Chapter 20

Anaphoric binding

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This chapter is an introduction to the Binding Theory assumed within HPSG. While it was inspired by work on Government & Binding (GB), a key insight of HPSG's Binding Theory is that, contrary to GB's Binding Theory, reference to tree structures alone is not sufficient and reference to the syntactic level of argument structure is required. Since argument structure is tightly related to semantics, HPSG's Binding Theory is a mix of aspects of thematic Binding Theories and entirely configurational theories. This chapter discusses the advantages of this new view and its development into a strongly lexical binding theory as a result of shortcomings of earlier approaches. The chapter also addresses so-called exempt anaphors, that is, anaphors not bound inside of the clause or another local domain.

1 Introduction

Binding Theories deal with questions of semantic identity and agreement of coreferring items. For example, the reflexives in (1) must corefer, and agree in gender, with a coargument:

(1)   a.   Peter$_i$ thinks that Mary$_j$ likes herself$_{*i/j/*k}$.
      b.   * Peter$_i$ thinks that Mary$_j$ likes himself$_{*i/*j/*k}$.
      c.   * Mary$_i$ thinks that Peter$_j$ likes herself$_{*i/*j/*k}$.
      d.   Mary$_i$ thinks that Peter$_j$ likes himself$_{*i/j/*k}$.

The indices show what bindings are possible and which ones are ruled out. For example, in (1a), *herself* cannot refer to *Peter*, it can refer to *Mary* and it cannot refer to some discourse referent that is not mentioned in the sentence (indicated by the index *k*). Binding of *himself* to *Mary* is ruled out in (1b), since *himself*

has an incompatible gender. Expressions like *Mary, the morning star, Venus, fear* are so-called *referring expressions* (r-expressions, Chomsky 1981: 102). They refer to an entity in the discourse. Speakers may use pronouns or reflexives to refer to the same entity. This is coreference. Further, several r-expressions may refer to the same entity. For example, *morning star, evening star* and *Venus* refer to the same object. As was mentioned above, English uses grammatical means to help resolving the reference of pronouns and reflexives. Pronouns can also be used to relate r-expressions that do not refer. For example, coindexing can be established with all kinds of nominal expressions, including quantified ones and negated NPs like *no animal* (see Bach & Partee 1980: 128–129).

(2)   No animal$_i$ saw itself$_i$.

So binding is not coreference.

At first look it may seem possible to account for the binding relations of reflexives at the semantic level with respect to thematic roles (Jackendoff 1972: Section 4.10; Wilkins 1988; Williams 1994: Chapter 6): it seems to be the case that reflexives and their antecedents have to be semantic arguments of the same predicate.[1] For examples like (1), a theory assuming that reflexives and their antecedents have to fill a semantic role of the same head makes the right predictions, since the reflexive is the undergoer of *likes* and the only possible antecedent is the actor of *likes*.[2] However, there are raising predicates like *believe* that do not assign semantic roles to their objects but that nevertheless allow coreference of the raised element and the subject of *believe* (Manning & Sag 1998: 128):[3]

(3)   John$_i$ believes himself$_i$ to be a descendant of Beethoven.

The fact that *believes* does not assign a semantic role to its object is confirmed by the possibility of embedding predicates with an expletive subject under *believe*:[4]

(4)   Kim believed there to be some misunderstanding about these issues.

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[1]See Riezler (1995) for a way to formalize this in HPSG. See Reinhart & Reuland (1993) for an approach to Binding mixing constraints at the semantic and syntactic level. Kubota (2021: Section 4.3), Chapter 29 of this volume discusses an approach to binding operating on semantic formulae.

[2]See Dowty (1991) and Van Valin (1999) on semantic roles. Dowty suggested role labels like proto-agent and proto-patient and Van Valin proposed the labels actor and undergoer. We use the latter here. See also Davis, Koenig & Wechsler (2021: Section 4.1), Chapter 9 of this volume on actor and undergoer and linking in HPSG.

[3]See Pollard & Sag (1994: Chapter 3.5) and Abeillé (2021), Chapter 12 of this volume on raising. See also Reinhart & Reuland (1993: 679) on Binding Theory and raising.

[4]The example is from Pollard & Sag (1994: 137). See the sources cited above for further discussion.

So, it really is the clause or – to be more precise – some syntactically defined local domain in which reflexive pronouns have to be bound, provided the structure is such that an appropriate antecedent could be available in principle.[5]   In cases like (5), no antecedent is available within the clause and in such situations, a reflexive may be bound by an element outside the clause.

(5) John_i was going to get even with Mary. That picture of himself_i in the paper would really annoy her, as would the other stunts he had planned.[6]

Reflexives without an element that could function as a binder in a certain local domain are regarded as exempt from Binding Theory. Section 2.3 deals with so-called exempt anaphors in more detail.

Personal pronouns cannot bind an antecedent within the same domain of locality in English:

(6) a. Peter_i thinks that Mary_j likes $\text{her}_{*i/*j/k}$.
b. Peter_i thinks that Mary_j likes $\text{him}_{i/*j/k}$.
c. Mary_i thinks that Peter_j likes $\text{her}_{i/*j/k}$.
d. Mary_i thinks that Peter_j likes $\text{him}_{*i/*j/k}$.

As the examples show, the pronouns *her* and *him* cannot be coreferent with the subject of *likes*. If a speaker wants to express coreference, he or she has to use a reflexive pronoun as in (1).

Interestingly, the binding of pronouns is less restricted than that of reflexives, but this does not mean that anything goes. For example, a pronoun cannot bind a full referential NP if the NP is embedded in a complement clause and the pronoun is in the matrix clause:

(7) a. $\text{He}_{*i/*j/k}$ thinks that Mary_i likes Peter_j.
b. $\text{He}_{*i/*j/k}$ thinks that Peter_i likes Mary_j.

The sentences discussed so far can be assigned a structure like the one in Figure 1. Chomsky (1981: Section 3.2; 1986: Section 3) suggested that tree-configurational properties play a role in accounting for binding facts. He uses the notion of c(onstituent)-command going back to work by Reinhart (1976). c-command is

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[5]Another argument against a Binding Theory relying exclusively on semantics involves different binding behavior in active and passive sentences: since the semantic contribution is the same for active and passive sentences, the difference in binding options cannot be explained in semantics-based approaches. Binding and passive is discussed more thoroughly in Section 4. For a general discussion of thematic approaches to binding see Pollard & Sag (1992: Section 8) and Pollard & Sag (1994: Section 6.8.2).
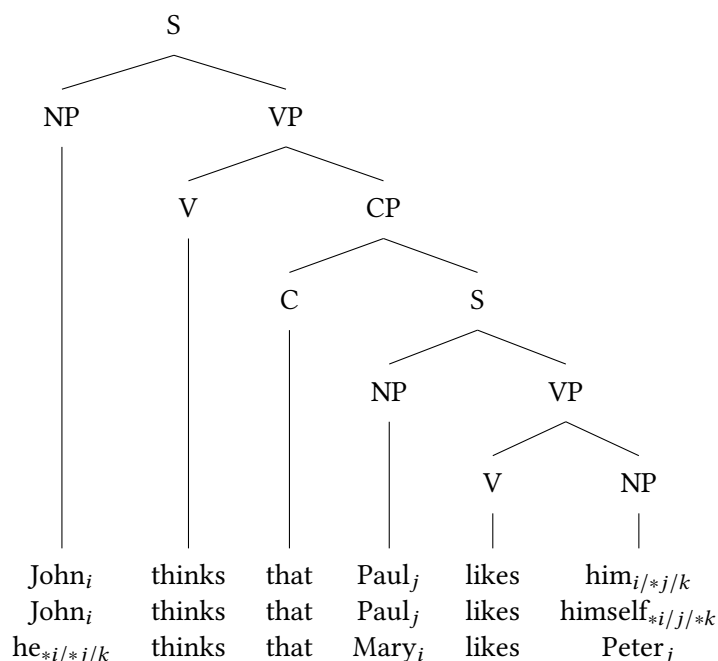
[6]Pollard & Sag (1994: 270)

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                              S
                        ┌─────┴─────┐
                       NP           VP
                        │      ┌─────┴─────┐
                        │      V           CP
                        │      │      ┌─────┴─────┐
                        │      │      C           S
                        │      │      │      ┌─────┴─────┐
                        │      │      │     NP           VP
                        │      │      │      │      ┌─────┴─────┐
                        │      │      │      │      V           NP
                        │      │      │      │      │           │
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John$_i$	thinks	that	Paul$_j$	likes	him$_{i/*j/k}$
John$_i$	thinks	that	Paul$_j$	likes	himself$_{*i/j/*k}$
he$_{*i/*j/k}$	thinks	that	Mary$_i$	likes	Peter$_j$

Figure 1: Tree configuration of examples for binding

a relation that holds between nodes in a tree. According to one definition, a node c-commands its sisters and the constituents of its sisters.[7]

To take an example, the NP node of *John* c-commands all other nodes dominated by S. The V of *thinks* c-commands everything within the CP, including the CP node; the C of *that* c-commands all nodes in S, including also S; and so on. The CP c-commands the *think*-V, and the *likes him*-VP c-commands the *Paul*-NP. By definition, a Y binds Z in the case that Y and Z are coindexed and Y c-commands Z. One precondition for being coindexed (in English) is that the person, number and gender features of the involved items are compatible, since these features are part of the index.

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[7] "Node A c(onstituent)-commands node B if neither A nor B dominates the other and the first branching node which dominates A dominates B." Reinhart (1976: 32)

Chomsky (1986) uses another definition that allows one to go up to the next maximal projection dominating A. As of 2020-02-25 the English and German Wikipedia pages for c-command have two conflicting definitions of c-command. The English version follows Sportiche et al. (2013: 168), whose definition excludes c-command between sisters: "Node X c-commands node Y if a sister of X dominates Y."

Now, the goal is to find restrictions that ensure that English reflexives are bound locally, that personal pronouns are not bound locally and that r-expressions like proper names and full NPs are not bound by other expressions (anaphors, personal pronouns or r-expressions). The conditions that were developed for GB's Binding Theory are complex. They also account for the binding of traces that are the result of moving elements by transformations (Chomsky 1981, but given up in Chomsky 1986). While it is elegant to subsume filler-gap relations (and other relations between moved items and their traces) under a general Binding Theory, proponents of HPSG think that coindexed semantic indices and filler-gap dependencies are crucially different.[8] Where traces (if they are assumed at all) can occur is restricted by other components of the theory. For an overview of the treatment of nonlocal dependencies in HPSG, see Borsley & Crysmann (2021), Chapter 13 of this volume.

I will not go into the details of the Binding Theory in Mainstream Generative Grammar (MGG)[9], but I will give a verbatim description of the ABC of Binding Theory (ignoring movement). Chomsky distinguishes between so-called r-expressions, personal pronouns, reflexives and reciprocals. The latter two are subsumed under the term *anaphor*. Principle A says that an anaphor must be bound in a certain local domain. Principle B says that a pronoun must not be bound in a certain local domain, and Principle C says that a referential expression must not be bound by another item at all.

Some researchers have questioned whether syntactic principles like Chomsky's Principle C and the respective HPSG variant should be formulated at all, and it has been suggested to leave an account of the unavailability of bindings like the binding of *he* to full NPs in (7) to pragmatics (Bolinger 1979: 302; Bresnan 2001: 227–228; Bouma, Malouf & Sag 2001: 44). Walker (2011: Section 6) discussed the claims in detail and showed why Principle C is needed and how data that was considered problematic for syntactic Binding Theories can be explained in a configurational Binding Theory in HPSG. So, while it ultimately may turn out

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[8]The HPSG treatment of relative and interrogative pronouns in each of those types of clause is special, but this is due to their special distribution: they have to be part of a phrase that is initial in the relative or interrogative clause. See Arnold & Godard (2021), Chapter 14 of this volume on relative clauses in HPSG. Bredenkamp (1996: Section 7.2.3) was an early suggestion about modeling binding relations of personal pronouns and anaphors by the same means as filler-gap dependencies. I will discuss approaches relying on HPSG's general apparatus for nonlocal dependencies without assuming that the phenomena are of the same kind in Section 6.

[9]I follow Culicover & Jackendoff (2005: 3) in using the term *Mainstream Generative Grammar* when referring to work in Government & Binding (Chomsky 1981) or Minimalism (Chomsky 1995).

that Principle C should be dropped from Binding Theory (Varaschin, Culicover & Winkler 2021), the following discussion includes a discussion of Principle C in its various forms.

2 A non-configurational Binding Theory

As was noted above, English pronouns and reflexives have to agree with their antecedents in gender. In addition, there is agreement in person and number. This is modeled by assuming that referential units come with a referential index in their semantic representation.[10] (On referential indices and coindexation vs. coreference, see Bach & Partee 1980: Section 6.3.) The following makeup of the semantic contribution of nominal objects is assumed.

(8) Representation of semantic information contributed by nominal objects adapted from Pollard & Sag (1994: 248):

$$
\begin{bmatrix}
\textit{nom-obj} \\
\text{INDEX} \begin{bmatrix} \textit{index} \\ \text{PER} \quad \textit{per} \\ \text{NUM} \quad \textit{num} \\ \text{GEN} \quad \textit{gen} \end{bmatrix} \\
\text{RESTRICTIONS} \ \textit{set of restrictions}
\end{bmatrix}
$$

Every nominal object comes with a referential index with person, number and gender information and a set of restrictions. In the case of pronouns, the set of restrictions is the empty set, but for nouns like *house*, the set of restrictions

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[10]There is also resolved agreement in the case of (conjoined or split) antecedents with different gender/person:

  (i) a. I told John that we should leave.
      b. Tom told Mary that they should leave. (Bresnan 1982: 396)

See Abeillé & Chaves (2021: Section 4.3), Chapter 16 of this volume for more on conjoined antecedents. Anaphoric agreement is also discussed in Chapter 6 (Wechsler 2021: Section 4.1). The approach discussed in Section 6 is powerful enough to introduce additional indices for binding that are not related to individual nodes in a tree like the NP nodes for *Paul* and *Mary* but that represent the set of the combined indices for *Paul* and *Mary*.

  See Levine (2010) for special cases, for example, singular gender-neutral *they* (p. 275):

  (ii) I know someone$_i$ who thinks they$_i$ are the greatest thing since sliced bread.

See also Wechsler (2021: Section 4), Chapter 6 of this volume on the distinction between concord and index agreement.

would contain something like *house′*(*x*) where *x* is the referential index of the noun *house*. Nominal objects can be of various types. The types are ordered hierarchically in the inheritance hierarchy given in Figure 2. Nominal objects

nom-obj
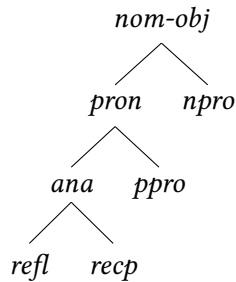|
pron   *npro*
|
ana   *ppro*
|
refl   *recp*

Figure 2: Type hierarchy of nominal objects

(*nom-obj*) can either be pronouns (*pron*) or non-pronouns (*npro*). Pronouns can be anaphors (*ana*) or personal pronouns (*ppro*), and anaphors are divided into reflexives (*refl*) and reciprocals (*recp*).

HPSG's Binding Theory differs from GB's Binding Theory in referring less to tree structures and more to the notion of obliqueness of arguments of a head. The syntactic arguments of a head are represented in a list called the argument structure list (Davis, Koenig & Wechsler 2021, Chapter 9 of this volume). This list is the value of the feature ARG-ST. The ARG-ST elements are descriptions of arguments of a head containing syntactic and semantic properties of the selected arguments but not their daughters. So, they are not complete signs but *synsem* objects. See Abeillé & Borsley (2021), Chapter 1 of this volume for more on the general setup of HPSG theories. The list elements are ordered with respect to their obliqueness, the least oblique element being the first element (Pollard & Sag 1992: 266):[11]

(9)   SUBJECT > PRIMARY > SECONDARY > OTHER COMPLEMENTS
              OBJECT   OBJECT

This order was suggested by Keenan & Comrie (1977: 66). It corresponds to the level of syntactic accessibility of grammatical functions. Elements higher in this

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[11]While Pollard & Sag (1987: 120) use Keenan & Comrie's (1977) version of the Obliqueness Hierarchy in (i), they avoid the terms *direct object* and *indirect object* in Pollard & Sag (1992: 266, 280) and Pollard & Sag (1994: 24).

  (i)   SUBJECT > DIRECT > INDIRECT > OBLIQUES > GENITIVES > OBJECTS OF
                OBJECT   OBJECT   COMPARISON

hierarchy are less oblique and can participate more easily in syntactic constructions, such as reductions in coordinated structures (Klein 1985: 15), topic drop (Fries 1988), non-matching free relative clauses (Bausewein 1991: Section 3; Pittner 1995: 195; Müller 1999a: 60–62), passive and relativization (Keenan & Comrie 1977: 96, 68) and depictive predication (Müller 2008: Section 2). In addition, Pullum (1977) and Pollard & Sag (1987: 174) argued that this hierarchy plays a role in constituent order. And, of course, it was claimed to play an important role in Binding Theory (Grewendorf, 1983: 176; 1985: 160; 1988: 60; Pollard & Sag 1994: Chapter 6).

The ARG-ST list plays an important role for linking syntax to semantics (Davis, Koenig & Wechsler 2021, Chapter 9 of this volume). For example, the index of the subject and the object of the verb *like* are linked to the respective semantic roles in the representation of the verb:[12]

(10)   *like*:

$$\begin{bmatrix} \text{ARG-ST } \left\langle \text{NP}_{\boxed{1}}, \text{NP}_{\boxed{2}} \right\rangle \\ \text{CONT } \begin{bmatrix} \textit{like-rel} \\ \text{ACTOR} \quad \boxed{1} \\ \text{UNDERGOER } \boxed{2} \end{bmatrix} \end{bmatrix}$$

Much more can be said about linking in HPSG, and the interested reader is referred to Wechsler (1995), Davis (2001), Davis & Koenig (2000) and Davis, Koenig & Wechsler (2021), Chapter 9 of this volume.

After these introductory remarks, I now turn to the details of HPSG's Binding Theory. Figure 3 shows a version of Figure 1 including ARG-ST information. The main points of HPSG's Binding Theory can be discussed with respect to this simple figure: (non-exempt) anaphors have to be bound locally. The definition of the domain of locality is rather simple. One does not have to refer to tree configurations, since all arguments of a head are represented locally in a list. Simplifying a bit, reflexives and reciprocals must be bound to elements preceding them in the ARG-ST list (but see Section 2.3 for so-called exempt anaphors) and a pronoun like *him* must not be bound by a preceding element in the same ARG-ST list.

To be able to specify the conditions on binding of anaphors, personal pronouns and non-pronouns, some further definitions are necessary. The following definitions are definitions of *local o-command*, *o-command*, and *o-bind*. The terms are

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[12]$\text{NP}_{\boxed{1}}$ is an abbreviation for a feature description of a nominal phrase with the index $\boxed{1}$. The feature description in (10) is also an abbreviation. Path information leading to CONT is omitted, since it is irrelevant for the present discussion.
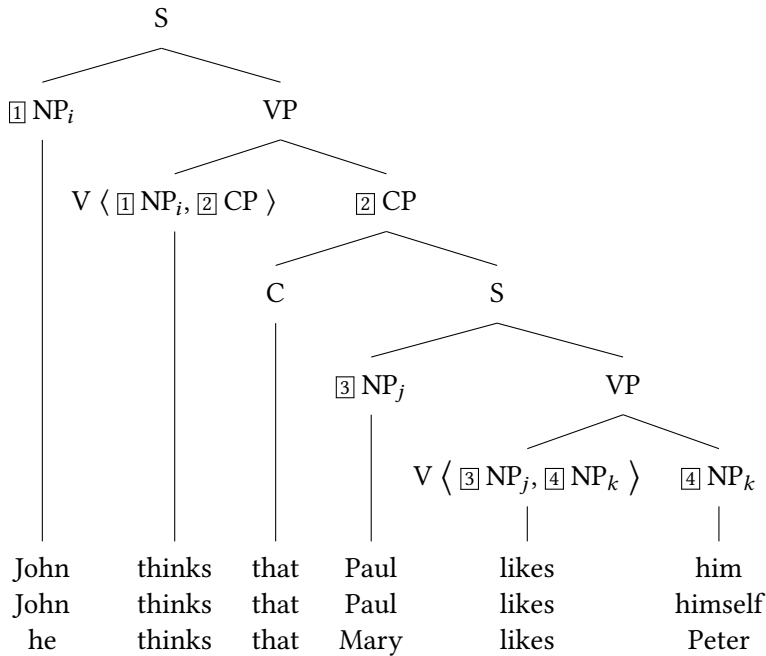
Figure 3: Tree configuration of examples for binding with ARG-ST lists

reminiscent of *c-command*, but the "o" in place of the "c" is intended to indicate the important role of the obliqueness hierarchy. The definitions are as follows:

(11)   Let Y and Z be *synsem* objects with distinct LOCAL values, Y referential. Then Y *locally o-commands* Z just in case Y is less oblique than Z.

For some X to be less oblique than Y, it is required that X and Y are on the same ARG-ST list.

(12)   Let Y and Z be *synsem* objects with distinct LOCAL values, Y referential. Then Y *o-commands* Z just in case Y locally o-commands X dominating Z.

(13)   Y (*locally*) *o-binds* Z just in case Y and Z are coindexed and Y (locally) o-commands Z. If Z is not (locally) o-bound, then it is said to be (*locally*) *o-free*.

(11) says that an ARG-ST element locally o-commands any other ARG-ST element to the right of it. The condition of non-identity of the two elements under consideration in (11) and (12) is necessary to deal with cases of raising, in which one

element may appear in various different ARG-ST lists. It is also needed to rule out unwanted command relations in the case of nonlocal dependencies, since the local value of a filler is shared with its gap. See Abeillé (2021), Chapter 12 of this volume for discussion of raising in HPSG and Borsley & Crysmann (2021), Chapter 13 of this volume on unbounded dependencies in HPSG. The condition that Y has to be referential excludes expletive pronouns like *it* in *it rains* from entering o-command relations. Such expletives are part of ARG-ST and valence lists, but they are entirely irrelevant for Binding Theory, which is the reason for their exclusion in the definition. Pollard & Sag (1994: 258) discuss the following examples going back to observations by Freidin & Harbert (1983: 65) and Kuno (1987: 95):

(14)   a.   They$_i$ made sure that it was clear to each other$_i$ that this needed to be done immediately.
     b.   They$_i$ made sure that it wouldn't bother each other$_i$ to invite their respective friends to dinner.

According to Pollard & Sag (1994: Section 3.6), the *it* is an expletive. They assume that extrapositions with *it* are accounted for by a lexical rule that introduces an expletive and a *that* clause or an infinitival verb phrase into the valence list of the respective predicates (see also Abeillé & Borsley 2021: Section 4.2, Chapter 1 of this volume). Since the *it* is not referential, it is not a possible antecedent for the anaphors in sentences like (14), and hence a Binding Theory built on the definitions in (11) and (12) will make the right predictions.[13]

The definition of o-command uses the relations of *locally o-command* and *dominate*. With respect to Figure 3, one can say that NP$_i$ o-commands all nodes below the CP node because NP$_i$ locally o-commands the CP and the CP node dominates everything below it. So NP$_i$ o-commands C, NP$_j$, VP, V and NP$_k$.

The definition of *o-bind* in (13) says that two elements have to be coindexed and there has to be a (local) o-command relation between them. The indices include person, number and gender information (in English), so that *Mary* can bind *herself* but not *themselves* or *himself*. With these definitions, the binding principles can now be stated as follows:

(15)   HPSG Binding Theory (preliminary)
    Principle A   A locally o-commanded anaphor must be locally o-bound.
    Principle B   A personal pronoun must be locally o-free.
    Principle C   A non-pronoun must be o-free.

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[13]But see the discussion of (33c) below.

Principle A accounts for the ungrammaticality of sentences like (16):

(16) a. * Mary$_i$ likes himself$_j$.

b. *likes*:
ARG-ST $\langle$ NP$_i$, NP[*ana*]$_j$ $\rangle$

Since both *Mary* and *himself* are members of the ARG-ST list of *likes*, there is an NP that locally o-commands *himself*. Therefore there should be a local o-binder. But since the indices are incompatible because of mismatching gender values, *Mary* cannot o-bind *himself*, making *himself* locally o-free and hence in conflict with Principle A.

Similarly, the binding in (17) is excluded, since *Mary* locally o-binds the pronoun *her* and hence Principle B is violated.

(17) a. Mary$_i$ likes her$_{*i}$.

b. *likes*:
ARG-ST $\langle$ NP$_i$, NP[*ppro*]$_{*i}$ $\rangle$

Finally, Principle C accounts for the ungrammaticality of (18):

(18) a. He$_i$ thinks that Mary likes Peter$_{*i}$.

b. *thinks*:
ARG-ST $\langle$ NP$_i$, CP $\rangle$

c. *likes*:
ARG-ST $\langle$ NP, NP[*npro*]$_{*i}$ $\rangle$

Since *he* and *Peter* are coindexed and since *he* o-commands *Peter*, *he* also o-binds *Peter*. According to Principle C, this is forbidden, and hence bindings like the one in (18a) are ruled out.

2.1 Ditransitives

For ditransitives, there are three elements on the ARG-ST list: the subject, the primary object and the secondary object. If the secondary object is a reflexive, Principle A requires this reflexive to be coindexed with either the primary object or the subject. Hence, the bindings in (19) are predicted to be possible and (20) is out, since neither *I* nor *you* is a possible binder of *herself* because of number mismatches:

(19) a. John$_i$ showed Mary$_j$ herself$_j$.
ARG-ST $\langle$ NP$_i$, NP$_j$, NP[*ana*]$_j$ $\rangle$

b. John$_i$ showed Mary$_j$ himself$_i$.
ARG-ST $\langle$ NP$_i$, NP$_j$, NP[*ana*]$_i$ $\rangle$

(20)   *I$_i$ showed you$_j$ herself$_k$.
         ARG-ST $\langle$ NP$_i$, NP$_j$, NP[*ana*]$_k$ $\rangle$

Note that configuration-based Binding Theories like the one entertained in GB and Minimalism require the primary object to c-command the secondary object but not vice versa. This results in theories that have to assume certain branchings and, in some cases, even auxiliary nodes (Adger 2003: Section 4.4). In HPSG, the branching that is assumed does not depend on binding facts, and, indeed, ternary branching VPs (Pollard & Sag 1994: 40) as well as binary branching ones have been assumed (see Müller 2021a: Section 3, Chapter 10 of this volume for discussion).

The list-based Binding Theory outlined above seems very simple. So far I have explained binding relations between coarguments of a head where the coarguments are NPs or pronouns. But there are also prepositional objects, which have an internal structure with the referential NPs embedded within a PP. Pollard & Sag (1994: 246, 255) discuss examples like (21):

(21)   a. John$_i$ depends [on him$_{*i}$].
         b. Mary talked [to John$_j$] [about himself$_j$].

As noted by Bach & Partee (1980: 137, Section 6.5.6), Chomsky (1981: 226), and Pollard & Sag (1994: 246), examples like the second one are a problem for the GB Binding Theory, since *John* is inside the PP and does not c-command *himself*. See Figure 4. Examples involving case-marking prepositions are no problem for
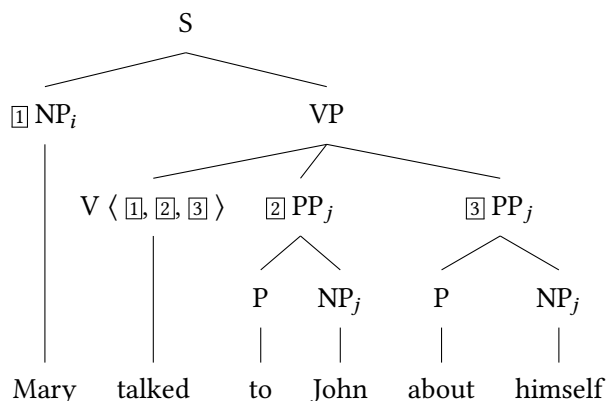

Figure 4: Binding within prepositional objects poses a challenge for GB's Binding Theory

HPSG, however, since it is assumed that the semantic content of prepositions is identified with the semantic content of the NP they select. Hence, the PP *to John* has the same referential index as the NP *John* and the PP *about himself* has the same index as *himself.* The ARG-ST list of *talked* is shown in (22):

(22)   *talked*:
       ARG-ST $\langle$ NP$_i$, PP[*to*]$_j$, PP[*about, ana*]$_j$ $\rangle$

The Binding Theory applies as it would apply to ditransitive verbs. Since the first PP is less oblique than the second one, it can bind an anaphor in the second one. The same is true for the example in (21a) and the lexical item for *depend* with the ARG-ST in (23):

(23)   *depend*:
       ARG-ST $\langle$ NP$_i$, PP[*on, ppro*]$_{*i}$ $\rangle$

Since the subject is less oblique than the PP object, it locally o-commands the PP, and even though the pronoun *him* is embedded in a PP and not a direct argument of the verb, the pronoun cannot be bound by *John*. An anaphor would be possible within the PP object, though. And of course the subject NP can bind NPs within both PP arguments of *talked*: both *to herself* and *about herself* would be possible as well.

2.2 Binding and nonlocal dependencies

Examples like (24) are covered by HPSG's Binding Theory, since *himself* is fronted via HPSG's nonlocal mechanism (see Borsley & Crysmann 2021, Chapter 13 of this volume) and there is a connection between the fronted element and the missing object.

(24)   a.   Himself$_i$, Trump$_i$ really admires _.
       b.   *admire*:
            ARG-ST $\langle$ NP$_i$, NP[*gap, ana*]$_i$ $\rangle$

Therefore, the LOCAL value of *himself* is identified with the LOCAL value of the object in the ARG-ST list of *admires*, and since the object is local to the subject of admire, it has to be bound by the subject. But there is more to say about binding and nonlocal dependencies in HPSG. Pollard & Sag (1994: 265) point out an interesting consequence of the HPSG treatment of nonlocal dependencies: since nonlocal dependencies are introduced by traces that are lexical elements, rather than by deriving one structure from another as is common in Transformational Grammar, there is no way to reconstruct a phrase with all its internal structure

into the position of the trace. Since traces do not have daughters, $\_j$ in (25) has the same local properties (part of speech, case, referential index) as *which of Claire's$_i$ friends*, without having its internal structure.

(25)   I wonder [which of Claire's$_i$ friends]$_j$ [we should let her$_i$ invite $\_j$ to the party]?

Since extracted elements are not reconstructed into the position where they would be usually located, (25) is not related to (26):

(26)   We should let her$_{*i}$ invite which of Claire's$_i$ friends to the party?

Claire would be o-bound by *her* in (26), violating Principle C, but since traces do not have daughters, no problem arises in (25).

Some of the more recent theories of nonlocal dependencies even do without traces (Bouma, Malouf & Sag 2001). These are discussed in more detail in Borsley & Crysmann (2021), Chapter 13 of this volume. For the treatment of binding data, it does not matter whether there is a trace or not: traceless accounts of extraction assume that members of the ARG-ST list, which contains all arguments, are not mapped onto the valence lists. So for the lexical item in (10), one would assume the two variants in (28) that play a role in the analysis of the sentences in (27):

(27)   a. I like bagels.
       b. Bagels, I like.

(28)   a. *like* without extraction: b. *like* with extraction:

$$
\begin{bmatrix}
\text{SUBJ} & \langle \boxed{1}\,\text{NP} \rangle \\
\text{COMPS} & \langle \boxed{2}\,\text{NP} \rangle \\
\text{ARG-ST} & \langle \boxed{1}\,\text{NP}, \boxed{2}\,\text{NP} \rangle
\end{bmatrix}
\qquad
\begin{bmatrix}
\text{SUBJ} & \langle \boxed{1}\,\text{NP} \rangle \\
\text{COMPS} & \langle\,\rangle \\
\text{ARG-ST} & \langle \boxed{1}\,\text{NP}, \text{NP}\big[\,gap\,\big] \rangle
\end{bmatrix}
$$

gap stands for a special type that is used to indicate that a certain argument is a gap rather than an overtly realized element. Gaps pass their nonlocal information up to the mother node, which is indicated by a slash in the figures in Figure 5. The traceless analysis does not differ from the trace-based approach as far as the makeup of the ARG-ST list is concerned. In a trace-based analysis, the trace is an argument of the verb. Thus, the description of the accusative object is identified with the description in the COMPS list, and this element is identical to the second element of the ARG-ST list. This means that we can talk about the same ARG-ST configurations for both types of theories and abstract away from the concrete realization of extraction. Pollard & Sag's (1994: 265) analysis of (25) works in both worlds: in the traceless analysis, there is no element that could
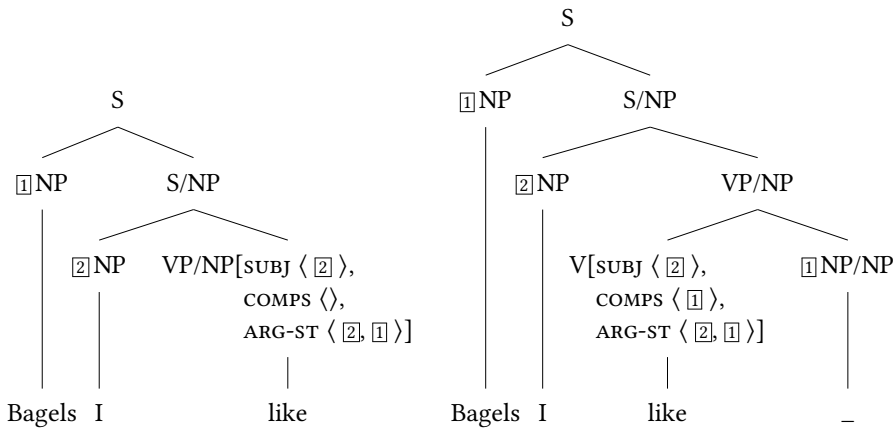
Figure 5: Traceless and trace-based analyses of fronting

have daughters, and in the trace-based analysis, there is a trace, but since traces are simple lexical items in HPSG without internal structure (Pollard & Sag 1994: 164), there is nothing like the "reconstruction" known from GB.[14]

---

[14]Müller (1999b: Section 20.2) discussed the examples in (i), which seem to be problematic for theories in which the internal structure of extracted material plays no role:

(i) a. [Karl$_i$'s friend]$_j$, he$_{*i}$ knows _$_j$.

b. Karls$_i$ Freund kennt er$_{*i}$.
Karl's friend   knows he
'He knows Karl's friend.'

According to the definition of o-command, *he* locally o-commands the object of *knows*. This object is a gap. Therefore the local properties of *Karl's friend* are in relation to *he*, but since gaps/traces do not have daughters, there is no o-command relation between *he* and *Karl*, hence *Karl* is o-free and Principle C is not violated. Thus, there is no explanation for the impossibility of binding *Karl* to *he*. In order to fix this, the definition of dominance could be changed so that GB's notion of reconstruction would be mimicked (Müller 1999b: 409–410). According to Müller's definition, a trace or gap would "dominate" the daughters of its filler. While this would account for cases like (28), the account of (25) would be lost.

Steve Wechsler (p.c. 2021) pointed out that the totally non-configurational Binding Theory that is discussed in Section 3 also "reconstructs" the fronted element into the position of the gap. Filler and gap share LOCAL values, and since *which* is the head of *which of Claire's friends*, there is an o-command relation between *her* and *Claire*, and hence (25) should be ungrammatical.

Alternatively, one might not assume "reconstruction", instead explaining the effects by different means like pragmatics or processing, as was suggested in the references cited above.

2.3 Exempt anaphors

The statement of Principle A has interesting consequences: if an anaphor is not locally o-commanded, Principle A does not say anything about requirements for binding. This means that anaphors that are initial in an ARG-ST list may be bound outside of their local environment. Example (5) from Pollard & Sag (1994: 270) – repeated here as (29) for convenience – shows that a reflexive can even be bound to an antecedent outside of the sentence:

(29)   John$_i$ was going to get even with Mary. That picture of himself$_i$ in the paper would really annoy her, as would the other stunts he had planned.[15]

A further example are NPs within adverbial PPs. Since there is nothing in the PP *around himself* that is less oblique than the reflexive, the principles governing the distribution of reflexives do not apply and hence both a pronoun and an anaphor is possible:[16]

(30)   a.   John$_i$ wrapped a blanket around him$_i$.
       b.   John$_i$ wrapped a blanket around himself$_i$.

Which of the pronouns is used is said to depend on the *point of view* of the speaker (Kuroda 1973; for further discussion and a list of references, see Pollard & Sag 1994: 270).

The exemptness of anaphors seems to cause a problem, since the Binding Theory does not rule out sentences like (31):

(31)   * Himself sleeps.

This is not a real problem for languages like English, since such sentences are ruled out anyway; *sleeps* requires an NP in the nominative and *himself* is accusative (Brame 1977: 388; Pollard & Sag 1994: 262). But Müller (1999b: Section 20.4.6) pointed out that German has subjectless verbs like *frieren* 'be cold' and *dürsten* 'be thirsty' that govern an accusative:

(32)   a.   Den   Mann friert.
            the.ACC man   cold.is
            'The man is cold.'

---

[15]Pollard & Sag (1994: 270)

[16]There are various conflicting judgements of examples like (30) in the literature. For an overview and an experiment confirming the judgement in (30), see Golde (1999: Chapter 3).

b. * Einander   friert.[17]
    each.other.ACC cold.is

c. Den   Mann dürstet.
    the.ACC man   thirsts
    'The man is thirsty.'

d. * Sich   dürstet.
    SELF.ACC thirst

However, as Kiss (2012: 158, 161) – discussing his own data and referring to Frey (1993: 131) – pointed out, anaphors are not exempt in German. So, examples like (32b) and (32d) are correctly ruled out by a general ban on unbound anaphors in German.

The contrast in (33) seems to be problematic. The analysis suggested by Pollard & Sag (1994: 149) assumes that an extraposition *it* is inserted into the ARG-ST list and the clause is appended to this list:

(33) a. That Sandy snores bothers me.
          bother: ARG-ST: ⟨ S, NP ⟩

      b. It bothers me that Sandy snores.
          bother: ARG-ST: ⟨ NP[*it*], NP[*ppro*], S ⟩

      c. * It bothers myself that Sandy snores.
          bother: ARG-ST: ⟨ NP[*it*], NP[*ana*], S ⟩

According to Pollard & Sag (1994: 149), the *it* in (33b–c) is non-referential. This would mean that there is nothing that o-commands the accusative object, making anaphors exempt in the object position, and hence sentences like (33c) would be predicted to be grammatical. However, they are not, which seems to argue for an analysis that treats the extraposition *it* as a referential element (Müller 1999b: 215, 232).

2.4 Inalienable possession NPs

Koenig (1999) examines examples like (34) in which a definite noun phrase is interpreted as a body part of some other argument of the involved verb. Koenig discusses French data, but a parallel construction exists in German as well.[18]
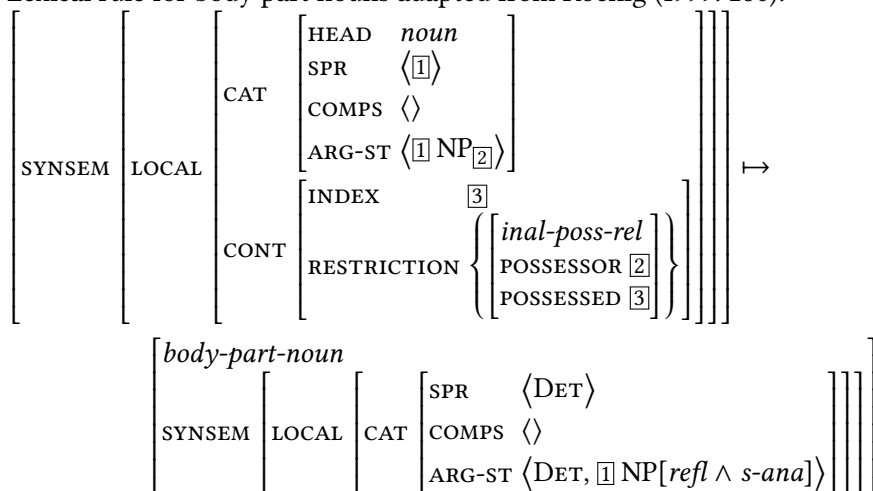
---

[17]Fanselow (1986: 349)

[18]See also Sailer (2021: 796), Chapter 17 of this volume for discussion of body parts in the context of idioms.

(34) Marc$_i$ a   avancé le pied$_i$.   (French)
Marc has advanced the foot
'Marc$_i$ moved his$_i$ foot forward.'

Koenig argues that these inalienable possession NPs should be interpreted by making recourse to the same mechanism as used in Binding Theory, rather than argument linking (see Davis, Koenig & Wechsler 2021, Chapter 9 of this volume on linking).[19] In addition to what Binding Theory predicts, he defines the concept of an Active Zone (Langacker 1984) in order to further restrict possible candidates for the possessor. He also formulates restrictions that have to hold on semantic roles filled by the possessor and the body part. Although an exploration of all of this would take us too far away from the topic at hand, I want to discuss Koenig's lexical rule for possessive nouns, which he assumes to be similar to what is given in (35):

(35) Lexical rule for body part nouns adapted from Koenig (1999: 256):

$$
\begin{bmatrix}
\text{SYNSEM} \begin{bmatrix} \text{LOCAL} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{HEAD} & noun \\ \text{SPR} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle\rangle \\ \text{ARG-ST} & \langle \boxed{1}\, \text{NP}_{\boxed{2}} \rangle \end{bmatrix} \\ \text{CONT} \begin{bmatrix} \text{INDEX} & \boxed{3} \\ \text{RESTRICTION} & \left\{ \begin{bmatrix} inal\text{-}poss\text{-}rel \\ \text{POSSESSOR } \boxed{2} \\ \text{POSSESSED } \boxed{3} \end{bmatrix} \right\} \end{bmatrix} \end{bmatrix} \end{bmatrix}
\end{bmatrix} \mapsto
$$

$$
\begin{bmatrix}
body\text{-}part\text{-}noun \\
\text{SYNSEM} \begin{bmatrix} \text{LOCAL} \begin{bmatrix} \text{CAT} \begin{bmatrix} \text{SPR} & \langle \text{DET} \rangle \\ \text{COMPS} & \langle\rangle \\ \text{ARG-ST} & \langle \text{DET}, \boxed{1}\, \text{NP}[refl \wedge s\text{-}ana] \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix}
\end{bmatrix}
$$

The lexical rule maps a body part noun selecting for a possessive NP ($\boxed{1}$) via its SPR feature onto a body part noun selecting for a definite article. Since by convention features not mentioned in the lexical rule are taken over from the input, the output has the same CONT value as the input. The output has the specification that the element in the ARG-ST is of type *refl* and *s-ana*. Pronominal elements of this type behave like reflexive pronouns and have to be bound in the subject domain.

---

[19]Steve Wechsler (p.c., 2021) pointed out that in the light of Schwarz's (2019) theory of weak definites, a reanalysis of the phenomena discussed in this section may be possible. I leave this for further research.

(36) a. Body part noun with possessive pronoun:

$$
\begin{bmatrix}
\text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{noun} \\ \text{SPR} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \rangle \\ \text{ARG-ST} & \langle \boxed{1}\,\text{NP}_{\boxed{2}} \rangle \end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{INDEX} & \boxed{3} \\ \text{RESTR} & \left\{ \begin{bmatrix} \textit{inal-poss-rel} \\ \text{POSSESSOR} & \boxed{2} \\ \text{POSSESSED} & \boxed{3} \end{bmatrix} \right\} \end{bmatrix}
\end{bmatrix}
$$

b. Body part noun with definite determiner:

$$
\begin{bmatrix}
\text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{noun} \\ \text{SPR} & \langle \textsc{Det} \rangle \\ \text{COMPS} & \langle \rangle \\ \text{ARG-ST} & \langle \textsc{Det},\ \text{NP}[\textit{refl} \wedge \textit{s-ana}]_{\boxed{2}} \rangle \end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{INDEX} & \boxed{3} \\ \text{RESTR} & \left\{ \begin{bmatrix} \textit{inal-poss-rel} \\ \text{POSSESSOR} & \boxed{2} \\ \text{POSSESSED} & \boxed{3} \end{bmatrix} \right\} \end{bmatrix}
\end{bmatrix}
$$

The two lexical items can be used to analyze (37) and (34), respectively.

(37) Marc_i a   avancé son_i pied.
      Marc has advanced his   foot
      'Marc_i moved his$_i$ foot forward.'

While in (37) a possessive pronoun is selected by the body part noun in (36a), this is not the case in the analysis of (34). But in terms of binding, the situation is similar: in both sentences there is an initial element in the ARG-ST that is linked to the possessor role of the noun. The possessive pronoun has, of course, a pronominal index, and the NP in the ARG-ST in (36b) has a pronominal index as well, since this is what was specified in the lexical rule. So Koenig's approach can account for the data without assuming any additional structure or additional empty pronominal elements.

2.5 Long-distance reflexives

A lot of work on binding in various frameworks deals with English and how to formulate the ABC of Binding Theory. However, work by Dalrymple (1993) shows convincingly that there is considerable crosslinguistic variation. Following Dalrymple, researchers working in HPSG have suggested various types of

pronominal elements that have to be bound in various domains (Abeillé et al. 1998; Koenig 1999; Xue et al. 1994; Pollard & Xue 1998; Branco & Marrafa 1999; Hellan 2005). Those working on languages that have so-called long-distance reflexives like Mandarin Chinese, Portuguese and Norwegian (Xue, Pollard & Sag 1994; Pollard & Xue 1998; Branco & Marrafa 1999; Hellan 2005) have suggested a fourth binding principle.[20] In such languages, there are pronouns that must be bound, but they may be bound locally or non-locally. Such pronouns are called Z-pronouns, and the binding principle responsible for them is Principle Z (Branco & Marrafa 1999: 171). Adding Principle Z to the preliminary version of HPSG's Binding Theory, we get:

(38)   HPSG Binding Theory
       Principle A   A locally o-commanded anaphor must be locally o-bound.
       Principle B   A personal pronoun must be locally o-free.
       Principle C   A non-pronoun must be o-free.
       Principle Z   An o-commanded anaphor must be o-bound.

Principle Z is like Principle A, but with the requirement that anaphors must be o-bound rather than locally o-bound. The requirement to be o-bound includes the option of being locally o-bound, but nonlocal o-binding is possible as well.

3 A totally non-configurational Binding Theory

The initial definition of o-command contains the notion of dominance and hence makes reference to tree structures. Pollard & Sag (1994: 279) pointed out that the binding of *John* by *he* in (39a) is correctly ruled out because *he* o-commands the trace of *John*, and hence Principle C is violated. But since they follow GPSG in assuming that English has no subject traces (Pollard & Sag 1994: Chapter 4.4), this account would not work for (39b).

(39)   a. John$_{*i}$, he$_i$ said you like $\_i$.
       b. John$_{*i}$, he$_i$ claimed left.

Later work in HPSG abolished traces altogether (Bouma, Malouf & Sag (2001); Borsley & Crysmann (2021), Chapter 13 of this volume, but see Müller & Machicao y Priemer (2019: Section 4.9) for a trace-based approach and Müller 2004; 2020: Chapter 19 on empty elements in general), and hence Binding Theory cannot rely on dominance any longer. This section deals with the revised version of Binding Theory that does not make reference to dominance. The revised non-

---

[20]For discussion of some of these languages and further examples from other languages and an analysis in LFG, see Dalrymple (1993).

configurational variant of o-command suggested by Pollard & Sag (1994: 279) has the form in (40):[21]

(40)   Let Y and Z be *synsem* objects with distinct LOCAL values, Y referential. Then Y o-commands Z just in case either:

   i.   Y is less oblique than Z; or

   ii. Y o-commands some X that has Z on its ARG-ST list; or

   iii. Y o-commands some X that is a projection of Z (i.e., the HEAD values of X and Z are token-identical).
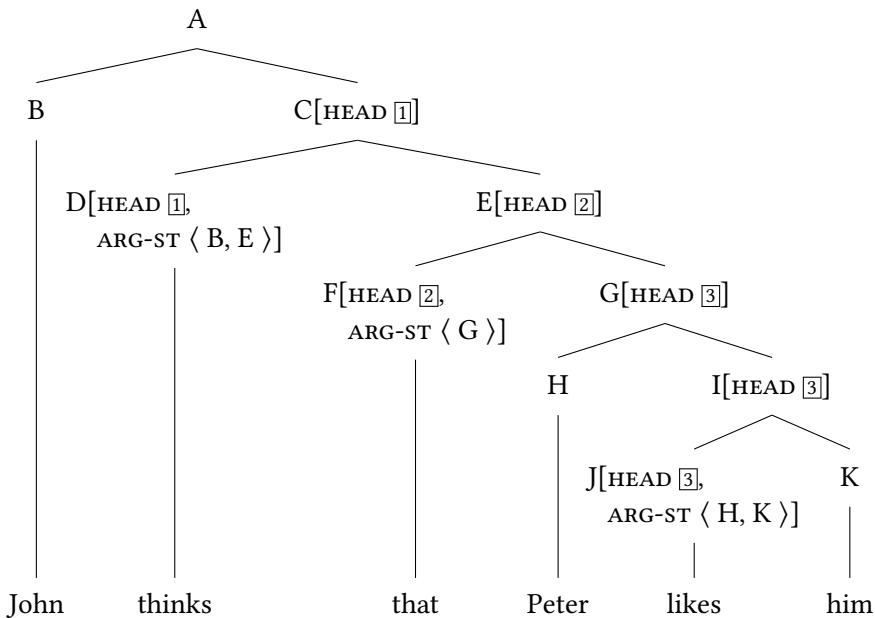
The o-command relation can be explained with respect to Figure 6.

Figure 6: Tree for explanation of the o-command relation

According to the definition in (40), B o-commands E by the definition's clause i, since B and E are in the ARG-ST list of *thinks* and B is less oblique than E. B o-commands F, since it o-commands E and E is a projection of F (clause iii). B also o-commands G, since B o-commands F and F has G on its ARG-ST list (clause ii). Since B o-commands G, it also o-commands J, since G is a projection of J (clause iii). And because of all this, B also o-commands H and K, since B o-commands J and both H and K are members of the ARG-ST list of J (clause ii).

---

[21]I have replaced "subcategorized by" with reference to the ARG-ST list.

This recursive definition of o-command is impressive in that it can account for binding phenomena in approaches that do not have empty nodes for traces in the tree structures. However, there are still open issues.[22],[23]

As was pointed out by Hukari & Levine (1996: 490), Müller (1999b: Sect 20.4.1) and Walker (2011), adjuncts pose a challenge for the non-configurational Binding Theory. For example, a referential NP can be part of an adjunct, and since adjuncts are usually not part of ARG-ST lists, they would not be covered by the definition of o-command given above. *John* is part of the reduced relative clause modifying *woman* in (41).

(41)   He$_{*i}$ knows the woman loved by John$_i$.

Since the relative clause does not appear on any ARG-ST list, *he* does not o-command *John*, and hence there is no Principle C violation and the binding should be fine, yet it is not.

Several authors suggested including adjuncts into ARG-ST lists of verbs (Chung 1998: 168; Przepiórkowski 1999: 240; Manning, Sag & Iida 1999: 60), but this would result in conflicts with Binding Theory if applied to the nominal domain (Müller 1999b: Section 20.4.1). The reason is that nominal modifiers have a semantic contribution that contains an index that is identical to the index of the modified noun.[24] If there are several such modifiers, we get a conflict, since we

---

[22]One was already mentioned in footnote 19.

[23]Note that the label *totally non-configurational Binding Theory* seems to suggest that dominance relations do not play a role at all, and hence this version of Binding Theory could be appropriate for HPSG flavors like Sign-Based Construction Grammar (SBCG) that do not have daughters in linguistic signs (see Sag 2012 and Müller 2021c: Section 1.3.2, Chapter 32 of this volume for discussion). But this is not the case. The definition of o-command in (40) contains the notion of projection. While this notion can be formalized with respect to a complex linguistic sign having daughters in Constructional HPSG, as assumed in this volume, this is impossible in SBCG, and one would have to refer to the derivation tree, which is something external to the linguistic signs licensed by a SBCG theory. See also footnote 8.

[24]See Arnold & Godard (2021: Section 2.2), Chapter 14 of this volume and Müller (1999a) on relative clauses. Sag (1997) suggests an approach to relative clauses in which a special schema is assumed that combines the modified noun with a verbal projection. This approach does not have the problem mentioned here. However, prenominal adjuncts would remain problematic as the following example (based on Müller 1999b: 412) shows:

(i)   Sie$_{*i}$ kennt das Kim$_i$ begeisternde Buch.
      she   knows the Kim enthusing   book
      'She knows the book enthusing Kim.'

The adjectival participle behaves like a normal adjectival modifier. For Principle C to make the right predictions, there should be a command relation between *sie* 'she' and the parts of the prenominal modifier. See also Arnold & Godard (2021: 631), Chapter 14 of this volume. PP adjuncts within nominal structures like *the house in the valley* are a further instance of problematic examples.

have several coindexed non-pronominal indices on the same ARG-ST list, which would violate Principle C.

There are two possible solutions that come to mind. The first one is fairly ad hoc: one can assume two different features for different purposes. There could be the normal index for establishing coindexation between heads and adjuncts and heads and arguments, and there could be a further index for binding. Adjectives would then have a referential index for establishing coindexation with nouns and an additional index referring to a state, which would be irrelevant for the binding principles.

The second solution to the adjunct problem might be seen in defining o-command with respect to the DEPS list. The DEPS list is a list of dependents that is the concatenation of the ARG-ST list and a list of adjuncts that are introduced on this list (Bouma, Malouf & Sag 2001: 12). Binding would be specified with respect to ARG-ST and dominance with respect to DEPS (which includes everything on ARG-ST). The lexical introduction of adjuncts has been criticized because of scope issues by Levine & Hukari (2006: 153), but there are also problems related to binding. Hukari & Levine (1996: 490) pointed out that there are differences when it comes to the interpretation of pronouns in examples like (42a,b) and (42c,d):

(42) a. They$_i$ went into the city without anyone noticing the twins$_{*i/j}$.
      b. They$_i$ went into the city without the twins$_{*i/j}$ being noticed.
      c. You can't say anything to them$_i$ without the twins$_{i/j}$ being offended.
      d. You can't say anything about them$_i$ without Terry criticizing the twins$_{i/j}$ mercilessly.

While the subject pronoun cannot be coreferential with *the twins* inside the adjunct, the object pronoun in (42c,d) can. In relation to the discussion of examples like (42), Walker (2011: 233) noted that whether binding of the subject pronoun is possible also depends on the attachment position of the adjunct. While binding of a subject pronoun into a VP adjunct is impossible (43a), binding into a sentential adjunct is fine (43b).

(43) a. They$_{*i}$ could never do anything [without the twins$_i$ feeling insecure about it].
      b. They$_i$ hadn't been on the road for half an hour [when the twins$_i$ noticed that they had forgotten their money, passports and ID].

If we simply register adjuncts on the DEPS list, we are unable to refer to their position in the tree, and hence we cannot express any statement needed to cover the differences in (43). Note that this is crucially different for elements on the ARG-ST list in English, since the ARG-ST of a lexical item basically determines the

trees it can appear in in English: the first element appears to the left of the verb as the subject, and all other elements appear to the right of the verb as complements. However, this is just an artifact of the rather strict syntactic system of English. It is not the case for languages with freer constituent order like German, which causes problems for Binding Theories that do not take the linearization of elements into account (see Grewendorf 1985: 140 and Riezler 1995: 12 for crucial examples).

There is another issue related to the totally non-configurational version of the Binding Theory: in 1994, HPSG was strictly head-driven. There were rather few schemata, and most of them were headed. Since then, more and more constructional schemata were suggested that do not necessarily have a head. For example, relative clauses were analyzed as involving an empty relativizer (Pollard & Sag 1994: Chapter 5; Arnold & Godard 2021: Section 2.2, Chapter 14 of this volume). One way to eliminate this empty element from grammars is to assume a headless schema that directly combines the relative phrase and the clause from which it is extracted (Müller 1999a: Section 2.7; Sag 2010: 522; Müller & Machicao y Priemer 2019: 345).[25] In addition, there were proposals to analyze free relative clauses such that the relative phrase is the head (Wright & Kathol 2003: 383). So, if *whoever* is the head of *whoever is loved by John*, the whole relative clause is not a projection of *loved*. Furthermore, *is loved by John* is not an argument of *whoever*, and hence there is no appropriate connection between the involved elements. This means that the arguments of *loved* will not be found by the definition of o-command in (40). Consequently, *John* is not o-commanded by *he*, which predicts that the binding in (44) is possible, but it is not.

(44)   He$_{*i}$ knows whoever is loved by John$_i$.

Further examples of phenomena that are treated using unheaded constructions are serial verbs in Mandarin Chinese: Müller & Lipenkova (2009) argue that VPs are combined to form a new complex VP with a meaning determined by the combination. None of the combined VPs contributes a head. No VP selects for another VP.

There seems to be no way of accounting for such cases without the notion of dominance (but see Section 6 for a lexical solution). For those insisting on grammars without empty elements, the solution would be a fusion of the definition given in (40) with the initial definition involving dominance in (12). Hukari & Levine (1995) suggested such a fusion. This is their definition of vc-command:

---

[25]See Sag (1997) for another suggestion without empty relativizers.

(45) v(alence-based) c-command:
      Let α be an element on a valence list that is the value of the valence feature
      γ and α′ the DTRS element whose SYNSEM value is structure-shared with
      α. Then if the constituent that would be formed by α′ and one or more
      elements β has a null list as its value for γ, α vc-commands β and all its
      descendants.

Rewritten in more understandable prose, this definition means that if we have
some constituent α′, then its counterpart in the valence list vc-commands all
siblings of α′ and their descendants, provided the valence list on which α′ is
selected is empty at the next higher node. We have two valence lists that are
relevant in the verbal domain: SUBJ (some authors use SPR instead) and COMPS.
The COMPS list is empty at the VP node and the SUBJ list is empty at the S node.
So, the definition in (45) makes statements about two nodes in Figure 7: the lower
VP node and the S node. For Figure 7, this entails that the object NP *the car* vc-
commands *bought*, since *the car* is an immediate daughter of the first projection
with an empty COMPS list. The NP *they* vc-commands the VP *bought the car*
without anybody noticing the twins, since both are immediately dominated by
the node with the empty SUBJ list.
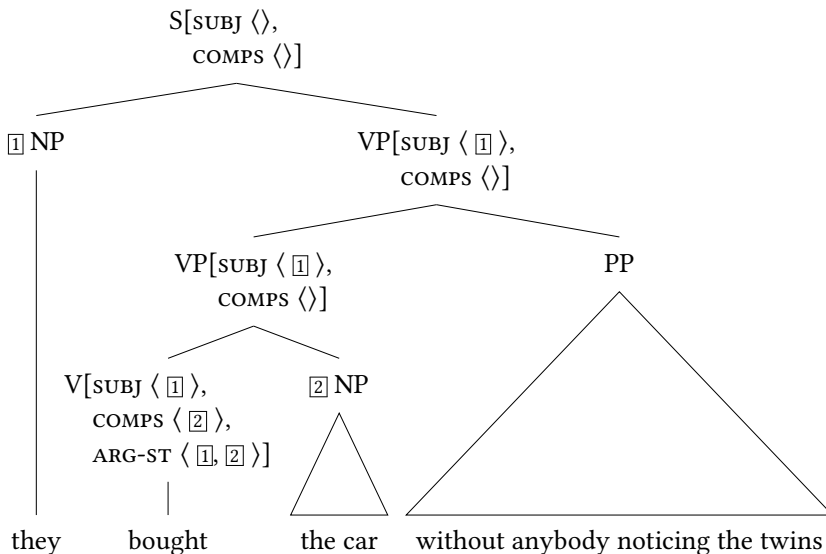
Figure 7: Example tree for vc-command: the subject vc-commands the adjunct
because it is in the valence list of the upper-most VP and this VP domi-
nates the adjunct PP

The proposal by Hukari & Levine was criticized by Walker (2011: 235), who argued that the modal component *would be formed* in the definition is not formalizable. Walker suggested the following revision:

(46) Let α, β, γ be *synsem* objects, and β′ and γ′ signs such that β′: [SYNSEM β] and γ′: [SYNSEM γ]. Then α vc-commands β iff

 i. γ′: [SS|LOC|CAT|SUBJ ⟨ α ⟩] and γ′ dominates β′, or

 ii. α locally o-commands γ and γ′ dominates β′.

Principle C is then revised as follows:

(47) Principle C: A non-pronominal must neither be bound under o-command nor under a vc-command relation.

Walker uses the tree in Figure 8 to explain her definition of vc-command. The second clause in the definition of vc-command is the same as before: it is based on local o-command and domination. What is new is the first clause. Because of this clause, the subject vc-commands the adjunct, since the subject ⟨1⟩ is in the SUBJ list of the top-most VP (α) and this top-most VP (γ′) dominates the adjunct PP (β′).
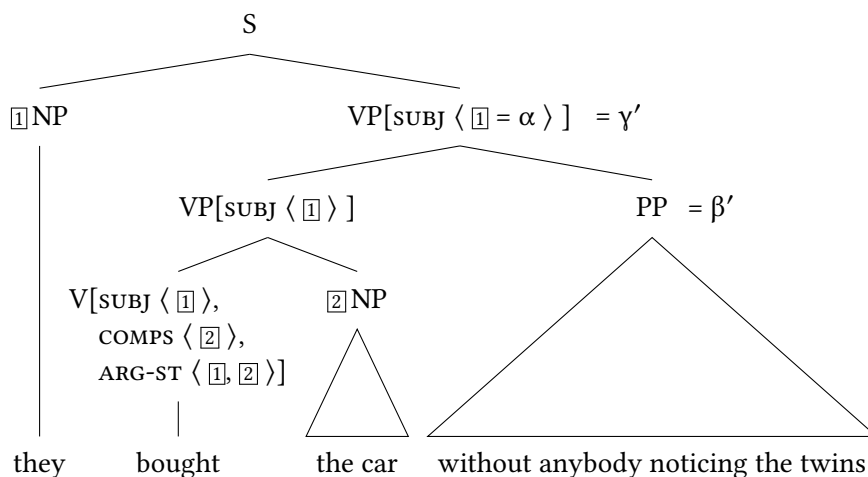
Figure 8: Version of Figure 7 using Walker's labels α, β, and γ

Apart from the elimination of the modal component in the definition of vc-command, there is a further difference between Hukari & Levine's and Walker's definitions: the former applies to Specifier-Head structures, in which the singleton element of the SPR list is saturated. We will return to this in Section 6.1. Note also that the definition of Hukari & Levine includes the sibling VP among the

items commanded by the subject, while Walker's definition includes elements dominated by this VP only.[26] This difference will also matter in Section 6.1.

Hukari & Levine's examples involve a subject-object asymmetry. Interestingly, a similar subject-object asymmetry seems to exist in German, as Grewendorf (1985: 148) pointed out. The following example is based on his example:

(48)   a.   In Marias$_i$ Wohnung erwartete sie$_i$ ein   Blumenstrauß.
             in Maria's flat   waits   her.ACC a.NOM bouquet
             'A bouquet waits for Maria in her flat.'

     b.   * In Marias$_i$ Wohnung erwartete sie$_i$ einen Blumenstrauß.
             in Maria's flat   waits   she.NOM a.ACC bouquet
             Intended: 'Maria waits for a bouquet in her flat.'

While the fronted adjunct can bind the object in (48a), binding the subject in (48b) is ruled out. Walker's proposals for English would not help in such examples, since in grammars of German, all arguments of finite verbs are represented in one valence list. Hence the highest domain in which vc-command is defined (taking Hukari & Levine's definition) is the full clause, since COMPS would be empty at this level. There is the additional problem that the adjunct is fronted in a nonlocal dependency (German is a V2 language; see Erdmann 1886: Chapter 2.4; Paul 1919: 69, 77; Müller 2015: Section 3) and that the arguments are scrambled in (48a). There is no VP node in the analysis of (48a) that is commonly assumed in HPSG grammars of German, and it is unclear how a reconstruction of the fronted adjunct into a certain position could help explain the differences in (48).

Concluding this section, it seems that a totally non-configurational Binding Theory seems to be impossible because of adjuncts, and the combination of configurational and non-configurational parts seems appropriate.

Section 6 discusses an alternative approach that collects indices in lists. This can be done in a way that gets the adjunct binding facts right.

4 Binding and passive: ARG-ST lists with internal structure

Manning & Sag (1998) discuss binding in passive clauses. They suggest that the passive be analyzed as a lexical rule demoting the subject argument and adding an optional PP.[27]

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[26]The situation is similar to the different versions of c-command in MGG. See footnote 7.

[27]See also Manning & Sag (1998: 114, 116), Müller (2003), Müller & Ørsnes (2013), and Blevins (2003: 512) for lexical rule-based analyses of the passive in English, German, Danish, Balto-Finnic and Balto-Slavic. Davis, Koenig & Wechsler (2021: Section 5.3), Chapter 9 of this volume give an overview.

(49)   Lexical rule for the passive in English:

$$\left[\textsc{arg-st} \; \langle \mathrm{NP}_i, \boxed{1}, ... \rangle \right] \mapsto \left[\textsc{arg-st} \; \langle \boxed{1}, ... \rangle \; (\oplus \langle \mathrm{PP}[by]_i \rangle) \right]$$

The lexical rule applies to a verb with at least two arguments: the NP_i and $\boxed{1}$. It licenses the lexical item for the participle. The ARG-ST list of the participle does not contain the subject NP any longer, but instead, a PP object that is coindexed with the same argument i is appended to the list. The lexical rule does not show the CONT value in the input and the output. A notational convention regarding lexical rules is that values of features that are not mentioned are taken over unchanged from the input. For our example, this means that linking is not affected. The index of the initial element in the input i was linked to a certain role and this index – now associated with the PP – is linked to the same semantic role in the output. The PP does not assign a role. It just functions like one of the prepositional objects discussed on page 900–901 above. The examples in (50) illustrate:

(50)   a.   John disappointed himself.
            ARG-ST $\langle \mathrm{NP}_i, \mathrm{NP}_j \rangle$ disappoint(i,j)

       b.   John was disappointed by himself.
            ARG-ST $\langle \mathrm{NP}_j, \mathrm{PP}[by]_i \rangle$ disappoint(i,j)

(50a) shows the linking to the arguments of the finite verb *disappoint*; the subject is linked to the first argument and the object to the second. In the passive case in (50b), the logical object is realized as the subject but still linked to the second argument of *disappoint*. The former subject, now realized as a PP, is linked to the first argument.

The passive example in (50b) would – if one would just put the reflexive in subject position – correspond to (51):

(51)   * Himself disappointed John.
            ARG-ST $\langle \mathrm{NP}_j, \mathrm{NP}_i \rangle$ disappoint(i,j)

Of course (51) is ungrammatical because of the case of the reflexive pronoun: it is accusative and hence cannot function as subject (Brame 1977: 388). But the example would also be bad for binding reasons: the reflexive cannot bind a more oblique argument. In any case, the discussion shows that a purely thematic theory of binding would not work, since the semantic representation in the examples above is the same. It is the obliqueness of arguments that differs and this difference makes different binding options available.

So, the lexical rule-based approach to the passive makes the right predictions as far as the English data is concerned, but Perlmutter (1984) argued that more complex representations are necessary to capture the fact that some languages

allow binding to the logical subject of the passivized verb. He discusses examples from Russian. While usually the reflexive has to be bound by the subject as in (52a), the antecedent can be either the subject or the logical subject in passives like (52b):

(52)   a.   Boris$_i$ mne   rasskazal anekdot o   sebe$_i$.
            Boris.NOM me.DAT told   joke   about SELF
            'Boris told me a joke about himself.'

       b.   Eta kniga   byla kuplena Borisom$_i$ dlja sebja$_i$.
            this book.NOM was bought   Boris.INSTR for SELF
            'This book was bought by Boris for himself.'

In order to capture the binding facts, Manning & Sag (1998) suggest that passives of verbs like *kupitch* 'buy' have the following representation, at least in Russian.

(53)   *kuplena* 'bought':
$$\begin{bmatrix} \text{ARG-ST} \ \langle \ \text{NP}[\textit{nom}]_j, \ \langle \ \text{NP}[\textit{instr}]_i, \text{PRO}_j, \text{PP}_k \ \rangle \ \rangle \\ \\ \text{CONT} \ \begin{bmatrix} \textit{buying} \\ \text{ACTOR} \qquad i \\ \text{UNDERGOER} \quad j \\ \text{BENEFICIARY} \quad k \end{bmatrix} \end{bmatrix}$$

The ARG-ST list is not a simple list like the list for English; rather, it is nested. The complete ARG-ST list of the lexeme *kupitch* 'buy' is contained in the ARG-ST list of the passive. The logical subject is realized in the instrumental, and the logical object is stated as PRO$_j$ on the embedded ARG-ST but as full NP in the nominative on the top-most ARG-ST list. This setup makes it possible to account for the fact that a long-distance reflexive (see p. 908) like the reflexive in the PP may refer to one of the two subjects: the nominative NP in the upper ARG-ST list and the NP in the instrumental in the embedded list. The PRO element is kept as a reflex of the argument structure of the lexeme. Such PRO elements also play a role in binding phenomena in languages like Chi-Mwi:ni, also discussed by Manning & Sag.

In order to facilitate distributing the elements of such nested ARG-ST lists to valence features like SUBJ and COMPS, Manning & Sag (1998: 124, 140) use a complex relational constraint that basically flattens the nested ARG-STs again and removes all occurrences of PRO. An alternative would be to keep the ARG-ST list for linking, case assignment and scope and use additional lists related to the ARG-ST list for binding. Such lists can contain PRO indices and additional indices for complex coordinations (see Section 6.2). An approach assuming additional lists is discussed in Section 6.

5 Austronesian: Disentangling ARG-ST and grammatical functions

So far I have discussed binding for English with some occasional reference to Mandarin Chinese, Portuguese and German. The question is whether Binding Theory is universal, that is, whether it is a set of constraints holding for all languages, or whether language-specific solutions are necessary, maybe involving a general machinery for establishing such solutions. In this section, I explore approaches suggested for Austronesian languages.

Manning & Sag (1998) discuss data from Toba Batak, a Western Austronesian language. They assume that the ARG-ST elements are ordered with the actor first and the undergoer second, but since Toba Batak has two ways to realize arguments, the so-called *active voice* and the *objective voice*, either of the arguments can be the subject.

(54) a. Mang-ida si Ria si Torus   (Toba Batak)
          AV-see   PM Ria PM Torus
          'Torus sees/saw Ria.'

      b. Di-ida si Torus si Ria
          OV-see PM Torus PM Ria
          'Torus sees/saw Ria.'

Manning & Sag argue that the verb and the adjacent NP form a VP which is combined with the final NP to yield a full clause. They further argue that neither sentence in (54) is a passive or anti-passive variant of the other. Instead, they suggest that the two variants are simply due to different mappings from argument structure (ARG-ST) to surface valence (SUBJ and COMPS). They provide the following lexical items:

(55) a. *mang-ida* 'AV-see':   b. *di-ida* 'OV-see':

$$
\begin{bmatrix}
\text{PHON} & \langle\, \textit{mang-ida} \,\rangle \\
\text{SUBJ} & \langle\, \boxed{1} \,\rangle \\
\text{COMPS} & \langle\, \boxed{2} \,\rangle \\
\text{ARG-ST} & \langle\, \boxed{1}\,\text{NP}_i,\, \boxed{2}\,\text{NP}_j \,\rangle \\
\text{CONT} & \begin{bmatrix} \textit{seeing} \\ \text{ACTOR} \quad i \\ \text{UNDERGOER} \quad j \end{bmatrix}
\end{bmatrix}
\qquad
\begin{bmatrix}
\text{PHON} & \langle\, \textit{di-ida} \,\rangle \\
\text{SUBJ} & \langle\, \boxed{2} \,\rangle \\
\text{COMPS} & \langle\, \boxed{1} \,\rangle \\
\text{ARG-ST} & \langle\, \boxed{1}\,\text{NP}_i,\, \boxed{2}\,\text{NP}_j \,\rangle \\
\text{CONT} & \begin{bmatrix} \textit{seeing} \\ \text{ACTOR} \quad i \\ \text{UNDERGOER} \quad j \end{bmatrix}
\end{bmatrix}
$$

The order of the elements in the ARG-ST list corresponds to the grammatical functions as realized in the active voice. The analysis of (54b) is given in Figure 9.

Since the second argument, the logical object and undergoer, is mapped to SUBJ in (55b), it is combined with the verb last.
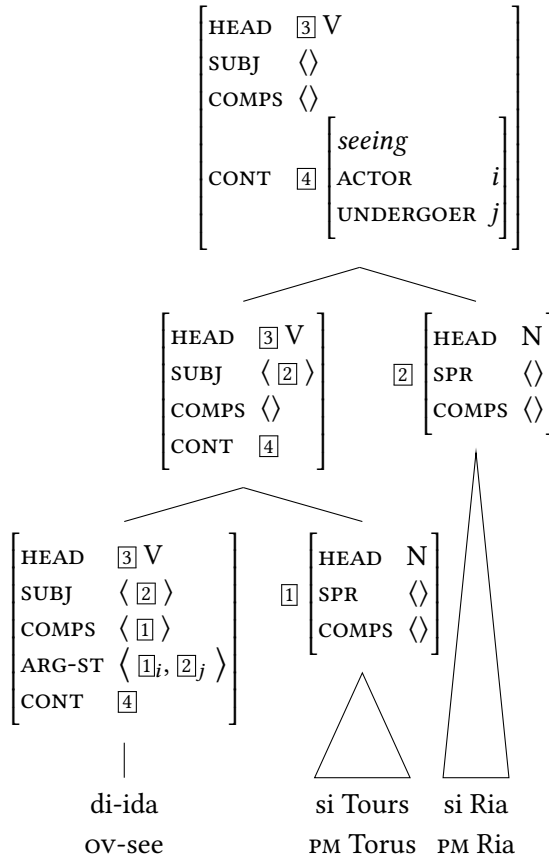
$$
\begin{bmatrix}
\text{HEAD} & \boxed{3}\ \text{V} \\
\text{SUBJ} & \langle\rangle \\
\text{COMPS} & \langle\rangle \\
\text{CONT} & \boxed{4}
\begin{bmatrix}
\textit{seeing} \\
\text{ACTOR} & i \\
\text{UNDERGOER} & j
\end{bmatrix}
\end{bmatrix}
$$

$$
\begin{bmatrix}
\text{HEAD} & \boxed{3}\ \text{V} \\
\text{SUBJ} & \langle\ \boxed{2}\ \rangle \\
\text{COMPS} & \langle\rangle \\
\text{CONT} & \boxed{4}
\end{bmatrix}
\qquad
\boxed{2}
\begin{bmatrix}
\text{HEAD} & \text{N} \\
\text{SPR} & \langle\rangle \\
\text{COMPS} & \langle\rangle
\end{bmatrix}
$$

$$
\begin{bmatrix}
\text{HEAD} & \boxed{3}\ \text{V} \\
\text{SUBJ} & \langle\ \boxed{2}\ \rangle \\
\text{COMPS} & \langle\ \boxed{1}\ \rangle \\
\text{ARG-ST} & \langle\ \boxed{1}_i, \boxed{2}_j\ \rangle \\
\text{CONT} & \boxed{4}
\end{bmatrix}
\qquad
\boxed{1}
\begin{bmatrix}
\text{HEAD} & \text{N} \\
\text{SPR} & \langle\rangle \\
\text{COMPS} & \langle\rangle
\end{bmatrix}
$$

di-ida	si Tours	si Ria
ov-see	PM Torus	PM Ria

Figure 9: Analysis of the Toba Batak example in objective voice according to Manning & Sag (1998: 120)

But since binding is taken care of at the ARG-ST list and this list is not affected by voice differences, this account correctly predicts that the binding patterns do not change, regardless of how the arguments are realized. As the following examples show, it is always the logical subject, the actor (the initial element on the ARG-ST list), that binds the non-initial one.

(56) a. [Mang-ida diri-na$_i$] si John$_i$.   (Toba Batak)
      AV-saw   self-his PM John
      'John saw himself.'

b. * [Mang-ida si John*i*] diri-na*∗i*.
   AV-saw PM John self-his
   Intended: 'John saw himself.' with *himself* as the (logical) subject

(57) a. * [Di-ida diri-na*i*] si John*i*   (Toba Batak)
         OV-saw self-his PM John
         Intended: 'John saw himself.' with *himself* as the (logical) subject

   b. [Di-ida si John*i*] diri-na*i*
      OV-saw PM John   self-his
      'John saw himself.'

Manning & Sag (1998: 121) point out that theories relying on tree configurations will have to assume rather complex tree structures for one of the patterns in order to establish the required c-command relations. This is unnecessary for ARG-ST-based Binding Theories.

Wechsler & Arka (1998) discuss similar data from Balinese and provide a parallel analysis. This analysis is also discussed in Davis, Koenig & Wechsler (2021: Section 3.3), Chapter 9 of this volume. The analysis is similar to what was just shown for Toba Batak: the elements on the ARG-ST list of simplex predicates are ordered according to the thematic hierarchy as suggested by Jackendoff (1972). But there is an important additional aspect that was already discussed in Section 1 with respect to English: ARG-ST-based theories work for raising examples as well. So even though raised elements do not get a semantic role from the head they are raised to, they can be bound by arguments of this head. Wechsler (1999: 189–190) illustrates this with the following examples:

(58) a. Cang ngaden awak cange / *cang suba   mati.   (Balinese)
         1sg AV.think myself   me already dead
         'I believed myself/*me to be dead already.'

   b. Awak cange / *cang kaden   cang suba   mati.
      myself   me ov.think 1sg already dead
      'I believed myself/*me to be dead already.'

   c. ARG-ST of 'AV/ov.think':
      ⟨ NP*i*, $\boxed{1}$ NP:*ana*i*/*ppro*∗i*, XP[SUBJ ⟨ $\boxed{1}$ ⟩] ⟩

   d. 'dead':
      $$\begin{bmatrix} \text{SUBJ} & \langle\,\boxed{1}\,\rangle \\ \text{ARG-ST} & \langle\,\boxed{1}\,\text{NP}\,\rangle \end{bmatrix}$$

Even though *awak cange* 'myself' is the subject of *mati* 'dead' and raised to the second position of the ARG-ST of 'think' both in the agentive and the objective

voice ($\boxed{1}$), this element has to be a reflexive rather than a pronoun, as predicted by an ARG-ST-based theory. As the examples in (58a,b) show, this is independent of the realization in agentive or objective voice.

When a two-place verb is embedded under a raising predicate, the downstairs verb may be realized in objective voice. The raised element will be the object of the embedded verb. As the examples in (59) show, the raised object can be an anaphor, but not a full pronoun, bound by the subject of the raising verb. This is independent of the realization of the raising verb in agentive or objective voice:

(59) a. Ia$_i$ nawang awakne$_i$ / ia$_{*i}$ lakar tangkep polisi.   (Balinese)
3rd AV.know self   3rd FUT   OV.arrest police
'He$_i$ knew that the police would arrest self$_i$/him$_{*i}$.'

   b. Awakne$_i$ / Ia$_{*i}$ tawang=a$_i$ lakar tangkep polisi.
self   3rd OV.know=3 FUT   OV.arrest police
'He$_i$ knew that the police would arrest self$_i$/him$_{*i}$.'

   c. ARG-ST of 'AV/OV.know':
⟨ NP$_i$, $\boxed{1}$ NP:*ana$_i$/ppro$_{*i}$*, VP[SUBJ ⟨ $\boxed{1}$ ⟩] ⟩

   d. 'OV.arrest':
$\begin{bmatrix} \text{SUBJ} & ⟨\,\boxed{1}\,⟩ \\ \text{ARG-ST} & ⟨\,\text{NP},\,\boxed{1}\,\text{NP}\,⟩ \end{bmatrix}$

(60) and (61) show the case in which the ARG-ST subject of 'think' is first person singular and the raised ARG-ST object is a third person singular pronoun. The object of 'see' has to be an anaphor rather than a personal pronoun, since it is local to the subject of 'see'. This is independent of the realization of the first two ARG-ST elements as subject or object of 'think'. (60) is the case in which the embedded verb is in agentive voice and hence the subject of 'see' is raised, and in (61), 'see' is in objective voice and hence the object of 'see' is raised.

(60) a. Cang ngaden ia$_i$ suba   ningalin awakne$_i$ / ia$_{*i}$.   (Balinese)
1sg AV.think 3rd already AV.see   self   3rd
'I believe him$_i$ to have seen himself$_i$ / him$_{*i}$.

   b. Ia$_i$ kaden   cang suba   ningalin awakne$_i$ / ia$_{*i}$.
3rd OV.think 1sg   already AV.see   self   3rd
'I believe him to have seen himself.'

   c. ARG-ST of 'AV/OV.think':
⟨ NP, $\boxed{1}$ NP$_i$, XP[SUBJ ⟨ $\boxed{1}$ ⟩] ⟩

   d. AV.'see':
$\begin{bmatrix} \text{SUBJ} & ⟨\,\boxed{1}\,⟩ \\ \text{ARG-ST} & ⟨\,\boxed{1}\,\text{NP},\,\text{NP}:\textit{ana}_i/\textit{ppro}_{*i}⟩ \end{bmatrix}$

(61) a. Cang ngaden awakne$_i$ suba tingalin=a$_i$.   (Balinese)
       1sg AV.think self$_i$ already OV.see=3

       'I believe him to have seen himself.'

    b. Awakne$_i$ kaden cang suba tingalin=a$_i$.
       self$_i$ OV.think 1sg already OV.see=3

       'I believe him to have seen himself.'

    c. ARG-ST of 'AV/OV.think':
       $\langle$ NP, ⒈ NP$_i$, XP[SUBJ $\langle$ ⒈ $\rangle$] $\rangle$

    d. OV.'see':
$$\begin{bmatrix} \text{SUBJ} & \langle\, \boxed{1}\, \rangle \\ \text{ARG-ST} & \langle\, \text{NP}_i,\ \boxed{1}\ \text{NP}:ana_i/ppro_{*i} \rangle \end{bmatrix}$$

As predicted by an ARG-ST-based Binding Theory, the bindings are independent of the realization in agentive or objective voice.

As many researchers have pointed out (van Noord & Bouma 1997: Section 5; Müller 1999b: Section 20.4.2), there is some slight imprecision when it comes to the scope of the binding principles. Principle A says that a locally o-commanded anaphor must be locally o-bound. But in raising constructions, there may be several lists on which an anaphor is locally o-commanded. Wechsler (1999) resolves this imprecision and assumes an existential version of Principle A, according to which a locally o-commanded anaphor has to be locally o-bound on *some* ARG-ST. In the example in (61), the respective ARG-ST list is the one of 'see'. In contrast, a universal interpretation is assumed for Principle B: a pronominal must be locally o-free in all ARG-ST lists in which it appears.

Wechsler (1999) compares GB analyses with ARG-ST-based HPSG analyses and shows that the GB analysis, which may seem to be parallel to the HPSG analysis, does not extend to the Balinese facts but results in an insoluble contradiction. In contrast, the lexical, ARG-ST-based HPSG Binding Theory together with a mapping from ARG-ST to grammatical functions gets the facts right without any further stipulations.

6 Explicit constructions of lists with possible antecedents

It was mentioned on p. 893 that HPSG sees binding as crucially different from nonlocal dependencies, while in GB the relation between a trace and its filler was seen as similar to pronoun binding. This section explains how the general mechanism for nonlocal dependencies (see Borsley & Crysmann 2021, Chapter 13 of this volume) can be used to account for binding data and in which way this solves or avoids problems of earlier approaches based on o-command. The idea to use the nonlocal mechanism was first suggested by Bredenkamp (1996: Section 7.2.3).

He did not work out his proposal in detail (see p. 104–105). He used the slash feature for percolation of binding information, which probably would result in conflicts with true nonlocal dependencies. Hellan (2005) developed an account using special nonlocal features for binding information. Both Bredenkamp and Hellan assume that the binding information is bound off in certain structures, as is common in the treatment of nonlocal dependencies in HPSG. In what follows, I look into Branco's (2002) account. Branco also uses the nonlocal machinery of HPSG but in a novel way, without something like a filler-head schema. Before looking into the details, I want to discuss two phenomena that have not been accounted for so far and that are problematic for a Binding Theory based on o-command: first, there is nothing that rules out nominal heads as binders, and second, there are problems with coordinations. Both problems can be solved if there is a bit more control of which indices are involved in binding relations in which local environment.

6.1 Nominal heads as binders

Pollard & Sag's (1994) definition of o-command has an interesting consequence: it does not say anything about possible binding relations between heads and their dependents. What is regulated is the binding relations between co-arguments and referential objects dominated by a more oblique coargument. As Müller (1999b: 419) pointed out, bindings like the one in (62) are not ruled out by the Binding Theory of Pollard & Sag (1994: Chapter 6):

(62) his_{*i} father_i

The possessive pronoun is selected via spr and hence a dependent of *father* (Müller 2021b; Machicao y Priemer & Müller 2021; Wechsler 2021: 230, Chapter 6 of this volume), but the noun does not appear in any arg-st list (assuming an NP analysis, see also Van Eynde 2021, Chapter 8 of this volume for discussion). The consequence is that Principles B and C do not apply, and the o-command-based Binding Theory simply does not have anything to say about (62). This problem can be fixed by assuming Hukari & Levine's (1995) version of Principle C together with their definition of vc-command in (45). This would also cover cases like (63):[28]

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[28]Giuseppe Varaschin pointed out to me that many *i*-within-*i* violations may be due to semantic/pragmatic constraints. So his_i father_i would be a person X such that X is a father of X. Since 'father' is an irreflexive predicate, the binding would clash with our expectations. Culicover (1997: 71) discusses the following example:

(i)   One finds [many books about themselves$_i$]$_i$ on Borges's literary output.

So maybe large parts of the explanation of *i*-within-*i* effects can be found in semantics/pragmatics.

(63) his$_{*i}$ father of John$_i$

What is not accounted for so far is Fanselow's (1986: 344) examples in (64):

(64) a. * die Freunde$_i$ voneinander$_i$
          the friends   of.each.other

      b. der Besitzer$_i$ seines$_{*i}$ Bootes
          the owner   of.his   boat

These examples would be covered by an *i*-within-*i*-Condition as suggested by Chomsky (1981: 212). Chomsky's condition basically rules out configurations like the one in (65):

(65) (… x$_i$ …)$_i$

Pollard & Sag (1994: 244) consider the *i*-within-*i*-Condition in their discussion of GB's Binding Theory but do not assume anything like this in their papers. Nor was anything of this kind adopted anywhere else in the discussion of binding. Having such a constraint could be a good solution, but as Fanselow (1986: 343) working in GB pointed out, such a condition would also rule out cases like his examples in (66):

(66) a. die sich$_i$ treue   Frau$_i$
          the SELF faithful woman
          'the woman who is faithful to herself'

      b. die einander$_i$ verachtenden Männer$_i$
          the each.other despising   men
          'the men who despise each other'

German allows for complex prenominal adjectival phrases. The subject of the respective adjectives or adjectival participles are coindexed with the noun that is modified. Since the reflexive and reciprocal in (66) are coindexed with the non-expressed subject, and since this subject is coindexed with the modified noun (Müller 2002: Section 3.2.7), a general *i*-within-*i*-Condition cannot be formulated for HPSG grammars of German. The problem also applies to English, although English does not have complex prenominal adjectival modifiers. Relative clauses basically produce a similar configuration:

(67) a. the woman$_i$ seeing herself$_i$ in the mirror
      b. That woman$_i$ listening to her$_i$ own voice on the radio is Barbra Strei-sand.[29]

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[29]Varaschin (2021: 50)

The non-expressed subject in (67a) is the antecedent for *herself*, and since this element is coindexed with the antecedent noun of the relative clause, we have a parallel situation. Similarly, the subject of *listening* is the antecedent of *her*.

Chomsky (1981: 229, Fn. 63) notes that his formulation of the *i*-within-*i*-Condition rules out relative clauses and suggests a revision. However, the revised version would not rule out the examples in (62)–(64) above either, so it does not seem to be of much help.

In a version of the Binding Theory that is based on command relations in tree configurations, some special constraint seems to be needed that rules out binding by and to the head of nominal constructions unless this binding is established by adnominal modifiers directly. The approach to binding discussed below accounts for *i*-within-*i* problems by explicitly collecting indices that are possible antecedents and excluding the unwanted indices in this collection. But before we look into the details, I want to discuss another area that is problematic for tree-configurational approaches in general, not just for the HPSG approach based on o-command.

6.2 Binding and coordination: Questions of locality

Müller (1999b: Section 20.4.7) pointed out that examples like (68) involving anaphors within coordinations are problematic for the HPSG Binding Theory:

(68)   Wir beschreiben ihm$_i$ [sich$_i$ und seine Familie].
       we   describe   him   SELF and his   family
       'We describe him and his family to him.'

Since *sich* 'SELF' is not local to *ihm* 'him' and since reflexives are not exempt in German (Kiss 2012: 158–159), *ihn* 'him' would be expected as the only option for a pronominal element within the coordination.

Fanselow (1987: 112) discussed such examples in the context of a GB-style Binding Theory. See also Müller (1999b: 420) for attested examples. Such sentences pose a challenge for the way locality is defined as part of the definition of local o-command. Local o-command requires that the commander and the commanded phrase are members of the same ARG-ST list (11), but the result of coordinating two NPs is usually a complex NP with a plural index:

(69)   Der Mann und die Frau   kennen / * kennt das Kind.
       the man and the woman know   knows the child
       'The man and the woman know the child.'

The NP *der Mann und die Frau* 'the man and the woman' is an argument of *kennen* 'to know'. The index of *der Mann und die Frau* 'the man and the woman' is local with respect to *das Kind* 'the child'. The indices of *der Mann* 'the man' and *die Frau* 'the woman' are embedded in the complex NP.

For the same reason, *sich* is not local to *ihm* in (68). This means that the anaphor is not locally o-commanded in any of the sentences, and hence Binding Theory does not say anything about the binding of the reflexive in these sentences: the anaphors are exempt.

For the same reason, *ihn* 'him' is not local to *er* 'he' in (70b), and hence the binding of *ihn* 'him' to *er* 'he', which should be excluded by Principle B, is not ruled out.[30]

(70)   a. Er_i sorgt nur für [sich_i und seine Familie].
            he cares only for SELF and his   family
            'He cares for himself and his family only.'

         b. Er_i sorgt nur für [ihn_{*i} und seine Familie].
            he cares only for him and his   family

Reinhart & Reuland (1993) develop a Binding Theory that works at the level of syntactic or semantic predicates. Discussing the examples in (71), they argue that the semantic representation is (72) and hence their semantic restrictions on reflexive predicates apply.

(71)   a.   The queen invited both Max and herself to our party.

         b.   * The queen_1 invited both Max and her_1 to our party.

(72)   the queen (λ x (x invited Max & x invited x))

Such an approach solves the problem for coordinations with *both … and …* having a distributive reading. Reinhart & Reuland (1993: 677) explicitly discuss coordinations with a collective reading. Since we have a collective reading in examples

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[30]If one assumed transformational theories of coordination deriving (69) from (i) below (see for example Wexler & Culicover 1980: 303 and Kayne 1994: 61, 67 for proposals to derive verb coordination from VP coordination plus deletion), the problem would be solved. However, as has been pointed out frequently in the literature, such transformation-based theories of coordinations have many problems (Bartsch & Vennemann 1972: 102; Jackendoff 1977: 192–193; Dowty 1979: 143; den Besten 1983: 104–105; Klein 1985; Eisenberg 1994; Borsley 2005: 471), and nobody has ever assumed something parallel in HPSG (see Abeillé & Chaves (2021), Chapter 16 of this volume on coordination in HPSG).

(i) Er_i sorgt nur für sich und er_i sorgt nur für seine Familie.
     he cares only for SELF and he cares only for his   family

like (70), examples like (70) continue to pose a problem. There are, however, ways to cope with such data: one is to assume a construction-based account to binding domains. The details of an account that makes this possible will be discussed in the following subsection.

6.3 The list-threading approach to binding

The discussion of early HPSG approaches to binding revealed a number of problems. The proposals are based on tree configurations and on command relations. This is basically the conceptual inheritance of the GB Binding Theory, of course with a lot of improvements. The general problem seems to be that the command relations are defined in a uniform way, without taking into account special configurations such as coordinate structures.

Now, there is a more recent approach to binding that looks technical at first, but it is the solution to the problems caused by an approach that assumes one command relation that is supposed to work for all structures in all languages. Branco (2002) suggested an approach that collects indices that are available for binding in certain binding domains.[31] The ways in which these indices are collected can be specified with reference to particular constructions, allowing the problems mentioned so far to be circumvented.

Branco (2002) argues that sentences with wrong bindings of pronouns and/or reflexives are not syntactically ill-formed, but rather semantically deviant. For the representation of his Binding Theory, he assumes Underspecified Discourse Representation Theory (UDRT; Reyle 1993; Frank & Reyle 1995) as the underlying formalism for semantics (see also Koenig & Richter 2021: Section 6, Chapter 22 of this volume).

Similar to the notions assumed in Minimal Recursion Semantics (MRS; Copestake, Flickinger, Pollard & Sag 2005; see also Koenig & Richter 2021: Section 6.1, Chapter 22 of this volume for an introduction to MRS), there is an attribute for distinguished labels that indicate the upper (L-MAX) and lower (L-MIN) bounds for quantifier scope, and there is a set of subordination conditions for quantifier scope (the HCONS set in MRS), as well as a list of semantic conditions (the RELS set in MRS). In addition, Branco suggests a feature ANAPH(ORA) for handling the Binding Theory constraints. Information about the anaphoric potential of nominals is represented there. There is a reference marker represented under R(EFERENCE)-MARK(ER), and there is a list of reference markers under AN-TEC(EDENTS). The list is set up in a way so that it contains the antecedent can-

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[31]For a much more detailed overview of Branco's approach, see Branco (2021).

didates of a nominal element. Furthermore, Branco adds special lists containing antecedents for special types of anaphora. The lists are named after the binding principles that were already discussed in previous sections: LIST-A contains all reference markers of elements that locally o-command a certain nominal expression *n* ordered with respect to their obliqueness, and LIST-Z contains all o-commanders, also including everything from LIST-A. The elements in LIST-Z may come from various embedded clauses and are also ordered with respect to their obliqueness. The list LIST-U contains all the reference markers in the discourse context including those not linguistically introduced. The list LIST-LU is an auxiliary list that will be explained below.

(73)

$$
\begin{bmatrix}
\text{LOC}|\text{CONT} & \begin{bmatrix}
udrs \\
\text{LS} & \begin{bmatrix} \text{L-MAX} \;\boxed{1} \\ \text{L-MIN} \;\boxed{1} \end{bmatrix} \\
\text{SUBORD} \;\{...\} \\
\text{CONDS} \;\{...\} \\
\text{ANAPH} & \begin{bmatrix} \text{R-MARK } refm \\ \text{ANTEC } \; list(refm) \end{bmatrix}
\end{bmatrix} \\[2em]
\text{NONLOC}|\text{BIND} & \begin{bmatrix}
bind \\
\text{LIST-A} \; list(refm) \\
\text{LIST-Z} \; list(refm) \\
\text{LIST-U} \; list(refm) \\
\text{LIST-LU} \; list(refm)
\end{bmatrix}
\end{bmatrix}
$$

The lists containing possible antecedents for various nominal elements are represented under NONLOCAL as the value of a newly introduced feature BIND. These binding lists differ from other NONLOCAL features in that nothing is ever removed from them (for unbounded dependencies and NONLOCAL features in general, see Borsley & Crysmann (2021), Chapter 13 of this volume). Before I provide the principles that determine the list values, I will explain them on an example. Figure 10 shows the relevant aspects of the analysis of (74):

(74)   Every student thought that she saw herself.

The noun phrase *every student* introduces the reference marker (R-MARK) $\boxed{3}$ for e-type anaphora (Evans 1980) and, as the value of VAR, the value used for bound-variable anaphora interpretations (Reinhart 1983). This is $\boxed{2}$ in the example. The pronouns *she* and *herself* introduce the reference markers $\boxed{4}$ and $\boxed{5}$ respectively. All these reference markers are added to the bookkeeping list LIST-LU of the respective lexical items: *she* has $\boxed{4}$ in its LIST-LU, and *herself* has $\boxed{5}$ in this list. The
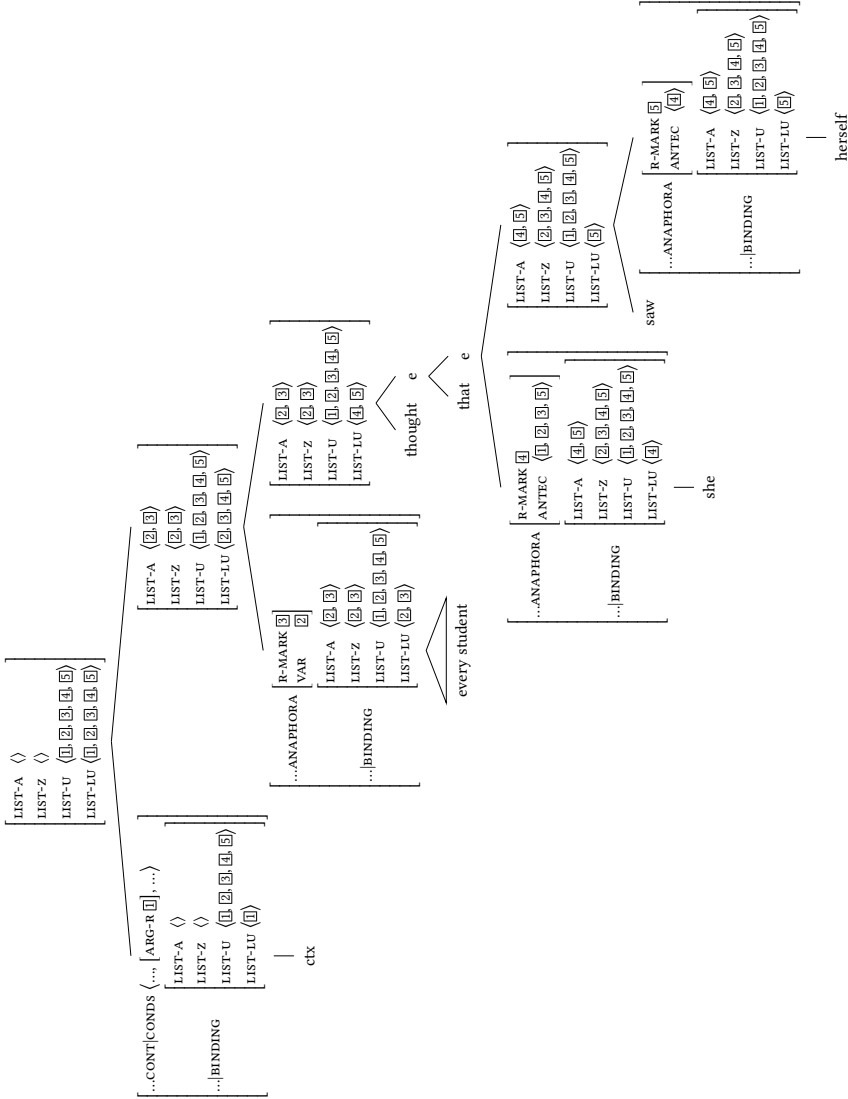
Figure 10: Partial grammatical representation of *Every student thought that she saw herself.*

noun phrase *every student* has both the variable ② and the reference marker (③) in the LIST-LU. As can be seen by looking at the individual nodes in Figure 10, the elements of LIST-LU in daughters are collected at the mother node. The element *ctx* is an empty element that stands for the non-linguistic context. It is combined with one or more sentences to form a text fragment (see also Lücking, Ginzburg & Cooper (2021), Chapter 26 of this volume for discourse models and HPSG). The CONDS list of the *ctx* element contains semantic relations that hold of the world, and all reference markers contained in these relations are also added to the LIST-LU list. In the example, this is just ①. The example shows just one sentence that is combined with the empty head, but in principle there can be arbitrarily many sentences. The LIST-LU list at the top node contains all reference markers contained in all sentences and the non-linguistic context.

The top node of Figure 10 is licensed by a schema that also identifies the LIST-U value with the LIST-LU value. The LIST-U value is shared between mothers and their daughters, and since LIST-LU is a collection of all referential markers in the tree and this collection is shared with LIST-U at the top node, it is ensured that all nodes have a LIST-U value that contains all reference markers available in the whole discourse. In our example, all LIST-U values are ⟨ ①, ②, ③, ④, ⑤ ⟩.

LIST-A values are determined with respect to the argument structures of governing heads. So the LIST-A value of *thought* is ⟨ ②, ③ ⟩, and the one of *saw* is ⟨ ④, ⑤ ⟩. The LIST-A values of NP or PP arguments are identical to the ones of the head, hence *she* and *herself* have the same LIST-A value as *saw*, and *every student* has the same LIST-A value as *thought*. Apart from this, the LIST-A value is projected along the head path in non-nominal and non-prepositional projections. For further cases, see Branco (2002: 77).

The value of LIST-Z is determined as follows (Branco 2002: 77): for all sentences combined with the context element, the LIST-Z value is identified with the LIST-A value. Therefore, the LIST-Z value of *every student thought that she saw herself* is ⟨ ②, ③ ⟩: the LIST-A value is projected from *thought* and then identified with the LIST-Z value. In sentential daughters that are not at the top-level, the LIST-Z value is the concatenation of the LIST-Z value of the mother and the LIST-A value of the sentential daughter. In other non-filler daughters of a sign, the LIST-Z value is structure shared with the LIST-Z value of the sign. For example, *she* and *saw* and *herself* have the same LIST-Z value, namely ⟨ ②, ③, ④, ⑤ ⟩.

Branco (2002: 78) provides the lexical item in (75) for a pronoun. The interesting thing about the analysis is that all information that is needed to determine possible binders of the pronoun are available in the lexical item of the pronoun. The relational constraint `principleB` takes as input the LIST-A list ③, the LIST-U

(75)   Parts of the SYNSEM value for *she*:

$$
\begin{bmatrix}
\text{LOC}|\text{CONT}
\begin{bmatrix}
\text{LS} & \begin{bmatrix} \text{L-MAX } \boxed{1} \\ \text{L-MIN } \boxed{1} \end{bmatrix} \\[2ex]
\text{SUBORD} \{\} \\[1ex]
\text{CONDS} & \left\{ \begin{bmatrix} \text{LABEL } \boxed{1} \\ \text{DREF } \boxed{2} \end{bmatrix} \right\} \\[2ex]
\text{ANAPH} & \begin{bmatrix} \text{R-MARK } \boxed{2} \\ \text{ANTEC} \ \texttt{principleB}\big(\boxed{4}, \boxed{3}, \boxed{2}\big) \end{bmatrix}
\end{bmatrix} \\[6ex]
\text{NONLOC}|\text{BIND}
\begin{bmatrix}
\text{LIST-A} & \boxed{3} \\
\text{LIST-Z} & list(refm) \\
\text{LIST-U} & \boxed{4} \\
\text{LIST-LU} & \big\langle \boxed{2} \big\rangle
\end{bmatrix}
\end{bmatrix}
$$

list $\boxed{4}$ and the reference marker of the pronoun under consideration ($\boxed{2}$). The result of the application of `principleB` is the list of reference markers that does not contain elements locally o-commanding the pronoun, since all o-commanders of the reference marker $\boxed{2}$, which are contained in the LIST-A, are removed from LIST-U (the list of all reference markers in the complete discourse). In the case of *she* in our example, `principleB` returns the complete discourse $\langle \boxed{1}, \boxed{2}, \boxed{3}, \boxed{4}, \boxed{5} \rangle$ minus all reference markers of elements less oblique than $\boxed{4}$, which is the empty list (since $\boxed{4}$ is the first element of $\langle \boxed{4}, \boxed{5} \rangle$ in Figure 10), minus $\boxed{4}$, since the pronoun is not a possible antecedent of itself. So, the list of possible antecedents of *she* is $\langle \boxed{1}, \boxed{2}, \boxed{3}, \boxed{5} \rangle$. This list contains $\boxed{5}$ as a possible binder, which is of course unwanted. According to Branco (2002: 84), *herself* as a binder of *she* is ruled out, since *she* binds *herself*.

The SYNSEM value for *herself* is shown in (76). LIST-A contains the reference markers of locally o-commanding phrases ($\boxed{3}$). Together with the reference marker of *herself* ($\boxed{2}$), $\boxed{3}$ is the input to the relational constraint `principleA`. This constraint returns a list containing all possible binders for $\boxed{2}$, that is, all elements of $\boxed{3}$ that are less oblique than $\boxed{2}$. If there is no such element, the returned list is the empty list and the anaphor is exempt (see Section 2.3).

The example discussed here involves a personal pronoun and a reflexive. The antecedents were determined by the relational constraints `principleB` and `principleA`. Further relational constraints are assumed for long-distance reflexives (`principleZ`) and normal referential NPs (`principleC`). `principleC` is part of the description of the specifier used in non-lexical anaphoric nominals (Branco 2002: 79).

(76)   Parts of the SYNSEM value for *herself*:

$$
\begin{bmatrix}
\text{LOC}|\text{CONT} & \begin{bmatrix}
\text{LS} & \begin{bmatrix} \text{L-MAX} & \boxed{1} \\ \text{L-MIN} & \boxed{1} \end{bmatrix} \\
\text{SUBORD} & \{\} \\
\text{CONDS} & \left\{ \begin{bmatrix} \text{LABEL} & \boxed{1} \\ \text{DREF} & \boxed{2} \end{bmatrix} \right\} \\
\text{ANAPH} & \begin{bmatrix} \text{R-MARK} & \boxed{2} \\ \text{ANTEC} & \texttt{principleA}(\boxed{3}, \boxed{2}) \end{bmatrix}
\end{bmatrix} \\
\text{NONLOC}|\text{BIND} & \begin{bmatrix}
\text{LIST-A} & \boxed{3} \\
\text{LIST-Z} & \textit{list(refm)} \\
\text{LIST-U} & \textit{list(refm)} \\
\text{LIST-LU} & \langle \boxed{2} \rangle
\end{bmatrix}
\end{bmatrix}
$$

The setting-up of the LIST-A and LIST-U lists is flexible enough to take care of problems that are unsolvable in the standard HPSG approach (and in GB approaches). For example, the LIST-U list of a noun phrase can be set up in such a way that the reference marker of the whole NP, which is introduced by the specifier, is not contained in the LIST-U list of the $\overline{\text{N}}$ that is combined with it. As pointed out by Branco (2002: 76), this solves *i-within-i* puzzles, which were discussed in Section 6.1.

Note also that this flexibility in determining the lists of possible local antecedents on a construction specific basis makes it possible for the first time to account for puzzling data like the coordination data discussed in Section 6.2. If the coordination analysis standardly assumed in HPSG (see Abeillé & Chaves 2021, Chapter 16 of this volume) is on the right track, a special rule for licensing coordination is needed, and this rule can also incorporate the proper specification of binding domains with respect to coordination.

Summing up, it can be said that the lexical, list-based solution discussed in this last section provides flexibility in defining binding domains and can cope with the *i-within-i* problem and problems of locality.

7 Conclusion

I have discussed several approaches to Binding Theory in HPSG. It was shown that the valence-based approach that refers to the ARG-ST list of lexical items has advantages over proposals that exclusively refer to tree configurations. Since tree configurations play a minor role in HPSG's Binding Theory, binding data does

not force syntacticians to assume structures branching in a certain way. This sets HPSG apart from theories like Government & Binding and Minimalism, in which empty nodes are assumed for sentences with ditransitive verbs in order to account for binding facts (Borsley & Müller 2021: 1284–1286, Chapter 28 of this volume).

A further highlight is the treatment of so-called exempt anaphors, that is, anaphors that are not commanded by a possible antecedent. Pollard & Sag (1992) argued that these anaphors should not be regarded as constrained by the Binding Theory and hence that binding by antecedents outside of the clause or the projection are possible.

Finally, a lexical approach to binding that makes all the relevant binding information available locally within lexical items of pronouns/reflexives/reciprocals was discussed. This approach is flexible enough to deal with problematic aspects like the *i*-within-*i* situations and locality problems in coordinated structures.

Abbreviations

AV agentive voice
OV objective voice
PM pivot marker

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