Chapter 21

Anaphoric Binding

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The interpretation of anaphors depends on their antecedents and respective semantic value. This chapter presents the constraints on the admissible antecedents of nominal anaphors, and thus on their interpretation, that are based on grammatical relations and structure. The integration into grammar of these anaphoric binding constraints, as well as of the semantic representation of anaphors, is also presented here.

1 Introduction

In large enough contexts, a nominal anaphoric expression may have more admissible antecedents than the antecedent that happen to be eventually selected to co-specify its interpretation. And when occurring in a given syntactic position, different anaphoric expressions may have different sets of admissible antecedents. This is illustrated in the examples below, with three anaphors from English — *herself*, *her*, and *the little girl* — occurring in the same position, each with different sets of admissible antecedents.

(1) Mary's friend knowns that Paula's sister described Joan to herself/her/the little girl.

For the expression *the little girl*, either *Mary* or *Paula* is an admissible antecedent. For *her*, in turn, its set of admissible antecedents also includes *Mary's friend*, while *herself* has *Paula's sister* and *Joan* as admissible antecedents.

Such differences in terms of sets of admissible antecedents is the basis for the partition of nominal anaphoric expressions into different groups according to their anaphoric capacity. It has been an important topic of research to determine

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how many such groups or types of anaphoric expressions there are, what expressions belong to which type in each language, and what exactly are the sets of admissible antecedents for each type.

The results of this inquiry have been condensed in a handful of anaphoric binding constraints, or principles, which seek to capture the relative positioning of anaphors and their admissible antecedents in grammatical representations.

From an empirical perspective, these constraints stem from what appears as quite cogent generalisations and exhibit a universal character, given the hypothesis of their parameterised validity across languages. From a conceptual point of view, in turn, the relations among binding constraints involve non-trivial cross symmetry, which lends them a modular nature and provides further strength to the plausibility of their universal character.

Accordingly, binding principles, together with their auxiliary notions, have been considered one of the most significant modules of grammatical knowledge, usually termed as binding theory.

This grammar module is presented in the present chapter. In the next Section 2, the empirical generalisation captured in the binding constraints are introduced, together with the relevant auxiliary notions and parameterisation options.

The key ingredients for the integration of binding constraints into grammar are discussed in Section 3, and a detailed account of this integration is provided in the following Section 4, which is then illustrated with the support of a working example in Section 5.

The following Section 6 is devoted to discuss how the account of anaphoric binding presented in the previous Sections ensures a neat interface of grammar with reference processing systems, and thus supports a seamlessly articulation of binding constraints with anaphora resolution.

In the penultimate Section 7, additional binding constraints are introduced that hold from the perspective of the antecedents, rather from the perspective of the anaphors, together with the respective supporting empirical evidence.

The final Section 8 is devoted to underline the design features that were identified as crucial for an account of the grammar of anaphoric binding constraints, and to provide an outlook to promising avenues for future research that may further enhance our understanding of binding and of the semantics of nominal anaphors.

2 Empirical generalizations

Since the so called integrative approach to anaphora resolution was set up,[1] it is common wisdom that factors determining the antecedents of anaphors divide into filters, or hard constraints, and preferences, or soft constraints. The former exclude impossible antecedents and help to circumscribe the set of admissible antecedents; the latter interact to converge on the eventual antecedent among the admissible antecedents. So-called binding principles are a notorious subset of hard constraints on anaphora resolution: They capture generalisations concerning the constraints on the relative positioning of anaphors with respect to their admissible antecedents in the grammatical geometry of sentences.

We present below the definition of binding constraints,[2] paired with some illustrative examples. These constraints on the anaphoric capacity of nominals induce a partition of the set of anaphors into four classes. According to this partition, every nominal phrase anaphor is of one of the following anaphoric types: Short-distance reflexive, long-distance reflexive, pronoun, or non-pronoun:

(2) **Principle A**: A locally o-commanded short-distance reflexive must be locally o-bound.

... X_x... [Lee$_i$'s friend]$_j$ thinks [[Max$_k$'s neighbour]$_l$ likes himself$_{*x/*i/*j/*k/l}$].

Principle Z: An o-commanded long-distance reflexive must be o-bound.

... X_x... [O amigo do Lee$_i$]$_j$ acha [que [o vizinho do Max$_k$]$_l$
... X_x... the friend of_the Lee thinks that the neighbour of_the Max
gosta dele próprio$_{*x/*i/j/*k/l}$]. (Portuguese)
likes of_him self
'... X_x... [Lee$_i$'s friend]$_j$ thinks [[Max$_k$'s neighbour]$_l$ likes
him$_{*x/*i/j/*k}$/ himself$_l$]'

Principle B: A pronoun must be locally o-free.

... X_x... [Lee$_i$'s friend]$_j$ thinks [[Max$_k$'s neighbour]$_l$ likes him$_{x/i/j/k/*l}$].

[1] (Carbonell & Brown 1988; Rich & LuperFoy 1988; Asher & Wada 1989) whose practical viability was extensively checked out in (Lappin & Leass 1994; Mitkov 1997)

[2] This is the approach to binding theory proposed in (Pollard & Sag 1994: Chap.6) and subsequent developments in (Xue et al. 1994; Branco 1996; Branco & Marrafa 1997; Manning & Sag 1999; Wechsler 1999; Koenig 1999; Branco & Marrafa 1999; Richter et al. 1999; Golde 1999; Branco 2000c; Kiss 2001; Branco 2002a,c,b) *i.a.*

Principle C: A non-pronoun must be o-free.

... X_x... [Lee$_i$'s friend]$_j$ thinks [[Max$_k$'s neighbour]$_l$ likes the boy$_{x/i/*j/k/*l}$].

2.1 Parameterisation

The empirical generalisations presented above are rendered with the help of a few auxiliary notions. For many of these auxiliary notions, their final value or definition is amenable to be set according to a range of options: As briefly exemplified below, this parameterisation may be driven by the particular language at stake, by the relevant predicator selecting the anaphor, by the specific anaphoric form, etc.

These are the definitions of those auxiliary notions:

O-binding is such that x o-binds y iff x o-commands y and x and y are coindexed (*o-freeness* is non o-binding).

Coindexation is meant to represent an anaphoric link between the expressions with the same index ('... X_x ...' represents a generic, extra-sentential antecedent). Plural anaphors with so-called split antecedents, that is concomitantly more than one antecedent, have a sum of indexes as a subscript, as exemplified below by *them* being interpreted as referring to John and Mary:[3]

(3) John$_i$ told Mary$_j$ that Kim talked about them$_{i+j}$.

Command *o-command* is a partial order defined on the basis of obliqueness hierarchies, possibly embedded in each other along the relation of subcategorisation: "Y o-commands Z just in case either Y is less oblique than Z; or Y o-

[3]When at least one of the antecedents in a split antecedent relation does not comply with the relevant binding principle (and there is at least one that complies with it), the acceptability of that anaphoric link degrades. Apparently, the larger the number of antecedents that violate the binding constraint the less acceptable is the anaphoric link: While both examples below are not fully acceptable, two coindexations out of three, via j and k, in violation of the Principle B render example b. less acceptable than example a., which has one coindexation only, via k, in violation of that binding constraint (Seeley 1993: 313):

(i) a. ? The doctor$_i$ told the patient$_j$ [that the nurse$_k$ would protect them$_{i+j+k}$ during the storm].

b. ?? The doctor$_i$ said [that the patient$_j$ told the nurse$_k$ about them$_{i+j+k}$].

As for plural reflexives, which in turn comply with Principle A, they accept split antecedents only in exempt positions — on the notion of exemption, see Section 2.2.

commands some X that subcategorises for Z; or Y o-commands some X that is a projection of Z" (Pollard & Sag 1994: p.279).[4] Accordingly, in a clause, the Subject o-commands the Direct Object, the Direct Object o-commands the Indirect Object, etc.; and in a multi-clausal sentence, the arguments in the upwards clauses o-command the arguments in the successively embedded clauses.

In languages like English, the o-command order can be established over the obliqueness hierarchies of active and passive sentences alike:[5]

(4) a. John$_i$ shaved himself$_i$.
b. John$_i$ was shaved by himself$_i$.

In some other languages, only the obliqueness hierarchy of the unmarked construction of a given syntactic alternation is available to support the o-command order relevant for binding constraints both in the unmarked and the marked constructions of that alternation.

This is the case, for example, of the alternation active/objective voice in Toba Batak. In this language, a reflexive in Object position of an active voice sentence can have the Subject as its antecedent, but not vice-versa:[6]

(5) a. mang-ida diri-na$_i$ si John$_i$. (Toba Batak)
[ACTIVE-saw himself$_{\text{OBJECT}}$]$_{\text{VP}}$ PM John$_{\text{SUBJECT}}$
'John$_i$ saw himself$_i$.'
b. mang-ida si John$_i$ diri-na$_{*i}$.
[ACTIVE-saw PM John$_{\text{OBJECT}}$]$_{\text{VP}}$ himself$_{\text{SUBJECT}}$

Taking the objective voice paraphrase corresponding to the active sentence above, the binding pattern is inverted: A reflexive in Subject position can have the Object as its antecedent, but not vice-versa, thus revealing that the obliqueness hierarchy relevant for the verification of its binding constraint remains the hierarchy of the corresponding active voice sentence above:

(6) a. di-ida diri-na$_{*i}$ si John$_i$.
[OBJECTIVE-saw himself$_{\text{OBJECT}}$]$_{\text{VP}}$ PM John$_{\text{SUBJECT}}$
b. di-ida si John$_i$ diri-na$_i$.
[OBJECTIVE-saw PM John$_{\text{OBJECT}}$]$_{\text{VP}}$ himself$_{\text{SUBJECT}}$
'John$_i$ saw himself$_i$.'

[4] For a discussion of the notion of obliqueness as well as further references on this topic, see (Pollard & Sag 1987: Sec.5.2).
[5] (Jackendoff 1972; Pollard & Sag 1994).
[6] (Manning & Sag 1999: p.72).

Subject-orientedness o-command may take the shape of a linear or a non linear order depending on the specific obliqueness hierarchy upon which it is realised.

In a language like English, the arguments in the subcategorisation frame of a predicator are typically arranged in a linear obliqueness hierarchy.

In some other languages, the obliqueness hierarchy upon which the o-command order is based may happen to be non linear: In the subcategorisation frame of a predicator, the Subject is less oblique than any other argument while the remaining arguments are not comparable to each other under the obliqueness relation. As a consequence, in a clause, a short-distance reflexive with an Indirect Object grammatical function, for instance, may only have the Subject as its antecedent, its only local o-commander.[7]

This Subject-orientedness effect induced on the anaphoric capacity of reflexives by the non linearity of the o-command relation can be observed in contrasts like the following:[8]

(7) a. Lars$_i$ fortalte Jon$_j$ om seg selv$_{i/*j}$. (Norwegian)
Lars told Jon about self *selv*
'Lars$_i$ told Jon$_j$ about himself$_{i/*j}$.'

b. Lars$_i$ fortalte Jon$_j$ om ham selv$_{*i/j}$.
Lars told Jon about him *selv*
'Lars$_i$ told Jon$_j$ about him$_{*i/j}$.'

In the first sentence above, the reflexive cannot have the Direct Object as its antecedent given that the Subject is its only local o-commander in the non linear obliqueness hierarchy. In the second sentence, under the same circumstances, a pronoun presents the symmetric pattern: It can have any co-argument as its antecedent except the Subject, its sole local o-commander.

Locality The *local domain* of an anaphor results from the partition of sentences and associated grammatical geometry into two zones of greater or less proximity with respect to the anaphor.

Typically, the local domain coincides with the immediate selectional domain of the predicator directly selecting the anaphor, as in the examples above in (2).

[7] For a thorough argument and further evidence also motivated independently of binding facts see (Branco 1996; Branco & Marrafa 1997; Branco 2000c). In some languages, there can be an additional requirement that the Subject be animate to qualify as a commander to certain anaphors. On this, see (Huang & Tang 1991; Xue et al. 1994) about Chinese *ziji*, among others.

[8] Lars Hellan p.c. See also (Hellan 1988: p.67).

In some cases, there may be additional requirements that the local domain is circumscribed by the first selecting predicator that happens to be finite, bears tense or indicative features, etc.[9] One such example can be the following:[10]

(8) a. Jón$_i$ segir að [Maria$_j$ elskar sig$_{*i/j}$]. (Icelandic)
Jón says-IND that Maria loves-IND himself
'Jón$_i$ says that [Maria$_j$ loves himself$_{*i}$/herself$_j$].'

b. [Jón$_i$ segir að Maria$_j$ elski sig$_{i/j}$].
Jón says-IND that Maria loves-SUBJ himself
'[Jón$_i$ says that Maria$_j$ loves himself$_i$/herself$_j$].'

In the first sentence above, the verb in the embedded clause is Indicative and the local domain of its Direct Object is circumscribed to this clause as the reflexive cannot have the Subject of the upwards clause as its antecedent. The second sentence is identical to the first one except that the mood of the embedded verb is now Subjunctive. This leads to a change in the local domain of the reflexive: It can now have also the upwards Subject as its antecedent, thus revealing that its local domain is determined by the first selecting verb in the Indicative, which happens now to be the verb of the upwards clause.

In some other languages, there are anaphors whose local domain is the immediate selectional domain not of the directly selecting predicator but of the immediately upwards predicator, irrespective of the inflectional features of the directly or indirectly selecting predicators. This seems to be the case of the Greek *o idhios*:[11]

(9) O Yannis$_i$ ipe stin Maria [oti o Costas$_j$ pistevi [oti o Vasilis$_k$
the Yannis told the Maria that the Costas believes that the Vasilis
aghapa ton idhio$_{??i/j/*k}$]]. (Greek)
loves the same.
'Yannis$_i$ told Maria that [Costas$_j$ believes that [Vasilis$_k$ loves
him$_{??i/j/*k}$]]'

Languages shows diversity concerning which of these options are materialized and which grammatical and lexical means are brought to bear.[12] Additionally, not all languages have anaphors of every one of the anaphoric types: For instance, English is not known to have long-distance reflexives.

[9] Vd. (Manzini & Wexler 1987; Koster & Reuland 1991; Dalrymple 1993) for further details.
[10] (Manzini & Wexler 1987: p.47).
[11] Alexis Dimitriadis p.c. See also (Iatridou 1986; Varlokosta & Hornstein 1993).
[12] (Dimitriadis et al. 2005).

2.2 O-bottom positions: reshuffling and exemption

For the interpretation of an anaphor to be accomplished, an antecedent has to be found for it. Such an antecedent is to be picked from the set of its o-commanders, if the anaphor is a long-distance reflexive, or from the set of its local o-commanders, if it is a short-distance reflexive. This requirement may not be satisfied in some specific cases, namely when the reflexive occurs in a syntactic position such that it is the least element of its o-command order, in an o-bottom position for short. In such circumstances, it has no o-commander (other than itself, if the o-command relation is formally defined as a reflexive relation) to qualify as its antecedent.

Reshuffling As a consequence, in some cases, the binding domain for the reflexive which happens to be the least element of its local obliqueness order may be reshuffled, being reset as containing the o-commanders of the reflexive in the domain circumscribed by the immediately upwards predicator.[13] One such case for a nominal domain can be found in the following example:[14]

(10) a. Gernot$_i$ dachte, dass Hans$_j$ dem Ulrich$_k$ [Marias$_l$ Bild von sich$_{*i/*j/*k/l}$] überreichte. (German)
Gernot thought that Hans the Ulrich Maria's picture of self gave
'Gernot$_i$ thought that Hans$_j$ gave Ulrich$_k$ [Maria$_l$'s picture of himself$_{*i/*j/*k}$/herself$_l$].'

b. Gernot$_i$ dachte, dass [Hans$_j$ dem Ulrich$_k$ ein Bild von sich$_{*i/j/k}$ überreichte].
Gernot thought that Hans the Ulrich a picture of self gave
'Gernot$_i$ thought that [Hans$_j$ gave Ulrich$_k$ [a picture of himself$_{*i/j/k}$]].'

In the first sentence above, the short-distance reflexive is locally o-commanded by *Maria* and only this nominal can be its antecedent. In the second sentence, the reflexive is the first element in its local obliqueness hierarchy and its admissible antecedents, which form now its local domain, are the nominals in the obliqueness hierarchy of the immediately upwards predicator.

The null subject in languages like Portuguese is another example of a short-distance reflexive that is in an o-bottom position and whose local domain is

[13] (Branco 2005b).

[14] Tibor Kiss p.c., which is a development with regards to his data in (Kiss 2001).

reshuffled:[15]

(11) O médico$_i$ disse-me [que [o director do Pedro$_j$]$_k$ ainda não
the doctor told-me that the director of_the Pedro yet not
reparou [que $\emptyset_{*i/*j/k}$ cometeu um erro]]. (Portuguese)
noticed that made a mistake.
'The doctor$_i$ told me [that [Pedro$_j$'s director]$_k$ didn't notice yet [that
he$_{*i/*j/k}$ made a mistake]]'

In the example above, as the null reflexive is in an o-bottom position, its local domain gets reshuffled to include the immediately upwards o-commander *Pedro's director*, and once it is thus o-commanded, in accordance do Principle A, it cannot take other nominal in the sentence, viz. *the doctor* or *Pedro*, as its admissible antecedent given none of these o-commands it.

Exemption In some other cases, this resetting of the binding domain is not available. In such cases, the reflexive is in the bottom of its local obliqueness order and is observed to be exempt of its typical binding regime: The reflexive may take antecedents that are not its o-commanders or that are outside of its local or immediately upward domains,[16] as illustrated in the following example:[17]

(12) Mary$_i$ thought the artist had done a bad job, and was sorry that her parents came all the way to Columbus just to see the portrait of herself$_i$.

In an exempt position, a reflexive can even have so-called split antecedents, as illustrated in the following example with a short-distance reflexive:[18]

(13) Mary$_i$ eventually convinced her sister Susan$_j$ that John had better pay visits to everybody except themselves$_{i+j}$.

That is an option not available for reflexives in non exempt positions:

(14) Mary$_i$ described$_j$ John to themselves$_{*(i+j)}$.

Some long-distance reflexives may also be exempt from their binding constraint if they occur in the bottom of their o-command relation. In such cases, they can have an antecedent in the previous discourse sentences or in the context, or a deictic use, as illustrated in the following example:

[15] (Branco 2007).
[16] (Pollard & Sag 1994: p.263).
[17] (Golde 1999: p.73).
[18] (Zribi-Hertz 1989: p.42).

(15) [O Pedro e o Nuno]$_i$ também conheceram ontem a Ana. Eles
the Pedro and the Nuno also met yesterday the Ana. They
próprios$_i$ ficaram logo a gostar muito dela. (Portuguese)
próprios stayed immediately to liking much of_her
'[Pedro and Nuno]$_i$ also met Ana yesterday. They$_i$ liked her very much
right away.'

Such options are not available in non exempt positions:[19]

(16) A Ana também conheceu ontem [o Pedro e o Nuno]$_i$. Ela
The Ana also met yesterday the Pedro and the Nuno. She
ficou logo a gostar muito deles próprios$_{*i}$. (Portuguese)
stayed immediately to liking much of_them *próprios*
'Ana also met [Pedro and Nuno]$_i$ yesterday. She liked them$_{*i}$ very much
right away.'

Admittedly, an overarching interpretability condition is in force in natural languages requiring the meaningfulänchoring of anaphors to antecedents. Besides this general requirement, anaphors are concomitantly ruled by specific constraints concerning their particular anaphoric capacity, including the sentence-level constraints in (2), i.e. the binding principles. When reflexives are in o-bottom positions, an o-commander (other than the reflexive itself) may not be available to function as antecedent and anchor their interpretation. Hence, such specific binding constraints, viz. Principle A and Z, cannot be satisfied in a "meaningful" way and the general interpretability requirement may supervene them. As a consequence, in cases displaying so-called exemption from binding constraints, o-bottom reflexives appear to escape their specific binding regime to comply with such general requirement and its interpretability be rescued.

The anaphoric links of exempt reflexives have been observed to be governed by a range of non sentential factors (from discourse, dialogue, non linguistic context, etc.), not being determined by the sentence-level binding principles in (2).[20]

3 Binding Constraints at the Syntax-Semantics Interface

Like other sorts of constraints on semantic composition, binding constraints impose grammatical conditions on the interpretation of certain expressions —

[19]For further details, vd. (Branco & Marrafa 1999).
[20]For further details, vd. (Kuno 1987; Zribi-Hertz 1989; Golde 1999) among others.

anaphors, in the present case — based on syntactic geometry.[21] This should not be seen, however, as implying that they express grammaticality requirements. By replacing, for instance, a pronoun by a reflexive in a sentence, we are not turning a grammatical construction into an ungrammatical one, even if we assign to the reflexive the antecedent adequately selected for the pronoun. In that case, we are just asking the hearer to try to assign to that sentence a meaning that it cannot express, in the same way as what would happen if we asked someone whether he could interpret *The red book is on the white table* as describing a situation where a white book is on a red table.

In this example, given how they happen to be syntactically related, the semantic values of *red* and *table* cannot be composed in a way that this sentence could be used to describe a situation concerning a red table, rather than a white table.

Likewise, if we take the sentence *John thinks Peter shaved him*, given how they happen to be syntactically related, the semantic values of *Peter* and *him* cannot be composed in a way that this sentence could be used to describe a situation where John thinks that Peter shaved himself, i.e. Peter, rather than a situation where John thinks that Peter shaved other people, e.g. Paul, Bill, etc., or even John himself.

The basic difference between these two cases is that, while in the first the composition of the semantic contributions of *white* and *table* (for the interpretation of their NP *white table*) is constrained by local syntactic geometry, in the latter the composition of the semantic contributions of *John* and *him* (for the interpretation of the NP *him*) is constrained by non-local syntactic geometry.

These grammatical constraints on anaphoric binding should thus be taken as conditions on semantic interpretation, given they that delimit (non-local) aspects of meaning composition, rather than aspects of syntactic wellformedness.[22]

These considerations leads one to acknowledge that, semantically, an anaphor should be specified in the lexicon as a function whose argument is a suitable representation of the context — providing a semantic representation of the NPs available in the discourse vicinity —, and delivers both an update of its anaphoric potential — which is instantiated as the set of its grammatically admissible antecedents — and an update of the context, against which other NPs are inter-

[21] For a discussion of proposals in the literature that have tried to root binding principles on non-grammatical, cognitive search optimisation mechanisms, and their pitfalls, see (Branco 2000a; 2003; 2004).

[22] This approach is in line with (Gawron & Peters 1990), and departs from other approaches where binding constraints have been viewed as wellformedness conditions, thus belonging to the realm of Syntax: "[they] capture the distribution of pronouns and reflexives" (Reinhart & Reuland 1993: p.657).

preted.[23] Naturally, all in all, there will be four of such functions available to be lexically associated with anaphors, each corresponding to one of the different four classes of anaphors, in accordance with the four binding constraints A, Z, B or C.[24]

3.1 Semantic patterns

For an anaphoric nominal *n*, the relevant input context may be represented in the form of a set of three lists of reference markers,[25] **A**, **Z** and **U**. List **A** contains the reference markers of the local o-command order where *n* is included, ordered according to their relative grammatical obliqueness; **Z** contains the markers of the (local and non local) o-command order where *n* is included, i.e. reference markers organised in a possibly multi-clausal o-command relation, based upon successively embedded clausal obliqueness hierarchies; and **U** is the list of all reference markers in the discourse context, possibly including those not linguistically introduced.

The updating of the context by an anaphoric nominal *n* may be seen as consisting simply in the incrementing of the representation of the former, with a copy of the reference marker of *n* being added to the three lists above.

The updating of the anaphoric potential of *n*, in turn, delivers a representation of the contextualised anaphoric potential of *n* in the form of the list of reference markers of its admissible antecedents. This list results from the binding constraint associated with *n* being applied to the relevant representation of the context of *n*.

Given this setup, the algorithmic verification of binding constraints consists of a few simple operations, and their grammatical specification will consist thus in stating each such sequence of operations in terms of the grammar description formalism.

If the nominal *n* is a short-distance reflexive, its semantic representation is updated with **A′**, where **A′** contains the reference markers of the o-commanders of *n* in **A**.

If *n* is a long-distance reflexive, its semantic representation includes **Z′**, such that **Z′** contains the o-commanders of *n* in **Z**.

[23] (Branco 1998b; 2000b; 2002a).

[24] This is in line with (Johnson & Klein 1990) concerning the processing of the semantics of nominals, and also the spirit (but by no means the letter) of the dynamic semantics framework — vd. (Chierchia 1995) and (Stalnaker 1998) *i.a.*

[25] See (Karttunen 1976; Kamp 1981; Heim 1982; Seuren 1985; Kamp & Reyle 1993) for the notion of reference marker.

If n is a pronoun, its semantics should include the list of its non-local o-commanders, that is the list **B**=**U**\(**A′**∪[r-mark$_n$]) is encoded into its semantic representation, where r-mark$_n$ is the reference marker of n.

Finally if n is a non-pronoun, its updated semantics keeps a copy of list **C**=**U**\(**Z′**∪[r-mark$_n$]), which contains the non-o-commanders of n.

3.2 Binding principles and other constraints for anaphor resolution

These lists **A′**, **Z′**, **B** and **C** collect the reference markers that are antecedent candidates at the light only of the relevant binding constraints, which are relative positioning filters in the process of anaphor resolution.[26] Their elements have to be submitted to the other constraints and preferences of this process so that one of them ends up being chosen as the antecedent.

In particular, some of these markers may eventually turn up not being admissible antecedent candidates due to the violation of some other constraints — e.g. those requiring similarity of morphological features or of semantic type — that on a par with binding constraints have to be complied with. For example, in this example *John described Mary to himself*, by the sole constraining effect of Principle A, [r-mark$_{John}$, r-mark$_{Mary}$] is the list of antecedent candidates of *himself*, which will be narrowed down to [r-mark$_{John}$] when all the other filters for anaphor resolution have been taken into account, including the one concerning similarity of morphological features, as *Mary* and *him* do not have the same gender feature value.

In this particular case, separating these two type of filters — similarity of morphological features and binding constraints — seems to be the correct option, required by plural anaphors with so called split antecedents. In an example of this type, such as *John$_i$ told Mary$_j$ they$_{i+j}$ would eventually get married*, where *they* is resolved against *John* and *Mary*, the morphological features of the anaphor are not identical to the morphological features of each of its antecedents, though the relevant binding constraint applies to each of them.[27]

[26] See Branco (1999: Chap.2) for an overview of filters and preferences for anaphor resolution proposed in the literature.

[27] This was noted by (Higginbotham 1983). In this respect, this approach improves on the proposal in (Pollard & Sag 1994), where the token-identity of indices — internally structured in terms of Person, Number and Gender features — is meant to be forced upon the anaphor and its antecedent in tandem with the relevant binding constraint.

For further reasons why token-identity between the reference markers of the anaphor and the corresponding antecedent is not a suitable option for every anaphoric dependency, see the discussion below in Section H on the semantic representation of different modes of anaphora.

When a plural anaphor takes more than one antecedent, as in the example above, its (plural) reference marker will end up being semantically related with a plural reference marker resulting from some semantic combination of the markers of its antecedents. Separating binding constraints from other constraints on the relation between anaphors and their antecedents are thus compatible with and justified by proposals for plural anaphora resolution that take into account split anaphora.[28]

3.3 Computational tractability

It is also worth noting the computational tractability of the grammatical compliance with binding principles is ensured given the polynomial complexity of the underlying operations described above.

Let n be the number of words in the input sentence to be parsed, which for the sake of the simplicity of the argument, and of the worst case scenario, is assumed to be made only of anaphors. Assume also that the sets **A**, **Z** and **U**, of length n at worst, are available at each node of the parsed tree via copying or via list appending (more details about this in the next Sections), a process of constant time complexity.

At worst, the operations involved at each leaf node of the tree to obtain one of the sets **A′**, **Z′**, **B** or **C** are: list copying and list appending operations, performed in constant time; extraction of the predecessors of an element in a list, which is of linear complexity; or at most one list complementation, which can be done in time proportional to $nlog(n)$. This gives the specific procedure of verifying binding constraints in a sentence of length n tractable complexity of $O(n^2 \log n)$ in the worst case.[29]

[28] That is the case e.g. of (Eschenbach et al. 1989). According to this approach, the set of antecedent candidates of a plural anaphor which result from the verification of binding constraints has to receive some expansion before subsequent filters and preferences apply in the anaphor resolution process. The reference markers in that set, either singular or plural, will be previously combined into other plural reference markers: It is thus from this set, closed under the semantic operation of pluralisation (e.g. i-sum a la (Link 1983)), that the final antecedent will be chosen by the anaphor resolver.

[29] For a thorough discussion of alternative procedures for the compliance with binding principles and their drawbacks, see (Branco 2000d), very briefly summarised here:

The verification of binding constraints proposed in (Chomsky 1980; 1981) requires extra-grammatical processing steps of non tractable computational complexity (Correa 1988; Fong 1990) which, moreover, are meant to deliver a forest of indexed trees to anaphor resolvers.

In Lexical Functional Grammar, the account of binding constraints requires special purpose extensions of the description formalism (Dalrymple 1993), which ensures only a partial handling of these constraints.

4 Binding Constraints in the Grammar

In this section, the binding constraints presented above receive a principled integration into formal grammar.

For the sake of brevity, we focus on the English language. Given the discussion in the previous Sections, the parameterisation for other languages will follow from this example by means of seamless adaptation.

We show how the module of binding theory is specified with the description language of HPSG, as an extension of the grammar fragment in the Annex of the foundational HPSG book,[30] following the feature geometry in Ivan Sag's proposed extension of this fragment to relative clauses,[31] and adopting a semantic component for HPSG based on Underspecified Discourse Representation Theory (UDRT).[32]

As exemplified in (17), this semantic component is encoded as the value of the feature CONT(ENT). This value, of sort *udrs*, has a structure permiting that the mapping into underspecified discourse representations be straightforward.[33]

The value of subfeature CONDS is a set of labeled semantic conditions. The hierarchical structure of these conditions is expressed by means of a subordination relation of the labels identifying each condition, a relation that is encoded as the value of SUBORD. The attribute LS defines the distinguished labels, which indicate the upper (L-MAX) and lower (L-MIN) bounds for a semantic condition within the overall semantic representation to be constructed.

The integration of binding theory into formal grammar consists of a simple extension of this semantic component for the *udrs* of nominals, enhancing it with the subfeature ANAPH(ORA). This new feature keeps information about the anaphoric potential of the corresponding anaphor *n*. Its subfeature ANTEC(EDENTS) keeps record of how this potential is realised when the anaphor enters a grammatical construction: Its value is the list with the antecedent candidates of *n* which comply with the relevant binding constraint for *n*. And its subfeature R(EFERENCE)-MARK(ER) indicates the reference marker of *n*, which is contributed by its referential force to the updating of the context.

On a par with this extension of the LOC value, also the NONLOC value is extended with a new feature, BIND(ING), with subfeatures LIST-A, LIST-Z, and LIST-U.

For accounts of binding principles in the family of Categorial Grammar frameworks, see (Szabolcsi 1989; Hepple 1990; Morril 2000), and for a critical overview, see (Jäger 2001).

[30] (Pollard & Sag 1994: Annex).

[31] (Sag 1997).

[32] (Frank & Reyle 1995).

[33] (Reyle 1993).

These lists provide a specification of the relevant context and correspond to the lists **A**, **Z** and **U** above. Subfeature LIST-LU is a fourth, auxiliary list encoding the contribution of the local context to the global, non local context, as explained in the next subsections.[34]

4.1 Handling the anaphoric potential

Given this adjustment to the grammatical geometry, the lexical definition of a pronoun, for instance, will include the following SYNSEM value:

[34]For the benefit of readability, the working example in (17) displays only the more relevant features for the point at stake. The NONLOC value has this detailed definition in (Pollard & Sag 1994):

$$\begin{bmatrix} \text{TO-BIND} & \textit{nonloc1} \\ \text{INHERITED} & \textit{nonloc1} \end{bmatrix}$$

And these are the details of the extension we are using, where the information above is coded now as a *u(nbounded) d(ependency) c(onstructions)* object:

$$\begin{bmatrix} \text{UDC} & \begin{bmatrix} \text{TO-BIND} & \textit{nonloc1} \\ \text{INHERITED} & \textit{nonloc1} \end{bmatrix} \\ \text{BIND} & \begin{bmatrix} \text{LIST-A} & \textit{list(refm)} \\ \text{LIST-Z} & \textit{list(refm)} \\ \text{LIST-U} & \textit{list(refm)} \\ \text{LIST-LU} & \textit{list(refm)} \end{bmatrix} \end{bmatrix}$$

Given this extension, HPSG principles constraining NONLOC feature structure, or part of it, should be fine-tuned with adjusted feature paths in order to correctly target the intended (sub)feature structures.

(17)
$$\begin{bmatrix} \textsc{loc}|\textsc{cont} & \begin{bmatrix} \textsc{ls} & \begin{bmatrix} \textsc{l-max} & \boxed{1} \\ \textsc{l-min} & \boxed{1} \end{bmatrix} \\ \textsc{subord} & \{\} \\ \textsc{conds} & \left\{ \begin{bmatrix} \textsc{label} & \boxed{1} \\ \textsc{dref} & \boxed{2} \end{bmatrix} \right\} \\ \textsc{anaph} & \begin{bmatrix} \textsc{r-mark} & \boxed{2} \\ \textsc{antec} & \boxed{5}\ \mathit{principleB}\left(\boxed{4},\boxed{3},\boxed{2}\right) \end{bmatrix} \end{bmatrix} \\ \textsc{nonloc}|\textsc{bind} & \begin{bmatrix} \textsc{list-a} & \boxed{3} \\ \textsc{list-z} & \mathit{list(refm)} \\ \textsc{list-u} & \boxed{4} \\ \textsc{list-lu} & \langle \boxed{2} \rangle \end{bmatrix} \end{bmatrix}$$

In this feature structure, the semantic condition in CONDS associated to the pronoun corresponds simply to the introduction of the discourse referent 2 as the value of DREF.

This semantic representation is expected to be further specified as the lexical entry of the pronoun gets into the larger representation of the relevant utterance. In particular, the CONDS value of the sentence will be enhanced with a condition specifying the relevant semantic relation between this reference marker 2 and one of the reference markers in the value 5 of ANTEC. The latter will be the antecedent against which the pronoun will happen to be resolved, and the condition where the two markers will be related represents the relevant type of anaphora assigned to the anaphoric relation between the anaphor and its antecedent.[35]

The anaphoric binding constraint associated with pronouns, in turn, is specified as the relational constraint *principleB*/3 in the value of ANTEC. This is responsible for the realisation of the anaphoric potential of the pronoun as it enters a grammatical construction. When the arguments of this relational constraint are instantiated, it returns list **B** as the value of ANTEC.

As discussed in Section 3.1, this relational constraint *principleB*/3 is defined to take all markers in the discourse context (in the first argument and given by the LIST-U value), and remove from them both the local o-commanders of the pronoun (included in the second argument and made available by the LIST-A value) and the marker corresponding to the pronoun (in the third argument and given by the DREF value).

[35] More details on the interface with anaphora resolvers and on the semantic types of anaphora in Section 6.

Finally, the contribution of the reference marker of the pronoun to the context is ensured via token-identity between R-MARK and a LIST-LU value.

The piling up of this reference marker in the global LIST-U value is determined by a new HPSG principle specific to binding theory, to be detailed in the next Section 4.2.

The SYNSEM of other anaphors — ruled by principles A, C or Z — are similar to the SYNSEM of pronouns above. The basic difference lies in the relational constraints to be stated in the ANTEC value. Such constraints — *principleA*/2, *principleC*/3 and *principleZ*/2 — encode the corresponding binding principles and return the realised anaphoric potential of anaphors according to the surrounding context, coded in their semantic representation under the form of a list in the ANTEC value. Such lists — **A′**, **C** or **Z′**, respectively — are obtained by these relational constraints along the lines discussed in Section 3.1.

Note that, for non-lexical anaphoric nominals in English, namely those ruled by Principle C, the binding constraint is stated in the lexical representation of the determiners contributing to the anaphoric capacity of such NPs. Also the reference marker corresponding to an NP of this kind is brought into its semantic representation from the R-MARK value specified in the lexical entry of its determiner.

Accordingly, for the values of ANAPH to be visible in the signs of non lexical anaphors, Clause I of the Semantics Principle in UDRT[36] is extended with the requirement that the ANAPH value is token-identical, respectively, with the ANAPH value of the specifier daughter, in an NP, and with the ANAPH value of the nominal complement daughter, in a subcategorized PP.

Note also that for short-distance reflexives, exemption from the constraining effect of the corresponding Principle A occurs when *principleA*(3,2) returns the empty list as the value of feature ANTEC:[37]

[36] (Frank & Reyle 1995: p.12).

[37] This account applies also to exempt occurrences of long-distance reflexives.

(18)
$$\begin{bmatrix} \textsc{loc}|\textsc{cont} & \begin{bmatrix} \textsc{ls} & \begin{bmatrix} \textsc{l-max} & \boxed{1} \\ \textsc{l-min} & \boxed{1} \end{bmatrix} \\ \textsc{subord} & \{\} \\ \textsc{conds} & \left\{ \begin{bmatrix} \textsc{label} & \boxed{1} \\ \textsc{dref} & \boxed{2} \end{bmatrix} \right\} \\ \textsc{anaph} & \begin{bmatrix} \textsc{r-mark} & \boxed{2} \\ \textsc{antec} & \boxed{4}\ \mathit{principleA}\left(\boxed{3},\boxed{2}\right) \end{bmatrix} \end{bmatrix} \\ \textsc{nonloc}|\textsc{bind} & \begin{bmatrix} \textsc{list-a} & \boxed{3} \\ \textsc{list-z} & \mathit{list(refm)} \\ \textsc{list-u} & \mathit{list(refm)} \\ \textsc{list-lu} & \langle \boxed{2} \rangle \end{bmatrix} \end{bmatrix}$$

This happens if the reference marker of the reflexive [2] is the first element in the relevant obliqueness hierarchy, i.e. it is the first element in the LIST-A value in [3], thus o-commanding the other possible elements of this list and not being o-commanded by any of them.

As discussed in Section 2.2, given its essential anaphoricity, a reflexive has nevertheless to be interpreted against some antecedent. As in the exempt occurrences no antecedent candidate is identified by virtue of Principle A activation, the anaphora resolver — which will operate then on the empty ANTEC list[38] — has thus to resort to antecedent candidates outside the local domain of the reflexive: This implies that it has to find antecedent candidates for the reflexive which actually escape the constraining effect of Principle A. The resolver will then be responsible for modeling the behavior of reflexives in such exempt occurrences, in which case the anaphoric capacity of these anaphors appears as being exceptionally ruled by discourse-based factors.

4.2 Handling the context representation

Turning now to the representation of the context, this consists in the specification of the constraints on the values of the attributes LIST-A, LIST-Z, LIST-U and LIST-LU. This is handled by adding an HPSG principle to the grammar, termed the Binding Domains Principle (BDP). This principle has three clauses constraining signs with respect to these four lists of reference markers. A full understanding

[38] Vd. Section 6 for more details of the interface between grammar and reference processing systems.

of their details, presented below, will be facilitated with the working example discussed in detail in the next Section 5.

Clause I of BDP is responsible for ensuring that the values of LIST-U and LIST-LU are appropriately setup at the different places in a grammatical representation:

(19) **Binding Domains Principle**, Clause I

i. The LIST-LU value is identical to the concatenation of the LIST-LU values of its daughters in every sign;

ii. the LIST-LU and LIST-U values are token-identical in a sign of sort *discourse*;

iii. i. the LIST-U value is token-identical to each LIST-U value of its daughters in a non-NP sign;

ii. in an NP sign *k*:

- in Spec-daughter, the LIST-U value is the result of removing the elements of the LIST-A value of Head-daughter from the LIST-U value of *k*;
- in Head-daughter, the LIST-U value is the result of removing the value of R-MARK of Spec-daughter from the LIST-U value of *k*.

By virtue of (i.), LIST-LU collects up to the outmost sign in a grammatical representation — which is of sort *discourse* — the markers contributed to the context by each NP. Given (ii.), this list with all the markers is passed to the LIST-U value at this outmost sign. And (iii.) ensures that this list with the reference markers in the context is propagated to every NP.

Subclause (iii.ii) prevents self-reference loops due to anaphoric interpretation, avoiding what is known in the literature as the i-within-i effect — recall that the R-MARK value of non lexical NPs is contributed by the lexical representation of their determiners, in Spec-daughter position, as noted above.

The HPSG top ontology is thus extended with the new subsort *discourse* for signs: $sign \equiv word \vee phrase \vee discourse$. This new type of linguistic object corresponds to sequences of sentential signs. A new Schema 0 is also added to the Immediate Dominance Principle, where the Head daughter is a phonologically null object of sort *context(ctx)*, and the Text daughter is a list of phrases.

As the issue of discourse structure is out of the scope of this chapter, we adopted a very simple approach to the structure of discourses which suffices for the present account of binding theory. As discussed in the next Section 5,

this object of sort *ctx* helps representing the contribution of the non linguistic context to the interpretation of anaphors.

As to the other two Clauses of the Binding Domains Principle, Clause II and Clause III, they constrain the lists LIST-A and LIST-Z, respectively, whose values keep a record of o-command relations.

BDP-Clause II is responsible for constraining LIST-A:

(20) **Binding Domains Principle**, Clause II

i. Head/Arguments: in a phrase, the LIST-A value of its head, and of its nominal (or nominal preceded by preposition) or trace Subject or Complement daughters are token-identical;

ii. Head/Phrase:

  i. in a non-nominal and non-prepositional sign, the LIST-A values of a sign and its head are token-identical;

  ii. in a prepositional phrase,

    - if it is a complement daughter, the LIST-A values of the phrase and of its nominal complement daughter are token-identical;
    - otherwise, the LIST-A values of the phrase and its head are token-identical;

  iii. in a nominal phrase,

    - in a maximal projection, the LIST-A value of the phrase and its Specifier daughter are token-identical;
    - in other projections, the LIST-A values of the phrase and its head are token-identical.

This clause ensures that the LIST-A value is shared between a head-daughter and its arguments, given (i.), and also between the lexical heads and their successive projections, by virtue of (ii.).

On a par with this Clause II, it is important to make sure that at the lexical entry of any predicator *p*, LIST-A includes the R-MARK values of the subcategorised arguments of *p* specified in its ARG-S value. Moreover, the reference markers appear in the LIST-A value under the same partial order as the order of the corresponding *synsem* in ARG-S. This is ensured by the following constraints on the SYNSEM values of the lexical entries of predicators:

(21)

$$\left[\textsc{loc|cont|arg-s}\left\langle \cdots, \left[\textsc{loc|cont|anaph|r-mark}\ \boxed{\text{i}}\right], \cdots \right\rangle\right] \longrightarrow \left[\textsc{nonloc|bind|list-a}\left\langle \cdots, \boxed{\text{i}}, \cdots \right\rangle\right]$$

$$\left[\textsc{loc|cont|arg-s}\left\langle \begin{array}{l} \cdots, \left[\textsc{loc|cont|anaph|r-mark}\ \boxed{\text{k}}\right], \\ \cdots, \left[\textsc{loc|cont|anaph|r-mark}\ \boxed{\text{l}}\right], \cdots \end{array} \right\rangle\right] \longrightarrow \left[\textsc{nonloc|bind|list-a}\left\langle \cdots, \boxed{\text{k}}, \cdots, \boxed{\text{l}}, \cdots \right\rangle\right]$$

In case a subcategorised argument is quantificational, it contributes also with its VAR value to the make up of LIST-A:[39]

(22)

$$\left[\textsc{loc|cont|arg-s}\left\langle \cdots, \left[\textsc{loc|cont|anaph}\begin{bmatrix} \textsc{r-mark} & \boxed{\text{r}} \\ \textsc{var} & \boxed{\text{v}} \end{bmatrix}\right], \cdots \right\rangle\right] \longrightarrow \left[\textsc{nonloc|bind|list-a}\left\langle \cdots, \boxed{\text{v}}, \boxed{\text{r}}, \cdots \right\rangle\right]$$

Finally, BDP-Clause III ensures that LIST-Z is properly constrained:

(23) **Binding Domains Principle**, Clause III
For a sign F:

i. in a Text daughter, the LIST-Z and LIST-A values are token-identical;
ii. in a non-Text daughter,
    i. in a sentential daughter, the LIST-Z value is the concatenation of the LIST-Z value of F with the LIST-A value;
    ii. in a Head daughter of a non-lexical nominal, the LIST-Z value is the concatenation of L with the LIST-A value, where L is the list which results from taking the list of o-commanders of the R-MARK value, or instead of VAR value when this exists, of its Specifier sister from the LIST-Z value of F;
    iii. in other, non-filler, daughters of F, the LIST-Z value is token-identical to the LIST-Z value of F.

By means of (i.), this Clause III ensures that, at the top node of a grammatical

[39] More details on this and on the e-type anaphora vs. bound-variable anaphora distinction are discussed in the next Sections.

representation, LIST-Z is set up as the LIST-A value of that sign.

Moreover, given (ii.), it is ensured that LIST-Z is successively incremented at suitable downstairs nodes — those defining successive locality domains for binding, as stated in (ii.i) and (ii.ii) — by appending, in each of these nodes, the LIST-A value to the LIST-Z value of the upstairs node.

From this description of the Binding Domains Principle, it follows that the locus in grammar for the parameterisation of what counts as a local domain for a particular language is the specification of BDP–Clauses II and III for that language.

5 A Working Example

In order to better illustrate the binding constraints specified in the previous Section 4, as well as the outcome obtained from a grammar with such specification of binding theory, we discuss now the working example below and the corresponding grammatical representation in Figure 1.

(24) Every student said [he likes himself].

This is a multi-clausal sentence with two anaphoric nominals in the embedded clause, a pronoun (*he*) and a short-distance reflexive (*himself*), and a quantificational NP (*every student*) in the upper clause. In this sentence, the reflexive has the pronoun as the only admissible antecedent, and the pronoun, in turn, can either have the quantificational NP as antecedent or be resolved against an antecedent not introduced in the sentence.

Figure 1 presents an abridged version of the grammatical representation produced by the grammar for a discourse that contains only this sentence. The feature structures below the constituency tree correspond to partial grammatical representations of the leave constituents, while the ones above the tree correspond to partial representations of some of its non terminal nodes.

5.1 Circumscribing the Anaphoric Context

Let us start considering the representation of the context.

Taking the representation of obliqueness hierarchies first, one can check that in the upper nodes of the matrix clause, due to the effect of BDP–Clause III, the LIST-Z value is obtained from the value of LIST-A, with which it is token-identical, thus comprising the list ⟨54, 247⟩. In the nodes of the embedded clause, in turn, the LIST-Z value is the concatenation of that upper LIST-Z value and the LIST-A

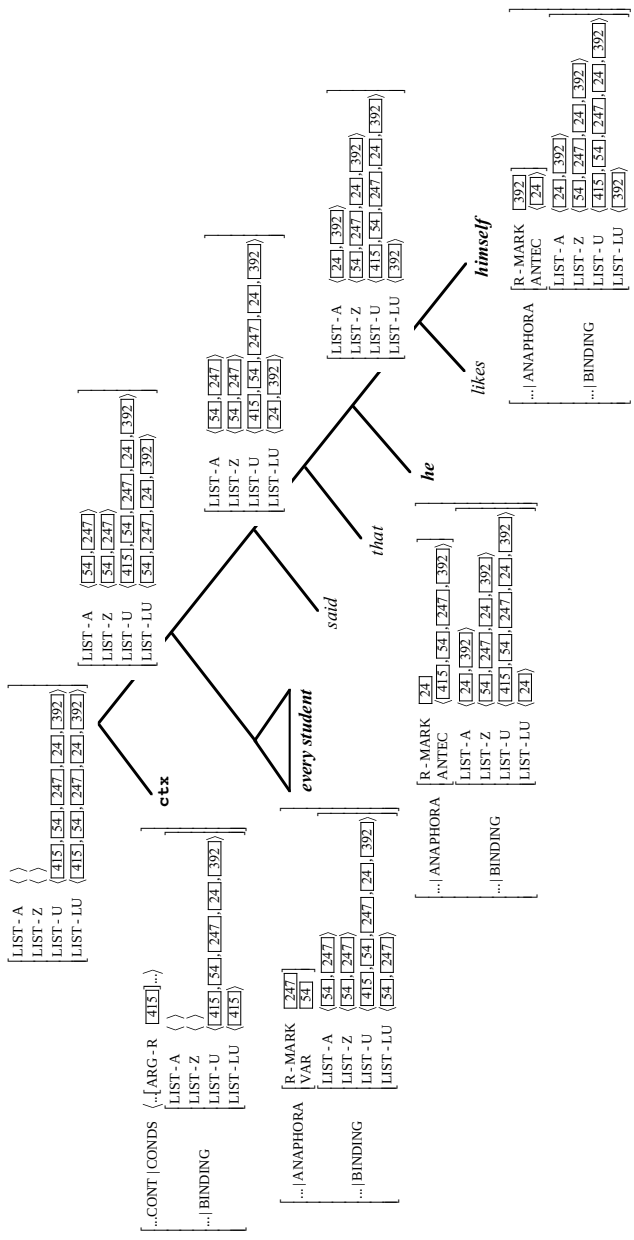


Figure 1: Partial grammatical representation of *Every student said he likes himself.*

value in the embedded clause ⟨[24], [392]⟩, from which the list ⟨[54], [247], [24], [392]⟩ is obtained.

In any point of the grammatical representation, the LIST-A values are obtained from the subcategorization frames of the local verbal predicators, as constrained by BDP–Clause II and the lexical constraints in (21) and (22). Therefore, ⟨[24], [392]⟩ is the LIST-A value of *likes*, and ⟨[54], [247]⟩, is the LIST-A value of *said*.

Observing now LIST-LU, we see that as one ascends in the representation of the syntactic constittuency, the list gets longer since by the effect of BDP–Clause I, the LIST-LU value at a given node gathers the reference markers of the nodes dominated by it. Consequently, at the discourse top node, LIST-LU ends up as a list including all reference markers: Both those introduced in the discourse by the NPs in the example sentence and ⟨[415]⟩ the one available in the non linguistic context, from which the list ⟨[415], [54], [247], [392]⟩ is the result.

Note that in cases where the discourse contains more than one sentence, BDP–ClauseI (i.) ensures that LIST-LU ends up with all reference markers from every sentence of the discourse.

BDP–Clause I also ensures that this list of all reference markers is passed to the LIST-U value of the top node, and that this LIST-U value is then percolated down to all nodes of the grammatical representation, including the nodes of anaphoric nominals.

5.2 Circumscribing the Anaphoric Potential

Considering now the representation of the NPs, we take a closer look at the leaf nodes in the constituency tree.

Contribution to the context Let us consider first how the NPs contribute to the representation of the context.

Every phrase contributes to the global anaphoric context by passing the tag of its reference marker into its own LIST-LU.

In the case of a quantificational NP, like *every student*, two tags are passed, corresponding to the VAR value [54] — token-identical with the DREF value of the restrictor and providing for bound-variable anaphora interpretations — and the R-MARK value [247] — providing for e-type anaphora.

While the semantic types of anaphora are addressed in further detail in Section 6.2, it is of note at this point that a DRT account of e-type anaphora is followed here.[40] Accordingly, a quantificational NP contributes a plural reference

[40] (Kamp & Reyle 1993: p.311ff).

marker to the semantic representation of the discourse that may serve as the antecedent in (e-type) anaphoric links. In a sentence like *Every bald man snores*, for instance, the quantificational NP contributes the plural reference marker which stands for the bald men that snore. Such marker is introduced in the discourse representation via the application of the DRT Abstraction operator Σ, which takes the restrictor and the nuclear scope of the determiner and introduces the plural marker that satisfies the corresponding semantic conditions.[41]

In order to incorporate such an account of e-type anaphora into UDRT,[42] the reference marker standing for the plurality satisfying the semantic condition obtained with Σ-abstraction, in the CONDS value of a determiner, is made token-identical with its R-MARK value. The *synsem* of the lexical entry for *every*, for instance, results thus as follows, where 1 is the marker obtained via Σ-abstraction:

(25)
$$\left[\begin{array}{ll}
\textsc{loc}|\textsc{cont} & \left[\begin{array}{ll}
\textsc{ls} & \left[\begin{array}{ll}\textsc{l-max} & \boxed{4}\\ \textsc{l-min} & \boxed{5}\end{array}\right]\\
\textsc{subord} & \{\boxed{4}>\boxed{3},\boxed{4}>\boxed{5},\boxed{8}\geq\boxed{5}\}\\
\textsc{conds} & \left\{\begin{array}{l}\left[\begin{array}{ll}\textsc{label} & \boxed{4}\\ \textsc{rel} & \textit{every}\\ \textsc{res} & \boxed{3}\\ \textsc{scope} & \boxed{5}\end{array}\right], \left[\begin{array}{ll}\textsc{label} & \boxed{3}\\ \textsc{dref} & \boxed{2}\end{array}\right],\\ \left[\begin{array}{ll}\textsc{label} & \boxed{5}\\ \textsc{dref} & \boxed{7}\end{array}\right], \left[\begin{array}{ll}\textsc{label} & \boxed{8}\\ \textsc{rel} & \Sigma\textit{-abstraction}\\ \textsc{arg1} & \boxed{2}\\ \textsc{arg2} & \boxed{7}\\ \textsc{dref} & \boxed{1}\end{array}\right]\end{array}\right\}\\
\textsc{anaph} & \left[\begin{array}{ll}\textsc{r-mark} & \boxed{1}\\ \textsc{var} & \boxed{2}\end{array}\right]
\end{array}\right]\\
\textsc{nonloc}|\textsc{bind} & \left[\begin{array}{ll}\textsc{list-a} & \textit{list(refm)}\\ \textsc{list-z} & \textit{list(refm)}\\ \textsc{list-u} & \textit{list(refm)}\\ \textsc{list-lu} & \langle\boxed{2},\boxed{1}\rangle\end{array}\right]
\end{array}\right]$$

Contribution by the context Let us look now at how the representation of the context is encoded in each NP.

[41] (Kamp & Reyle 1993: p.310).
[42] (Frank & Reyle 1995).

It should be noted that the suitable values of LIST-A, LIST-Z and LIST-U at the different NP nodes are enforced by the combined effect of the three Clauses of BDP.

Due to, respectively, BDP–Clause II (iii.) and BDP–Clause I (iii.i.), LIST-Z and LIST-U values result from token-identity, respectively, with LIST-Z and with LIST-U of the immediately dominating node in the constituency tree — that is the case, for instance, with the lists ⟨54, 247⟩ and ⟨415, 54, 247, 24, 392⟩ in the non-pronoun *every student* and in the sentential node dominating it.

Due to BDP–Clause II (i.), LIST-A value, in turn, is obtained via token-identity with LIST-A of the subcategorising predicator — that is the case, for instance, with the list ⟨24, 392⟩ in the reflexive *himself* and in its predicator *likes*.

Realisation of anaphoric potential As to the anaphoric nominals, let us check now how their anaphoric potential is circumscribed in each specific occurrence.

The value of ANTEC is a list that records the grammatically admissible antecedents of the corresponding anaphor at the light of binding constraints.

As the result of the relational constraint *principleA*/2, the semantic representation of the reflexive *himself* includes the attribute ANTEC with the singleton list ⟨24⟩ as value, indicating that the only antecedent candidate available in this sentence is the pronoun in the embedded clause whose reference marker is identified as 24 in its own semantic representation.

The semantic representation of the pronoun *he*, in turn, includes the feature ANTEC with a value that is the list of its antecedent candidates, ⟨415, 247, 54, 392⟩, thus indicating that, in this sentence, the pronoun can be anaphorically linked to every nominal except itself, in line with the relational constraint *principleB*/3.

This ANTEC list includes antecedent candidates for the pronoun that will be dropped out by preferences or constraints on anaphoric links other than just the grammatical binding constraint expressed in Principle B. For instance, the plural reference marker 247, which is the R-MARK value of *every student*, will eventually be excluded by the anaphora resolver given that the singular pronoun *he* cannot entertain an e-type anaphoric link with a universally quantified NP whose reference marker obtained by Σ-abstraction is a plurality.

Also the marker 392 of the reflexive will be eventually discarded from this ANTEC list as a suitable antecedent by the resolver system since this would lead to an interpretive loop where the pronoun and the reflexive would be the sole antecedents of each other.

Non-linguistic context Finally, in order to illustrate how the non linguistic context may be represented in the linguistic representation of sentences, in this example, the reference marker 415 was introduced in the semantic representation

of the ctx node.

The CONDS value of this node is meant to capture the possible contribution of the non-linguistic context at stake for the interpretation of the discourse. Like in the lexical entries of nominals, in the feature representation of *ctx*, the reference marker 415 is integrated in the LIST-LU value. By the effect of BDP–Clause I, this reference marker ends up added to the list of all reference markers, from both the linguistic discourse and the non-linguistic context, which is the shared value of features LIST-LU and LIST-U at the top node in Figure 1.

6 Interface with Reference Processing Systems

The appropriateness of the approach presented above to the grammatical constraints on anaphoric binding extends to its suitable accounting of the division of labor between grammars and reference processing systems and the interfacing between them.

6.1 Anaphora Resolution

While ensuring that the grammatical anaphoric binding constraints are specified and verified as part of the global set of grammatical constraints, this approach provides for a suitable hooking up of the grammar with modules for anaphor resolution.

Feature ANTEC is the neat interface point between them: Its value with a list of antecedent candidates that comply with binding theory requirements is easily made accessible to anaphor resolvers. This list will be then handled by a resolver where further non grammatical soft and hard constraints on anaphor resolution will apply and will filter down that list until the most likely candidate will be determined as the antecedent.

6.2 Semantic Types of Anaphora

This approach also provides a convenient interface for anaphoric links of different semantic types — exemplified below — to be handled and specified by

reference processing systems:

(26) a. John$_i$ said that he$_i$ would leave soon. (coreference)
b. Kim$_i$ was introduced to Lee$_j$ and a few minutes later they$_{i+j}$ went off for dinner. (split anaphora)
c. Mary could not take [her car]$_i$ because [the tyre]$_i$ was flat. (bridging anaphora)
d. [Fewer than twenty Parliament Members]$_i$ voted against the proposal because they$_i$ were afraid of riots in the streets. (e-type anaphora)
e. [Every sailor in the Bounty]$_i$ had a tattoo with [his mother's]$_i$ name on the left shoulder. (bound anaphora)

Example (26a) displays a coreference relation, where *he* has the same semantic value as its antecedent *John*.

A case of split antecedent can be found in (26b) as *they* has two syntactic antecedents and it refers to an entity comprising the two referents of the antecedents.

The referent of *the tyre* is part of the referent of its antecedent *his car* in (26c), thus illustrating a case of so called bridging anaphora (also know as indirect or associative anaphora), where an anaphor may refer to an entity that is e.g. an element or part of the denotation of the antecedent, or an entity that includes the denotation of the antecedent, etc.[43]

In (26d) *they* has a so called non-referential antecedent, *fewer than twenty Parliament Members*, from which a reference marker is inferred to serve as the semantic value of the plural pronoun: *they* refer to those Parliament Members, who are fewer than twenty in number, and who voted against the proposal. Example (26d) illustrates a case of e-type anaphora,[44] and this inference mechanism to obtain an antecedent marker from a non referring nominal was presented in Section 5.2.

Finally in (26e), though one also finds a quantificational antecedent for the anaphoric expression, the relation of semantic dependency differs to the one in the previous example. The anaphoric expression *his mother* does nor refer to the mother of the sailors of the Bounty. It acts rather in the way of a bound variable of logical languages — for each sailor *s*, *his mother* refers to the mother of *s* — thus exemplifying a case of so called bound anaphora.[45]

[43] See (Poesio & Vieira 1998) for an overview.
[44] (Evans 1980).
[45] (Reinhart 1983).

Given that the semantic relation between antecedent marker and anaphor marker can be specified simply as another semantic condition added to the CONDS value, a DRT/HPSG representation for the resolved anaphoric link under the relevant semantic type of anaphora is straightforward and the integration of the reference processing outcome into grammatical representation can be seamlessly ensured.

For the sake of the illustration of this point, assume that a given reference marker **x** turns out to be identified as the antecedent for the anaphoric nominal Y, out of the set of antecedent candidates for Y in its ANTEC value. This antecedent **x** can be related to the reference marker **y** of anaphor Y by means of an appropriate semantic condition in its CONDS value. Such a condition will be responsible for modelling the specific mode of anaphora at stake.

For instance, coreference will require the expected condition $\mathbf{y}{=}_{coref}\mathbf{x}$, as exemplified below with the CONT value of the pronoun in (17) extended with a solution contributed by an anaphor resolver, where 7 would be the marker picked up as the plausible antecedent.

(27)
$$\begin{bmatrix}
\text{LS} & \begin{bmatrix}\text{L-MAX} & \boxed{1}\\ \text{L-MIN} & \boxed{1}\end{bmatrix}\\
\text{SUBORD} & \{\boxed{1}{=}\boxed{6}\}\\
\text{CONDS} & \left\{\begin{bmatrix}\text{LABEL} & \boxed{1}\\ \text{DREF} & \boxed{2}\end{bmatrix}, \begin{bmatrix}\text{LABEL} & \boxed{6}\\ \text{REL} & =_{coref}\\ \text{ARG1} & \boxed{2}\\ \text{ARG2} & \boxed{7}\end{bmatrix}\right\}\\
\text{ANAPH} & \begin{bmatrix}\text{R-MARK} & \boxed{2}\\ \text{ANTEC} & \boxed{5}\langle \ldots, \boxed{7}, \ldots\rangle\end{bmatrix}
\end{bmatrix}$$

An instance of bridging anaphora, in turn, may be modelled by *bridg*(**x**, **y**), where *bridg* stands for the relevant bridging function between **y** and **x**, and similarly for the other semantic anaphora types.

6.3 Coreference Transitivity

It is also noteworthy that the interfacing of grammar with reference processing systems ensured by this approach to grammatical anaphoric binding constraints provides a neat accommodation of coreference transitivity.

If as a result of the process of anaphor resolution, a given anaphor N and another anaphor B end up being both coreferent with a given antecedent A, then

they end up being coreferent with each other. That is, in addition to having marker r_a as an admissible antecedent in its set of candidate antecedents, that anaphor N has also to eventually have marker r_b included in that set.

This is ensured by including, in the CONDS value in (17), semantic conditions that follow as logical consequences from this overall coreference transitivity requirement that is operative at the level of the reference processing system with which grammar is interfaced:

$$\forall r_a, r_b((\boxed{2} =_{coref} r_b \wedge r_a =_{coref} r_b) \Rightarrow (\langle r_a \rangle \cup \boxed{5} = \boxed{5}))$$

An important side effect of this overall constraint is that "accidental" violations of Principle B are prevented, as illustrated with the help of the following example.

(28) * The captain$_{i/j}$ thinks he$_i$ loves him$_j$.

Given that the Subject of the main clause does not locally o-command any one of them, either the pronoun *he* or the pronoun *him* can have the nominal phrase *the captain* as antecedent, in compliance with Principle B. By transitivity of anaphoric coreference though, the reference marker of *he* is made to belong to the admissible set of antecedents of *him*, which violates Principle B. Hence, by the conjoined effect of coreference transitivity and of Principle B, that "accidental" violation of Principle B that would make *he* an (o-commanding) antecedent in this example of *him* is blocked.

By the same token, "accidental" violations of Principle C with an analogous pattern as above, but for non pronouns, are prevented:

(29) * When John$_{i/j}$ will conclude his therapy, [the boy$_i$ will stop believing [that the patient$_j$ is a Martian]].

Separately, *the boy* and the *the patient* can have *John* as antecedent, in accordance to Principle C. But *the patient* — because is o-commanded by *the boy* — cannot have it as antecedent, which, also here, is ensured by a conjoined effect of the coreference transitivity requirement and the relevant Principle C.

Accordingly, when the semantic type of anaphora is not one of coreference, no coreference transitivity holds, and there happens no "accidental" violation of Principle C. This is illustrated in the following example with bridging anaphora instead, where two non pronouns, though occurring in the same clause, like in (29) , can be resolved against the same antecedent — in contrast with that example above, where such possibility is blocked.

(30) Quando [o robot]$_i$ concluiu a tarefa, o operador viu que [a roda]$_i$ estava a esmagar [o cabo de alimentação]$_i$. (Portuguese)
when the robot concluded the task, the operator saw that the wheel was to smash the cord of power
'When [the robot]$_i$ concluded the task, the operator saw that [his$_i$ wheel] was smashing [his$_i$ power cord].'

Another range of examples where the semantic type of anaphora is not one of coreference — also with no coreference transitivity holding — and thus also where there happens no "accidental" violation of the respective binding principle can be found for reflexives, as illustrated in the following example.

(31) The captain$_i$ thinks he$_{i/j}$ loves himself$_{*i/j}$.

The reflexive *himself* can have *he* as antecedent, because the later locally o-commands it, but cannot have *the captain* as antecedent because the later does not locally o-command it. But while the semantic anaphoric relation between *the captain* and *he* is one of coreference, the semantic anaphoric relation between *he* and *himself* is not, being rather one of bound anaphora.[46] Hence, the coreference transitivity requirement does not apply and the referent of *the captain* does not land into the set of possible antecedents of the reflexive, thus not inducing an "accidental" violation of Principle A. Example (31) can thus felicitously be interpreted as the captain thinking that the agent of loving him is him, resulting from *himself* having *him* as antecedent and *him* having *the captain* as antecedent.

7 Binding Principles for Antecedents

The account of binding theory presented in this chapter is also serendipitous in terms of improving the accuracy of empirical predictions offered by a formal grammar with respect to anaphoric binding restrictions that are outside the realm of the binding principles in (2).

Differently from a non quantificational NP, which contributes one reference marker to the representation of the context, a quantificational NP contributes two markers. This appears to have important consequences in terms of the specific binding capacity of such markers (and of the respective nominal expressions introducing them) as antecedents of anaphors.

[46] Confluent evidence that reflexives entertain a bound anaphora relation with their antecedents was also observed when their inability to enter split anaphora relations in non exempt positions was noted in Section 2.2.

Note first that a reference marker introduced by a non quantificational NP, such as *this sailor* or *the captain who knows this sailor*, can be the antecedent both of anaphors that it o-commands, and of anaphors that it does not o-command:

(32) a. [The captain who knows this sailor]$_i$ thinks Mary loves him$_i$.
b. [The captain who knows [this sailor]$_i$] thinks Mary loves him$_i$.

The two markers introduced by a quantificational NP, in turn, present a different behaviour. They exhibit symmetric features with respect to each other in several respects. The fact that one of them can serve as an antecedent in e-type anaphora, while the other can serve as an antecedent in bound-variable anaphora is certainly one of such symmetries, as observed in the previous Sections. But there are more.

Let us take a quantificational NP, introduced for instance by the quantifier *every*, acting as an antecedent. This imposes different Number requirements on its anaphors depending on the type of reading at stake, e-type or bound-variable anaphora, so that the underlying occurrence of each one of the corresponding two markers can be tracked down.

For ease of reference, let us refer to the marker in the R-MARK value, introduced by Σ-abstraction, as the e-marker, and to the marker in the the VAR value, introduced by the restrictor argument of the determiner, as the v-marker.

The contrast below illustrates that, in an e-type anaphoric link, the e-marker is a plurality:

(33) Every sailor$_i$ has many girlfriends. They$_i$/He$_{*i}$ travel(s) a lot.

And the next contrast illustrates that, in a bound-variable anaphoric link, the v-marker is singular:

(34) Every sailor$_i$ shaves themselves$_{*i}$/himself$_i$.

The following contrasts can now be considered. An e-marker can be the antecedent of anaphors that it does not o-command, in (35b), but cannot be the antecedent of anaphors that it o-commands, in (35a):

(35) a. * [Every captain who knows this sailor]$_i$ thinks Mary loves them$_i$.
b. [The captain who knows [every sailor]$_i$] thinks Mary loves them$_i$.

This contrast is symmetric to the contrast for the other reference marker: A v-marker can be the antecedent of anaphors that it o-commands, in (36a), but cannot be the antecedent of anaphors that it does not o-command, in (36b):

(36) a. [Every captain who knows this sailor]$_i$ thinks Mary loves him$_i$.
b. * [The captain who knows [every sailor]$_i$] thinks Mary loves him$_i$.

As these contrasts are empirically observed as patterns holding for quantificational NPs in general (not only for those introduced by *every*), constraints emerge on which anaphors different markers can be the antecedents of, in case such markers are introduced by quantificational NPs.

E-markers and v-markers of a given quantificational NP induce a partition of the space of their possible anaphors when that NP is acting as an antecedent: A v-marker is an antecedent for anaphors in the set of its o-commanded anaphors, while an e-marker is an antecedent for anaphors in the complement of such set, i.e. in the set of its non o-commanded anaphors.

This implies that on a par with the grammatical constraints on *the relative positioning of antecedents with respect to anaphors* as in (2), there are also grammatical constraints on *the relative positioning of anaphors with respect to their antecedents* when the corresponding markers are introduced by quantificational NPs. Building on the same auxiliary notions, these "reverse" binding constraints receive the following definition as R-Principles E and V:

(37) **R-Principle E**: An e-marker antecedent cannot o-bind its anaphor (in e-type anaphora).

[Every captain who knows [every sailor]$_i$]$_j$ thinks Mary loves them$_{i/*j}$.

R-Principle V: A v-marker antecedent must o-bind its anaphor (in bound-anaphora).

[Every captain who knows [every sailor]$_i$]$_j$ thinks Mary loves him$_{*i/j}$.

It is worth noting that these principles account also for what has been observed in the literature as the weak crossover effect.[47] In the example below, displaying a case of weak crossover, the anaphoric link is ruled out by R-Principle V since the quantificational NP does not o-command the pronoun.

(38) * [The captain who knows him$_i$] thinks Mary loves every sailor$_i$.

Weak crossover constructions appear thus as a sub-case of the class of constructions ruled out by the binding constraints for antecedents.

[47] See (Jacobson 2000: Sec.2.1) for an extensive overview of accounts of weak crossover. For an account of strong crossover in HPSG see (Pollard & Sag 1994: p.279).

To the best of our knowledge, the integration of the reverse anaphoric constraints E and V in (37) into HPSG — like what is obtained in Section 4 above for Principles A–Z in (2) — was not worked out yet in the literature. It is an open research issue for future work.[48]

8 Getting Deeper into the Semantics of Anaphors

The approach to the grammatical specification of anaphoric binding constraints presented in the previous sections follows these key ingredients:

- Interpretation: Binding constraints are grammatical constraints on interpretation contributing to the contextually determined semantic value of anaphors — rather than syntactic wellformedness constraints.
- Lexicalisation: Binding constraints are properties of anaphors determining how their semantic value can be composed or co-specified, under a non-local syntactic geometry, with the semantic value of other expressions — rather than properties of grammatical representations of sentences as such: Accordingly, the proper place of these constraints in grammar is at the lexical description of the relevant anaphoric units (e.g. the English pronoun *him*, or the Portuguese multiword long distance reflexive *ele próprio*) or the anaphora inducing items (e.g. the English definite article *the* that introduces non-pronouns).
- Underspecification: Binding constraints delimit how the anaphoric potential of anaphors can be realised when they enter a grammatical construction — rather than determining the eventual antecedent: On the one hand, this realisation of anaphoric potential is not a final solution in terms of circumscribing the elected antecedent, but a space of grammatically admissible solutions; on the other hand, this realisation of anaphoric potential has to be decided, locally, in terms of non-local information: Accordingly, an

[48] Besides an explicit formal specification of (37) in terms of HPSG, there are also empirical aspects that ask to be worked out in future work. For weak crossover, for instance, it is interesting to note Jacobson's remarks: "... it is well known that weak crossover (WCO) is indeed weak, and that the effect can be ameliorated in a variety of configurations. To list a few relevant observations: WCO violations are much milder if the offending pronoun is within a sentence rather than in an NP; the more deeply one embeds the offending pronoun the milder the WCO effect; WCO effects are ameliorated or even absent in generic sentences; they are milder in relative clauses than in questions [...] For example, the possibility of binding in *Every man's$_i$ mother loves him$_i$* remains to be accounted for." (Jacobson 2000: p.120).

underspecification-based strategy is required to pack ambiguity and non-locality.

- Articulation: Binding constraints are grammatical constraints — rather than anaphora resolvers: Accordingly, grammars, where grammatical anaphoric constraints reside, and reference processing systems, where further constraints on the resolution of anaphora reside, are autonomous with respect to each other, and their specific contribution gains from them being interfaced, rather than being mixed up.

Binding principles capture the relative positioning of anaphors and their admissible antecedents in grammatical representations. As noted at the introduction of the present chapter, together with their auxiliary notions, they have been considered one of the most outstanding modules of grammatical knowledge.

From an empirical perspective, these constraints stem from quite cogent generalisations and exhibit a universal character, given the hypothesis of their parameterised validity across anaphoric expressions and natural languages.

From a conceptual point of view, in turn, the relations among binding constraints involve non-trivial cross symmetry which lends them a modular nature and provides further strength to the plausibility of their universal character.

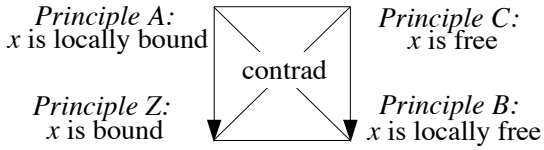
The recurrent complementary distribution of the admissible antecedents of a pronoun and of a short-distance reflexive in the same, non exempt syntactic position, in different languages from different language families, has perhaps been the most noticeable symmetry. But given also the recurrent complementary distribution of the admissible antecedents of a long-distance reflexive and of a non pronoun in the same, non exempt syntactic position, a similar symmetry is also found between these two other types of anaphors.

Another double symmetry worth noting is the one between short- and long-distance reflexives, on the one hand, and non pronouns and pronouns on the other hand. Both sorts of reflexives present the same binding regime but over o-command orders whose length is possibly different: The set of admissible antecedents of a short-distance reflexive is a subset of the set of admissible antecedents of a long-distance reflexive in the same, non exempt syntactic position. A symmetry similar to this one is displayed by non pronouns and pronouns with respect to a given syntactic position: The set of admissible antecedents of a non pronoun is a subset of the set of admissible antecedents of a pronoun.

8.1 Quantificational Strength of Nominal Anaphors

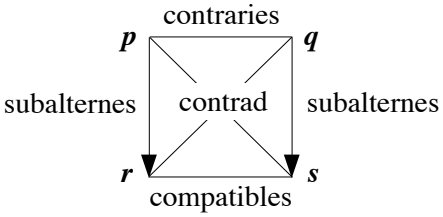
When these symmetries are further explored, the intriguing observation that emerges with respect to the empirical generalisations in (2), known as binding principles, is that when stripped away from their procedural phrasing and non-exemption safeguards, they instantiate a square of logical oppositions:

(39)



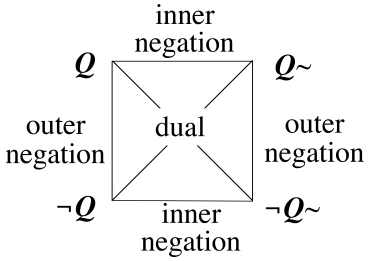
Like in the Aristotelian square of opposition, depicted in (40), there are two pairs of *contradictory* constraints, which are formed by the two diagonals, (Principles A, B) and (C, Z). One pair of *contrary* constraints (they can be both false but cannot be both true) is given by the upper horizontal edge (A, C). One pair of *compatible* constraints (they can be both true but cannot be both false) is given by the lower horizontal edge (Z, B). Finally two pairs of *subcontrary* constraints (the first coordinate implies the second, but not vice-versa) are obtained by the vertical edges, (A, Z) and (C, B).

(40)



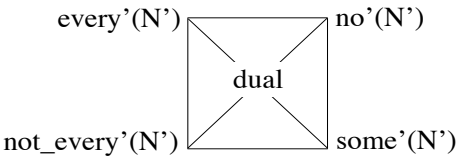
The empirical emergence of a square of oppositions for the semantic values of natural language expressions naturally raises the question about the possible existence of an associated square of duality — and importantly, about the quantificational nature of these expressions.

(41)



It is of note that the classical square of oppositions in (40) is different and logically independent from the square of duality in (41) — with the semantic values of the English expressions *every N*, *no N*, *some N* and *not every N*, or their translational equivalents in other natural languages, providing the classical example of an instantiation of the latter:

(42)



The difference lies in the fact that inner negation, outer negation and duality (concomitant inner and outer negation) are third order concepts, while compatibility, contrariness and implication are second order concepts. As a consequence, it is possible to find instantiations of the square of oppositions without a corresponding square of duality, and vice-versa.[49]

Logical duality has been a key issue in the study of natural language and, in particular, in the study of quantification as this happens to be expressed in natural language. It is a pattern noticed in the semantics of many linguistic expressions and phenomena, ranging from the realm of determiners to the realm of temporality and modality, including topics such as the semantics of the adverbials *still*/*already* or of the conjunctions *because*/*although*, etc.[50]

Under this pattern, one recurrently finds groups of syntactically related expressions whose formal semantics can be rendered as one of the operators arranged in a square of duality. Such a square is made of operators that are interdefinable by means of the relations of outer negation, inner negation, or duality. Accordingly, the emergence of a notoriously non trivial square of logical duality between the semantic values of natural language expressions has been taken as a major empirical touchstone to ascertain their quantificational nature.[51]

By exploring these hints, and motivated by the intriguing square of opposition in (39), the empirical generalizations captured in the binding principles were shown to be the effect of four quantifiers that instantiate a square of duality like (41).[52]

[49] Vd. (Löbner 1987) for examples and discussion.

[50] (Löbner 1987; 1989; 1999; ter Meulen 1988; Koning 1991; Smessaert 1997).

[51] Vd. (Löbner 1987; van Benthem 1991). While noting that the ubiquity of the square of duality may be the sign of a semantic invariant possibly rooted in some cognitive universal, (van Benthem 1991: p.23) underlined its heuristic value for research on quantification inasmuch as "it suggests a systematic point of view from which to search for comparative facts".

[52] (Branco 1998a; 2001; 2005a; 2006).

For instance, Principle A is shown to capture the constraining effects of the existential quantifier that is part of the semantic value of short-distance reflexives. Like the existential quantifier expressed by other expressions, such as the adverbial *already*,[53] this a phase quantifier. What is specific here is that the quantification is over a partial order of reference markers, the two relevant semi-phases over this order include the local o-commanders and the other reference markers that are not local o-commanders, respectively for the positive and the negative semi-phases, and the so-called parameter point in phase quantification is the reference marker of the eventual antecedent for the anaphoric nominal at stake.

Accordingly, the other three quantifiers — corresponding to the other three binding Principles B, C and Z — are defined by means of this existential one being under external negation (quantifier expressed by pronouns), internal negation (by non pronouns) or both external and internal negation (by long-distance reflexives).

While these findings deepen the rooting of binding constraints into the semantics of anaphoric nominals,[54] more importantly, they also point towards promising research directions with the potential to advance our understanding of the grammar of anaphoric binding, in particular, and more widely, to further our insights into the semantics of nominals, in general.

8.2 Doubly Dual Nominals

A shared wisdom is that nominals convey either quantificational or referential force. These findings imply that nominals with "primary" referential force (e.g. *John*, *the book*, *he*, ...) have also a certain "secondary" quantificational force: They express quantificational requirements — over reference markers, i.e. entities that live in linguistic representations —, but do not directly quantify over extra-linguistic entities, like the other "primarily" quantificational nominals (e.g. *every man*, *most students*, ...) do.

This duality of semantic behaviour, however, turns out not to be that much surprising if one takes into account a symmetric duality with regards to "primarily" quantificational nominals, which is apparent when they are able to act as antecedents in e-type anaphora. Nominals with "primary" quantificational force have also a certain "secondary" referential force: They have enough referential strength to evoke and introduce reference markers in the linguistic representation that can be picked as antecedents by anaphors — and thus support the

[53] (Löbner 1987).

[54] Their fully-fledged discussion and justification are outside the scope of the present chapter. A thorough presentation can be found in (Branco 2005a).

referential force of the latter —, but they cannot be used to directly refer to extra-linguistic entities, like the other "primarily" referential terms do.

As a result, the duality quantificational vs. referential nominals appears thus as less strict and more articulated than it has been assumed. Possibly taking indefinite descriptions aside, every nominal makes a contribution in both semantic dimensions of quantification and reference but with respect to different universes. Primarily referential nominals have a dual semantic nature — they are primarily referential (to extra-linguistic entities) and secondarily quantificational (over linguistic entities) —, which is symmetric of the dual semantic nature of primarily quantificational ones — these are primarily quantificational (over extra-linguistic entities) and secondarily referential (to linguistic entities).

Abbreviations

BDP - Binding Domains Principle
DRT - Discourse Representation Theory
HPSG - Head-Driven Phrase Structure Grammar
UDRT - Underspecified Discourse Representation Theory

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Part III

Other levels of description