Chapter 13

Unbounded dependencies

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Unbounded dependencies of the kind that are found in *wh*-interrogatives, relative clauses, and other constructions have been a major focus of research in HPSG. They typically involve a gap of some kind and some distinctive higher structure, often involving a filler in a non-argument position with the properties of the gap. HPSG has developed detailed proposals about the bottom of the dependency, the middle, and the top. In the case of the top of the dependency, complex hierarchies of phrase types have been employed to handle the distinctive properties of the various unbounded dependency constructions. Analyses have also been developed for unbounded dependencies with a resumptive pronoun, the special properties of *wh*-interrogatives, extraposition phenomena, and filler-gap mismatches.

1 Introduction

Since Ross (1967) and Chomsky (1977), it has been clear that many languages have a variety of constructions involving an unbounded (or long distance) dependency (henceforth UD). *Wh*-interrogatives and relative clauses are important examples, but, as we will see, there are many others. Typically these constructions contain a gap (in the sense that a dependent is missing) and some distinctive higher structure, and neither can appear without the other. The following illustrate:

(1) a. What did you put _ on the table?
b. * You put _ on the table?

Robert D. Borsley & Berthold Crysmann. 2021. Unbounded dependencies. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar: The handbook*, 515–572. Berlin: Language Science Press. DOI: ??

c. * What did you put it on the table?

In (1a) there is a gap (indicated by the underscore) in object position and the distinctive higher structure involves the interrogative pronoun *what* and the pre-subject auxiliary *did*. (1b), where the gap is present but not the distinctive higher structure, is ungrammatical, as is (1c), where the distinctive higher structure appears but not the gap. The interrogative pronoun *what* in (1a) is known as a filler, a constituent in a non-argument position with the properties of the gap. But the distinctive higher structure does not always include a filler. English relative clauses may or may not have a filler:

(2) the book [(which) you put _ on the table]

As we will see below, there are also UD constructions which never have a filler. When there is a filler in a UD construction, it normally has all the properties of the associated gap. Thus, in the following, the filler and the gap are of the same category:

(3) a. [$_{\text{NP}}$ Who] did Kim talk to _ (NP)?
b. [$_{\text{PP}}$ To whom] did Kim talk _ (PP)?
c. [$_{\text{AP}}$ How long] is a piece of string _ (AP)?
d. [$_{\text{AdvP}}$ How quickly] did you do it _ (AdvP)?

They typically match in other respects as well. For example, if they are nominal, they match in number, as the following illustrate:

(4) a. [$_{\text{NP}[sg]}$ Which student] do you think _ (NP[*sg*]) knows the answer?
b. [$_{\text{NP}[pl]}$ Which students] do you think _ (NP[*pl*]) know the answer?

In languages with grammatical gender or morphological case, they also share these properties. In addition to syntactic properties, unbounded dependencies also establish matching of semantic properties: i.e., in (1a), the filler *what* is understood to fill an argument role of *put*, just as an in situ complement would. The term *unbounded* is used here because the gap and the distinctive higher structure with which it is associated can be indefinitely far apart. The following illustrate:

(5) a. What does she regret that she put _ on the table?
b. What did she say she regrets that she put _ on the table?
c. What do you think she says she regrets that she put _ on the table?

There are, however, some restrictions here commonly referred to as island phenomena. These are discussed by Chaves (2021), Chapter 15 of this volume. There are a few further points that we should make at the outset. We have focused so far on UD constructions where an obligatory dependent, a subject or complement, is missing. But UDCs are certainly not restricted to subjects and complements. There are examples where the filler has an adjunct role such as (3d) or the following:

(6) {Where / When / How / Why} did you talk to Lee_?

There are also UD constructions with no gap at all. Instead they have a so-called *resumptive pronoun* (RP). The following Welsh example with the RP in italics illustrates:

(7) Pa ddyn werthodd Ieuan y ceffyl iddo *fo*?
which man sell.PAST.3SG Ieuan the horse to.3SGM he
'Which man did Ieuan sell the horse to?'

Finally, we should note that there are some cases where filler and gap do not match.

(8) a. Kim will sing, which Lee won't _.
b. * Which won't Lee _?

In (8a) the filler is a nominal expression, but the gap is a non-finite VP. The *wh*-interrogative in (8b) shows that it is not normally possible to have a nominal filler associated with a VP gap, but in (8a) it is fine. We explore the HPSG approach to these matters in the following pages. In Section 2, we outline the basic HPSG approach to UDs. Then in Section 3, we focus on the nature of gaps, i.e. the bottom of the dependency, and in Section 4 we look more closely at the middle of UDs. In Section 5, we consider the top of UDs and highlight the variety of UD constructions. In Section 6, we look at resumptive pronouns. Then, in Section 7, we consider some further aspects of *wh*-interrogatives, including pied-piping and *wh*-in-situ phenomena, Section 8 deals with extraposition, and, in Section 9, we take a look at filler-gap mismatches. Finally in Section 10, we summarise the chapter, followed by an appendix comparing HPSG to SBCG.

2 The basic approach

An analysis of UDs needs an account of gaps, of the structures at the top of UDs, and of the connection between them. Central to the HPSG approach is the feature SLASH, occasionally called GAP in some recent works, which provides information about the presence of UD gaps inside a constituent.[1] Much HPSG work assumes the feature geometry (9), following Pollard & Sag (1994: Chapter 4):

(9) HPSG feature geometry: nonlocal and local features

$$\begin{bmatrix} \textit{synsem} & \\ \textsc{local} & \begin{bmatrix} \textit{local} & \\ \textsc{category} & \textit{category} \\ \textsc{content} & \textit{content} \end{bmatrix} \\ \textsc{nonlocal} & \begin{bmatrix} \textit{nonlocal} & \\ \textsc{slash} & \textit{set(local)} \\ \ldots & \end{bmatrix} \end{bmatrix}$$

As this indicates, SLASH is part of the value of the feature NONLOCAL. Its value is a set of *local* feature structures. If we use traditional category labels as abbreviations for local feature structures, we can say that a constituent containing an NP gap is [SLASH {NP}], a constituent containing a PP gap is [SLASH {PP}], and so on.

Turning to gaps, a central question is whether there is a phonologically empty element in the constituent structure or nothing at all. Both positions have been developed within HPSG, but probably the view that there is nothing at all in constituent structure is the more widely assumed position. We will adopt that for now and return to the issues in Section 3. Assuming this position, example (1a), repeated here as (10), will contain a V with just a single complement sister, namely the predicative PP *on the table*.

(10) What did you put _ on the table?

Because the V contains an NP gap, it will be [SLASH {NP}], and so will the constituents that contain it, with the exception of the complete sentence. Thus, we have the schematic structure illustrated in Figure 13.1.

Obviously, we need to ask what ensures that the SLASH feature plays just the right role here. First, however, we need to say more about gaps.

[1] The basic approach derives from the earlier Generalised Phrase Structure Grammar (GPSG) framework (Gazdar, Klein, Pullum & Sag 1985) and can be traced back to Gazdar (1981). The feature's name equally derives from this heritage, referring to the GPSG notation whereby X/Y stands for a category X containing a gap of category Y.

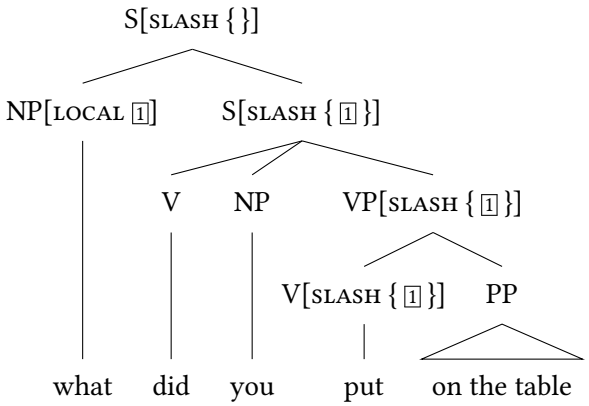


Figure 13.1: Extraction by SLASH feature percolation

On the view of gaps we are focusing on here, they are only represented in ARG-ST lists. Thus, the verb *put* in (10) has a gap in its ARG-ST list and therefore only a PP in its COMPS list and in constituent structure. Gaps have the feature make up given in (11):

(11) Representation of gaps, according to Pollard & Sag (1994: 161):
$$\begin{bmatrix} \textsc{local} & \boxed{1} \\ \textsc{nonlocal} & \left[\textsc{slash} \ \{\boxed{1}\}\right] \end{bmatrix}$$

Thus, *put* in (10) will have an element of this form in an ARG-ST list where 1 is the LOCAL value of an NP.

Returning now to SLASH, a widely assumed approach involves the following assumptions:

(12) a. The SLASH value of a head is normally the same as the union of the SLASH values of its arguments.
b. The SLASH value of a phrase is normally the same as that of its head.

We will consider how these ideas are formalised in Section 4. For now we will just discuss their implications for the analysis of (10). Essentially they mean that it has the following more elaborate analysis, as given in Figure 13.2.

Clause (12a) is responsible for the SLASH values on P and both Vs, while clause (12b) is responsible for the SLASH values on PP, VP, and the lower S. This approach to the distribution of SLASH crucially involves heads and is commonly said to be head-driven.

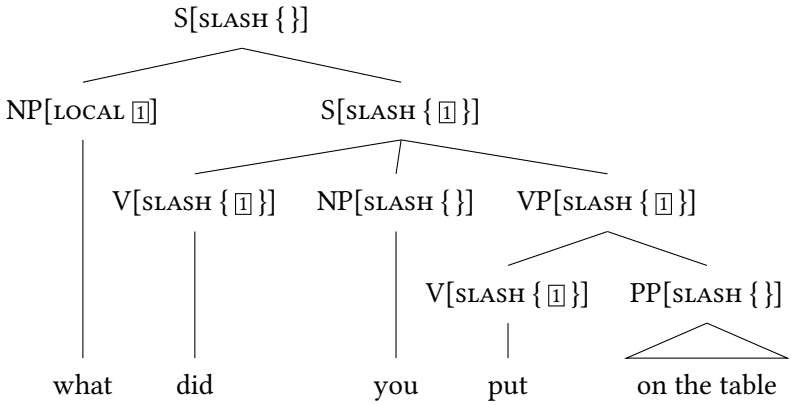


Figure 13.2: Head-driven SLASH feature percolation

The lower S in Figures 13.1 and 13.2 is the head of the higher S, but they do not have the same value for SLASH. This is because they represent the top of the dependency. If information about gaps were available above the top of the dependency, it would be possible to have another filler higher in the tree, as in (13).

(13) * What do you wonder what Kim saw _?

The top of the dependency in Figures 13.1 and 13.2 is a head-filler phrase and the constraint on head-filler phrases needs to ensure that the higher S is [SLASH { }]. One might propose the following constraint:

(14) Head-filler phrase (singleton SLASH set):
head-filler-ph ⇒
$$\begin{bmatrix} \textsc{slash} & \{\} \\ \textsc{hd-dtr}\ \boxed{1} & \begin{bmatrix} \textsc{comps} & \langle\rangle \\ \textsc{slash} & \{\boxed{2}\} \end{bmatrix} \\ \textsc{dtrs} & \left\langle \left[\textsc{local}\ \boxed{2}\right], \boxed{1} \right\rangle \end{bmatrix}$$

This says that a head-filler phrase is SLASH { } and has a head daughter which has a saturated COMPS list and has a single local feature structure in its SLASH set and a non-head daughter whose LOCAL value is the local feature structure in the SLASH set of the head. Standardly, however, a slightly more general constraint is assumed along the following lines:

(15) Head-filler phrase:[2]
head-filler-ph ⇒
$$\begin{bmatrix} \textsc{slash} & \boxed{3} \\ \textsc{hd-dtr} & \boxed{1}\begin{bmatrix} \textsc{comps} & \langle\rangle \\ \textsc{slash} & \{\boxed{2}\} \cup \boxed{3} \end{bmatrix} \\ \textsc{dtrs} & \left\langle \left[\textsc{local}\ \boxed{2}\right], \boxed{1} \right\rangle \end{bmatrix}$$

This allows the SLASH set of the head to contain more than one member and any additional members form the SLASH set of the whole phrase (3). This is necessary for an example like (16) from Chaves (2012: 473), where indices are used to link fillers and gaps.

(16) This is the person who$_i$ I can't remember [which papers]$_j$ I sent copies of $\__j$ to $\__i$.

Examples of this form often seem unacceptable, but this is probably a processing matter, see Chaves (2012: Section 3) for discussion. See also Section 6 for long relativisation with resumption in Hausa or Modern Standard Arabic.

3 More on gaps

We now look more closely at the nature of gaps. The central question here is: what exactly are gaps? We noted in the last section that it has been widely assumed that gaps are only represented in ARG-ST lists, but that some HPSG work assumes that they are empty categories, often called traces. There is a third possibility which might be considered, namely that gaps are represented in ARG-ST lists and in VALENCE lists, i.e. SUBJ and COMPS lists, but not in constituent structures. However, it seems that this position has rarely been considered. One complicating factor is that there seem to be differences between complement gaps and both subject and adjunct gaps. A consequence of this is that the question "what are gaps?" could have different answers for different sorts of gaps, and in fact different answers have sometimes been given.

Complement gaps seem to have had rather more attention than subject or adjunct gaps, perhaps because there are many different kinds of complements, hence many different kinds of complement gaps. We will look first at complement gaps, and in particular, the gap in (1), repeated here as (17).

(17) What did you put _ on the table?

Probably the most widely assumed position is that gaps are only represented in ARG-ST lists (see Sag 1997: Section 4.1, Bouma, Malouf & Sag 2001: Section 2.2, Ginzburg & Sag 2000: Chapter 5.1 and Sag 2010: 508). On this view, the verb *put* will have the following syntactic properies:

$$\begin{bmatrix} \textsc{head} & \textit{verb} \\ \textsc{slash} & \{\boxed{2}\} \\ \textsc{subj} & \langle \boxed{1} \rangle \\ \textsc{comps} & \langle \boxed{3} \rangle \\ \textsc{arg-st} & \left\langle \boxed{1}\ \text{NP},\ \text{NP}\begin{bmatrix}\textsc{local}\ \boxed{2} \\ \textsc{slash}\ \{\boxed{2}\}\end{bmatrix}, \boxed{3}\ \text{PP} \right\rangle \end{bmatrix}$$

Figure 13.3: Representation of a slashed verb (traceless)

We ignore the COMPS feature and the issue of what ensures that the verb here has the same SLASH value as the gap. We will discuss the latter in the next section.

The view that gaps are empty categories was a feature of early HPSG work, notably Pollard & Sag (1994: Chapter 4), and it has been assumed in some more recent work, e.g. Levine & Hukari (2006: 191,385), Borsley (2009), Borsley (2013: Section 4.2), and Müller (2014). On this view, the VP will have the following structure:

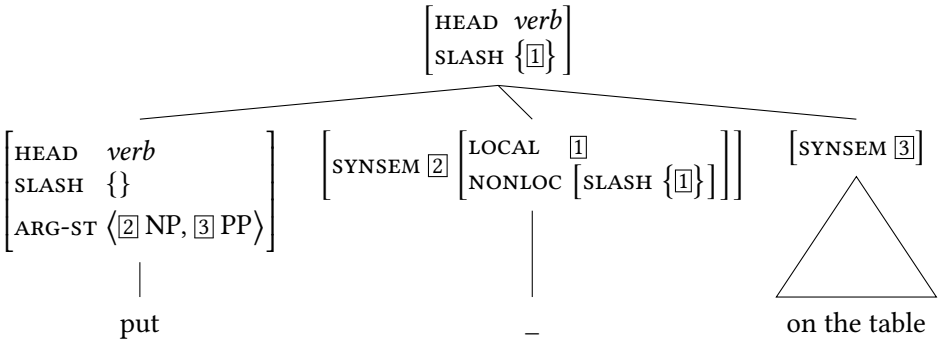


Figure 13.4: Representation of a slashed VP (with trace)

Again we ignore the COMPS feature and how the VP here has the same SLASH value as the gap.

It is not easy to choose between these two approaches. One argument in favour of the first view, advanced, for example, in Bouma et al. (2001: Section 3.5.2), is

that it makes it unsurprising that a gap cannot be one conjunct of a coordinate structure, as in the following:

(18) a. * Which of her books did you find both [[a review of _] and _]?
b. * Which of her books did you find [_ and [a review of _]]?

It is not obvious why this should be impossible if gaps are empty categories.[3]

A second argument in favour of a traceless approach comes from languages which morphologically treat slashed transitives on a par with intransitives, like Hausa (Crysmann 2005a) or Mauritian Creole French (Henri 2010). In Hausa and Mauritian, verbs morphologically register whether a direct object is realised locally or not: in both languages, a "short" form is used with locally realised direct objects, whereas the long form is used with intransitives as well as in the case of object extraction. Consider the following examples from Hausa, partially adapted from Newman (2000: 632–633):

(19) Sun hūtà.
3PL.CMPL rest.A
'They rested.'

(20) a. Sun rāzànā.[4]
3PL.CMPL terrorise.A
'They terrorised (someone).'
b. Sun rāzànà fařar-hǔlā.[5]
3PL.CMPL terrorise.C civilian(s)
'They terrorised the civilians.'
c. Fařar-hǔlā nè sukà rāzànā.
civilian(s) FOC 3PL.CMPL terrorise.A
'The civilians, they terrorised.'

[3] Coordination is a problem for any empty category, not just the empty categories that represent gaps in some HPSG work. Various empty categories have been proposed in the HPSG literature, most prominently the empty relativiser of Pollard & Sag (1994: Chapter 5). Sag et al. (2003: Section 15.3.5) propose that African American Vernacular English has a phonologically empty form of the copula. This analysis requires some mechanism to prevent this form from appearing as a conjunct. It is likely that a mechanism that can do this will also prevent the empty categories that represent gaps from being conjuncts.

[4] Newman (2000: 632)

[5] Newman (2000: 632)

Hausa verbs are lexically transitive or intransitive, and they are classified into one of seven morphological grades.[6] Intransitives only have a single form (A-form), which is characterised by a long vowel (in grade 1), cf. (19). Transitives, however, display an alternation depending on the mode of realisation of the direct object: if used intransitively, they pattern with intransitive verbs in using the A-form (long vowel in grade 1), but with an in situ direct object (20a), they obligatorily surface in the C-form (20b), which has a short vowel in grade 1. Once the direct object is extracted, we find the long vowel A-form again, in parallel to the intransitive use of transitives and true intransitives. In sum, the morphology of Hausa treats complement extraction on a par with argument suppression or lexical intransitives, i.e. as if the direct object complement simply were not there. Similar observations appear to hold for Mauritian (Henri 2010: Section 4.2.3). Thus, if nonlocal realisation corresponds to lexical valence reduction, the Hausa (and Mauritian) facts are straightforwardly accounted for, whereas the generalisation would be lost, if gaps were considered phonologically empty syntactic elements.

However, the lexical approach to argument extraction has some possibly non-trivial implications for other lexical sub-theories of HPSG that make crucial reference to valence lists, which includes lexical theories of agreement and case. This is because gaps will not be present on the valence lists of word-level signs. The theory of ergativity proposed by Manning & Sag (1999: Section 5.2) in terms of mapping between ARG-ST and valence lists is actually formulated as constraints on lexemes, since e.g. the linking of the highest argument to the first element on COMPS (ergative subject) needs to be specified independently of whether this argument is realised by a local or a non-local dependency. The same holds of course for the linking of objects in accusative languages.[7]

Similar considerations apply to agreement: if agreement treats local and non-local arguments alike, it is clear that agreement controllers cannot be identified in a general fashion in terms of the valence features of word-level signs: thus, if agreement relations need to make reference to valence rather than argument structure, this can only be

[6] We restrict discussion here to grade 1, although the syntactic pattern is systematic across grades, only giving rise to different patterns of exponence. See the Hausa grammars by Newman (2000) and Jaggar (2001) for details, and Crysmann (2005a) for evidence in favour of a morphological treatment.

[7] Crysmann (2009) exploits the fact that extracted arguments do not appear on the valence lists of word-level signs and formulates local case assignment for Nias as a constraint on *word*, effectively exempting topicalised arguments from objective case assignment.

JP: Is the difference between lexemes and words explained anywhere? BC: It should be, but there must be a better place than the chapter on UDCs!

established at the level of lexemes. The relevant evidence comes from languages, where the highest argument on ARG-ST does not necessarily correspond to the highest grammatical function, i.e. SUBJ valence: while some ergative languages display agreement with the highest argument on ARG-ST, e.g. Udi (Harris 1984), Archi (Kibrik 1994) shows agreement with the absolutive argument, suggesting that SUBJ is the right place to establish the relation. In Nias (Crysmann 2009), we find agreement with SUBJ in the realis, and with the least oblique argument in the irrealis (ARG-ST). Finally, in Welsh, we observe a parallelism in the agreement between subjects of finite verbs and the objects of prepositions and non-finite verbs: according to Borsley (1989: Section 4), a unified treatment can be given if subjects of finite verbs are the first element on COMPS, an assumption that directly captures Welsh VSO word order.[8]

Given the broad empirical support for valence lists as one of the loci of case and agreement constraints, it is clear that these constraints must hold for lexemes, not words under a traceless, lexical approach to unbounded dependencies.

We turn now to subject gaps. Here a central question is: "how similar or how different are they to complement gaps?" The following illustrate a well-known contrast, which suggests that they may be significantly different:

(21) a. Who do you think Kim saw _?
b. Who do you think _ saw Kim?

(22) a. Who do you think that Kim saw _?
b. * Who do you think that _ saw Kim?

The examples in (21) show that a gap is possible in object position in a complement clause whether or not it is introduced by *that*. In contrast, the examples in (22) suggest that a gap is only possible in subject position in a complement clause if it is not introduced by *that*. Pollard & Sag (1994: Chapter 4.4) approach this contrast by stipulating that gaps cannot appear in subject position. This accounts for the ungrammaticality of examples like (22b). Examples like (22a) are allowed by allowing verbs like *think* to take a VP complement and have a non-empty value for SLASH. Ginzburg & Sag (2000: Chapter 5.1.3) offer a very different account,

[8] Borsley (2016: Section 5.4) argues on rather different grounds that agreement in the Caucasian language Archi involves constraints on constituent structure, which will favour a trace-based perspective on extraction.

in which subject gaps appear both in ARG-ST list and SUBJ lists. They suggest that examples like (22b) are ungrammatical because *that* cannot combine with a constituent which has a non-empty SUBJ list.

An important fact about subject gaps is that they are not completely impossible in a complement clause introduced by *that*. In particular, they are acceptable if *that* is followed by an adverbial constituent. The following illustrates:

(23) Who did you say that tomorrow _ would regret his words?

Ginzburg & Sag (2000: Chapter 5.1.3) offer an account of such examples, but Levine & Hukari (2006: Chapter 2.3.2) argue that it is unsatisfactory. More generally, they argue that subject gaps are like complement gaps in various respects and therefore should have the same basic analysis. They propose an analysis with an empty category for both types of gap. Thus, their approach differs both from the widely assumed approach, which has no empty categories, and the approach of Pollard and Sag, which has them in complement position but not in subject position.

We turn now to adjunct gaps. It is not obvious that there is a gap in examples like (6) repeated as (24), because no obligatory constituent is missing.[9]

(24) $\left\{\begin{array}{l}\text{Where}\\ \text{When}\\ \text{How}\\ \text{Why}\end{array}\right\}$ did you talk to Lee _?

However, Hukari & Levine 1995 show that such examples may display what are often called *extraction path effects*, certain phonological or morphosyntactic phenomena which appear between a gap and the associated higher structure (see the discussion of example (29) on page 529). Hence, it seems that they must involve a filler-gap dependency, on a par with examples with a complement gap.

Of course, there are a variety of positions that are compatible with this conclusion. Bouma et al. (2001: 12) and Ginzburg & Sag (2000: 168, fn. 2) propose that verbal adjuncts are optional extra complements. On this view, the gaps in the examples in (24) are complement gaps. Levine (2003) and Levine & Hukari (2006: Chapter 3.5–3.6) argue against this approach with examples like the following:

(25) In how many seconds flat do you think that [Robin found a chair, sat down, and took off her logging boots]?

[9] This position has initially been taken in Pollard & Sag (1994: 176–180).

This is a query about the total time taken by three distinct events. Levine and Hukari propose a fairly traditional analysis of verbal adjuncts in which they are modifiers of VP, and combine this with the assumption that gaps are empty categories. The interpretation of examples like (25) follows straightforwardly on this analysis. If indeed argument extraction contrasts with adjunct extraction in terms of whether the gap is introduced lexically (on ARG-ST) or phrasally, this may provide a direct account of the fact that the use of a resumptive strategy in extraction is by and large restricted to arguments. As discussed by Crysmann & Reintges (2014), resumptives are obligatory for arguments in Coptic, whereas gap-type extraction is the only possibility for modifiers.

A rather different approach is developed in Chaves (2009). Like Levine & Hukari (2006: Chapter 3), he assumes that verbal adjuncts are modifiers of VP, but he rejects the idea that gaps are empty categories. He shows in particular that the possibility for a filler to correspond to a group is neither limited to adjunct extraction nor to events, but may also be observed with NP complements whose gaps are properly contained within each conjunct, as shown by the following examples:

(26) a. Setting aside illegal poaching for a moment, how many sharks$_{i+j}$ do you estimate [[$\__i$ died naturally] and [$\__j$ were killed recreationally]]?

b. [[Which pilot]$_i$ and [which sailor]$_j$] will Joan invite $\__i$ and Greta entertain $\__j$ (respectively)?

He suggests that the treatment of coordination must be relaxed in such a way as to permit the creation of group individuals and group events on the mother's SLASH where the daughters' SLASH values contain the individual or event variables of the group's members. This provides an account of complement extraction as in (26), but it also provides a straightforward account of the cumulative scoping facts in (25).

4 The middle of the dependency

In the middle of an unbounded dependency we typically have a phrase (or a clause) with the same value for SLASH as a non-head daughter. As we noted in Section 2, it is widely assumed that this relation is mediated by the head daughter. The SLASH value of a head is normally the same as that of its arguments, and the SLASH value of a phrase is normally the same as that of its head. However, as we will see, this head-driven approach to the distribution of SLASH hasn't always been adopted.

Central to the head-driven approach is the SLASH Amalgamation Principle, which we can formulate as follows, following Ginzburg & Sag (2000: 199):

(27) SLASH Amalgamation Principle:

$$word \Rightarrow / \begin{bmatrix} \textsc{synsem} & \left[\textsc{nonloc} \left[\textsc{slash} \boxed{1} \cup \ldots \cup \boxed{n}\right]\right] \\ \textsc{arg-st} & \left\langle \left[\textsc{nonloc} \left[\textsc{slash} \boxed{1}\right]\right], \ldots, \left[\textsc{nonloc} \left[\textsc{slash} \boxed{n}\right]\right] \right\rangle \end{bmatrix}$$

This is a default constraint, as indicated by the '/'. Essentially, it says that by default the SLASH value of a word is the union of the SLASH values of its arguments. Being merely a default constraint will accommodate examples like the following:

(28) The professor is hard [to talk to _].

Here, the adjective *hard* takes an infinitival complement with a non-empty SLASH feature but this SLASH feature is not passed on any further, but rather coindexed with the subject of the adjective.[10]

To ensure that the SLASH value of a phrase is normally the same as that of its head, much work employs a Slash Inheritance Principle, which stipulates that a phrase and its head have the same value for SLASH except at the top of a dependency (see, e.g. Bouma et al. 2001: 20). An alternative approach developed in Ginzburg & Sag (2000: Chapter 5.1) uses the Generalised Head Feature Principle for this purpose. This says that a headed phrase and its head daughter have the same SYNSEM values unless some other constraint requires something different. Among other things, this ensures that a headed phrase and its head daughter normally have the same value for SLASH.

One argument in favour of a head-driven approach to the distribution of SLASH is so-called extraction path effects, certain phonological or morphosyntactic phenomena which appear between a gap and the associated higher structure (see Hukari & Levine 1995; Bouma et al. 2001: Section 3.2). Irish provides one of many examples that have been discussed. In Irish, the verbal particle *goN* only occurs with structures that do not contain gaps, while *aL* only occurs between a filler and a gap. The following (Bouma et al. 2001: 26) illustrate:[11]

[10] The non-local nature of *tough*-constructions appears to be a peculiarity of English: similar constructions in German and French do exist, but they feature local (passive-like) dependencies. See Abeillé et al. (1998) and Aguila-Multner (2018) for French, as well as Müller (2002: Section 3.1.5) for German. Even for English, the unboundedness of the construction has been challenged: Grover (1995) questions the acceptability of English *tough*-constructions involving a UDC out of finite clauses and suggests a local account instead.

[11] In some accounts these particles are taken to be complementisers. The N indicates that *go* triggers nasal mutation while L indicates that *a* triggers lenition.

(29) a. Shíl mé goN mbeadh sé ann.
thought I VPART would be he there
'I thought that he would be there.'

b. An fear aL shíl mé aL bheadh ann.
the man VPART thought I VPART would.be there
'the man that I thought would be here'

Within a head-driven approach to SLASH, this is just a contrast between a verb which is [SLASH { }] and a verb which is [SLASH {[ ]}], and is completely unproblematic.

Early HPSG assumed an approach to SLASH which was not head-driven (see Pollard & Sag 1994: Chapter 4), and related approaches are assumed in Levine & Hukari (2006) and Chaves (2012: 497). A problem with a head-driven approach is that it says nothing about examples where an unbounded dependency crosses the boundary of a non-headed phrase such as a coordinate structure. Thus, it does not deal with examples of asymmetric coordination like the following:

(30) a. How much can you [drink _] and [still stay sober]]?

b. How many lakes can we [[destroy _] and [not arouse public antipathy]]?

Early HPSG (Pollard & Sag 1994: Chapter 4) accounts for the distribution of SLASH by means of the Nonlocal Feature Principle, and related principles are proposed by Levine & Hukari (2006: 354) and Chaves (2012: 497). These principles ensure that the SLASH value of a phrase reflects the SLASH values of all its daughters (using set union) and apply equally to headed and non-headed structures. Thus, the examples in (30) are no problem for these latter approaches. However, they seem to require some extra element to handle extraction path effects. So, it is not easy to choose between these approaches and the head-driven approach.

A further point that we should emphasise here is that both approaches to the distribution of SLASH allow structures like the one in Figure 13.5.

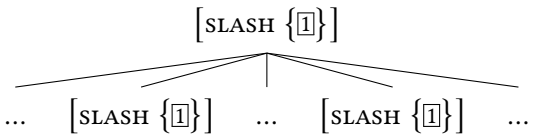


Figure 13.5: Across-the-board (ATB) extraction: conflation of SLASH values

In other words, both allow more than one daughter of a phrase with a non-empty SLASH value to have the same value. This means that we expect structures in which a single filler is associated with more than one gap. Thus, examples like the following are no problem:

(31) a. What did Kim [[cook _ for two hours] and [eat _ in four minutes]]?
b. Which person did you [invite _ [without thinking _ would actually come]]?

Example (31a), where the two gaps are in a coordinate structure is standardly said to be a case of across-the-board extraction. (31b) is traditionally seen as involving an ordinary gap followed by a parasitic gap. However, for HPSG, all these gaps have essentially the same status (see Levine & Hukari 2006 and Chaves 2012 for extensive discussion).

5 The top of the dependency: The diversity of unbounded dependency constructions

We now look more closely at the top of unbounded dependencies. This is where most of the diversity of unbounded dependency constructions resides. They are largely the same at the bottom of the dependency and in the middle, but at the top of the dependency, they differ from each other in a variety of ways. We noted at the outset that the distinctive higher structure in an unbounded dependency construction may contain a filler, but does not always. In other words, it may be a head-filler phrase, but it may not, and there are a number of other possibilities. Moreover, head-filler phrases can have quite different properties in different constructions.

In the introduction to this chapter we mentioned *wh*-interrogatives and relative clauses as two examples of unbounded dependency constructions. In English the former always involve a head-filler-phrase,[12] while the later sometimes do but sometimes do not. There are *wh*-relatives and non-*wh*-relatives of various kinds. English *wh*-interrogatives and *wh*-relatives look quite similar. They seem to involve many of the same lexical items: *who*, *which*, *when*, *where*, *why*, and, as the following show, both may be finite or non-finite:

[12] On some analyses of examples like the following, *who* is just a subject and not a filler:

(i) Who knows the answer?

However, for other work, this is a filler just like the *wh*-elements in the text.

(32) a. Who should I talk to _?
b. I wondered [who to talk to _].

(33) a. someone [who I should talk to _]
b. someone [to whom to talk _]

But there are differences. *Wh*-interrogatives, but not *wh*-relatives, allow *what* and *how*:

(34) a. What did Kim say _?
b. * the thing [what Kim said _]

(35) a. How did Lee do it _?
b. * the way [how Lee did it _]

In *wh*-interrogatives, *which* combines with a following nominal except in cases of ellipsis. Thus, in (36), *book* is necessary unless it is clear that books are under discussion.

(36) Which book did Kim buy _?

Notice also that non-finite *wh*-relatives only allow a PP as a filler. Thus, (37) is not possible as an alternative to (33b).

(37) * someone [who to talk to _]

Thus, the fillers in the two constructions differ in a number of ways. The heads also differ in that *wh*-interrogatives have auxiliary + subject order in main clauses (unless the *wh*-phrase is the subject), something which does not occur in *wh*-relatives.

Wh-interrogatives and *wh*-relatives are not the only unbounded dependency constructions that inolve a head-filler phrase. Topicalisation sentences such as the following are another:

(38) a. Beer, I like _.
b. To London, I went _.

Unlike *wh*-interrogatives and *wh*-relatives, these are always finite. Also required to be finite are what have been called *the*-clauses (Borsley 2004; Sag 2010: 490–494,524–527, Borsley 2011), the components of comparative correlatives such as (39).

(39) The more I read _, the more I understand _.

The-clauses have the unusual property that they may contain the complementiser *that*:

(40) The more that I read _, the more that I understand _.

Obviously, this is not possible in *wh*-interrogatives and *wh*-relatives.

(41) a. * I wonder [who that Lee saw _].
b. * the man [who that Lee saw _]

Within HPSG the obvious approach to the sorts of facts we have just highlighted involves a number of subtypes of the type *head-filler-phrase*, as in Figure 13.6.

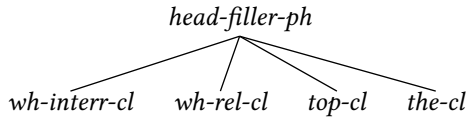


Figure 13.6: Hierarchy of head-filler phrases

As was noted in Abeillé & Borsley 2021, Chapter 1 of this volume, much HPSG work assumes two distinct sets of phrase types. Assuming this position, *wh-interr-cl* will not just be a subtype of *head-filler-ph* but also a subtype of *interr-cl*, the type *wh-rel-cl* will also be a subtype of *rel-cl*, and *top-cl* and *the-cl* will both be subtypes of *decl-cl*. This gives the type hierarchy in Figure 13.7.

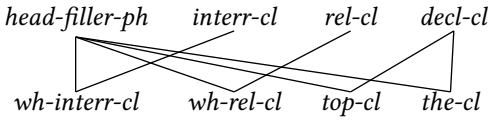


Figure 13.7: Hierarchy of extraction clause types (preliminary)

Constraints on *interr-cl* will capture the properties that all interrogatives share, most obviously interrogative semantics. Constraints on *rel-cl* will capture what all relatives have in common, especially modifying an appropriate nominal constituent.[13] Finally, constraints on *decl-cl* will capture the properties on declaratives, especially declarative semantics. Constraints on *wh-interr-cl* and *wh-rel-cl* will ensure that their fillers take the appropriate form. Constraints on *top-cl* and

[13] Non-restrictive relatives can also modify various kinds of non-nominal constituents. See Arnold (2004) and Arnold & Borsley (2008).

the-cl will restrict their fillers and also require their heads to be finite. Further complexity is probably necessary to handle all the facts noted above. To ensure that non-finite *wh*-relatives only allow a PP filler while finite *wh*-relatives allow either an NP or a PP filler, it is probably necessary to postulate two subtypes of *wh-rel-cl*. As for the fact that *the*-clauses may contain the complementiser *that*, one way to deal with this is to postulate a subtype of *head-filler-ph*, *standard-head-fill-ph*, with *wh-interr-cl*, *wh-rel-cl*, and *top-cl* as its subtypes. This new type will be subject to a constraint preventing its head from containing a complementiser. The type *the-cl* will not be a subtype of this new type and hence will be able to contain a complementiser (see Borsley 2011: 13–15 for discussion). All this suggests the type hierarchy in Figure 13.8. This is complex, but then the facts are

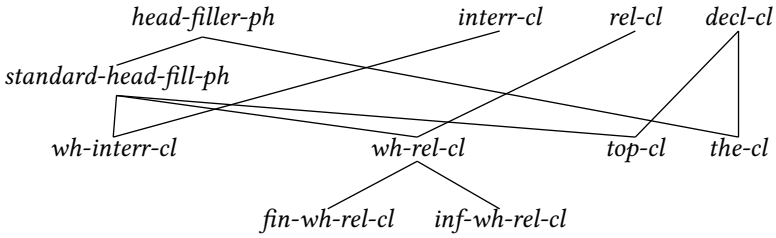


Figure 13.8: Hierarchy of extraction clause types (final)

complex, as we have seen. Crucially, such a hierarchy allows a straightforward account of both the similarities and the differences among these constructions.

We turn now to cases where there is no filler. We start with the so-called *tough* construction, exemplified by (28), repeated here as (42).

(42) The professor is hard [to talk to _].

Here, there is a gap following the preposition *to*, and the initial NP *the professor* is understood as the object of *to*. But this NP is not a filler, but a subject. Like any subject, it is preceded by an auxiliary in an interrogative:

(43) Is the professor hard [to talk to _]?

Moreover, it is clear that it cannot share a local feature structure with the gap, since it is in a position associated with nominative case, whereas the gap is in a position associated with accusative case. This suggests that adjectives like *hard* may take an infinitival complement with a SLASH value containing a nominal local feature structure which is coindexed with its subject. The coindexing will ensure that the subject has the right interpretation without getting into difficulties over case. It seems, then, that we need something like the lexical description in (44) in order to account for *hard* in examples like (42) and (43):

(44) Lexical representation of *tough* adjectives (preliminary):

$$\left[\textsc{synsem}\left[\textsc{local|cat}\left[\begin{array}{ll}\textsc{head} & \textit{adj}\\ \textsc{subj} & \langle \textsc{np}\left[\textsc{index}\ \boxed{\text{i}}\right]\rangle\\ \textsc{comps} & \left\langle \textsc{vp}\left[\begin{array}{ll}\textsc{vform} & \textit{inf}\\ \textsc{slash} & \{\textsc{np}\left[\textsc{index}\ \boxed{\text{i}}\right]\}\end{array}\right]\right\rangle\end{array}\right]\right]\right]$$

But there is more to be said here. *Hard* and its infinitival complement are the top of a dependency. It is essential that the AP *hard to talk to* should not have the same SLASH value as the infinitival complement *to talk to*. How this should be prevented depends on what approach to the distribution of SLASH values is assumed. However, if this involves a default SLASH Amalgamation Principle of the kind discussed in Section 4, it is a fairly simple matter. A default SLASH Amalgamation Principle ensures that the SLASH value of a word is normally the same as the SLASH value of its arguments. We can override the principle in the present case by giving adjectives like *hard* lexical descriptions of the following form:

(45) Lexical representation of *tough* adjectives (final):

$$\left[\begin{array}{ll}\textsc{synsem} & \left[\begin{array}{ll}\textsc{local|cat} & \left[\begin{array}{ll}\textsc{head} & \textit{adj}\\ \textsc{subj} & \langle \textsc{np}\left[\textsc{index}\ \boxed{\text{i}}\right]\rangle\\ \textsc{comps} & \left\langle \textsc{vp}\left[\begin{array}{ll}\textsc{vform} & \textit{inf}\\ \textsc{slash} & \{\textsc{np}\left[\textsc{index}\ \boxed{\text{i}}\right]\}\cup \boxed{1}\end{array}\right]\right\rangle\end{array}\right]\\ \textsc{nonlocal} & \left[\textsc{slash}\ \boxed{1}\right]\end{array}\right]\end{array}\right]$$

This ensures that the SLASH value of such adjectives is the SLASH value of the infinitival complement minus the NP that is coindexed with its subject. Where this NP is the only item in the complement's SLASH value, the adjective will be [SLASH { }], and so will the AP that it heads. However, it is possible to have an additional item in the SLASH value, as in the following example, adapted from Pollard & Sag (1994: 169):

(46) Which violin is this sonata [easy to play _ on _]?

Here, *which violin* is understood as the object of *on* and *this sonata* as the object of *play*. The infinitival complement *to play on* will have two items in its SLASH set, one associated with *which violin* and one associated with *this sonata*. The constraint in (45) will ensure that only the former appears in the SLASH set of *easy*, and hence only this appears in the SLASH set of *easy to play on*.

The term "lexical binding of SLASH" is often applied to situations like this in which a lexical item makes some structure the top of a dependency. This is a

plausible approach to adjectives like *hard* and also to adjectives modified by *too* or *enough*, as in the following:

(47) a. Lee is too important for you to talk to.
b. Lee is important enough for you to talk to.

Lexical binding is also a plausible approach to relative clauses which have not a filler, but a complementiser. This may include English *that* relatives such as that in (48) (although some HPSG work, e.g. Sag 1997: Section 5.4, has analysed *that* as a relative pronoun and hence a filler):

(48) the man [that you talked to _]

If relative *that* is a complementiser, and complementisers, are heads, as in much HPSG work, it can be given a lexical description like the one in (49):

(49) Lexical representation of relative complementiser *that*:

$$\left[\begin{array}{l}\textsc{synsem}\left[\begin{array}{ll}\textsc{nonlocal} & [\textsc{slash}\ \boxed{1}] \\ \textsc{local|cat} & \left[\begin{array}{ll}\textsc{head} & \left[\begin{array}{l}\textit{complementiser} \\ \textsc{mod}\ \mathrm{NP}[\textsc{index}\ \boxed{\mathrm{i}}]\end{array}\right] \\ \textsc{subj} & \langle\rangle \\ \textsc{comps} & \left\langle \mathrm{S}\left[\begin{array}{l}\textsc{vform}\ \textit{fin} \\ \textsc{slash}\ \{\mathrm{NP}[\textsc{index}\ \boxed{\mathrm{i}}]\}\cup\boxed{1}\end{array}\right]\right\rangle\end{array}\right]\end{array}\right]\end{array}\right]$$

This says that *that* takes a finite clause as its complement and modifies an NP, that the SLASH value of the clause includes an NP which is coindexed with the antecedent noun selected via MOD, and that any additional members of the complement's SLASH set form the SLASH set of *that*. Normally there will be no other members and *that* will be [SLASH {}].[14]

Further issues arise with zero relatives, which contain neither a filler nor a complementiser, such as the following English example:

(50) the man [you talked to _]

For Sag (1997: Section 6), these are one type of non-*wh*-relative and are required to have a MOD value coindexed with an NP in the SLASH value of the head daughter. But an issue arises about semantics. Assuming the main verb in a zero relative has the same semantic interpretation as elsewhere, a zero relative will have

[14] This is essentially the approach that is taken to relatives in Modern Standard Arabic in Alqurashi & Borsley (2012).

clausal semantics and not the modifier semantics that one might think is necessary for a nominal modifier. Sag's solution is to propose a special subtype of *head-adjunct-phrase* called *head-relative-phrase*, which allows a relative clause with clausal semantics to combine with a nominal and be interpreted in the right way. One might well wonder how satisfactory this approach is.

Sag (2010: Section 5.4) shows that it is a simple matter to assign modifier semantics to a relative clause where the basic clause is the daughter of some other element, as it is when there is a filler or a complementiser. The basic clause can have clausal semantics, and the mother can have modifier semantics. This suggests that zero relatives, too, might be analysed as daughters of another element with modifier semantics. One might do this, as Sag (2010: 531) notes, with a special unary branching phrase type (Müller 1999b: Section 10.3.2). Alternatively, one might postulate a phonologically null counterpart of relative *that*.[15]

There are various other issues about the top of the dependency. Consider, for example, cleft sentences such as (51).

(51) It was on the table that he placed the book _.

Clefts consist of *it*, a form of *be*, a focused constituent, and a clause with a gap. In (51) the focused constituent is a PP and so is the gap. It looks, then, as if the focused constituent shares its main properties with the gap in the way that a filler would. However, there are also clefts where it is clear that the focused constituent does not share an index with the gap. Consider e.g. the following:

(52) It's me that _ likes beer.

Here the focused constituent is first person singular, but the gap is third person singular, as shown by the form of the following verb. Given the standard assumption that person, number and gender features are a property of indices, it follows that they cannot have the same index. There are important challenges here.

Agreement in German may shed some more light on this:

(53) a. Da habe ich, der / die sonst immer
there have.1SG I who.SG.M who.SG.F otherwise always
rechtzeitig kommt, doch tatsächlich verschlafen.
on.time come.3SG indeed verily overslept
'I, who is otherwise always on time, have indeed overslept.'

[15] This is the approach that is taken to zero relatives in Modern Standard Arabic in Alqurashi & Borsley (2012: Section 4).

b. Da habe ich, der ich sonst immer rechtzeitig
there have.1SG I who.SG.M I otherwise always on.time
komme, doch tatsächlich verschlafen.
come.1SG indeed verily overslept
'I, who is otherwise always on time, have indeed overslept.'

In (53a), we find a reduced agreement pattern in number and gender between the relative pronoun and the antecedent noun, to the exclusion of person. Within the relative clause, however, we find full person/number subject agreement on the verb. In (53b), however, the relative pronoun is post-modified by the pronoun *ich* 'I', triggering full agreement with both the antecedent noun and the embedded verb. French, by contrast, observes full agreement of all three INDEX features:

(54) C'est moi qui suis venu(e).
it's me who am come.M/F
'It's me who came.'

Thus, relative pronouns and complementisers seem to differ cross-linguistically as to the features which show agreement with the antecedent.

Also quite challenging are free relatives. They look rather like head-filler phrases. The initial constituent of a free relative behaves like a filler, reflecting the properties of the gap.

(55) a. whichever student you think knows/*know the answer
b. whichever students you think know/*knows the answer

But the initial constituent also behaves like a head, determining the distribution of the free relative.

(56) a. Kim will buy what(ever) Lee buys.
b. * Kim will buy where(ever) Lee goes.

(57) a. Kim will go where(ever) Lee goes.
b. * Kim will go what(ever) Lee buys.

In case languages like German, the matching effect generally includes case specifications (Müller 1999a).

Most work on free relatives has assumed that the initial constituent is a filler and not a head (Groos & van Riemsdijk 1981; Grosu 1989) or a head and not a filler (Bresnan & Grimshaw 1978). But the obvious suggestion is that it is both a filler

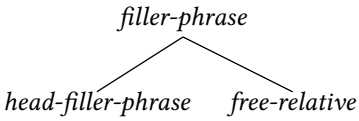


Figure 13.9: Hierarchy of filler phrases

and a head, a position espoused in Huddleston & Pullum (2002: Chapter 12.6). This idea can be implemented within HPSG by analysing free relatives and head-filler phrases as subtypes of *filler-phrase*, as shown in Figure 13.9.
filler-phrase will be subject to a constraint like that proposed earlier for head-filler phrases except that it will say nothing about the head-daughter. *head-filler-phrase* will be subject to a constraint identifying the second daughter as the head, while *free-relative* will be subject to a constraint identifying the first daughter as the head (among other things).[16]

Naturally, there may be complications here. German, for example, has some free relatives in which the case of the *wh*-element differs from that which the position of the free relative leads one to expect. This looks like a problem for the idea that the initial constituent is a head, but it may not be if heads and the associated phrases only share syntactic properties by default, as in much HPSG work.[17]

6 Resumptive pronouns

Ever since Vaillette (2001), resumption has been treated as an unbounded dependency within HPSG, on a par with SLASH dependencies, rather than as a case of anaphoric binding. The main motivation for treating resumption similar to extraction lies with the fact that in a variety of languages dependencies involving a pronominal at the bottom of the dependency behave similarly to UDCs involving a gap at the extraction site.

Vaillette (2001) investigates resumption in Hebrew and shows on the basis of across-the-board (ATB) extraction, parasitic gaps, and crossover that resumptive dependencies are indistinguishable from gap dependencies except for their

[16] The constraint on free relatives will also need to ensure that the first daughter takes the appropriate form and that the second daughter is finite.

[17] Müller (1999a) pursues a rather different approach to free relatives: in order to reconcile mismatches between the case requirement that is internal to the relative clause and the one that is selected for the free relative as a whole, he suggests a unary schema that mediates between the different case requirements.

reduced sensitivity to extraction islands. In order to reconcile the UDC-like properties of resumption with the difference in island sensitivity, he introduces a dedicated non-local feature RESUMP. While using separate features for resumptive pronouns and gaps easily makes them distinguishable for the purposes of island constraints, it certainly has the drawback that formulation of the ATB constraint becomes quite cumbersome. The following example illustrates mixing of gaps and resumptives in ATB extraction in Hebrew:

(58) kol profesor$_i$ še dani roce lehazmin $\__i$ aval lo maarix *ʔoto*$_i$
every professor that Dani wants to.invite but not esteems him
maspik[18]
enough
'every professor that Dani wants to invite but doesn't respect enough'

Subsequent work on Persian (Taghvaipour 2005), Welsh (Borsley 2013) and Hausa (Crysmann 2012) essentially follows Vaillette, using ATB extraction as the main indicator for treating resumptive dependencies in a similar way to gap dependencies. What all these works have in common is that they rely on a single non-local feature, namely SLASH for both types of dependencies. In particular, these authors argue that mixing of strategies, as illustrated in (58) for Hebrew and in (62) for Hausa, suggests that both extraction strategies should be captured using a single non-local feature, i.e. SLASH. Despite this commonality, however, approaches differ as to how gap and resumptive dependencies are distinguished, if at all.

In his work on Welsh unbounded dependencies, Borsley (2010) observes that the choice between gap and resumptive pronoun is essentially determined by properties of the immediate environment of the bottom of the dependency: i.e. while possessors of nouns and complements of prepositions require a resumptive element when extracted, subjects, as well as direct objects of finite and non-finite verbs, only extract by means of filler-gap dependencies. Thus, the distribution of gaps vs. resumptives is practically disjoint.

Furthermore, he reports evidence that resumptives and gaps also pattern alike with respect to island constraints: while extraction out of the clausal complement in a complex NP is fine, with either a gap or a resumptive at the bottom, extraction out of a relative clause leads to ungrammaticality, again, independent of whether we find a gap or a resumptive.

[18] Sells (1984: 78)

(59) a. Dyma 'r dyn y credodd Dafydd [y si [y
here.is the man PRT believe.PAST.3S Dafydd the rumour PRT
gwelodd Mair (o)]].[19]
see.PAST.3S Mair he
'Here's the man who David believed the rumour that Mair saw.'

b. Dyma 'r dyn y credodd Dafydd [y si [y
here.is the man PRT believe.PAST.3SG Dafydd the rumour PRT
cest ti 'r llythyr 'na ganddo (fo)]].[20]
get.PAST.2SG you the letter DEM with.3S.M him
'Here's the man who David believed the rumour that you got that letter from.'

c. * Dyma 'r ffenest darais i ['r bachgen [dorrodd (hi)
that.is the window hit.PAST.1S I the boy break.PAST.3S she
ddoe]].[21]
yesterday

Moreover, with respect to the across-the-board (ATB) constraint, resumptives and gaps show the same behaviour as observed for Hebrew, easily permitting mixing. In addition, Welsh also has certain extraction path effects which are the same in gap and resumptive dependencies (see Borsley 2010 for details).

Given that the distribution of gaps and resumptives is regulated by the locally selecting head at the bottom of the dependency and that there is no need to distinguish the two types of dependencies along the extraction path (middle), Borsley (2010: 97) formulates what is probably the most simple and straightforward approach to resumption. In essence, he proposes "that we need structures in which a slashed preposition or noun has not a slashed argument but a pronominal argument coindexed with its slashed value". Consequently, he extends Slash Amalgamation to optionally include a SLASH element coindexed with an unslashed pronominal argument. This move licenses Welsh resumptives in a structure like the one in Figure 13.10 below.

Thus, the only difference between gaps and resumptives on his account is that the former give rise to a reentrancy of an element in SLASH with a LOCAL value on ARG-ST, whereas the latter merely involve reentrancy of INDEX values (between an NP *local* on SLASH and an NP *synsem* on ARG-ST).

[19] Borsley (2010: 91)
[20] Borsley (2010: 92)
[21] Borsley (2010: 92)

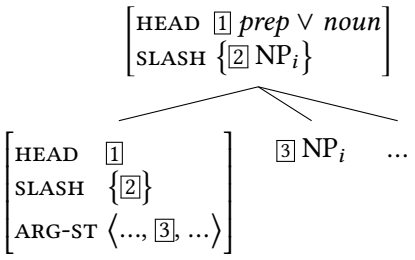


Figure 13.10: Representation of Welsh resumptives

The respective distribution of gaps and resumptives are finally accounted for by means of constraints on the binding theoretical status of the element at the bottom of the the dependency, i.e. *ppro* for resumptives and *npro* for gaps. See Müller & Branco (2021), Chapter 20 of this volume on Binding Theory in HPSG.

Borsley's decision to locate the resumptive function on the selecting head, rather than on the pronominal, not only provides a good match for the Welsh data, but it also addresses McCloskey's generalisation (McCloskey 2002: 192) that resumptives are always the ordinary pronouns, since no lexical ambiguity between slashed and unslashed pronouns is involved.[22]

In contrast to Borsley, who developed his theory of resumption on the basis of a language where the distribution of gaps vs. resumptives is entirely regulated by the immediate local environment and no difference in island sensitivity could be observed, Crysmann (2012) developed an alternative account for Hausa, a language where the distributions of gaps and resumptives partially overlap at the bottom of the dependency and where resumptive dependencies observe different locality constraints when compared to filler-gap dependencies.

Hausa patterns with a number of resumptive languages, including Welsh, in that use of a resumptive element is obligatory for complements of a preposition or the possessor of a noun. With direct and indirect objects, however, both resumptives and gaps are possible, as Jaggar's (2001: 534) examples in (60) show:

(60) a. mutầnên dà sukà ƙi sayar wà _ dà àbinci sukà fìta
men REL 3.P.CPL refuse sell to with food 3.P.CPL left
'The men they refused to sell food to left.'

b. mutầnên dà sukà ƙi sayar *musù* dà àbinci sukà fìta
men REL 3.P.CPL refuse sell to.them with food 3.P.CPL left
'The men they refused to sell food to left.'

[22] Cf. e.g. Abeillé & Godard (2007: 54–55) for an ambiguity approach, treating reentrancy of LOCAL and SLASH as optional for French pronouns.

In (60), both a bare dative marker *wà* 'to' is possible (with a gap), and a dative pronoun *musù* 'to.them'.

Moreover, gap and resumptive dependencies do behave differently with respect to strong islands: while extraction out of a relative clause or *wh*-island is impossible for gap dependencies, relativisation out of these islands is perfectly fine with resumptives.

(61) Gà tābōbîn$_j$ dà Àli ya san mùtumìn$_i$ dà zâi$_i$ yī
here.is cigarettes REL Ali 3.S.M.CPL know man REL 3.S.M.FUT do
musù$_j$ / *wà _$_j$ kwālī[23]
to.them to box
'Here are the cigarettes that Ali knows the man that (he) will make a box for.'

Crysmann (2012) further emphasises that relativisation (which may escape strong islands) resembles anaphoric relations, whereas filler-gap dependencies, as observed with *wh*-fronting, give rise to a matching effect. He therefore correlates relative complementisers and resumptives with minimal INDEX sharing, whereas filler-head structures, as well as gaps will require sharing of entire LOCAL values: while filler-head structures impose this stricter constraint at the top of the dependency, gaps obviously do so at the bottom. In order to express constraints on locality, Crysmann (2012; 2016) proposes that SLASH elements (of type *local*) should be distinguished as to their weight: while the type *local* always minimally includes indexical information, its subtypes *full-local* and *weak-local* differ as to the amount of additional information that must or must not be present. For *full-local*, which is appropriate for *synsem*, this includes categorial and full semantic information, whereas exactly categorial information is excluded for *weak-local*.

The hierarchy of *local* types provides for the possibility that *local* types on SLASH may only be partially specified: while gaps and filler-head structure require full reentrancy of a (*full-local*) LOCAL value, resumptives may be non-committal with respect to the weight distinction, only imposing the minimal index-sharing constraint. This ensures that both resumptives and gaps can be found at the bottom of a strong UDC with e.g. a *wh*-filler. Conversely, islands can narrow down the nature of SLASH elements to only pass on a SLASH set of *weak-local*, such that resumptives, but not gaps, will be licensed at the bottom in the case of long relativisation.

[23] Tuller (1986: 84)

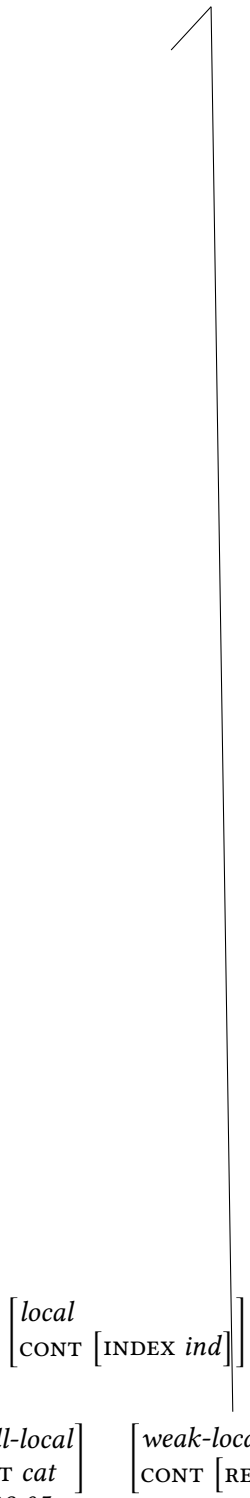


Figure 13.11: Hierarchy of *local* (Crysmann 2016: 202)

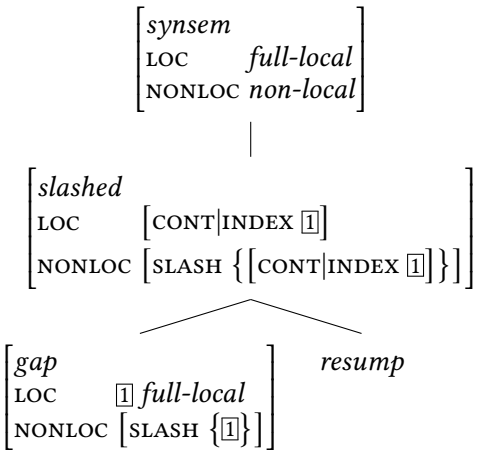


Figure 13.12: Hierarchy of *synsem* objects (Crysmann 2016: 202)

Underspecification of *local* at the bottom of a resumptive dependency permits mixing of gap and resumptive strategies in ATB extraction, as illustrated by the example below:

(62) [àbōkī-n-ā]$_i$ dà [[na zìyartà $\__i$] àmmā [bàn sàmē
friend-L-1.S.GEN REL 1.S.CPL visit but 1.S.NEG.CPL find
shì$_i$ à gidā ba]][24]
3.S.M.DO at home NEG
'my friend that I visited but did not find at home'

The obvious question is, of course, how these two approaches can be harmonised in order to yield a unified HPSG theory of resumption. It is clear that the theory advanced by Crysmann (2012) makes a more fine-grained distinction with regard to SLASH elements and should therefore be able to trivially account for languages where there is no difference in locality restrictions between resumptive and gap dependencies. In the case of Welsh, it will suffice to strengthen the constraints of strong islands, such as relative clauses, to block passing of any *local* on SLASH, rather than merely restricting it to *weak-local*. The other area where the theories need to be brought closer together concerns the issue of McCloskey's generalisation, which is straighforwardly derived by a syntactic theory of resumption, such as Borsley's. Some work in this direction has already been done: Crysmann (2016) suggests replacing his original ambiguity approach with

[24] Newman (2000: 539)

an underspecification approach, essentially following Borsley (2010) in locating the disambiguation between pronoun and resumptive function on the selecting head. While there are still differences of implementation, general agreement has been obtained that it should indeed be the head that decides on the pronominal's function, whether this is done via disjunctively amalgamating the index of a pronominal argument (Borsley 2010; Alotaibi & Borsley 2013), or else via a more elaborate system of *synsem* types that integrates more nicely with standard SLASH amalgamation (Crysmann 2016).

Similar consensus has been reached with respect to the need to have more fine-grained control on locality, again irrespective of implementation details: while Alotaibi & Borsley (2013) exploited constraints on case marking in order to capture the difference in locality of resumptives and gaps in Modern Standard Arabic, the weight-based analysis by Crysmann (2017) provides a more principled account of the data, essentially obviating stipulative nominative case assignment that fails to correspond to any overtly observable case marking.

Some questions still remain: Taghvaipour (2005: Section 6.5) suggests that in Persian, the distribution of gaps vs. resumptives is partly determined by the constructional properties of the top of the dependency, showing different patterns for *wh*-extraction, free relatives and ordinary relatives, and suggests that constructional properties of the top need to be transmitted via SLASH. However, percolation of constructional information across the tree does not play nicely with basic assumptions of locality within HPSG. It remains to be seen how the case of Persian can be analysed within the scope of the theories outlined above.

Another case study that deserves integration into the current HPSG theory of resumption concerns so-called hybrid chains in Irish (Assmann et al. 2010): in this language, the most deeply embedded complementisers register the difference between gaps and resumptives at the bottom, yet complementisers further up can switch between "resumptive marking" and "gap marking". While the authors use a single SLASH feature for both types of dependency, the objects in this set remain incompatible, thereby necessitating a great deal of disjunction. In order to bring this analysis fully in line with current HPSG, underspecification techniques may be fruitfully explored.

7 More on *wh*-interrogatives

7.1 Pied piping

So far, we have concentrated on unbounded dependencies as witnessed by extraction, captured in HPSG by SLASH feature inheritance. Another type of un-

bounded dependency involves pied-piping, as illustrated in (63b–d) and (64b–d), taken from Ginzburg & Sag (2000: 184).

(63) a. I wonder [[*what*] inspired them].
b. I wonder [[*whose* cousin] ate the pastry].
c. I wonder [[*whose* cousin's dog] ate the pastry].
d. I wonder [[to *whom*] they dedicated the building]

(64) a. the book [[*which*] inspired them]
b. the person [[*whose* cousin] ate the pastry]
c. the person [[*whose* cousin's dog] ate the pastry]
d. the person [[to *whom*] they dedicated the building]

In (63) the *wh*-word, a pronoun or determiner, that marks the (embedded) *wh*-interrogative clause may be arbitrarily deeply embedded inside the filler.

With relative clauses too, as witnessed by (64), the relative pronoun may be embedded inside the filler, and, again, arbitrarily deep. Furthermore, regardless of the level of embedding, the relative pronoun is coreferent with the antecedent noun, such that a mechanism is called for that can establish this token identity in a non-local fashion. This is most evident in languages where relative pronouns undergo agreement with the antecedent noun, as e.g. in German:

(65) a. das Buch [*das* mich inspirierte]
DEF.N.S book(N).S REL.N.S me inspired
'the book that inspired me'
b. die Person [*die* mich inspirierte]
DEF.F.S person(F).S REL.F.S me inspired
'the person that inspired me'
c. das Buch [[*dessen* / **deren* Rezension] mir gefiel]
DEF.N.S book(N).S REL.N.S.POSS REL.F.S.POSS review(F).S me pleased
'the book the review of which I liked'
d. die Autorin [[*deren* / **dessen* Roman] mir gefiel]
DEF.F.S author(F).S REL.F.S.POSS REL.M.S.POSS novel(M) me pleased
'the (female) author whose novel I liked'

In order to capture the fact that the filler of a *wh*-clause must contain a *wh*-word, or that the relative pronoun contained within the filler of a relative clause must structure-share its INDEX with the antecedent noun, HPSG builds on previous work in GPSG (Gazdar et al. 1985: Chapter 5.2), postulating the non-local features QUE/WH and REL. Pollard & Sag (1994: 164) have proposed a single Nonlocal Feature Principle that generalises from SLASH feature percolation to inheritance of QUE and REL, defining the value of each non-local feature of the mother as the set union of the nonlocal features of the daughters. See, however, Sag (1997: Section 4.2) and Ginzburg & Sag (2000: Chapter 7) for head-driven formulation of nonlocal feature percolation. add pages

One observation regarding pied piping in languages such as English or German pertains to the fact that *wh*-words tend to surface in the left periphery of the filler. Ginzburg & Sag (2000: 194, fn. 26) suggest that amalgamation of QUE/WH is restricted to the least oblique element on ARG-ST. This enables them to rule out (66b) while still being able to account for standard pied-piping with prepositional phrases (63d).

(66) a. I wonder [[whose picture] was on display].
b. * I wonder [[my picture of whom] was on display].

Indeed, from a cross-linguistic perspective, pied-piping of prepositions appears to be the far less marked option when compared to preposition stranding, which appears to be a peculiarity of English. This is supported not only by the ban on preposition stranding in German, French, and many other languages, but it is also corroborated by the distribution of resumptives (see Section 6).

To summarise, pied piping in HPSG is understood as a phenomenon that involves a second unbounded dependency: in addition to a SLASH dependency between the pied-piped filler and the extraction site, just like the ones we have discussed throughout this chapter, QUE or REL establish dependencies within the filler itself.

7.2 Multiple *wh*-questions

While in languages such as English, only one *wh*-phrase may be fronted per interrogative clause (and typically one phrase is indeed fronted), it is nevertheless possible to ask multiple questions, with additional *wh*-phrases remaining in situ, as witnessed by *what* in (67).

(67) Who asked who saw what?

According to the theory of Ginzburg & Sag (2000), only fillers in interrogative clauses are *wh*-marked, and *wh*-marking serves to ensure that a *wh*-quantifier contained in the filler is interpreted as a parameter of the local interrogative clause. In situ *wh*-phrases, by contrast, are still quantifiers, so they may scope higher than their syntactic position suggests. Ginzburg & Sag (2000: Section 5.3) follow Pollard & Sag (1994: Section 8.2) in adopting a Cooper storage, which enables them to have the in situ *wh*-quantifier in (67) retrieved either as a parameter of the embedded interrogative clause, or as a parameter of the matrix question. The WH feature thus not only ensures that a *wh*-interrogative is marked as such by a filler containing a *wh*-word, but it also fixes the semantic scope of ex-situ *wh*-phrases to their syntactic scope.[25] In situ *wh*-quantifiers, by contrast, are permitted to take arbitrarily wide scope.

In Slavic languages such as Russian or Serbo-Croatian (Penn 1999), there does not appear to be a constraint on the number of simultaneously fronted *wh*-phrases, as illustrated by the examples in (68) taken from Penn (1999: 163).

(68) a. Ko koga si mislio da je voleo?
who whom CL.2s thought Comp CL.3s loved
'Who did you think loved whom?'

b. * Ko si koga mislio da je voleo?
who CL.2s whom thought Comp CL.3s loved

Given that HPSG's nonlocal features, and in particular SLASH and QUE/WH, are set valued, multiple *wh*-fronting is a rather expected property. In fact, the grammar of English interrogatives as proposed by Ginzburg & Sag (2000) specifically stipulates that there be only a singleton WH set, and that head-filler structures cannot be recursive.

The point where Slavic multiple fronting poses a challenge is its interaction with second position clitics: it seems, as witnessed by the contrast in (68), that multiple fronted *wh*-phrases are treated as a constituent, as far as linearisation is concerned. Penn (1999) proposes a topological analysis based on extended word order domains (Reape 1990; Kathol 2000) in order to reconcile multiple fronted constituents with the second position property: in essence, multiple fillers are assigned to the same initial topological field and linearisation of clitics proceeds relative to that same initial field.

[25] Kathol (1998) uses the QUE feature in his analysis of partial *wh*-fronting in German.

7.3 *Wh* in situ

In the previous subsections, as in most of this chapter, we have capitalised on ex situ *wh*-constructions. However, even in languages like English, and even more in French, we do find constructions with clear interrogative semantics where nonetheless the *wh*-phrase stays in situ. Moreover, in languages such as Japanese or Coptic Egyptian, in situ realisation is the norm, rather than the exception. In this subsection we shall therefore discuss how HPSG's theory of unbounded dependencies has been put to use to account for this phenomenon.

In languages such as English, where standard *wh*-interrogatives are signalled by a *wh*-phrase ex situ (i.e. by a *wh*-filler), Ginzburg & Sag (2000: Chapter 7) identify two types of in situ *wh*-questions in English: so called reprise (or "echo") questions, which typically mimic the syntax and semantics of the speech act they are modelled on (e.g. an assertion, an order etc.), and direct in situ interrogatives, the latter being more strongly restricted pragmatically.

However, *wh* in situ may even be an unmarked, or even the default option for the expression of *wh*-interrogatives: Johnson & Lappin (1997: Section 6.2), studying Iraqi Arabic, made the important observation that *wh*-fronting is optional in this language, posing a challenge for transformational models at the time. In Iraqi Arabic, a *wh*-interrogative may be realised ex situ, as in (69a) or in situ, as in (69b).

(69) a. Mona shaafat meno?[26]
Mona saw whom
'Who did Mona see?'

b. Meno shaafat Mona?[27]
who saw Mona
'Who did Mona see?'

They propose a straightforward analysis within HPSG, suggesting to drop what can be regarded as a parochial constraint of English and related languages, and allow QUE feature percolation from the right clausal daughter.

What is more, they note that *wh* in situ and ex situ strategies do observe different locality restrictions, thereby lending further support to a difference in the type of nonlocal feature involved. While feature percolation for in situ *wh*-constructions cannot escape finite clauses (cf. the contrast in (70a,b), ex situ *wh*-

[26] Johnson & Lappin (1997: 318)
[27] Johnson & Lappin (1997: 320)

interrogatives, involving a SLASH dependency, are obviously not subject to this restriction, as witnessed by (70c).[28]

(70) a. Mona raadat tijbir Su'ad tisa'ad meno?
Mona wanted to.force Su'ad to.help who
'Who did Mona want to force Su'ad to help?'

b. * Mona tsawwarat Ali ishtara sheno?
Mona thought Ali bought what

c. Sheno tsawwarit Mona Ali ishtara?
what thought Mona Ali bought
'What did Mona think Ali bought?'

Yet, even this constraint, while valid for Iraqi Arabic, must be considered language-specific: Crysmann & Reintges (2014) study Coptic Egyptian, where *wh* in situ is the norm. They observe that the scope of an in situ *wh*-phrase is determined by the position of a relative complementiser and note that it can easily escape finite clauses, as shown in (71).

(71) ere əm=mɛɛʃe tʃo: əmmɔ=s [tʃe ang nim]?[29]
REL DEF.PL=crowd say PREP=3F.SG that I who
'Who do the crowds say that I am?' (Luke 9,18)

Their analysis builds on Johnson & Lappin (1997), yet suggests that QUE percolation in this language may be as unrestricted as SLASH percolation.

8 Extraposition

Another non-local dependency is extraposition, the displacement of a constituent towards the right. Extraposition is most often observed with heavy constituents, such as relative clauses or complement clauses, but it has also been attested with lighter constituents such as prepositional phrases and non-finite VPs. In German, where extraposition is particularly common in general (Uszkoreit et al. 1998), extraposed material can be extremely light, including adverbs and NPs (see Müller 1999b: Section 13.1 and Müller 2002: ix–xi for examples).

Apart from the obvious difference in the linear direction of the process, extraposition also contrasts with e.g. filler-gap dependencies with respect to the

[28] The examples in (70) are from Johnson & Lappin (1997: 318)
[29] Crysmann & Reintges (2014: 72)

domain of locality: e.g. island constraints that have been claimed to hold for extraction to the left, such as the Complex NP Constraint (Ross 1967: Section 4.1), clearly do not hold with complement clause nor relative clause extraposition, as the following examples by (Keller 1994: 4, 11) and Müller (G. 1996: 219) show:

(72) a. Planck hat [die Entdeckung $_i$] gemacht, [daß Licht
Planck has the discovery made that light
Teilchennatur hat.]$_i$[30]
particle nature has
'Planck made the discovery that light has particle properties.'

b. * [Daß Licht Teilchennatur hat]$_i$ hat Planck [die Entdeckung $_i$]
that light particle nature has has Planck the discovery
gemacht.[31]
made

(73) a. Ich habe [eine Frau $_i$] getroffen, [die das Stück gelesen
I have a woman met who the play read
hat]$_i$.[32]
has
'I met the woman who has read the play.'

b. * [die das Stück gelesen hat]$_i$, habe ich [eine Frau $_i$]
who the play read has have I a woman
getroffen.[33]
met

Conversely, while extraction to the left can easily cross finite clause boundaries (74), extraposition is said to be clause-bound, i.e. subject to the Right Roof Constraint (Ross 1967: Section 5.1.2).

(74) Was$_i$ hat Hans gesagt, [daß wir $_i$ kaufen sollten]?
what has Hans said that we buy should
'What did Hans say that we should buy?'

[30] Keller (1994: 4)
[31] Keller (1994: 11)
[32] Müller (G. 1996: 219)
[33] Müller (G. 1996: 219)

(75) a. [Daß Peter sich auf das Fest $\__i$ gefreut hat, [das Maria
that Peter SELF on the party looked.forward has which Maria
veranstaltet hat,]$_i$] hat niemanden gewundert.[34]
organised has has noone surprised
'That Peter was looking forward to the party that Maria had organised, did not surprise anyone.'

b. * [Daß Peter sich auf das Fest $\__i$ gefreut hat], hat
that Peter SELF on the party looked.forward has has
niemanden gewundert, [das Maria veranstaltet hat]$_i$[35]
noone surprised which Maria organised has

8.1 Extraposition via non-local features

Given the non-local nature of extraposition, a natural approach to this construction is by means of non-local features. Because extraposition differs from extraction in both direction and locality, Keller (1995) and Müller (1999b: Section 13.2) have proposed a distinct non-local feature EXTRA to capture this rightward-oriented dependency. Similar to lexical SLASH introduction, Keller (1995: 303) assumes two lexical extraposition rules, one for complement extraposition, the other for adjunct extraposition.

(76) Complement Extraposition Lexical Rule

$$\left[\begin{array}{l}\textsc{comps}\ \boxed{1} \oplus \left\langle \left[\textsc{loc}\ \boxed{4}\left[\textsc{cat}\left[\begin{array}{l}\textsc{head}\ \ \mathit{verb} \vee \mathit{prep}\\ \textsc{comps}\ \langle\rangle\end{array}\right]\right]\right]\right\rangle \oplus \boxed{2} \\ \textsc{nonloc}|\textsc{extra}\ \boxed{3}\end{array}\right] \mapsto \left[\begin{array}{l}\textsc{comps}\ \boxed{1} \oplus \boxed{2} \\ \textsc{nonloc}|\textsc{extra}\ \boxed{3} \cup \{\boxed{4}\}\end{array}\right]$$

(77) Adjunct Extraposition Lexical Rule

$$\left[\begin{array}{l}\textsc{loc}\ \boxed{2}\ \left[\textsc{cat}|\textsc{head}\ \mathit{noun} \vee \mathit{verb}\right] \\ \textsc{nonloc}|\textsc{extra}\ \boxed{1}\end{array}\right] \mapsto \left[\begin{array}{l}\textsc{loc}|\textsc{cont}\ \boxed{3} \\ \\ \textsc{nonloc}|\textsc{extra}\ \boxed{1} \cup \left\{\left[\textsc{cat}\left[\begin{array}{l}\textsc{head}\ \left[\begin{array}{l}\mathit{prep} \vee \mathit{rel}\\ \textsc{mod}|\textsc{loc}\ \boxed{2}\end{array}\right] \\ \textsc{cont}\ \boxed{3}\end{array}\right]\right]\right\}\end{array}\right]$$

[34] (Wiltschko 1994: 11; Keller 1994: 10)
[35] (Wiltschko 1994: 11; Keller 1994: 10)

The complement extraposition rule is straightforward: it removes a valency from the COMPS list and inserts its LOCAL value into the EXTRA set.

As for adjunct extraposition, the lexical rule equally inserts an element into the EXTRA set, yet constrains it to be a modifier that selects for the local value of the lexical head (via MOD).

Since EXTRA is a nonlocal feature, percolation up the tree, i.e. the middle of the dependency, is handled by the Nonlocal Feature Principle (Pollard & Sag 1994: 164).

At the top, the Head-Extra Schema will bind all extraposition dependencies, which are realised as extraposed daughters.[36]

(78) Head-Extra Schema

$$\begin{bmatrix} \textsc{synsem} & \left[\textsc{nonloc}|\textsc{extra}\ \boxed{X}\right] \\ \textsc{dtrs} & \begin{bmatrix} \textsc{head-dtr} & \left[\textsc{synsem}|\textsc{nonloc}|\textsc{extra}\ \left\{\boxed{1}\ldots\boxed{n}\right\}\cup\boxed{X}\right] \\ \textsc{extra-dtrs} & \left\langle\left[\textsc{synsem}|\textsc{loc}\ \boxed{1}\right]\ \ldots\ \left[\textsc{synsem}|\textsc{loc}\ \boxed{n}\right]\right\rangle \end{bmatrix} \end{bmatrix}$$

Order of extraposed daughters amongst each other and with respect to the head is regulated by linear precedence statements (see Müller (2021: Section 2), Chapter 10 of this volume on linear precedence constraints).

Keller (1995) discusses how salient differences between extraction and extraposition can be captured quite straightforwardly: to account, e.g., for the clause-boundedness, it will be sufficient to restrict the EXTRA set of clausal signs to be the empty set. Similarly, since extraposition (EXTRA) and extraction (SLASH) are implemented by different features, locality constraints imposed on SLASH will not hold for extraposition.

8.2 Extraposition as word order variation

An entirely different approach to extraposition has emerged as part of the HPSG work on linearisation using complex order domains. Following Reape (1994), who suggested that linearisation in scrambling languages such as German should operate on larger domains than local trees of depth one, Kathol (1995; 2000) and Kathol & Pollard (1995) have explored its suitability as a model for extraposition in German.

[36] We give a slightly simplified version of the schema, ignoring the PERIPHERY feature that was introduced to control for spurious ambiguity that could arise from string-vacuous extraposition. See Keller (1995: 304–305) for details. loc(x) denotes a function which takes as x a list of elements of type *sign* and returns a set containing the LOCAL values of the elements of x.

The connection between scrambling and extraposition does have some initial plausibility for freer word order languages such as German, since the maximal domain of extraposition, i.e. the clause, coincides with that of scrambling. However, even for German, extraposition from NPs already necessitates special mechanisms, such as partial compaction, that are specific to extraposition and have no analoguous motivation for scrambling, where only union and total compaction are used.[37] Once we approach languages such as English that display a much stricter order, yet still allow extraposition, a scrambling approach to extraposition becomes highly questionable.

8.3 Generalised modification

Another line of proposals capitalises on the differences between complement and adjunct extraposition: as argued by Kiss (2005: 284), the non-locality observed with relative clause extraposition in German, as in (79a) does not translate to complement extraposition in equal measure, cf. (79b).

(79) a. Man hat [die Frau [des Boten $_i$]] beschimpft, [der den
one has the wife of.the messenger scolded who the
Befehl überbrachte]$_i$.[38]
order delivered
'People have scolded the wife of the messenger who delivered the order.'

b. * Man hat [den Überbringer [der Mitteilung $_i$]] beschimpft, [daß
one has the messenger of.the message insulted that
die Erde rund ist]$_i$.[39]
the earth round is
'The messenger was insulted who delivered the message that the world is a sphere.'

While acceptable examples of complement extraposition from complex NPs can be found (see example (82) below, extraposition from adjuncts yields much sharper contrasts, which have not yet been contested:

[37] In linearisation-based HPSG, domain union creates an extended order domain, whereas compaction closes the domain by collapsing the list of domain objects into a single one. See Müller (2021: Section 6), Chapter 10 of this volume for explanation of linearization-based HPSG in general and Müller (2021: Section 6.3), Chapter 10 of this volume for a detailed discussion of the specific linearization-based approach to extraposition mentioned above.

[38] Haider (1996: 259)

[39] Kiss (2005: 282)

(80) a. * Hier habe ich [bei [den Beobachtungen $_i$]] faul auf der
here have I during the observations lazily on the
Wiese gelegen, [daß die Erde rund ist]$_i$.[40]
lawn laid that the earth round is
'I was lying here lazily on the lawn during the observations that the world is a sphere.'

b. Hier habe ich [bei [vielen Versuchen$_i$]] faul auf der Wiese
here have I during many attempts lazily on the lawn
gelegen, bei denen$_i$ die Schwerkraft überwunden wurde.[41]
laid during which the gravity overcome was
'I was lying here lazily on the lawn, during many attempts at which gravity was overcome.'

Interestingly enough, complement extraposition (80a) appears to pattern with leftward extraction (81) in this respect, which underlines the extraction-like property of complement extraposition:

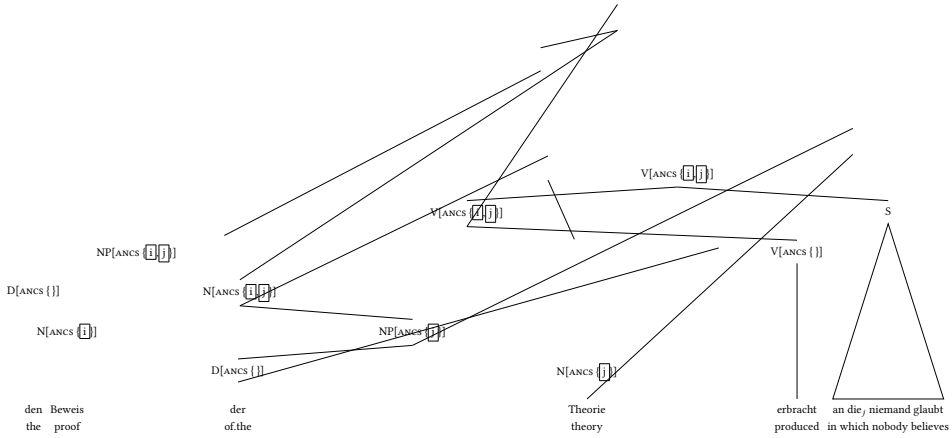
(81) * Das Verlies hat er, [als er $_i$ verließ], gelacht.[42]
the dungeons has he when he left laughed
'He laughed when he left the dungeons.'

Furthermore, Kiss observes that relative clause extraposition may give rise to split antecedents, and therefore concludes that this process should be better understood as an anaphoric one, rather than as extraction to the right.

Similar in spirit to Culicover & Rochemont (1990), Kiss (2005) suggests that relative clause extraposition can target any referential index introduced within the clause the relative attaches to. To that end, he proposes a set valued ANCHOR feature that indiscriminately percolates up the tree the index (and handle) of any nominal expression. In situ and extraposed relative clauses then semantically bind one of the INDEX/HANDLE pairs contained in the ANCHOR set of the head they syntactically adjoin to.[43,44]

The claim about the locality of complement extraposition has not been left unchallenged: Müller (1999b: 206; 2004a: 10) presents examples of complement clause extraposition that equally defy the Complex NP Constraint.

[40] Kiss (2005: 283)
[41] Kiss (2005: 285)
[42] Haider (1996: 261)
[43] See Koenig & Richter (2021: Section 6.1), Chapter 22 of this volume for an overview of Minimal Recursion Semantics, the meaning description language assumed by Kiss' approach.
[44] Crysmann (2005b) proposes to synthesise the approach by Kiss (2005) with that of Keller (1995), using a two-step percolation mechanism that effectively controls for spurious ambiguity.



(82) Ich habe [von [dem Versuch [eines Beweises [der Vermutung $\__i$]]]]
I have of the attempt of.a proof of.the hypothesis
gehört, [daß es Zahlen gibt, die die folgenden Bedingungen
heard that there numbers exist which the following conditions
erfüllen]$_i$.[45]
fulfil
'I have heard of the attempt at a proof of the hypothesis that there are numbers which fulfil the following conditions.'

Consequently, he suggests that complement extraposition and adjunct extraposition should both be handled by the same mechanism, i.e. a non-local EXTRA feature (Keller 1995; Müller 1999b).

Crysmann (2013a) challenges Müller's unified analysis on the grounds that it severely overgenerates. While he concedes that non-local complement extraposition is indeed possible, he argues that the two processes still need to be distinguished, because (i) only adjunct extraposition may target split antecedents and (ii) complements cannot extrapose out of adjuncts, whereas adjunct extraposition observes no such constraint. He further notes that non-local complement extraposition is subject to stronger bridging requirements than adjunct extraposition, both semantic and prosodic: as illustrated in (83), acceptability greatly improves with the semantic affinity between the complex NP from which extraposition proceeds and the verb that governs it.

[45] Müller (St. 2004b: 223)

(83) a. Er hat [ein Buch [über die Theorie $_i$]] gelesen, [daß Licht
he has a book about the theory read that light
Teilchennatur hat]$_i$.[46]
particle nature has
'He has read a book about the theory that light has particle properties.'

b. * Er hat [ein Buch [über die Theorie $_i$]] geklaut, [daß Licht
he has a book about the theory stolen that light
Teilchennatur hat]$_i$.[47]
particle nature has
'He has stolen a book about the theory that light has particle properties.'

(84) a. [Über Syntax]$_i$ hat Max sich [ein Buch $_i$] ausgeliehen.[48]
about syntax has Max SELF a book borrowed
'It's about syntax that Max has borrowed a book.'

b. * [Über Syntax]$_i$ hat Max [ein Buch $_i$] geklaut.[49]
about syntax has Max a book stolen
'It's about syntax that Max has stolen a book.'

While this effect for complement extraposition is similar to what has been observed for PP extraction out of NPs (De Kuthy 2002), cf. the examples in (84), it is of note that no such contrasts can be found for adjunct extraposition:

(85) a. Er hat [ein Buch [über die Theorie $_i$]] gelesen, [die
he has a book(N) about the theory(F) read which.F
derzeit kontrovers diskutiert wird]$_i$.[50]
currently controversially discussed is
'He has read a book about the theory which is under considerable debate at present.'

b. Er hat [ein Buch [über die Theorie $_i$]] geklaut, [die
he has a book(N) about the theory(F) stolen which.F

[46] Crysmann (2013b: 381)
[47] Crysmann (2013b: 381)
[48] De Kuthy (2001: 148)
[49] De Kuthy (2001: 148)
[50] Crysmann (2013b: 381)

derzeit kontrovers diskutiert wird]$_i$.
currently controversially discussed is
'He has stolen a book about the theory which is under considerable debate at present.'

Crysmann (2013a) unifies the anaphoric approach of Kiss (2005) for adjunct extraposition with the rightward-extraction approach of Keller (1995) and Müller 1999b, and suggests that both processes should be modelled by the same set-valued non-local feature (EXTRA), but that elements on that set should be distinguished as to whether they are mainly anaphoric elements (*weak-local*), or full-fledged *local* values (*full-local*), cf. Section 6. Under this perspective, extraposed adjuncts are expected to escape extraction islands (such as adjunct islands), as well as to modify split antecedents, simply because they involve a grammaticalised anaphoric process, not extraction. Conversely, complement extraposition involves an extraction-like dependency, making it more prone to island constraints, which may be bridged (complex NPs) or not (adjunct islands).

9 Filler-gap mismatches

As noted in the introduction, there are unbounded dependency constructions in which a filler apparently does not match the associated gap. In this section we will look briefly at two examples of such mismatches.

An interesting type of example is what Arnold & Borsley (2010) call auxiliary-stranding relative clauses (ASRCs). The following illustrate:

(86) a. Kim will sing, which Lee won't _.
b. Kim has sung, which Lee hasn't _.
c. Kim is singing, which Lee isn't _.
d. Kim is clever, which Lee isn't _.
e. Kim is in Spain, which Lee isn't _.
f. Kim wants to go home, which Lee doesn't want to _.

Which in these examples appears to be the ordinary nominal *which*, but the gap is a VP in (86a), (86b), (86c) and (86f), an AP in (86d), and a PP in (86e). One response to these data might be to propose that *which* in such examples is not the normal nominal *which*, but a pronominal counterpart of the categories which appear as complements of an auxiliary, mainly various kinds of VP. It is clear,

[50] Crysmann (2013b: 381)

however, that ordinary VP complements of an auxiliary cannot appear as fillers in a relative clause, as shown by the (b) examples in the following:

(87) a. This is the book, which Kim will read _.
b. * This is the book, [read which] Kim will _.

(88) a. This is the book, which Kim has read _.
b. * This is the book, [read which] Kim has _.

(89) a. This is the book, which Kim is reading _.
b. * This is the book, [reading which] Kim is _.

Thus, this does not seem a viable approach.

Arnold & Borsley (2010) propose that these examples involve a special kind of gap. As noted above, in a normal gap, the LOCAL value and the SLASH value match. However, as Webelhuth (2008) noted, there is no reason why we should not under some circumstances have what he calls a "dishonest gap", one whose LOCAL value and SLASH value do not match. Developing this approach, Arnold & Borsley (2010) propose that when an auxiliary has an unrealised complement, the complement optionally has a certain kind of nominal as the value of SLASH, which is realised as relative *which*. When SLASH has the empty set as its value, the result is an auxiliary complement ellipsis sentence. When SLASH has the nominal value, we have a dishonest gap, because the value of LOCAL is whatever the auxiliary requires, normally a VP of some kind, and the result is an ASRC.

A rather different type of example, discussed, among others, by Bresnan (2001: Chapter 2), Bouma et al. (2001: 25–26), and Webelhuth (2012), is the following:

(90) That he might be wrong, he didn't think of _.

Here, the apparent filler is a clause, but as the following shows, only an overt NP and not an overt clause is possible in the position of the gap.

(91) a. He didn't think of the matter.
b. * He didn't think of that he might be wrong.

The most detailed HPSG discussion of such examples is Webelhuth (2012). Webelhuth argues on the basis of examples like the following that initial clauses cannot be associated with a clausal gap:

(92) a. He was unhappy [that Sue was late again].

b. * [That Sue was late again] he was unhappy.

(93) a. Mary informed Bill [that Sue was late again].
b. * [That Sue was late again] Mary informed Bill.

(94) a. It seems [that John is guilty].
b. * [That John is guilty] it seems.

Thus, initial clauses can only be associated with a nominal gap. Bouma et al. (2001: 25–26) propose an analysis in which an NP gap has an S in its SLASH value. In other words, they propose a dishonest gap. Webelhuth (2012) argues against this approach and proposes an analysis in which an S[SLASH {NP}] in which the NP has a clausal interpretation can combine with a finite clause. Thus, Figure 13.13 gives the schematic structure for (90).

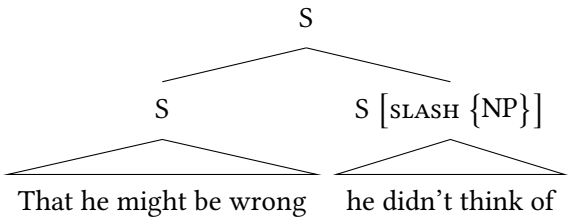


Figure 13.13: "Dishonest" gap

On this analysis, the initial clause is not a filler, and the construction is not a head-filler phrase. However, the analysis involves a normal unbounded dependency except at the top. In contrast, the Arnold and Borsley analysis of ASRCs outlined earlier involves a normal unbounded dependency except at the bottom.

10 Concluding remarks

The preceding pages have, among other things, highlighted the fact that there are some unresolved issues in the HPSG approach to unbounded dependencies. In particular, there is disagreement about whether or not gaps are empty categories and about whether or not the middle of a dependency is head-driven. It is important, therefore, to emphasise that a number of matters seem reasonably clear. In particular, it is generally accepted that unbounded dependencies involve a set- or list-valued feature called SLASH or, in some recent work, GAP. It is also

generally accepted that this is true of all types of unbounded dependencies, including those with a filler and those without, those with a gap and those with a resumptive pronoun, as well as dependencies with or without some kind of mismatch between filler and gap. Finally, it is generally accepted that the hierarchies of phrase types that are a central feature of HPSG provide an appropriate way to capture both the similarities among the many unbounded dependency constructions and the variety of ways in which they differ. The general approach seems to compare quite favourably with the approaches that have been developed within other approaches.

Appendix: Unbounded dependencies in Sign-Based Construction Grammar

This chapter has concentrated on the approach to unbounded dependencies that has been developed with Constructional HPSG. As has been discussed in a number of chapters, a version of HPSG called Sign-Based Construction Grammar (SBCG) was developed in the 2000s, which differs from Constructional HPSG in a number of ways (Sag 2012). Among other things, it has a somewhat different treatment of unbounded dependencies. In this appendix, we outline the main ways in which SBCG is different in this area.

Unlike Constructional HPSG, SBCG makes a fundamental distinction between signs and constructions. Constructions are objects which associate a mother sign (MTR) with a list of daughter signs (DTRS), one of which may be a head daughter (HD-DTR). Headed constructions thus take the following form:

(95)
$$\begin{bmatrix} cx & \\ \textsc{mtr} & sign \\ \textsc{dtrs} & list(sign) \\ \textsc{hd-dtr} & sign \end{bmatrix}$$

Constructions are utilised by the Sign Principle, which can be formulated as follows:

(96) Signs are well formed if either

a. they match some lexical entry, or

b. they match the mother of some construction.

Constructions and the Sign Principle are features of SBCG which are lacking in Constructional HPSG. Hence, they are complications. But they allow simplifications. In particular, they allow a simpler notion of sign without the features

DTRS and HD-DTR. This in turn allows the framework to dispense with *synsem* and *local* objects. The ARG-ST feature and the VALENCE feature, which replaces SUBJ and COMPS, take lists of signs and not *synsem* objects as their value. More importantly in the present context, the GAP feature, which replaces SLASH, takes as its value a list of signs and not *local* objects.

One might suppose that this view of GAP would entail that a filler and the associated gap have all the same syntactic and semantic properties, unlike within Constructional HPSG, where they only share the syntactic and semantic properties that are part of a *local* object and hence not the WH feature in *wh*-interrogatives. However, the framework allows constraints to stipulate that certain objects are the same except for some specified features. The constraint of the filler-head construction, which corresponds to HPSG's head-filler phrase, stipulates that the sign that is the filler is identical to the sign in the GAP list of its sister, except for the value of the WH feature and the REL feature used in relative clauses (Sag 2012: 166). Thus, filler and gap differ in the same way in SBCG and Constructional HPSG, but for different reasons.

At the bottom of dependency, things are rather different. The SBCG analysis allows a member of the ARG-ST list of a lexical head to appear not as a member of the word's VALENCE list, but as a member of its GAP list. We can illustrate with *read* in the following examples:

(97) a. I will read the book.
b. Which book will you read?

In (97a), *read* has the values in (98) for the three features:

(98)
$$\begin{bmatrix} \textsc{arg-st} & \langle \boxed{1}\ \text{NP}, \boxed{2}\ \text{NP} \rangle \\ \textsc{valence} & \langle \boxed{1}, \boxed{2} \rangle \\ \textsc{gap} & \langle\rangle \end{bmatrix}$$

Here, ARG-ST and VALENCE have the same value, and the value of GAP is the empty list. In (97b), the three features have the following values:

(99)
$$\begin{bmatrix} \textsc{arg-st} & \langle \boxed{1}\ \text{NP}, \boxed{2}\ \text{NP} \rangle \\ \textsc{valence} & \langle \boxed{1} \rangle \\ \textsc{gap} & \langle \boxed{2} \rangle \end{bmatrix}$$

Here, the second member of the ARG-ST list appears not in the VALENCE, but in the GAP list. This is rather different from HPSG. As discussed in Section 2, HPSG

gaps have a non-empty SLASH value. Here, gaps are just ordinary signs which appear in a GAP list and not in a VALENCE list.

This is an interesting alternative to the approach outlined in the main body of this chapter. However, it would need to be extended to account for some of the phenomena considered here.

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