SLASH value is identical to its head-daughter's SLASH value, then it must be [HEAD|SLASHED-SUBJ −]:

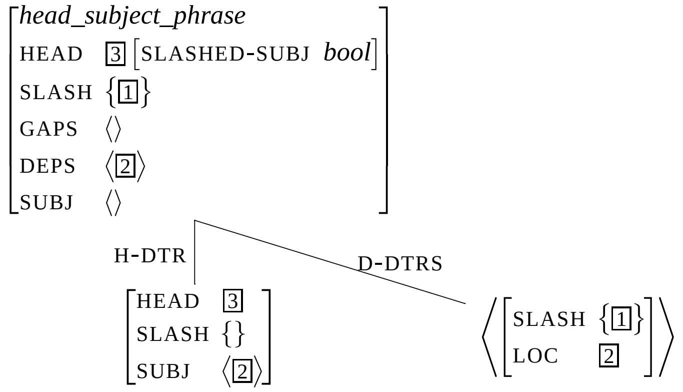
(30) constraint on the HEAD value of verbs with unslashed subjects

$$\begin{bmatrix} \textit{head\_subject\_phrase} \\ \text{SLASH} \quad \boxed{1} \\ \text{H-DTR}|\text{SLASH} \quad \boxed{1} \end{bmatrix} \rightarrow \begin{bmatrix}\text{SS}|\text{LOC}|\text{CAT}|\text{HEAD}|\text{SLASHED-SUBJ} \ - \end{bmatrix}$$

The constraint above in (30) ensures that whenever a head-subject phrase's dependent fails to contribute a new SLASH element, then both that head-subject phrase and (by the Head Feature Principle) its lexical head will be [HEAD|SLASHED-SUBJ −] and fail to bear slashed subject morphology. On the other hand, should a head-subject phrase's dependent contribute a new SLASH element, then either value for SLASHED-SUBJ (and hence either morphological paradigm) is appropriate. Thus, we have accounted for the optional case of morphological registration of slashed subjects, when the subject is realised as in (29b). The reader may verify that we have achieved this by checking that, in the head-subject structure below, neither value for SLASHED-SUBJ violates the constraint in (30).

[20] Actually, according to Chung (1994), for example (29b) to be acceptable without -*um*- infixation on the matrix verb, the filler would need to have more descriptive content than *hafa* provides. So with that particular filler, the matrix verb in (29b) does in fact exhibit the only acceptable morphology.

(31) head-subject phrase with a realised, slashed subject



It now remains necessary to ensure that verbs like the matrix verb in (28b), whose subject is unrealised, are obligatorily [HEAD|SLASHED-SUBJ +]. The following constraint does precisely this:

(32) constraint on the head value of verbs with gapped subjects

[*head_subject_phrase*, GAPS *ne_list*] → [SS|LOC|CAT|HEAD|SLASHED-SUBJ +]

5 Conclusion

In the confines of this paper, I have presented the elements of a trace-free theory of UDCs whose distinguishing claim is that being a phrase-stuctural adjunct and being extractable are not inconsistent properties.

Obviously, much work remains to be done before its adequacy as a framework for complete theories concerning the UDCs of particular languages can be evaluated. In particular, I have left unaddressed here the question of whether it is compatible with the considerable body of existing work in the HPSG framework regarding filler-gap constructions, such as Sag (1997)'s comprehensive treatment of English relative clauses and Ginzburg and Sag (2001)'s analysis of interrogative structures. Furthermore, although I have demonstrated that it is capable of characterising one of the classes of Chamorro gap-binding domain registration (namely the case of slashed subjects), it remains an open question whether all five classes may be analogously described.

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