Pied piping is a local dependency

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Abstract

As usual in the GPSG/HPSG paradigm, (Ginzburg and Sag 2000) treats pied piping as a nonlocal dependency, just like extraction. This treatment faces a number of problems, both conceptual and empirical ones. To solve them, I propose an alternative in which pied piping is treated as a local dependency. This alternative avoids the empirical problems with the nonlocal treatment, and is conceptually and formally simpler.

1 Introduction

Interrogative *wh*-clauses contain at least one *wh*-word. This word can occur in its canonical position, as in (1), but in many languages, including English, it is more common to extract it, both in root clauses (2) and in subordinate clauses (3).

(1) You said WHAT ?

(2) *What* did you say __?

(3) I do not know *what* she said __.

The extracted *wh*-constituent may be a phrase, as in:

(4) *How long* are they going to stay __?

(5) I wonder *which train* we should take __.

John Ross coined the term 'pied piping' for this phenomenon, suggesting that the *wh*-word lures the other words of the phrase away from their canonical position, in much the same way as the pied piper in the homonymous German fairy tale lured the rats—and later the children—away from their home town Hameln. A challenge for the treatment of pied piping is to define what exactly can/must be extracted along with the *wh*-word. Compare, for instance, (5) with (6-7).

(6) * I wonder *which* we should take __ train.

(7) * I wonder *take which train* we should __.

Apparently, the noun must follow the *wh*-determiner, but the verb must remain in situ. Restrictions on pied piping are commonly captured in terms of constraints on the internal structure of the extracted phrase. Henk van Riemsdijk, for instance, observed that the extracted phrase is typically introduced by either a *wh*-word or a preposition, and modeled this in terms of "a feature percolation approach with the (not implausible) proviso that percolation of this kind is limited to left branches, modulo a preceding preposition." (Van Riemsdijk 1994, 332). This accounts for the well-formedness of (4-5), since the *wh*-words are on the left branch of the AP *how long* and the NP *which train*. It also accounts for the fact that the *wh*-word may be preceded by a preposition, as in (8-9).

(8) *To whom* did you send that letter __?

(9)   I do not know *for how long* they will stay ⎵.

   Words of other categories may not precede the *wh*-word. This accounts for the ill-formedness of (7), in which it is preceded by a verb, as well as for the ill-formedness of (10) and (11), in which it is preceded by resp. a noun and an adjective.

(10)   * *Friends of whom* did they invite ⎵?

(11)   * I do not know *proud of what* we should be ⎵.
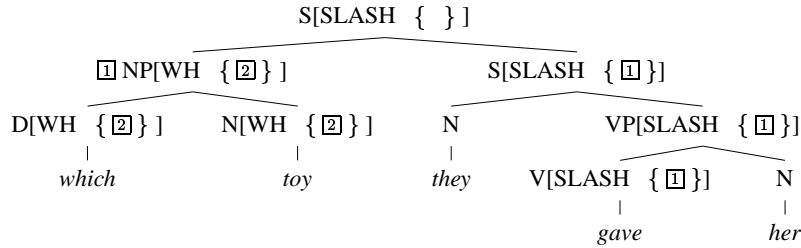
   At the same time, Van Riemsdijk's observation does not account for the ill-formedness of (6) and the contrast in (12).

(12)   I wonder *whose/*whom leaving the room* she was referring to ⎵.

   A recent attempt to provide a more complete and precise account is the HPSG-based treatment of pied piping in (Ginzburg and Sag 2000), henceforth GS-2000. It will be presented in section 2, evaluated in section 3 and replaced with an alternative in section 4.

2   The nonlocal head-driven treatment of GS-2000

As usual in the GPSG/HPSG paradigm, GS-2000 models extraction and pied piping in terms of feature sharing. The interrogative clause in *I do not know which toy they gave her* ⎵, for instance, is analysed as follows.
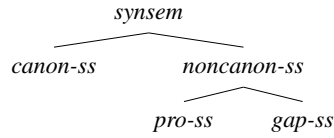
$$
\begin{array}{c}
\text{S[SLASH } \{ \ \} \text{]} \\
\overline{\hspace{4cm}} \\
\boxed{1}\,\text{NP[WH } \{ \boxed{2} \} \text{]} \qquad\qquad \text{S[SLASH } \{ \boxed{1} \} \text{]} \\
\text{D[WH } \{ \boxed{2} \} \text{]} \quad \text{N[WH } \{ \boxed{2} \} \text{]} \quad \text{N} \quad \text{VP[SLASH } \{ \boxed{1} \} \text{]} \\
| \qquad\qquad | \qquad\qquad | \\
\textit{which} \qquad\quad \textit{toy} \qquad\quad \textit{they} \quad \text{V[SLASH } \{ \boxed{1} \} \text{]} \quad \text{N} \\
| \qquad\qquad | \\
\textit{gave} \qquad\quad \textit{her}
\end{array}
$$

   The SLASH feature models extraction (2.1) and the WH feature pied piping (2.2).

2.1   Extraction

Since the GS-2000 treatment of extraction is head-driven, I start from the head of the clause, i.e. the verb *gave*. This is one of the forms of the lexeme *give*, which is ditransitive and which, hence, selects three NP arguments.

$$
\begin{bmatrix}
\textit{lexeme} \\
\text{SYNSEM}\,|\,\text{LOCAL}\,|\,\text{CAT}\,|\,\text{HEAD} \quad \textit{verb} \\[4pt]
\text{ARG-ST} \quad \left\langle \begin{bmatrix} \textit{synsem} \\ \text{LOCAL} \quad \text{NP} \end{bmatrix}, \begin{bmatrix} \textit{synsem} \\ \text{LOCAL} \quad \text{NP} \end{bmatrix}, \begin{bmatrix} \textit{synsem} \\ \text{LOCAL} \quad \text{NP} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

The mapping of lexemes onto words is modeled by lexical rules. They may change the phonological form of the sign, as in the case of *gave*, as well as its syntactic and semantic properties. For instance, since *gave* is finite, the first NP argument must be nominative. Besides, each of the selected arguments is assigned a more specific SYNSEM value.

$$
\begin{array}{c}
\textit{synsem} \\
\diagup \quad \diagdown \\
\textit{canon-ss} \qquad \textit{noncanon-ss} \\
\diagup \quad \diagdown \\
\textit{pro-ss} \qquad \textit{gap-ss}
\end{array}
$$

The objects of type *canon(ical)-s(yn)s(em)* are overtly realized, whereas those of type *noncan-ss* are not. The latter include the unrealized subjects of infinitival clauses (*pro-ss*) and the extracted arguments (*gap-ss*). The last NP in the ARG-ST value of *gave*, for example, is of type *gap-ss*.

$$
\begin{bmatrix}
\textit{word} \\
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \mid \text{HEAD} \mid \text{VFORM } \textit{finite} \\
\text{ARG-ST} \quad \left\langle
\begin{bmatrix} \textit{canon-ss} \\ \text{LOCAL} \quad \text{NP}[\textit{nom}] \end{bmatrix},
\begin{bmatrix} \textit{canon-ss} \\ \text{LOCAL} \quad \text{NP} \end{bmatrix},
\begin{bmatrix} \textit{gap-ss} \\ \text{LOCAL} \quad \text{NP} \end{bmatrix}
\right\rangle
\end{bmatrix}
$$

How the arguments are realized is spelled out by the ARGUMENT REALIZATION PRINCIPLE (Ginzburg and Sag 2000, 171).

$$
\textit{word} \quad \Rightarrow \quad
\begin{bmatrix}
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{SUBJ} \quad \boxed{A} \\
\text{SPR} \quad \boxed{B} \\
\text{COMPS} \quad \boxed{C} \ \ominus \ \textit{list (gap-ss)}
\end{bmatrix} \\
\text{ARG-ST} \quad \boxed{A} \ \oplus \ \boxed{B} \ \oplus \ \boxed{C}
\end{bmatrix}
$$

The ARG-ST list is divided in three parts. The members of the first sublist are realized as subjects, the members of the second sublist as specifiers and the members of the third sublist as complements, unless they are extracted. The extracted arguments are subsumed by a separate constraint which identifies their LOCAL value with their SLASH value (Ginzburg and Sag 2000, 170).

$$
\textit{gap-ss} \quad \Rightarrow \quad
\begin{bmatrix}
\text{LOCAL} \quad \boxed{1} \\
\text{SLASH} \quad \{\boxed{1}\}
\end{bmatrix}
$$

Since finite verbs have exactly one subject and no specifiers, and since the COMPS list does not contain the SYNSEM values of extracted arguments, the effect of these constraints on *gave* is the following:

$$
\begin{bmatrix}
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \mid \text{VFORM } \textit{finite} \\
\text{SUBJ} \ \langle \boxed{1} \rangle \\
\text{SPR} \ \langle \ \rangle \\
\text{COMPS} \ \langle \boxed{2} \rangle
\end{bmatrix} \\[4em]
\text{ARG-ST} \ \left\langle \boxed{1}
\begin{bmatrix}
\textit{canon-ss} \\
\text{LOCAL} \ \ \text{NP}[\textit{nom}]
\end{bmatrix},
\boxed{2}
\begin{bmatrix}
\textit{canon-ss} \\
\text{LOCAL} \ \ \text{NP}
\end{bmatrix},
\begin{bmatrix}
\textit{gap-ss} \\
\text{LOCAL} \ \ \boxed{3}\,\text{NP} \\
\text{SLASH} \ \{\boxed{3}\}
\end{bmatrix} \right\rangle
\end{bmatrix}
$$

In words, the first argument is realized as the subject, the second one as a complement, and the third one is stored in the SLASH value. The latter is inherited by the head of the extracted argument, i.e. the verb. This is modeled by the SLASH AMALGAMATION CONSTRAINT (Ginzburg and Sag 2000, 169).

$$
\textit{word} \ \Rightarrow \ /
\begin{bmatrix}
\text{SYNSEM} \mid \text{SLASH} \quad \boxed{A} \ \bigcup \ \ldots \ \bigcup \ \boxed{Z} \\
\text{ARG-ST} \quad \langle\, [\text{SLASH} \ \boxed{A}\,], \ \ldots \ , [\text{SLASH} \ \boxed{Z}\,] \,\rangle
\end{bmatrix}
$$

The SLASH value of the verb is, hence, the union of the SLASH values of its arguments. Since the SLASH values of the locally realized arguments are the empty set, this implies that the SLASH value of *gave* is identical to the one of its third argument.

$$
\begin{bmatrix}
\text{SYNSEM}
\begin{bmatrix}
\text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \mid \text{VFORM } \textit{finite} \\
\text{SUBJ} \ \langle \boxed{1} \rangle \\
\text{COMPS} \ \langle \boxed{2} \rangle
\end{bmatrix} \\[3em]
\text{SLASH} \ \ \{\} \cup \{\} \cup \{\boxed{3}\}
\end{bmatrix} \\[5em]
\text{ARG-ST} \ \left\langle \boxed{1}
\begin{bmatrix}
\textit{canon-ss} \\
\text{LOCAL} \ \ \text{NP}[\textit{nom}] \\
\text{SLASH} \ \{\}
\end{bmatrix},
\boxed{2}
\begin{bmatrix}
\textit{canon-ss} \\
\text{LOCAL} \ \ \text{NP} \\
\text{SLASH} \ \{\}
\end{bmatrix},
\begin{bmatrix}
\textit{gap-ss} \\
\text{LOCAL} \ \ \boxed{3}\,\text{NP} \\
\text{SLASH} \ \{\boxed{3}\}
\end{bmatrix} \right\rangle
\end{bmatrix}
$$

Given the GENERALIZED HEAD FEATURE PRINCIPLE (GHFP), which stipulates that the SYNSEM value of a phrase is—by default—identical to the one of its head daughter, the SLASH value of the verb is identified with the one of the VP and the one of the S. The latter is then combined with an extracted *wh*-phrase which has the same LOCAL value as the one of the gap. This excludes combinations in which these values do not match, as in *on which toy they gave her __*.

2.2 Pied piping

Returning now to pied piping, GS-2000 starts from the assumption that it is an unbounded dependency, just like extraction. This is motivated by the fact that extracted *wh*-words can be arbitrarily deeply embedded in the phrases which contain them, as in (13-14).

(13)   *Whose cousin's friend's dog* is she going to buy __?

(14)   *How much smarter (than Paul)* do you think she really is __?

In terms of the notation, this implies that the feature which models pied piping (WH) is a nonlocal feature, just like SLASH. Moreover, the propagation of its value is modeled by a constraint which closely resembles the one for slash amalgamation. It is called the WH-AMALGAMATION CONSTRAINT and spelled out as follows (Ginzburg and Sag 2000, 189).

$$
word \quad \Rightarrow \quad / \begin{bmatrix} \text{SYNSEM} \,|\, \text{WH} & \boxed{A} \; \bigcup \; \dots \; \bigcup \; \boxed{Z} \\ \text{ARG-ST} & \Big\langle [\text{WH} \; \boxed{A}], \; \dots \; , [\text{WH} \; \boxed{Z}] \Big\rangle \end{bmatrix}
$$

The WH value of a word is the union of the WH values of its arguments.[1] For example, the WH value of the noun *toy* in *I wonder which toy they gave her* __ is nonempty since it has an argument with a nonempty WH value.[2] Given the GHFP, this value is shared between the common noun and the NP. This treatment also copes with pied piping in PPs, as in:

(15)   I do not know *with which toy* they were playing __.

The WH value of the preposition includes the one of its NP argument, because of the WHAC, and is shared with the PP, because of the GHFP.

Besides the similarities with extraction there are some differences. Notice, for instance, that pied piping is restricted by a 'leftmost-modulo-preceding-preposition' constraint, while extraction is not. To model this GS-2000 adds two constraints which only apply to pied piping. The first is the WH-CONSTRAINT: "Any non-initial element of a lexeme's ARG-ST list must be [WH { }]." (p. 189). This accounts for the contrast in:

(16)   I do not know *whose friends* they invited __.

(17)   * I do not know *the friends of whom* they invited __.

---

[1]In situ *wh*-words have the empty set as their WH value. This is logical, for since they are not extracted, they do not trigger pied piping.

[2]The constraint is formulated as a default, since it is overridden by the extracted *wh*-words themselves: the WH value of *which*, for instance, is nonempty, even though it does not take any arguments.

Assuming that the lexeme *friend* selects two arguments, of which the first is a determiner and the second a PP[*of*], the WHC requires the WH value of the PP to be the empty set. This, in combination with the requirement that the WH value of an extracted phrase must be nonempty, accounts for the ill-formedness of (17). By contrast, (16) is not ill-formed, since the WH value of the first argument need not be empty. The second constraint is the WH-SUBJECT PROHIBITION (p. 189).

$$word \Rightarrow \left[\text{SYNSEM} \,|\, \text{LOCAL} \,|\, \text{CAT} \,|\, \text{SUBJ} \quad list\left(\left[\text{WH} \ \{ \ \} \right] \right) \right]$$

Assuming that the first argument of the verbal gerund in (18) is realized as a subject, this accounts for:

(18) * I wonder *whom leaving the room* she was referring to ___.

In short, pied piping is treated along the same lines as extraction, i.e. as an unbounded dependency whose constraints are modeled in a lexicalist head-driven way.

3   An evaluation of the nonlocal head-driven treatment

This section provides an evaluation of the nonlocal treatment of pied piping in GS-2000. I will demonstrate that the treatment of pied piping in NPs and APs relies on the stipulation of poorly motivated lexical rules (3.1) and on the postulation of nonbranching phrase structure rules (3.2), and that there are empirical problems with the treatment of pied piping in PPs (3.3) and in NPs with a predeterminer (3.4).

3.1   Poorly motivated lexical rules

Since the WH-CONSTRAINT applies to lexemes, rather than to words, its effect can only be measured if one also takes into account the rules which map lexemes onto words. These rules play, in fact, a crucial role in the treatment of pied piping in NPs and in APs, as will now be illustrated first for the nouns and then for the adjectives.

Typical of the common noun lexemes is that they have a determiner in the first position of their ARG-ST list (Ginzburg and Sag 2000, 190).

$$\begin{bmatrix} cn\text{-}lx \\ \text{SYNSEM} \,|\, \text{LOCAL} \,|\, \text{CAT} \,|\, \text{HEAD} \quad noun \\ \text{ARG-ST} \ \left\langle \text{DET} \right\rangle \oplus \boxed{A} \end{bmatrix}$$

The addition of information which is specific for the various forms of the lexeme, is left to the lexical rules. One of them is the SINGULAR ATTRIBUTIVE

NOUN LEXICAL RULE. It stipulates that the first argument of a singular nonpredicative noun is realized as a specifier and that the noun's SUBJ list is empty (p. 190).

$$
\textit{cn-lx} \quad \Rightarrow_{LR} \quad
\begin{bmatrix}
\textit{word} \\[2pt]
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD}
\begin{bmatrix}
\text{AGR} \mid \text{NUM} \quad \textit{sg} \\
\text{PRED} \quad -
\end{bmatrix} \\[6pt]
\text{SUBJ} \quad \langle \; \rangle \\[4pt]
\text{SPR} \quad \langle \boxed{1} \rangle
\end{bmatrix} \\[10pt]
\text{ARG-ST} \quad \langle \boxed{1} \rangle \oplus \boxed{A}
\end{bmatrix}
$$

Another such rule is the SINGULAR PREDICATIVE NOUN LEXICAL RULE, which stipulates that the determiner on the ARG-ST list of a singular predicative noun is preceded by an NP which is realized as a subject (p. 409).

$$
\textit{cn-lx} \quad \Rightarrow_{LR} \quad
\begin{bmatrix}
\textit{word} \\[2pt]
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD}
\begin{bmatrix}
\text{AGR} \mid \text{NUM} \quad \textit{sg} \\
\text{PRED} \quad +
\end{bmatrix} \\[6pt]
\text{SUBJ} \quad \langle \boxed{2} \rangle \\[4pt]
\text{SPR} \quad \langle \boxed{1} \rangle
\end{bmatrix} \\[10pt]
\text{ARG-ST} \quad \langle \boxed{2}, \boxed{1} \rangle \oplus \boxed{A}
\end{bmatrix}
$$

The determiner, hence, becomes the second argument, but since the addition of the subject takes place in the mapping of the lexeme onto the word, rather than in the lexeme itself, it is not subsumed by the WHC. This accounts for the well-formedness of (19).

(19)   I do not know *whose suitcase* this might be ＿.

Technically, these rules get the facts right, but the problem is that they simultaneously capture two distinctions which are mutually independent, i.e. the number distinction, on the one hand, and the distinction between attributive and predicative nouns, on the other hand. This implies that one needs another pair of lexical rules for the plural nouns. Such redundancy is, of course, undesirable, but—within the confines of the GS-2000 system—it is unavoidable, for if the subject were already present in the lexeme, the WHC would erroneously rule out (19), and if the subject is introduced in the mapping of lexemes onto words, then it cannot be but tied to a rule which simultaneously deals with inflection.

A similar problem holds for the adjectives. Their lexemes have an NP as the first element on their ARG-ST list which has to be realised as a subject (p. 197).

This subject is subsumed by the WHSP and since the other arguments are subsumed by the WHC, the WH value of the adjectives is invariably the empty set. This, however, is too restrictive, as shown by (20).

(20) I do not know *how happy* they really are __.

To repair this, GS-2000 adds a lexical rule which introduces a determiner in the ARG-ST list of the gradable adjectives. The rule is not spelled out and does not even have a name, but from the examples it can be inferred that it requires the extra argument to be realized as a specifier and to share its WH value with the adjective. The degree marker *how* in (20), hence, shares its nonempty WH value with the adjective *happy*. In this way, the WHC is circumvented, for since the addition of the specifier takes place in the mapping of the lexeme onto the word, its non-initial position does not matter. However, while its expediency is beyond doubt, the lexical rule suffers from the same defect as those for the common nouns: it simultaneously captures two distinctions which are mutually independent. More specifically. whether an adjective is gradable and how it is inflected are unrelated issues. This has no practical consequences for English, in which the adjectives are not inflected anyway, but for languages with adjectival inflection, such as Dutch and German, it causes a sizable amount of redundancy, since the gradable adjectives in these languages inflect in exactly the same way as the nongradable ones.

Besides the redundancy, there is the problem of the arbitrariness of these lexical rules. Notice, for instance, that the requirement of a specifier is introduced by a lexical rule in the case of the adjectives, whereas it is part of the lexemes in the case of the common nouns. Conversely, the requirement of a subject is part of the lexemes in the case of the adjectives, whereas it is introduced by a lexical rule in the case of the nouns. These differences are made to get the right results for pied piping, but are not motivated by any other facts or considerations. On the contrary, they obscure the fact that the distinction between attributive and predicative uses applies in the same way to NPs and APs.

3.2   Nonbranching phrase structure rules

Specifiers of nouns and adjectives can be left unrealised, as in *friends of my sister* and *proud of his country*. A natural way to model this is to mark their presence on the SPR list and the ARG-ST list as optional. This, however, cannot be done, since it would leave us with no account for the ungrammaticality of (21).

(21) * I do not know *friends of whom* they have invited __.

If the determiner is absent from the noun's ARG-ST list, the postnominal PP takes the first position, so that it is no longer subsumed by the WH-CONSTRAINT. To avoid this, the determiner must figure in the noun's ARG-ST list, and hence in its

SPR list, also if it is left unrealized. This in turn implies that one needs a separate phrase structure rule for the vacuous expansion from NP to N' (p. 191).[3]

$$
\begin{bmatrix}
\textit{bare-nom-ph} \\
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \mid \text{SPR} \; \langle \; \rangle \\[2em]
\text{DTRS} \quad \left\langle \boxed{1} \begin{bmatrix} \text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \begin{bmatrix} \text{HEAD} \quad \textit{noun} \\ \text{SPR} \quad \left\langle \begin{bmatrix} \text{LOCAL} \mid \text{CAT} \mid \text{HEAD} \quad \textit{det} \\ \text{WH} \; \{\, \} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix} \right\rangle \\[2em]
\text{HEAD-DTR} \quad \boxed{1}
\end{bmatrix}
$$
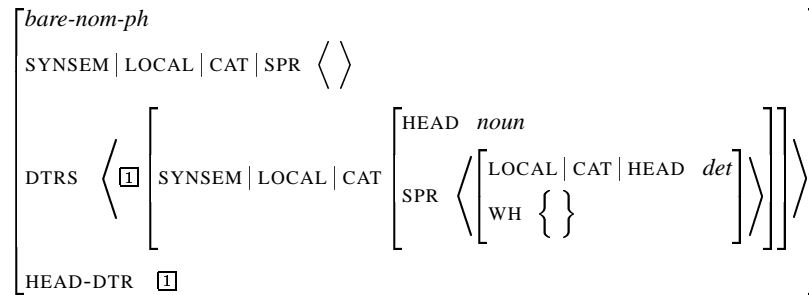
This saves the analysis, for since the absent specifier has the empty set as its WH value, and since the WH value of the PP complement is empty (because of the WHC), it follows that (21) is excluded. At the same time, though, the use of nonbranching rules introduces a level of arbitrariness in the grammar which is difficult to reconcile with the goals of a constraint-based lexicalist grammar. This is implicitly acknowledged in GS-2000, since it intentionally avoids the vacuous expansion from X' to X in the treatment of intransitive words, contrary to earlier versions of HPSG (Ginzburg and Sag 2000, 34).

3.3   Problems with PPs

If a preposition takes only one argument, this argument is, by definition, the first element on the ARG-ST list and, hence, exempt from WHC. Moreover, if the argument is realised as a complement, as in the case of the case marking prepositions, it is also exempt from the WHSP. This accounts for the grammaticality of (22).

(22)   I wonder *to whom* they gave the money __.

Predicative prepositions, by contrast, have another NP on their ARG-ST list which is realized as a subject (p. 196). Since this NP is part of the ARG-ST list of the lexeme, the NP complement is subsumed by the WHC, so that the following sentences are predicted to be ill-formed.

(23)   I wonder *in which countries* they have been __

(24)   I wonder *with whom* she will prefer to be __.

GS-2000 sees this as an asset, but most speakers do not regard these sentences as ill-formed. Even if they prefer the variant with a stranded preposition, they do not go as far as calling (23-24) ungrammatical.

---

[3]In the same vein, one needs a separate rule for the vacuous expansion from AP to A' (Ginzburg and Sag 2000, 198).

Another complication concerns the prepositional projections with a specifier, such as the adverbs in *just before the war* and *right under the table*. If the specifier contains a *wh*-word, it triggers pied piping, as in (25).

(25) *How long before the departure* do we have to be ready __?

Modeling this in the GS-2000 system inevitably leads to problems, for if the specifiers of prepositions are included in the ARG-ST list of the prepositional lexemes, their NP complements are subsumed by the WHC, which implies that the following sentences are erroneously rejected as ungrammatical.

(26) I wonder *after which party* Poirot met Maigret __.

(27) I wonder *under which table* Lee is hiding his toys __

Alternatively, if the specifiers are introduced by a lexical rule, as in the case of the gradable adjectives, the NP complements are the first arguments, so that the following sentences are erroneously accepted as well-formed.

(28) * I wonder *just after which party* Poirot met Maigret __.

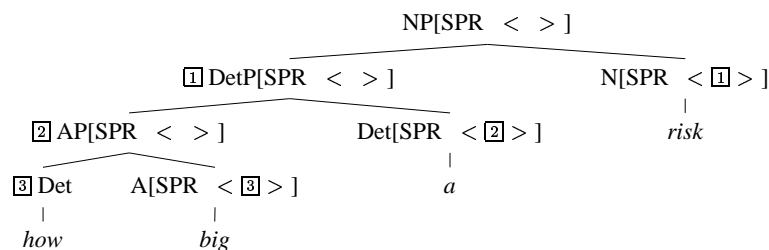(29) * I wonder *right under which table* Lee is hiding his toys __.

Moreover, whichever way the specifier is treated, since it is invariably optional, we will need a nonbranching phrase structure rule for the vacuous expansion from PP to P'.

3.4 Problems with predeterminers

In the examples discussed so far the extracted APs were either predicative or adverbial. They can also be extracted, though, when they are in a prenominal position, as in (30).

(30) I wonder *how big a risk* they are prepared to take __.

An unusual property of this combination is that the AP precedes the article. This implies that it cannot be the specifier of the noun, but at the same time it cannot be its subject either, since the NP is nonpredicative, and it cannot be its complement, since it precedes the noun. To bring it in line with the rest of the analysis, GS-2000 assumes that the AP is not a dependent of the noun, but of the article. More specifically, *how big* is treated as the first and only argument of the article (p. 200). It is realised as its specifier and, hence, exempt from both the WHC and the WHSP, so that it passes on its WH value to the article, from where it is passed on to the DetP and the NP.

```
                          NP[SPR  <  > ]
              ┌─────────────────┴──────────────────┐
        ① DetP[SPR  <  > ]                    N[SPR  < ① > ]
        ┌──────────┴──────────┐                    │
   ② AP[SPR  <  > ]      Det[SPR  < ② > ]         risk
   ┌──────┴──────┐            │
③ Det    A[SPR  < ③ > ]       a
   │          │
  how        big
```

The problem with this treatment is that *how big a* does not pass any of the usual constituency tests. It never occurs on its own and if the AP is moved to a postnominal or predicative position, it does not take the article along.

(31) This is *too big* a risk to take ＿.

(32) a. This is a risk *too big* to take ＿.

      b. * This is risk *too big a* to take ＿.

(33) a. For him, a risk is never *too big* to take ＿.

      b. * For him, risk is never *too big a* to take ＿.

Since *too* takes the same position in these APs as *how* in (30), this strongly suggests that the article in *how big a risk* combines with the noun to its right, rather than with the AP to its left. However, if this more plausible structure is adopted, the GS-2000 constraints no longer provide the result we need, since the WHAC does not foresee that a saturated NP can inherit the WH value of a prenominal AP.

3.5   Summing up

The nonlocal head-driven treatment of GS-2000 relies on poorly motivated lexical rules and nonbranching phrase structure rules to model pied piping in NPs and APs (3.1 and 3.2), it makes false predictions about pied piping in PPs (3.3), and it presupposes a highly implausible structure for NPs with predeterminers (3.4).[4]

4   A local functor-driven treatment

For the development of an alternative, I start from the assumption that pied piping is a local dependency, rather than an unbounded one. The fact that a *wh*-word can be arbitrarily deeply embedded in an extracted phrase, as in (13-14), does not provide conclusive evidence against a local treatment, since the kind of propagation which it involves is not fundamentally different from the iterative propagation which is assumed in the treatment of other phenomena which are standardly regarded as local, such as subject raising.

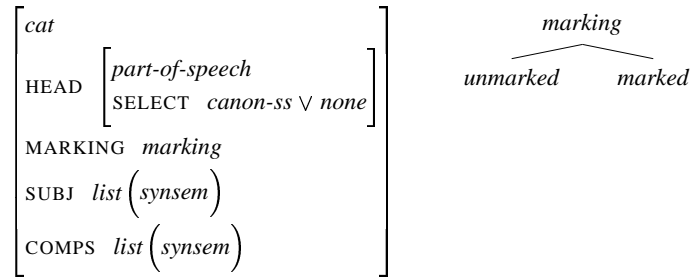(34)   There seems to have been some misunderstanding.

---

[4]There is also a wrinkle in the formalization: the WH-CONSTRAINT is the only constraint in GS-2000 which is not cast in TFS terms.

The existential *been* requires the pronoun *there* as its subject, but this requirement is not locally satisfied. Instead, it is passed on via the auxiliary *have* and the complementizer *to* to the finite verb *seems*, and it is only at that point that the requirement is satisfied. The subject NP can, hence, be arbitrarily far removed from the predicate by which it is selected, but this is not seen as evidence for a nonlocal treatment. Instead, the SUBJ feature is part of the LOCAL|CAT values, and its content is passed on in an iterative manner from the lower to the higher predicates. In much the same way, it is possible to deal with the arbitrarily deep embeddings of *wh*-words in extracted phrases. To model this I adopt another strategy than GS-2000. Instead of introducing a device which overgenerates (the WhAC) and then adding constraints which reduce it (WhC and WhSP), I employ a device which undergenerates (4.1) and then add some ways to enhance it (4.2 and 4.3).
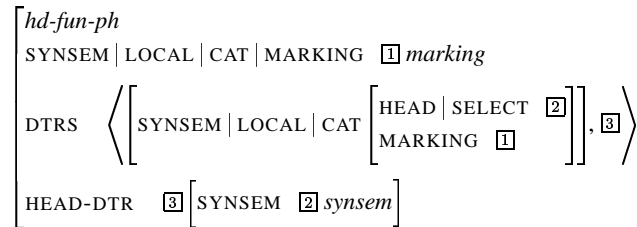
4.1 Functors

Several of the problems with the GS-2000 treatment can be traced back to the analysis of the specifiers, especially to the fact that they are selected by a lexical head. This not only necessitates the postulation of nonbranching phrase structure rules for NPs and APs (3.2), it also leads to unsolved problems in PPs (3.3), and it indirectly enforces the assignment of an implausible structure to nominals with predeterminers (3.4). To avoid these complications I drop the assumption that specifiers are selected by a lexical head. This does not cause any substantial loss of expressive power, since the co-occurrence restrictions which hold between a specifier and its head can be captured anyway in terms of the HEAD|SPEC feature of the specifier.

If the specifiers are no longer selected by their head, their treatment closely resembles the one of the adjuncts and the markers, as defined in (Pollard and Sag 1994). In fact, the remaining differences concern the part of speech; while the adjuncts belong to substantive parts of speech (N,V,A,P), the specifiers belong to functional parts of speech (Determiner, . . .), and the markers to a specific functional part of speech (Marker), which includes the complementizers and the coordinating conjunctions. This, however, is a weak basis for distinguishing between syntactic functions, since those functions are intended to capture cross-categorial generalizations. In the head-complement combination, for instance, both the head and its complement(s) can belong to any part of speech. To achieve the same level of cross-categorial generalization in the treatment of specifiers, adjuncts and markers, (Van Eynde 1998) introduced the head-functor type of combination. It covers all combinations in which the nonhead daughter selects and precedes its head. To spell it out I first redefine the objects of type *category*.

$$
\begin{bmatrix}
cat \\
\text{HEAD} \quad
\begin{bmatrix}
part\text{-}of\text{-}speech \\
\text{SELECT} \quad canon\text{-}ss \vee none
\end{bmatrix} \\
\text{MARKING} \quad marking \\
\text{SUBJ} \quad list\left(synsem\right) \\
\text{COMPS} \quad list\left(synsem\right)
\end{bmatrix}
\qquad
\begin{array}{c}
marking \\
\overbrace{\qquad\qquad\qquad} \\
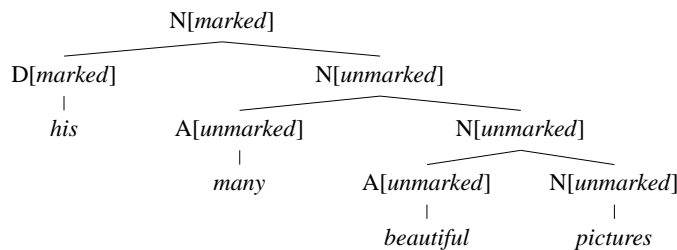unmarked \qquad marked
\end{array}
$$

The HEAD value contains the feature SELECT which models the selection of the head sister. Its value is either an object of type *canon-synsem* or *none*.[5] The SPR feature has been eliminated, since the specifiers are no longer selected by their head, and the MARKING feature, familiar from PS-94, has been re-introduced. The hierarchy of its values is language specific, but it minimally includes the types *marked* and *unm(arked)*.

Functors can now be defined as signs which select their head sister and which share their MARKING value with the mother.

$$
\begin{bmatrix}
hd\text{-}fun\text{-}ph \\
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \mid \text{MARKING} \quad \boxed{1}\ marking \\[2ex]
\text{DTRS} \quad
\left\langle
\begin{bmatrix}
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \mid \text{SELECT} \quad \boxed{2} \\
\text{MARKING} \quad \boxed{1}
\end{bmatrix}
\end{bmatrix}, \boxed{3}
\right\rangle \\[4ex]
\text{HEAD-DTR} \quad \boxed{3}
\begin{bmatrix}
\text{SYNSEM} \quad \boxed{2}\ synsem
\end{bmatrix}
\end{bmatrix}
$$

Prototypical examples of functors are the prenominal dependents. Assuming that the prenominals select an unmarked nominal as their head sister and that their MARKING value is of type *unmarked* in the case of adjectives and of type *marked* in the case of determiners, one gets the following analysis for *his many beautiful pictures*.

```
                      N[marked]
              _____|_____
         D[marked]          N[unmarked]
            |          _____|_____
           his     A[unmarked]      N[unmarked]
                       |         _____|_____
                      many   A[unmarked]   N[unmarked]
                                  |             |
                              beautiful      pictures
```

This allows the stacking of prenominal adjectives, but it excludes such ungrammatical combinations, as *beautiful his pictures* and *the his pictures*. It also excludes *the him* and *every who*, if one makes the plausible assumption that pronouns are inherently marked.

---

[5]The SELECT feature replaces the MOD and SPEC features of PS-94.

Superficially, the distinction between marked and unmarked nominals corresponds to the one between [SPR < >] and [SPR <XP>]. However, since the hierarchy of MARKING values can be extended with subtypes, and since these (sub)types can be enriched with further features, it provides a more flexible way to capture finer-grained distinctions, as demonstrated in Alleganza's treatment of Italian NPs (Allegranza 1998) and in Van Eynde's treatment of Dutch NPs (Van Eynde 2003). The latter, for instance, adds a feature for marking syntactic definiteness, thus capturing the fact that the definiteness value of an NP equals the one of its determiner.

Returning to the treatment of pied piping, I will assume that the appropriate locus for the WH feature is in the objects of type *marking*.

$$\text{MARKING}\begin{bmatrix} \text{WH} & wh \end{bmatrix} \qquad \overbrace{\quad\quad}^{wh} \atop negative \quad positive$$
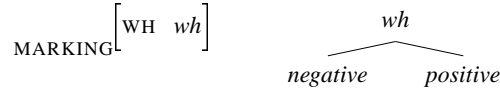
I also redefine the WH feature as boolean: *negative* corresponds to the empty set of GS-2000, *positive* to the nonempty set, and the underspecified *wh* to the set with an optional member. Employing this feature, we can now express the constraint that the nonhead daughter in a *wh*-interrogative clause (*wh-int-cl*) must be a sign with a positive WH value.

$$\begin{bmatrix} wh\text{-}int\text{-}cl \\ \text{DTRS} \quad \left\langle \begin{bmatrix} \text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \mid \text{MARKING} \mid \text{WH} & positive \end{bmatrix} , \boxed{1} \right\rangle \\ \text{HEAD-DTR} \quad \boxed{1} \end{bmatrix}$$
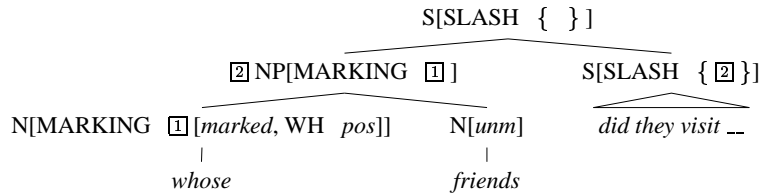
Next, I assume that all words are negatively marked for WH in the lexicon, except for the *wh*-words, i.e. the pronominal *what, who(m), whose*, the adjectival *which* and the adverbial *why, where, when, how*. They are inherently marked and receive the underspecified value *wh*.

$$\begin{bmatrix} word \\ \text{SYNSEM} \mid \text{LOCAL} \begin{bmatrix} \text{CAT} \mid \text{MARKING} \begin{bmatrix} marked \\ \text{WH} \quad wh \end{bmatrix} \\ \text{CONTENT} \quad parameter \end{bmatrix} \\ \text{ARG-ST} \quad \left\langle \ \right\rangle \end{bmatrix}$$

As such, they are compatible with the constraint above and, hence, admissible in the clause initial position. At the same time, they are also compatible with a negative WH value, which implies that they can be used in situ. In (35), for instance, the underspecified WH value of *what* is resolved to *positive* and the one of *whom* to *negative*.
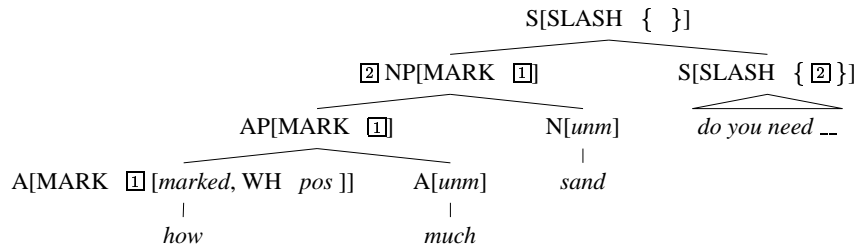
(35) I wonder *what* she said __ to *whom*.

If the extracted constituent is a phrase rather than a single word, the constraint on *wh*-interrogatives is satisfied, if the phrase has a *wh*-word as its functor. More specifically, since a phrase shares its MARKING value with its functor daughter, and since the WH feature is part of the MARKING value, it follows that the WH values propagate from functor to mother, as in:

S[SLASH { }]
　②NP[MARKING ①]　　　　S[SLASH {②}]
N[MARKING ①[*marked*, WH *pos*]]　　N[*unm*]　　*did they visit* __
　　　│　　　　　　　　　　　│
　　whose　　　　　　　　*friends*

Other *wh*-words which are used as functors include the pronominal determiners in *what color* and *whose leaving the room*, the adjectival determiner in *which table* and the degree adverb in *how quick(ly)*. Functors with a negative WH value, by contrast, make the entire phrase negatively charged. This is, for instance, the case for the the pronominal determiners in *this color* and *his leaving the room*, the adjectival determiner in *every bike* and the degree adverb in *too quick(ly)*.

Since functors may be phrasal, they can contain another functor, so that the MARKING value—and hence the WH value—of the extracted phrase equals the one of its functor's functor, as in the following NP.

S[SLASH { }]
　　　②NP[MARK ①]　　　　S[SLASH {②}]
　　AP[MARK ①]　　　N[*unm*]　　*do you need* __
A[MARK ①[*marked*, WH *pos*]]　A[*unm*]　│
　　　│　　　　　│　　　*sand*
　　how　　　*much*

The iterative propagation of the MARKING value can also be observed in extracted APs and PPs, as in:

(36)　I wonder *how much more likely* Kim is __ to do that.

(37)　*How long before the departure* do we have to be ready __?

The fact that the *wh*-word can be arbitrarily deeply embedded in the extracted phrase is, hence, dealt with in a strictly local manner.

It may be worth stressing that the WH value is propagated directly from the functor daughter to the mother, without mediation of the lexical head. This is not only formally simpler, it also avoids overgeneration. To see this, let us suppose, for the sake of the argument, that the WH values are propagated via the head. In that case, the common nouns, the gerunds and the gradable adjectives and adverbs must all be assigned the underspecified value *wh* in the lexicon, since they may end

up in the company of a positively specified functor. As a consequence, if there is no functor, as in *friends, quick(ly)* and *leaving*, the WH value remains underspecified, so that they are erroneously licensed as nonhead daughters in *wh*-interrogative clauses. This complication does not arise in the functor treatment, for since all words which are not *wh*-words receive the negative WH value, they cannot pass on a positive WH value to the phrases which they head.

4.2 Pied piping in PPs

For the treatment of pied piping in PPs we need an extra device.

(38)   I do not know *to whom* they sent that letter __.

(39)   *For how long* are they going to stay __?

The pronoun *whom* and the AP *how long* must share their positive WH value with the PP, but since they are not functor daughters, the propagation has to be modeled in some other way. For this purpose, I add the constraint that PPs share the WH value of their complement daughter.

$$
\begin{bmatrix}
\textit{hd-comp-ph} \\[4pt]
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \begin{bmatrix} \text{HEAD} & \textit{prep} \\ \text{MARKING} \mid \text{WH} & \boxed{2} \end{bmatrix} \\[14pt]
\text{DTRS} \quad \left\langle \boxed{1}, \Big[\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \mid \text{MARKING} \mid \text{WH} \quad \boxed{2} \Big] \right\rangle \\[14pt]
\text{HEAD-DTR} \quad \boxed{1} \begin{bmatrix} \textit{word} \\ \text{PHON} & \textit{list}\big(\textit{form}\big) \end{bmatrix}
\end{bmatrix}
$$

Also here, the WH value is passed on directly from the complement to the mother without mediation of the lexical head. This is motivated by the same consideration as in the case of the functors: if the preposition were to share the WH value of its complement, its own WH value would have to be underspecified, so that prepositions without complement would erroneously be admitted in the clause initial position of a *wh*-interrogative.

In contrast to the functors, the complements of prepositions do not share the entire MARKING value with the mother, but only the WH value. Otherwise, a PP with a marked NP complement, such as *after the party*, would be marked, and, hence, incompatible with a functor which requires an unmarked PP, as in *just after the party*.

The reason for including the PHON value of the preposition in the constraint is that it provides the means to express the intuition that there is a correlation between the phonological substance of the preposition and the felicity of pied piping. Many speakers, in fact, consider pied piping more felicitous if the lexical stress is on the first syllable of the preposition, as in *at* and *after*, than if it is on another syllable, as in *before* and *beside*.

(40)   I do not remember *at/after/?before which party* she met him __.

(41)   I do not know *on/under/?beside which table* he put the box __.

This intuition can be captured by a constraint on the PHON value of the preposition.
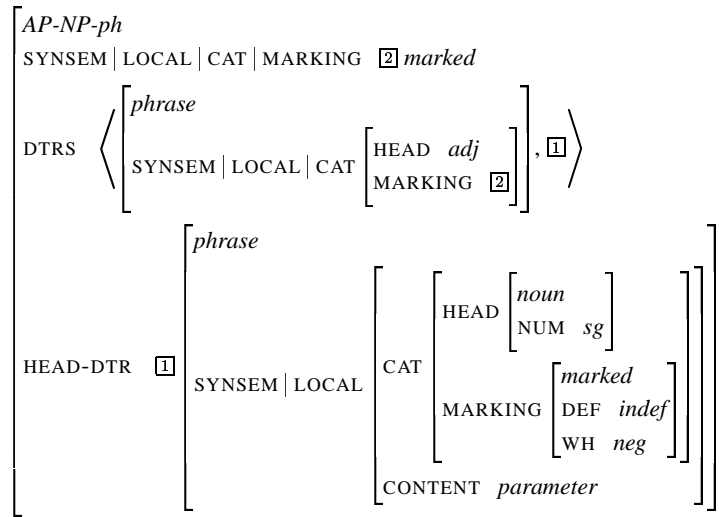
4.3   Some special cases

A combination which deserves some special attention is the one with a predeterminer, as in *how big a house*. Assuming that the prenominal AP is not a dependent of the article, but of the NP as a whole (see 3.4), this is a combination of a marked AP with a marked NP.
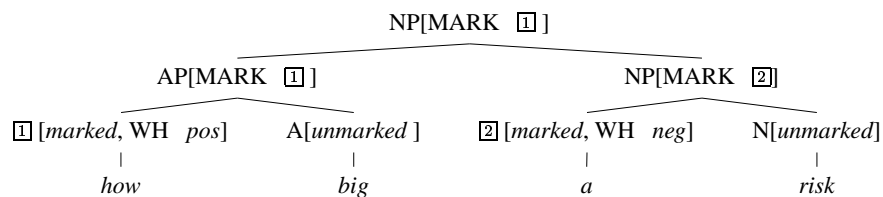
Most properties of this construction are accounted for by the functor analysis. The functor status of *how* accounts for the fact that it shares its MARKING value—and hence its WH value—with the AP and the functor status of the article accounts for the fact that it shares its MARKING value with the lower NP. The functor treatment also accounts for the ill-formedness of *a how big house*, for since the addition of the marked AP yields a marked NP, the latter is not compatible with the article, which requires an unmarked nominal.

What is not accounted for, however, is the fact that the higher NP shares its MARKING value with the AP. More specifically, it is not possible to treat the AP as a functor which selects a marked NP as its head, for since the SELECT value of the functor is shared with the one of its head daughter (*big*), the latter would be stipulated to require a marked NP as well, which is wrong. Instead, prenominal adjectives require an unmarked nominal, as illustrated by the contrast between *a big house* and * *big a house*. It is only when the adjective is preceded by a marked functor, such as *how, so, too*, that it combines with a marked NP. We are, hence, dealing with a combination which cannot be modeled in terms of lexical selection. For this reason, I model it in terms of a separate type of headed phrase with the following properties.

$$
\begin{bmatrix}
\textit{AP-NP-ph} \\
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT} \mid \text{MARKING} \quad \boxed{2}\ \textit{marked} \\[6pt]
\text{DTRS} \quad \left\langle
\begin{bmatrix}
\textit{phrase} \\
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \quad \textit{adj} \\
\text{MARKING} \quad \boxed{2}
\end{bmatrix}
\end{bmatrix}, \boxed{1}
\right\rangle \\[6pt]
\text{HEAD-DTR} \quad \boxed{1}
\begin{bmatrix}
\textit{phrase} \\
\text{SYNSEM} \mid \text{LOCAL}
\begin{bmatrix}
\text{CAT}
\begin{bmatrix}
\text{HEAD}
\begin{bmatrix}
\textit{noun} \\
\text{NUM} \quad \textit{sg}
\end{bmatrix} \\
\text{MARKING}
\begin{bmatrix}
\textit{marked} \\
\text{DEF} \quad \textit{indef} \\
\text{WH} \quad \textit{neg}
\end{bmatrix}
\end{bmatrix} \\
\text{CONTENT} \quad \textit{parameter}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Phrases of type *AP-NP-ph* have a marked AP as their nonhead daughter, and share their MARKING value—and hence their WH value—with that AP. The head daughter is an NP and is subject to a host of restrictions. The requirement that it be singular and marked excludes combinations with plural and determinerless NPs, as in *too big houses* and *how warm water*, the indefiniteness requirement excludes combinations with a definite determiner, as in *how big this house*, the requirement for a negative WH value excludes the combination with extracted interrogatives, as in *too big which house*, and the requirement for an NP of type *parameter* excludes combinations with quantified NPs, as in *so big some house*. Finally, the requirement that the head be phrasal excludes the combination with a pronoun, as in *too big anyone*. The net result is that the NP must be introduced by the indefinite article.[6]

In this construction-based treatment of the AP-NP combination, neither daughter selects the other. Instead, all relevant restrictions are spelled out in the definition of the phrase type, including the sharing of the MARKING—and hence the WH—value. For this reason, it is not necessary to assign a special status to the predeterminers in the treatment of pied piping, since their idiosyncracy is already captured on a more general level.

Another construction which requires some special attention is the one with the possessive clitic *'s*, as in *whose brother's bike*. To account for the possibility of pied piping the higher NP must share the WH value of the pronoun *whose*. This is partly covered by the functor treatment. More specifically, since *whose* is the functor in the lower NP *whose brother*, the latter inherits the MARKING value—and hence the WH value—of the pronoun. Similarly, since *whose brother's* is the functor in the higher NP *whose brother's bike*, the latter inherits the MARKING value—and hence

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[6] In this construction the indefinite article is not used as a quantifier. In fact, most uses of the indefinite article are not quantificational, see Discourse Representation Theory.

the WH value—of the possessive phrase. What the functor treatment does not account for, though, is for the combination of the possessive clitic with the lower NP. Treating the lower NP as the functor in *whose brother's* would be implausible, since it would imply that its head (*brother*) lexically selects the possessive clitic. Further evidence against this treatment is provided by such combinations as *a man's pride* and *people's habits*. The lower NPs in these combinations are indefinite or unmarked, but the higher NPs are inherently marked and definite, just like *his pride* and *my habits*. It is clear then that the lower NP had better not be treated as a functor. As an alternative, I adopt a construction-based treatment for the combination of the possessive clitic with a preceding NP.

$$
\begin{bmatrix}
\textit{NP-POSS-ph} \\[2ex]
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \mid \text{SELECT} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \quad \textit{noun} \\
\text{MARKING} \quad \textit{unmarked}
\end{bmatrix} \\[3ex]
\text{MARKING}
\begin{bmatrix}
\textit{marked} \\
\text{WH} \quad \boxed{2}
\end{bmatrix}
\end{bmatrix} \\[6ex]
\text{DTRS} \quad \left\langle
\begin{bmatrix}
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \quad \textit{noun} \\
\text{MARKING} \mid \text{WH} \quad \boxed{2}
\end{bmatrix}
\end{bmatrix}, \boxed{1} \right\rangle \\[4ex]
\text{HEAD-DTR} \quad \boxed{1}
\begin{bmatrix}
\textit{word} \\
\text{SYNSEM} \mid \text{LOCAL} \mid \text{CAT}
\begin{bmatrix}
\text{HEAD} \quad \textit{noun} \\
\text{MARKING} \quad \textit{marked}
\end{bmatrix} \\[3ex]
\text{ARG-ST} \quad \left\langle \; \right\rangle
\end{bmatrix}
\end{bmatrix}
$$

The clitic is the head daughter. It is a reduced possessive pronoun, comparable to the reduced personal pronoun in *let's dance*. Just like the other pronouns, it is inherently marked and it does not take any arguments. The nonhead daughter is an NP which shares its WH value with the mother. The latter, in its turn, is a functor which selects an unmarked nominal as its head. Given the GHFP, this SELECT value is shared with the clitic. The details of the propagation can be read off the following structure.

The lowest NP shares its MARKING value with the pronoun *whose*, the highest NP shares it with the possessive phrase, and the sharing of the WH value between the lowest NP and the possessive phrase is modeled by *NP-POSS-ph*.

It may be worth adding that the construction-based treatment of the AP-NP and NP-POSS combinations is not only motivated by the fact that they are not amenable to a purely lexicalist treatment, but also by the fact that they display unusual properties. In this respect, they are comparable to the inversion construction, which—at least in English—is so idiosyncratic that it is commonly assumed to require treatment in terms of a separate type of phrases, see PS-94.

4.4 Summing up

This concludes the survey of the ways in which positive WH values can be propagated. Together, they suffice to allow all the well-formed cases of pied piping in English *wh*-interrogatives.[7] At the same time, they are sufficiently restrictive to disallow the ill-formed ones. To show this, let us take another look at the ungrammatical sentences which were used in the previous sections.

(42)   a.   * I do not know *(the) friends of whom* they have invited __.

         b.   * I do not know *proud of what* we should be __.

         c.   * I wonder *take which train* we should __.

         d.   * *Stay how long* are they going to __?

         e.   * I wonder *whom leaving the room* she was referring to __.

(43)   a.   * I wonder *just after which party* Poirot met Maigret __.

         b.   * I wonder *right under which table* Lee is hiding his toys __.

(44)   * I wonder *which* we should take __ train.

The ill-formedness of the examples in (42) is due to the fact that nouns, adjectives and verbs are negatively specified for WH. This implies that their phrasal projections are also negatively specified, unless they are preceded by a nonhead daughter with a positive WH value. This can be a functor, a predeterminer or a possessive phrase, but not a complement, as in (a-c), an adjunct, as in (d), or a subject, as in (e). The examples in (43) are ill-formed, since the PPs contain a functor with a negative WH value, and the ungrammaticality of (44) follows from the fact that the *synsem* objects which are selected by functors must be of type *canon-ss*, which excludes the type *gap-ss*.

5   Conclusion

To model the pied piping in interrogative clauses GS-2000 proposes a nonlocal head-driven treatment. This treatment has a number of drawbacks: It relies on poorly motivated lexical rules and nonbranching phrase structure rules, it makes

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[7]Other languages may be more or less restrictive than English. German, for instance, allows pied piping in infinitival VPs, as in *Ich weiss nicht,* wen zu überzeugen *er sich vergeblich bemühte* __. This can be modeled along the same lines as the pied piping in English PPs, i.e. by allowing the VP[*zu-inf*] to share the WH value of its first complement daughter.

false predictions about pied piping in PPs, and it presupposes an implausible structure for NPs with predeterminers. To solve these problems I have proposed an alternative in which pied piping is treated as a local dependency. Technically, the WH feature is integrated in the CATEGORY objects, and the propagation of its values is modeled by constraints which are independently needed for the treatment of other phenomena, such as the sharing of the MARKING value in phrases of type head-functor. The resulting treatment has no separate constraints for the propagation of WH values (such as the WhAC, the WhC and WhSP), it has no nonbranching phrase structure rules, and it does not rely on lexical rules.[8]

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[8]Just like the GS-2000 treatment, the alternative local treatment also deals with pied piping in exclamative clauses, but not with pied piping in relative clauses.