Without an Index:
a lexicalist account of binding theory

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1 Introduction

Binding principles delimit the relative positioning of anaphors and their admissible antecedents in grammatical structure.[1] These principles stem from quite cogent empirical generalizations and exhibit a universal character, given the hypothesis of their parameterized validity across natural languages. Their mutual relations involve non-trivial cross symmetry, lending them a modular shape and providing further strength to the plausibility of their universal nature.[2]

In contrast to this, the encoding of anaphoric binding constraints into formal grammars has presented considerable difficulties. As an example of such difficulties, it is worth noting that the mainstream approach for this encoding, which dates back to (Chomsky, 1980) and is based on the exhaustive and overgenerating indexation of grammatical representations, has been shown to require extra-grammatical processing steps of non-tractable computational complexity (Correa, 1988; Fong, 1990).

As for HPSG, we would like to obtain a fully-fledged integration of binding theory into formal grammars. In the nine page Appendix of (Pollard and Sag, 1994), the fragment of grammar developed and discussed along this book is formally specified using the HPSG description formalism: Binding principles receive a definition in Chapter 6, but are a major part of grammatical knowledge discussed in this book that escapes such formal encoding.

While pointing out the fact that these constraints are waiting to be accommodated into HPSG grammars, Backofen et al. (1996, p.65) and Bredenkamp's (1996) discussion of this issue implies that some kind of essential limitation of the description formalism for representing grammatical knowledge might have been reached. In particular, Bredenkamp presents a detailed discussion of some apparent options to encode binding constraints in HPSG — coindexing as

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[1] We follow the definition of binding constraints proposed in (Pollard and Sag, 1994, Chap.6) and subsequent extension in (Xue, Pollard, and Sag, 1994) and (Branco and Marrafa, 1999) which include the fourth binding principle Z for long-distance reflexives.

[2] Vd. (Branco and Marrafa, 1999) for the binding square of oppositions, and (Branco, forth) for the quantificational structure of binding constraints and their organization into a square of logical duality.

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an unbounded dependency construction vs. type hierarchy to classify anaphors according to their anaphoric realization vs. type hierarchy to classify predicators in terms of the anaphoric realization of their arguments — and a thorough report of their shortcomings (Chap.7).

This pessimistic note is not completely shared by Richter, Sailer, and Penn (1999). Focusing on Principle B, these authors observe that the difficulties with its grammatical encoding have to do with the quantificational nature of its definition, and offer the conjecture that overcoming the problem of integrating binding theory into formal grammars will require redefining the generalizations captured in so-called binding principles by "looking at the linguistic phenomenon [of binding constraints] from a completely different angle than the original formulation" (p.291).

Our primary goal here is fully in line with this hint, and we argue for a conceptual shift on the understanding of the nature of binding constraints. On the basis of such discussion, and adopting a quite simple, underspecified representation of the semantics of anaphoric nominals, we introduce the rationale of a lexicalist account of binding constraints in formal grammars (Section 2).

Taking into account this rationale, we show how binding theory can then be integrated into grammar by providing a fully-fledged specification of binding constraints in terms of the current HPSG description formalism (Section 3). We then check this specification against a working example (Section 4).

2 The Lexical Nature of Binding Constraints

Binding constraints have been essentially viewed as well-formedness conditions, thus belonging to the realm of Syntax: "[they] capture the distribution of pronouns and reflexives" (Reinhart and Reuland, 1993, p.657). In line with (Gawron and Peters, 1990) we think these constraints should rather be understood as conditions on semantic interpretation, given they delimit (non-local) aspects of meaning composition, rather than aspects of syntactic combination.

Note that, like other kind of constraints on semantic composition, binding constraints impose conditions on the interpretation of certain expressions — anaphors, in the present case — based on syntactic geometry. This cannot 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 the example above, given how they happen to be syntactically related, the semantic values of *red* and *table* cannot be composed in a way that their sentence could be used to describe a situation concerning a red table, rather than a white table. Likewise, if we take *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 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.

This discussion leads us to consider that an anaphor should be semantically 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 an update both of (i) its anaphoric potential – which is instantiated as the set of its grammatically admissible antecedents – and of (ii) the context, against which other NPs are interpreted.

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

(i) The updating of the anaphoric potential of *n*, in turn, delivers a representation of the contextualized 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*.

(ii) 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 (Kamp and Reyle, 1993) of *n* being added to the three lists above.

Under this approach, the satisfaction of binding constraints result from a few simple operations, and their specification will consist 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**. If *n* is a pronoun, its semantics should include the list of its non-local o-commanders, that is the list **B**=**U**$\backslash$(**A'**$\cup$[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**$\backslash$(**Z'**$\cup$[r-mark$_n$]), which contains the non-ocommanders of *n*.

Note that 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.[3] Their elements have to be submitted to the other filters and preferences of this process so that one of them ends up being chosen as the antecedent. In particular, some of these markers may turn up not being admissible antecedent candidates due to violation of other filters — e.g. those requiring similarity of morphological features or of semantic type under certain circumstances — that on a par with binding constraints have to be complied with. For example, in *John described Mary to himself*, by the sole filtering 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.

In this particular case, separating these two type of filters — similarity of morphological

[3] See (Branco, 2000, Chap.2) for a list of filters and preferences for anaphor resolution proposed in the literature.

features from 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 (Higginbotham, 1983). In this respect we deviate from the proposal of Pollard and 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.[4]

3 Grammatical Encoding of Binding Theory

In this section we discuss how the module of binding theory can be specified with the basic description language of HPSG. As a starting point, we adopt the feature geometry designed in (Pollard and Sag, 1994), together with the proposal for a semantics component for HPSG based on Underspecified Discourse Representation Theory (UDRT) advocated in (Frank and Reyle, 1995). This semantic component is encoded as the value of the feature CONT(ENT) (vd. example below). This value, of sort *udrs*, has a structure which permits that the mapping into underspecified discourse representations (Reyle, 1993) be quite straightforward.

(1)
$$_{udrs}\begin{bmatrix} \text{LS} & \begin{bmatrix} \text{L-MAX} & \boxed{1} \\ \text{L-MIN} & \boxed{1} \end{bmatrix} \\ \text{SUBORD} & \left\{ \ldots \right\} \\ \text{CONDS} & \left\{ \ldots \right\} \end{bmatrix}$$

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 which 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.

As a proposal for the integration of binding theory into HPSG, we designed a simple extension of this semantic component for the *udrs* of nominals, enhancing it with feature 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

[4]In this point it is also worth noting that, 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 singular antecedents. Accordingly, this provides further motivation to separate binding constraints from other filters in the anaphor resolution process. In particular, the approach to binding we have been sketching is compatible with proposals for plural anaphora resolution that take into account split anaphora, as the one in (Eschenbach et al., 1989). According to this proposal, 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 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 pluralization (e.g. i-sum a la Link (1983)), that the final antecedent will be chosen by the anaphor resolver.

realized 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. 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.

(2)
$$\begin{bmatrix} \text{LOC}\,|\,\text{CONT} & \begin{bmatrix} \text{LS} & \begin{bmatrix}\text{L-MAX} & \boxed{1}\\ \text{L-MIN} & \boxed{1}\end{bmatrix}\\ \text{SUBORD} & \{\ldots\}\\ \text{CONDS} & \{\ldots\} \\ \text{ANAPH} & \begin{bmatrix}\text{R-MARK} & \textit{refm}\\ \text{ANTEC} & \textit{list(refm)}\end{bmatrix}\end{bmatrix}\\ \text{NONLOC}\,|\,\text{BIND} & \begin{bmatrix} \text{LIST-A} & \textit{list(refm)}\\ \text{LIST-Z} & \textit{list(refm)}\\ \text{LIST-U} & \textit{list(refm)}\\ \text{LIST-LU} & \textit{list(refm)}\end{bmatrix}\end{bmatrix}$$

On a par with this extension, the NONLOC value is also extended with a new feature, BIND(ING), with subfeatures LIST-A, LIST-Z, and LIST-U. 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 for encoding the contribution of the local context to the global, non local context, as explained in the next subsections.

For the sake of perspicuity, the examples below only display the important features for the point at stake. The NONLOC value has this definition in (Pollard and Sag, 1994):

(3)
$${}_{\textit{nonloc}}\begin{bmatrix}\text{TO-BIND} & \textit{nonloc1}\\ \text{INHERITED} & \textit{nonloc1}\end{bmatrix}$$

These are thus the details of the expansion we are assuming, where the original information is coded now as a *udc* object, which keeps record of the relevant non local information for accounting to *u(nbounded) d(ependency) c(onstructions)*:

(4)
$${}_{\textit{nonloc}}\begin{bmatrix}\text{UDC} & {}_{\textit{udc}}\begin{bmatrix}\text{TO-BIND} & \textit{nonloc1}\\ \text{INHERITED} & \textit{nonloc1}\end{bmatrix}\\ \text{BIND} & {}_{\textit{bind}}\begin{bmatrix} \text{LIST-A} & \textit{list(refm)}\\ \text{LIST-Z} & \textit{list(refm)}\\ \text{LIST-U} & \textit{list(refm)}\\ \text{LIST-LU} & \textit{list(refm)}\end{bmatrix}\end{bmatrix}$$

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

3.1 Representing the Context for Binding

We can turn now to the representation of the context for binding, in particular to the specification of the constraints on the values of the attributes LIST-A, LIST-Z, LIST-U and LIST-LU. This representation of the context can be handled by adding a new HPSG principle to the grammar fragment presented in the Annex of (Pollard and Sag, 1994), a principle we term the Binding Domains Principle (BDP). This principle consists of three clauses constraining signs with respect to these four lists of reference markers. A full understanding of their details, presented below, will be facilitated with the working example discussed in detail in the next Section.

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

(5) **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 — which is required to be 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) is meant to prevent self-reference loops due to anaphoric interpretation, avoiding what is known in the literature as the i-within-i effect — as noted above, the R-MARK value of non lexical NPs is contributed by the lexical representation of their determiners, in Spec-daughter position.

The HPSG top ontology was 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 was 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 paper, we adopted a very simple approach to the structure of discourses which suffices for the present account of binding. As discussed in detail in the next Section, this object of sort *ctx* is used to provide a rough simulation of the contribution of the non linguistic context to the interpretation of utterances.

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

BDP-Clause II below is responsible for constraining LIST-A.

(6) **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 non-nominal and non-prepositional signs, 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 passed from the lexical head to its successive projections, by virtue of (ii.), and also from the head-daughters to their arguments, given (i.).

On a par with this Clause, it is important to make sure that at the lexical entry of any predicator *p*, LIST-A include the R-MARK values of the possibly subcategorized arguments of *p* specified in its ARG-S value. Moreover, the reference markers appear in the LIST-A value under the same ordering as the ordering of the corresponding *synsem* in ARG-S.

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

(7) **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 non-lexical nominal Head daughters, 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 BDP–Clause III ensures that, at the top node of a grammatical 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 with 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 parameterization of what counts as a local domain for a particular language will be the specification of BDP–Clauses II and III for that language.

3.2 Lexical Constraints on Binding

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

(8)

$$\begin{bmatrix} \text{LOC}\,|\,\text{CONT} & \begin{bmatrix} \text{LS} & \begin{bmatrix}\text{L-MAX} & \boxed{1}\\ \text{L-MIN} & \boxed{1}\end{bmatrix}\\ \text{SUBORD} & \{\} \\ \text{CONDS} & \left\{\begin{bmatrix}\text{LABEL} & \boxed{1}\\ \text{DREF} & \boxed{2}\end{bmatrix}\right\} \\ \text{ANAPH} & \begin{bmatrix}\text{R-MARK} & \boxed{2}\\ \text{ANTEC} & \boxed{5}\ \textit{principleB}\left(\boxed{4},\boxed{3},\boxed{2}\right)\end{bmatrix}\end{bmatrix}\\ \text{NONLOC}\,|\,\text{BIND} & \begin{bmatrix}\text{LIST-A} & \boxed{3}\\ \text{LIST-Z} & \textit{list(refm)}\\ \text{LIST-U} & \boxed{4}\\ \text{LIST-LU} & \left\langle\boxed{2}\right\rangle\end{bmatrix}\end{bmatrix}$$

In this feature structure, the semantic condition in CONDS associated with the pronoun corresponds simply to the discourse referent $\boxed{2}$ in the value of DREF. This semantic representation is supposed 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 $\boxed{2}$ and one of the reference markers in the value $\boxed{5}$ of ANTEC. The latter will be the antecedent against which the pronoun will happen to be resolved, and the semantic condition where the two markers will be related represents the relevant mode of anaphora assigned to the anaphoric relation between the anaphor and its antecedent (e-type, bridging, bound-anaphora, etc.)

The binding constraint associated with pronouns, in turn, is specified as the relational constraint *principleB* in the value of ANTEC. This relational constraint is responsible for the updating 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 the previous Section, this relational constraint *principleB* should be 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).

Finally, the contribution of the reference marker of the pronoun to the context is ensured via token-identity between R-MARK and LIST-LU values. The piling up of this reference marker in the global LIST-U value is determined by the BDP discussed in the previous section. [5]

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*, *principleC* and *principleZ* — encode the corresponding binding principles and return the updated 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 the previous Section, thus involving the list append and list difference operations described there.

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 lexically 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 (Frank and Reyle, 1995, p.12) 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 (Pollard and Sag, 1994, p.263) occurs when *principleA*($\boxed{3}$,$\boxed{2}$) returns the empty list as the value of feature ANTEC:

[5] Consider sentence *John said that he shaved him*. Ignoring how other anaphors are resolved, in the light of Principle B, *he* can take *John* as its antecedent; likewise, *him* can take *John* as its antecedent. Nevertheless, if *he* actually ends up resolved against *John*, the latter cannot be the antecedent of *him*, and vice-versa. This specific resolution both of *he* and *him* blocks two anaphoric relations that would otherwise have been admissible. It induces a contingent violation of binding constraint B due to an accidental, transitive anaphoric relationship between *he* and *him* (vd. (Pollard and Sag, 1994, 74) for a discussion of cases of accidental coreference involving contingent violations of Principle C). Cases like this, of undesired transitive anaphoricity, are to be handled by filters other than binding constraints during the anaphor resolution process or may be handled at the level of semantic representation. Constraints may be introduced at the lexical semantic representation of pronouns: If the pronoun and another anaphor *a* have the same antecedent r_b, then the marker r_a of *a* has also to be an admissible antecedent of the pronoun. This can be ensured by including, in the CONDS value in (8), semantic conditions expressing that $\forall r_a, r_b((\boxed{2}=_{anaph}r_b \wedge r_a=_{anaph}r_b) \Rightarrow (\langle r_a\rangle \cup \boxed{5} = \boxed{5}))$.

(9)
$$\begin{bmatrix} \text{LOC}\,|\,\text{CONT} & \begin{bmatrix} \text{LS} & \begin{bmatrix}\text{L-MAX} & \boxed{1}\\ \text{L-MIN} & \boxed{1}\end{bmatrix} \\ \text{SUBORD} & \{\} \\ \text{CONDS} & \left\{\begin{bmatrix}\text{LABEL} & \boxed{1}\\ \text{DREF} & \boxed{2}\end{bmatrix}\right\} \\ \text{ANAPH} & \begin{bmatrix}\text{R-MARK} & \boxed{2}\\ \text{ANTEC} & \boxed{4}\ \mathit{principleA}\left(\boxed{3},\boxed{2}\right)\end{bmatrix}\end{bmatrix} \\ \text{NONLOC}\,|\,\text{BIND} & \begin{bmatrix}\text{LIST-A} & \boxed{3}\\ \text{LIST-Z} & \mathit{list(refm)}\\ \text{LIST-U} & \mathit{list(refm)} \\ \text{LIST-LU} & \left\langle\boxed{2}\right\rangle\end{bmatrix}\end{bmatrix}$$

This happens if the reference marker of the reflexive $\boxed{2}$ is the first element in the relevant obliqueness hierarchy, i.e. it is the first element in the LIST-A value in $\boxed{3}$, thus o-commanding the other possible elements of this list and not being o-commanded by any of them.[6]

Under these circumstances, 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 anaphor resolver — which will operate then on the empty ANTEC list — 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.[7]

4 A Working Example

In order to better illustrate the integration of binding constraints into grammar as well as the outcome obtained from an HPSG grammar with the above specification of binding theory, we discuss now the example below and the corresponding grammatical representation in Fig. 1.

(10) Every student said he likes himself.

Fig. 1 presents an abridged version of the grammatical representation produced by the implemented grammar for the discourse that contains only this sentence. The feature structures

[6] For the sake of the discussion, we concentrate in exempt occurrences of short-distance reflexives, as illustrated in the example: *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$_i$* (Golde, 1999, p.73). The account discussed here is straightforwardly extended to exempt occurrences of long-distance reflexives.

[7] Cf. (Kuno, 1987) and (Zribi-Hertz, 1989). See (Golde, 1999) for a recent discussion and further references on this issue.

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 the non terminal nodes.

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 $\langle \boxed{54},\boxed{247} \rangle$.

In the nodes of the embedded clause, the LIST-Z value is the concatenation of that upper LIST-Z value and the LIST-A value in the embedded clause $\langle \boxed{24}, \boxed{392} \rangle$, from which the list $\langle \boxed{54}, \boxed{247}, \boxed{24}, \boxed{392} \rangle$ is the result. 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. Therefore, $\langle \boxed{24},\boxed{392} \rangle$ is the LIST-A value of *likes*, and $\langle \boxed{54},\boxed{247} \rangle$ is the LIST-A value of *said*.

Observing now LIST-LU, we see that as one ascends in the constituency representation, 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 and $\boxed{415}$, the one available in the non linguistic context, from which the list $\langle \boxed{415}, \boxed{54}, \boxed{247}, \boxed{24}, \boxed{392} \rangle$ is the result. In cases where the discourse contains more than one sentence, BDP–Clause I (i.) ensures that LIST-LU ends up with all reference markers in 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.

Moving now to the representation of the NPs, we can take a closer look at the leaf nodes in the constituency tree. Let us consider first how the NPs contribute to the representation of the context.

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

In the case of the quantificational NP *every student*, two tags are passed, corresponding to the VAR value $\boxed{54}$ — token-identical with the DREF value of the restrictor and providing for bound-variable anaphora interpretations (Reinhart, 1983) — and the R-MARK value $\boxed{247}$ — providing for e-type anaphora (Evans, 1980).

We are assuming here an account of e-type anaphora in line with the approach in (Kamp and Reyle, 1993, p.311ff). According to this account, a quantificational NP contributes a plural reference marker to the semantic representation of discourse which 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 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 (Kamp and Reyle, 1993, p.310).

In order to incorporate such an account of e-type anaphora into Underspecified DRT as this is proposed in (Frank and Reyle, 1995), the reference marker standing for the plurality satisfying the semantic condition obtained with Σ-Abstraction in the CONDS value of a determiner is made

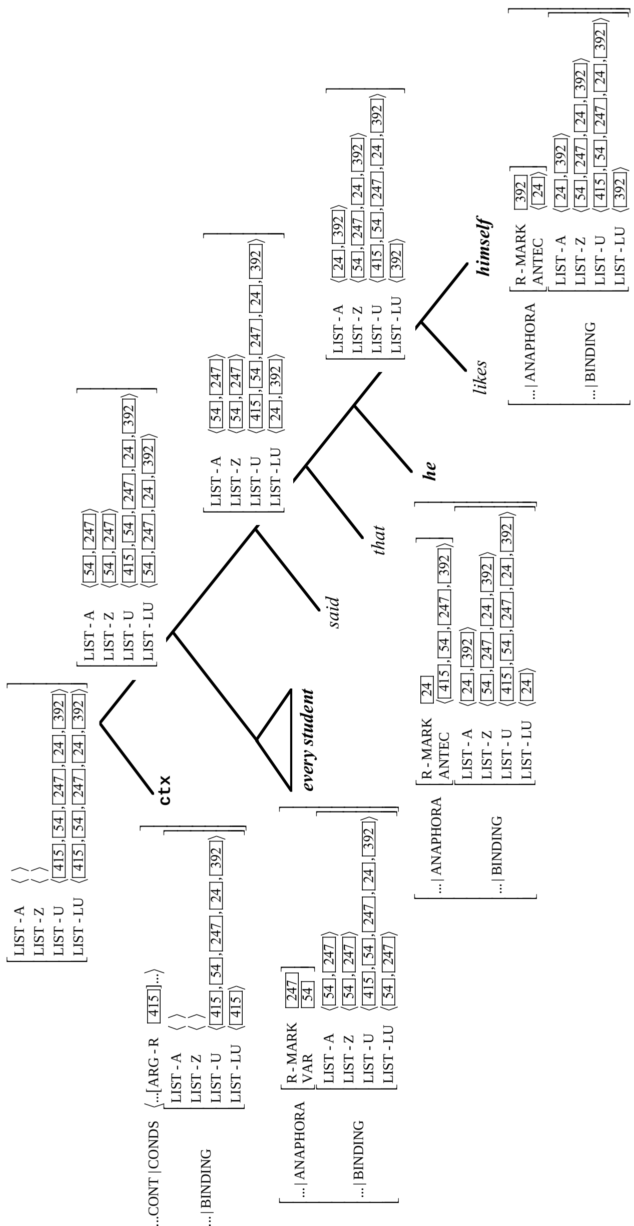

Figure 1: *Every student said he likes himself.*

token-identical with the R-MARK value. The *synsem* of the lexical entry for *every*, for instance, results as in (11) below, where $\boxed{1}$ is the marker obtained via Σ-Abstraction.

$$
(11)\quad
\begin{bmatrix}
\text{LOC} \mid \text{CONT} & \begin{bmatrix}
\text{LS} & \begin{bmatrix} \text{L-MAX} & \boxed{4} \\ \text{L-MIN} & \boxed{5} \end{bmatrix} \\
\text{SUBORD} & \left\{ \boxed{4}>\boxed{3}, \boxed{4}>\boxed{5}, \boxed{8}\geq\boxed{5} \right\} \\
\text{CONDS} & \left\{ \begin{array}{l}
\begin{bmatrix} \text{LABEL} & \boxed{4} \\ \text{REL} & \textit{every} \\ \text{RES} & \boxed{3} \\ \text{SCOPE} & \boxed{5} \end{bmatrix},
\begin{bmatrix} \text{LABEL} & \boxed{3} \\ \text{DREF} & \boxed{2} \end{bmatrix}, \\
\begin{bmatrix} \text{LABEL} & \boxed{5} \\ \text{DREF} & \boxed{7} \end{bmatrix},
\begin{bmatrix} \text{LABEL} & \boxed{8} \\ \text{REL} & \Sigma\textit{abstraction} \\ \text{ARG1} & \boxed{2} \\ \text{ARG2} & \boxed{7} \\ \text{DREF} & \boxed{1} \end{bmatrix}
\end{array} \right\} \\
\text{ANAPH} & \begin{bmatrix} \text{R-MARK} & \boxed{1} \\ \text{VAR} & \boxed{2} \end{bmatrix}
\end{bmatrix} \\
\text{NONLOC} \mid \text{BIND} & \begin{bmatrix}
\text{LIST-A} & \textit{list(refm)} \\
\text{LIST-Z} & \textit{list(refm)} \\
\text{LIST-U} & \textit{list(refm)} \\
\text{LIST-LU} & \left\langle \boxed{2}, \boxed{1} \right\rangle
\end{bmatrix}
\end{bmatrix}
$$

Looking now at how the representation of the context is encoded in each NP, 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, as discussed in the previous Section.

LIST-A value is obtained via token-identity with LIST-A of the subcategorizing predicator (BDP–Clause II (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 (respectively, BDP–Clause II (iii.) and BDP–Clause I (iii.i.)).

As to the anaphoric nominals, we can check how its anaphoric potential is circumscribed in each specific occurrence.

At this stage, the value of ANTEC is a list that records the grammatically admissible antecedents of the corresponding anaphor only at the light of binding constraints. In compliance with principle A predictions, the semantic representation of the reflexive includes the attribute ANTEC with the singleton list $\langle\boxed{24}\rangle$ 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 $\boxed{24}$ in its own semantic representation.

The semantic representation of the pronoun, in turn, also includes feature ANTEC, whose value is the list of the antecedent candidates, $\langle\boxed{415}, \boxed{247}, \boxed{54}, \boxed{392}\rangle$, thus indicating that, in this sentence, the pronoun cannot be anaphorically linked only with itself, at the the light of principle B.

This list includes antecedent candidates for the pronoun that will be dropped out by preferences or constraints on anaphoric links other than binding constraints. For instance, the plural reference marker $\boxed{247}$, which is the R-MARK value of *every student*, will eventually be excluded by the anaphor 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 $\boxed{392}$ of the reflexive will be discarded as a suitable antecedent by the resolver system since this would lead to an interpretive loop where the pronoun and the reflexive would be antecedents of each other.

Finally, in order to illustrate how the non linguistic context may be simulated in the linguistic representation of sentences, in this example the reference marker $\boxed{415}$ 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. As in the lexical entries of nominals, in the feature representation of *ctx* the reference marker $\boxed{415}$ was integrated in the LIST-LU value. This reference marker ends up added to the list of all reference markers both in the linguistic discourse and in the non linguistic context — the shared value of features LIST-LU and LIST-U at the top node in Fig.1 — by the effect of BDP–Clause I, as explained above for the markers introduced by other nodes.

5 Conclusions

Departing from the exhaustive indexation, syntax-driven approach to binding, we argued for an alternative, semantics-oriented rationale for binding principles. Under this new understanding of the nature of grammatical constraints on anaphoric binding, these principles are viewed as contributing to circumscribe the contextually determined semantic value of anaphoric nominals. This conceptual shift helped to find a fully-fledged formal specification of binding principles with the HPSG lean description formalism where these constraints are entered in the grammar as part of the information kept at the lexical entries of anaphoric expressions.

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