Reflexives and Reciprocals in LTAG

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1 Introduction

This paper presents an LTAG analysis of reflexives like *himself* and reciprocals like *each other*. These items need to find a c-commanding antecedent from which they retrieve (part of) their own denotation and with which they syntactically agree. The relation between anaphoric item and antecendent must satisfy the following important locality conditions (Chomsky (1981)).[1]

First, when the anaphoric item is the argument of a verb, its antecedent can be any (c-commanding and agreeing) NP argument of that **same** verb. If more than one antecedent is available, the sentence is ambiguous:

(1) John$_i$ introduces Bill$_j$ to himself$_{i/j}$

Second, in general the antecedent cannot be the argument of a **different** verb, as in (2). But two exceptions exist: Raising as in (3), and Exceptional Case Marking (ECM) constructions as in (4).

(2) *John$_i$ thinks that Mary likes himself$_i$

(3) John$_i$ seems to himself$_i$ to be a decent guy

(4) John$_i$ believes [himself$_i$ to be a decent guy]

Finally, when the anaphoric item is inside a host NP, again its antecedent can be an argument of the **same** noun but generally not of a **different** predicate, as in (5). However, if the host NP has no genitive or if the anaphoric item is the genitive itself, the antecedent can be a co-argument of the host NP rather than of the anaphoric item, as in (6)-(7).

(5) Sue$_i$ likes Mary$_j$'s pictures of herself$_{*i/j}$

(6) John$_i$ likes pictures of himself$_i$

[1] Other important interpretive aspects such as the difference between strong reciprocity and intermediate reciprocity lie outside the scope of the present paper (Dalrymple et al. (1998), Beck (2001)). For simplicity, locality will be illustrated only for strong reciprocity examples, but see footnote 5.

(7) [John and Mary]$_i$ like each other$_i$'s pictures.

To summarize, the local domain within which an anaphor needs to be bound comprises more than its co-arguments. It is, however, clearly restricted. The aim of this paper is to propose an analysis that determines the relevant local binding domain in a natural way, i.e., without additional stipulations. We will see that LTAG, a formalism that displays an extended domain of locality, is particularly well suited for such an analysis.

The paper is organized as follows. Section 2 gives an introduction to LTAG semantics. Section 3 examines a previous LTAG analysis of the phenomenon. The present proposal starts in section 4 with the basic analysis. Section 5 continues with reciprocals, section 6 with Raising and ECM constructions, and section 7 with complex NPs. Section 8 concludes.

2 LTAG semantics with semantic unification

LTAG (Joshi and Schabes (1997)) is a tree-rewriting formalism. An LTAG consists of a finite set of *elementary* trees associated with lexical items. The elementary trees represent extended projections of lexical items and encapsulate all syntactic/semantic arguments of the lexical anchor. Larger trees can be derived by substitution (replacing a leaf with a new tree) and adjunction (replacing an internal node with a new tree). In an adjunction, the new elementary tree has a special leaf, the *foot node* (marked with an asterisk). Such a tree is called an *auxiliary* tree. When adjoining such a tree to a node μ, in the resulting tree, the subtree with root μ from the old tree is put below the foot node. Non-auxiliary elementary trees are called *initial* trees. Each derivation starts with an initial tree.

LTAG derivations are represented by derivation trees that record the history of how the elementary trees are put together. Each edge stands for an adjunction or a substitution. The edges are equipped with addresses of the nodes where the substitutions/adjunctions take place. E.g., see the derivation in Fig. 1: Starting from the tree of *laugh*, the tree for *John* is substituted at position *np* and *sometimes* is adjoined at position *vp*.

In the semantics framework we are using (Kallmeyer and Romero (2005)), each elementary tree is linked to a semantic representation and a semantic feature structure description. The latter are used to compute (via conjunction and additional equations) assignments for variables in the representations. Semantic representations are sets of typed labelled formulas and of scope constraints. A scope constraint is an expression $x \geq y$ where x and y are propositional labels or meta-variables (cf. holes in Bos (1995)).

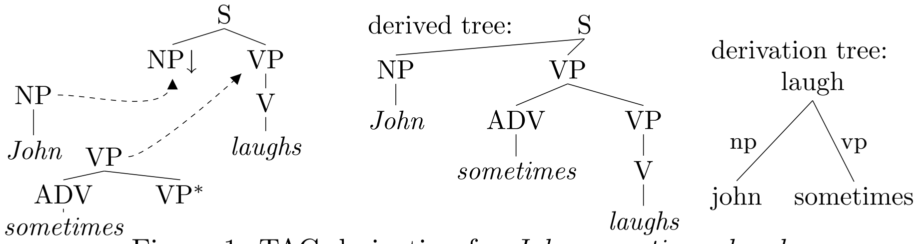

Figure 1: TAG derivation for *John sometimes laughs*

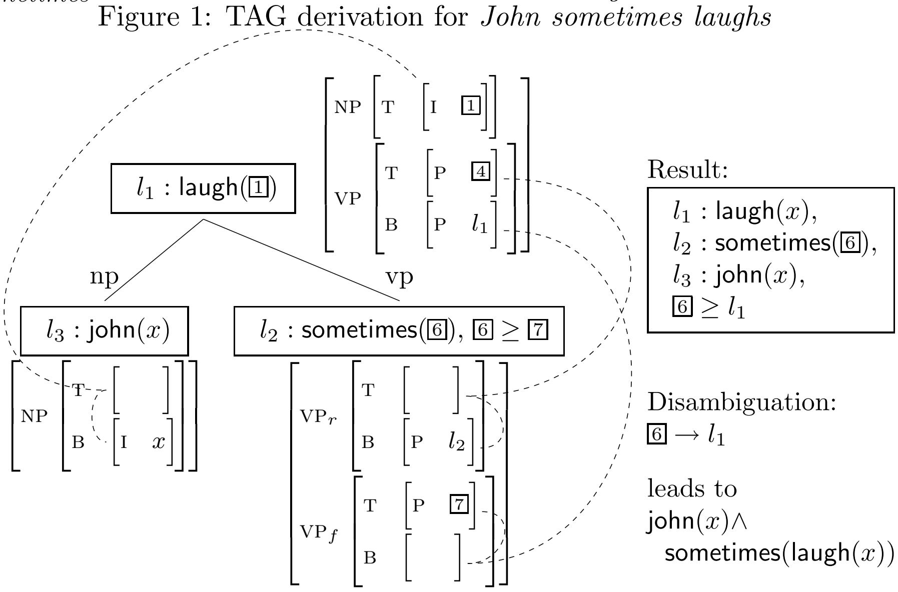

Figure 2: Semantic computation for *John sometimes laughs*

The formulas in a semantic representation contain meta-variables ($\boxed{1}$, $\boxed{2}$, etc.) Each semantic representation is linked to a semantic feature structure description. The meta-variables from the formulas can occur in these descriptions and to some of them values are assigned via feature equation. As an example see the representation of *laughs* at the top of Fig. 2. The fact that the argument $\boxed{1}$ of laugh appears in the top (T) feature of the subject node position NP indicates that this argument will be obtained from the semantics of the tree substituted at the subject node. The label of the laugh proposition, l_1, is linked to the bottom of the VP node. This signifies that the proposition l_1 is the minimal proposition corresponding to this node.

Semantic composition consists of conjoining feature structure descriptions while adding further feature value equations. In the derivation tree, elementary trees are replaced by their semantic representations plus the corresponding semantic feature structures. Then, for each edge in the derivation tree from γ_1 to γ_2 with position p: 1) The T feature of position p in γ_1 and the T feature of the root position in γ_2 are identified, 2) and if γ_2 is an auxiliary tree, then the B feature of the foot node of γ_2 and the B feature of position p in γ_1 are identified. Furthermore, for all γ in the derivation tree and for all positions p in γ such that there is no edge from γ to some other tree with position p: the T and B features of position p in γ are identified.

Fig. 2 shows the semantics for the derivation from Fig. 1. The formula $\mathsf{john}(x)$ is interpreted as meaning "there is a unique individual *John* and x is this individual". *Sometimes* scopes over a proposition $\boxed{6}$ and contributes a new proposition l_2. The feature value identifications lead to the identities marked with dotted lines. They yield the assignment $\boxed{1} = x$, $\boxed{7} = l_1$, $\boxed{4} = l_2$. This is then applied to the semantic representation and the union of the representations is built. In our example this gives the result in Fig. 2.

The resulting semantic representation is underspecified. In a further step, appropriate disambiguations must be found that assign propositional labels to propositional meta-variables respecting the scope constraints. The disambiguated representation is then interpreted conjunctively (see Fig. 2).

3 Ryant and Scheffler (2006)

Ryant and Scheffler (2006) account for binding in LTAG using the same framework for semantics as we do. Their lexical entry of an anaphor is a multicomponent set containing the NP tree with the anaphor and as a second component a degenerate NP auxiliary tree that adjoins to the antecedent. The syntactic and semantic features take care of agreement and coindexation. The fact that the anaphor has direct access to the antecedent NP has advantages. In particular, the analysis extends nicely to reciprocals as in (8). The reciprocal accesses the plural individual denoted by the antecedent and distributes over its atomic subparts.

(8) [John and Mary]$_i$ like each other$_i$

However, precisely the decision to locate the providing of the binding variable on the NP node of the antecedent forces Ryant and Scheffler to use flexible composition in order to avoid non-local MCTAG derivations. Flexible composition roughly allows a reordering of the derivation such that non-local MCTAG derivations become local. Its formal properties are not well-understood yet; in its general form it probably extends the generative capacity of TAG beyond set-local MCTAG (i.e., beyond mild context-sensitivity). This is why we prefer to avoid this extension of TAG.

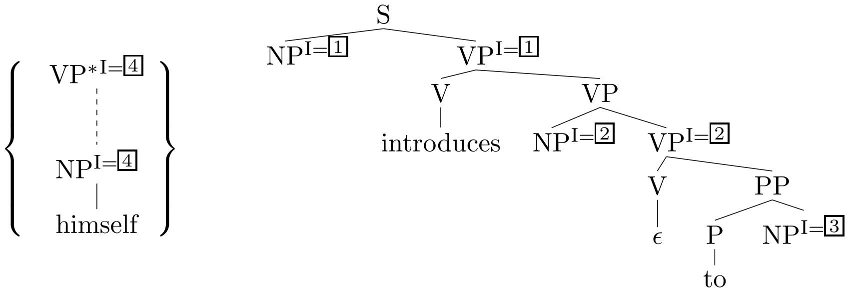

Figure 3: Distribution of the feature I in the analysis of (1)

Since flexible composition is very powerful, Ryant and Scheffler must assume an additional constraint to avoid overgeneration: a c-command relation between antecedent and anaphor that prohibits intervention of subjects.

4 The general analysis

We saw that, in (1) *John*$_i$ *introduces Bill*$_j$ *to himself*$_{i/j}$, the reflexive *himself* can be bound either by *John* or by *Bill*. We follow Ryant and Scheffler (2006) in assuming that there is only one lexical entry for *introduce* while the reflexive comes with a second component that searches for the antecedent. However, we propose this second component to be a VP auxiliary tree.[2]

Concretely, in the verbal tree, the individual of an NP is passed to its sister node on the verbal spine (see $\boxed{1}$ and $\boxed{2}$ in the *introduce* tree in Fig. 3). The lexical entry for *himself* consists of a multicomponent set with a dominance link. The VP component takes one of the I features on the verbal spine and identifies it with the individual of the NP. Thereby the coindexation between antecedent (VP tree) and anaphor (NP tree) is achieved. Depending on where the VP tree adjoins, *himself* is bound by *John* or *Bill*.

Himself can be bound higher than its surface position, but within a certain local domain: We require the derivation to be tree-local. This limits the relevant local domain to the tree to which the reflexive attaches. Since an NP passes its I variable only to its VP sister and since the lexical entry of the reflexive requires the VP component to dominate the anaphor, the antecedent consequently c-commands the anaphor.

Fig. 4 shows the semantic analysis of (1) with the reading where the reflexive is bound by *John*: the VP component adjoins to the VP sister of the

[2] A similar move from antecedent-adjunction to VP-adjunction has been proposed for reflexives in ellipsis in a Generative Grammar framework (Hestvik (1995)).

subject where it finds the variable x provided via the subject I feature. This is equated with the I feature of the NP component of *himself*. Consequently, x is the argument of *introduce* provided by the reflexive. We indicate the relevant I feature equations with dotted lines.[3]

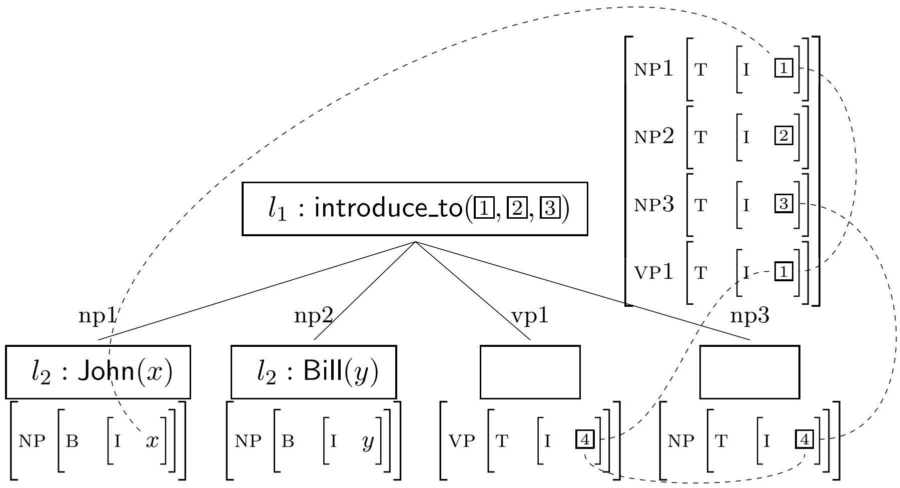

Figure 4: Analysis of (1), reading *John$_i$ introduces Bill$_j$ to himself$_i$*

5 Reciprocals

Reciprocals are like reflexives, except that they necessarily have plural-denoting antecedents and distribute over the subparts of the antecedent's plural individual.[4] The idea is that, first, the upper part of a reciprocal distributes over the plural sum coming from the sister to the VP-attachment position, and then –as with reflexives– it binds the variable introduced in the lower part. Note that the reciprocal has to change the argument of the verb from the plural sum into its atomic subparts. It therefore somehow has to operate on the I features. On the other hand, in case no reciprocal is involved, we want the I feature coming from the subject NP to be the argument of the verb. In order to achieve all this, we define the lexical entry for reciprocals in Fig. 5, and we put different I features on the top and bottom

[3] Besides the sharing of the individual variable in the semantics, binder and anaphor must agree in gender, person and number in the syntax. This can be done by passing a syntactic feature AGR via an intermediate feature BAGR ('agreement feature of the binder') from the binder to the anaphor, in a way parallel to the passing of the semantic I feature.

[4] See Link (1983) on plural individuals and the subpart relation $\sqsubseteq_A$.

of the VP in the verb's tree: the top one is the I feature from the NP node, the bottom one is the argument of the verb. If no distributive auxiliary tree adjoins, the two I features get identified. If a reciprocal's VP-component adjoins instead, the two I features will be separated by the root VP and foot VP of the adjoined reciprocal and thus will be kept distinct.[5]

VP
|
VP*
⋮
NP
|
each other

$$\boxed{\begin{array}{l} l_1 : \mathsf{every}(x, x \sqsubseteq_A \boxed{4}, \\ \qquad \mathsf{every}(y, y \sqsubseteq_A \boxed{4} \wedge x \neq y, \boxed{5})), \\ \boxed{5} \geq \boxed{6} \end{array}}$$

$$\begin{bmatrix} \text{VP}_r & \begin{bmatrix} \text{B} & \begin{bmatrix} \text{I} & \boxed{4} \\ \text{P} & l_1 \end{bmatrix} \end{bmatrix} \\ \text{VP}_f & \begin{bmatrix} \text{T} & \begin{bmatrix} \text{I} & x \\ \text{P} & \boxed{6} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \text{NP} & \begin{bmatrix} \text{T} & \begin{bmatrix} \text{I} & y \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Figure 5: The two elementary trees for *each other* and their semantics

The semantics of (8) [*John and Mary*]$_i$ *like each other*$_i$ is shown in Fig. 6. The plural sum $\boxed{4}$ is identified with z, while $\boxed{1}$ and $\boxed{2}$, the two arguments of like, are identified with x and y, the pairwise different atomic subparts of z.

6 Raising and ECM constructions

Since our derivations are tree-local –i.e., the two components of the anaphor attach to the same elementary tree–, we predict that, in general, the binder and the anaphor must be co-arguments of the same predicate. We now turn to constructions that allow for non co-arguments, and show how our analysis preserves or can be extended to preserve tree-locality in these cases as well.

6.1 Raising

In (3) *John*$_i$ *seems to himself*$_i$ *to be a decent guy*, the reflexive is an argument of the raising verb *seems* while the binder is an argument of the embedded infinitive *to be a decent guy*. This construction is actually not problematic for our analysis since in the LTAG analysis, *seems* is a VP auxiliary tree, consequently, it automatically obtains the I feature corresponding to *John* from the node it adjoins to. So, this feature is available for the VP tree of *himself* when adjoining to the root node of the *seems* tree.

[5] The distributivity induced by *each other* over its antecedent NP is captured in Fig. 5 with the universal quantification $\mathsf{every}(x, ...)$. Furthermore, we introduce $\mathsf{every}(y...)$ to derive the strong reciprocity reading of *each other*. To derive weaker types of reciprocity, we could treat *each other* as introducing a plural sum instead (Beck (2001)).

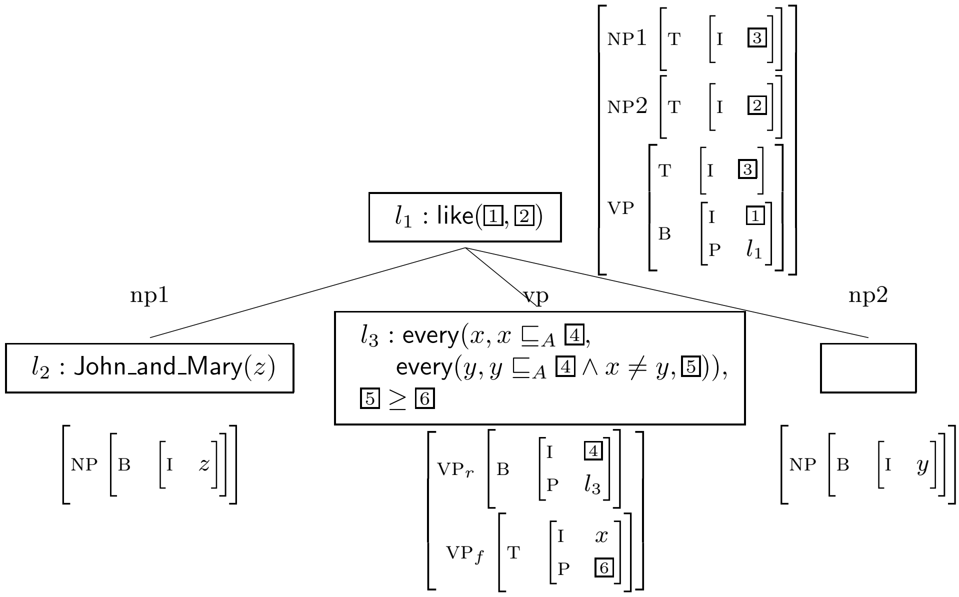

Figure 6: Analysis of (8) [*John and Mary*]$_i$ *like each other*$_i$

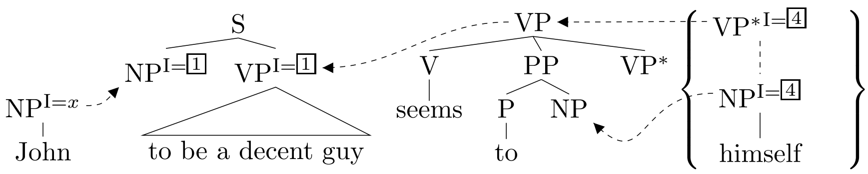

Figure 7: Analysis of (3)

Fig. 7 shows the distribution of the feature I in the analysis of (3). The I feature x from *John* is identified with the I $= \boxed{1}$ from the *decent_guy* tree, $\boxed{1} = x$. Because of the adjunction of *seems* to the VP node, I $= x$ is passed to the root of the *seems* tree. Consequently, when adding *himself*, it gets identified with the VP I and the NP I feature of *himself* ($\boxed{4} = x$).

6.2 ECM

In (4) *John*$_1$ *believes* [*himself*$_1$ *to be a decent guy*], the anaphor is the subject of the embedded clause while the binder is the subject of the matrix verb. Note that this binding from a higher clause is only possible if the anaphor appears in subject position, see (9).

(9) *John$_i$ believes [Mary to like himself$_i$]

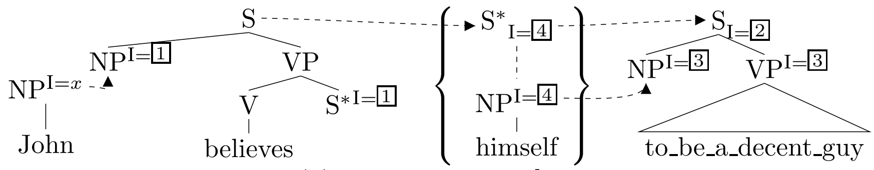

Figure 8: Analysis of (4) *John*$_1$ *believes* [*himself*$_1$ *to be a decent guy*]

Our analysis is sketched in Fig. 8. The main ingredients are the following: ECM verbs have the special property of providing the individual variable of their subject as a possible binder at their foot nodes (here I $= \boxed{1}$), i.e., at the argument slot for the embedded clause. Furthermore, *himself* in subject position has a special lexical entry.[6] Its upper part is an S auxiliary tree that obtains the binder from the bottom position. This request for a binding variable is then equated with the I feature at the foot node of the ECM verb.

(9) is ruled out because the object anaphor looks at a VP node in the *like* tree for its binder and cannot access the I feature provided by *John*.[7]

(10) [John and Mary]$_i$ want each other$_i$ to win

We now consider ECM constructions as (10) where the ECM subject is a reciprocal. Besides obtaining the binder from the embedding verb, the reciprocal must also provide a new argument for the embedding verb. The original idea underlying our analysis is to have two different I features on the auxiliary tree of the reciprocal, one for fetching the plural variable and one for passing the new atomic argument variable. However, here the auxiliary tree of *each other* does not adjoin onto the ECM verb *want*, but the adjunction goes in the other direction. Hence, we cannot put two different I features on top and bottom of the reciprocal's auxiliary tree to do the job. Therefore we introduce a second feature AI ("atomic individual") for individual variables. The analysis of (10) is sketched in Fig. 9.

The bottom features of the node to which *want* adjoins determine whether I and AI get identified or not. In case there is no distributive auxiliary tree, *want* adjoins directly to the S node of *win*, where I and AI are identified ($\boxed{2} = \boxed{6} = \boxed{1}$). In case there is a distributive tree from a reciprocal, *want* adjoins to the root of this tree, as in Fig. 9, and I and AI are kept

[6]Some syntactic feature ensures that this entry cannot be used in non-subject position.

[7]In order to rule out (9), Ryant and Scheffler (2006) need an explicit Subject Intervention Constraint since with the use of flexible composition they lose the locality that characterizes our approach.

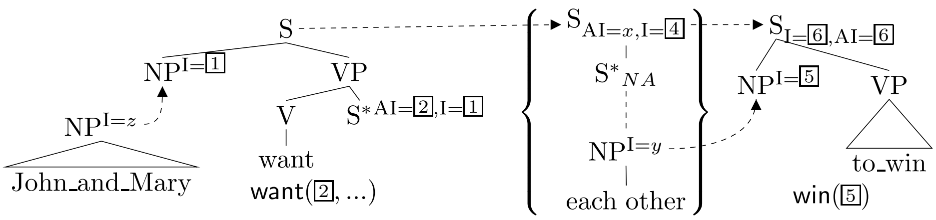

Figure 9: Analysis of (10) *John and Mary want each other to win*

separate: I $\boxed{1} = \boxed{4}$ will provide the plural individual serving as antecedent, and AI $\boxed{2} = x$ will provide the atomic individual serving as argument.[8]

7 Complex NPs

Other cases of apparent non-local binding occur with (6) *John$_i$ likes pictures of himself$_i$* and (7) [*John and Mary*]$_i$ *like each other$_i$'s pictures.* We distinguish two kinds of complex NPs that exhibit different constraints concerning the binding of embedded anaphors: subject-less complex NPs on the one hand and complex NPs with subject on the other.

In subject-less *picture*-NPs such as (6) we can allow the reflexive to access the VP node in the tree of the matrix verb that carries its binder by adopting an analysis that starts with the most deeply embedded NP and then adjoins the other ones on top of it (see Fig. 10). This reduces (6) to a case of local binding.[9] The analysis correctly predicts that an anaphor embedded in a subject-less NP can be bound by any appropriate argument NP of the matrix verb, see (12). Furthermore, it correctly predicts that in subject-less *picture*-NPs that are subjects of an embedded clause, the anaphor can even be bound higher as in (13).[10]

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[8] Note that the distributive auxiliary tree only affects the foot node of the embedding verb, not its root. Thus the embedded reciprocal cannot be bound by an NP in a higher clause; (11) is correctly ruled.

(11) * [John and Mary]$_i$ believe Paul and Sue to want each other$_i$ to win

[9] Such an analysis has already been proposed in LTAG (Kallmeyer and Scheffler (2004)).

[10] In this case, the special subject-reflexive entry from section 6.2 must be used.

We assume (14) to be excluded because of the inability of *himself* to have nominative case.

(14) * John$_i$ thinks that himself$_i$ is a decent guy

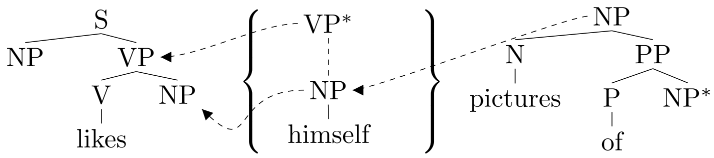

Figure 10: Analysis of (6) *John$_i$ likes pictures of himself$_i$*

(12) Bill showed John$_i$ pictures of himself$_i$

(13) John$_i$ thinks that the pictures of himself$_i$ are horrid

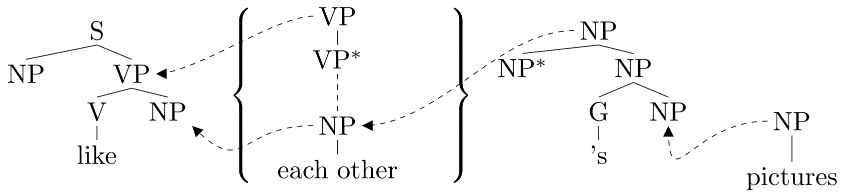

Figure 11: Analysis of (7) [*John and Mary*]$_1$ *like each other$_1$'s pictures*

In *picture*-NPs having a subject, we assume that the analysis starts with the subject NP, subsequently adjoining the genitive *'s* and the rest of the complex NP. (7) then also reduces to a case of local binding (see Fig. 11).[11]

8 Conclusion

In this paper we propose an account of reflexives and reciprocals in LTAG. In contrast to previous approaches, we use only tree-local MCTAG. Tree-local MCTAG are strongly equivalent to TAG, i.e., they have the same nice formal properties.

Our analysis of binding captures the following generalizations: 1) A reflexive/reciprocal can take as antecedent any higher co-argument NP; 2) taking an arguments of a different verb is in general impossible, except in raising and ECM constructions; 3) if the reflexive/reciprocal is an argument of a noun, the antecedent can be any higher NP argument of the verb the

[11] Obviously, an anaphor in object position cannot be bound by an argument of the matrix verb, i.e., (15) is correctly excluded.

(15) *John$_1$ likes Mary's pictures of himself$_1$

noun depends on as long as no subject intervenes. We use a multicomponent entry for reflexives/reciprocals containing a VP auxiliary tree that looks for the antecedent and an NP initial tree containing the lexical item. In addition to the binding requirement, reciprocals induce a distributive reading of the antecedent. We account for this, even in cases of non-local binding such as ECM-constructions.

The tree-locality gives rise to the locality restrictions that hold for binding; we do not need to stipulate any additional constraints. This indicates that tree-local MCTAG display exactly the extended domain of locality needed to account for the locality of anaphora binding in a natural way.

References

Beck, S.: 2001, 'Reciprocals are Definites', *Natural Language Semantics* 9, pp. 69-138.

Bos, J.: 1995, 'Predicate Logic Unplugged'. In: P. Dekker and M. Stokhof (eds.): *Proceedings of the 10th Amsterdam Colloquium*. pp. 133–142.

Chomsky, N.: 1981, *Lectures on Government and Binding*. Foris.

Dalrymple, M. et al.: 1998, 'Reciprocal expressions and the concept of reciprocity', *Linguistics and Philosophy* 21, pp. 159-210.

Hestvik, A.: 1995, 'Reflexives and Ellipsis', *Natural Language Semantics* 2, pp. 1-27.

Joshi, A. K. and Y. Schabes: 1997, 'Tree-Adjoning Grammars'. In: G. Rozenberg and A. Salomaa (eds.): *Handbook of Formal Languages*. Berlin: Springer, pp. 69–123.

Kallmeyer, L. and M. Romero: 2005, 'Scope and Situation Binding in LTAG using Semantic Unification'. Submitted to *Research on Language and Computation*.

Kallmeyer, L. and T. Scheffler: 2004, 'LTAG Analysis for Pied-Piping and Stranding of wh-Phrases'. In: *Proceedings of TAG+7*. Vancouver, pp. 32–39.

Link, G.: 1983, 'The logical analysis of plurals and mass terms: a lattice-theoretical approach'. In R. Baeuerle et al. (eds.): *Meaning, Use, and Interpretation of Language*. Berlin, de Gruyter, pp. 302–323.

Ryant, N. and T. Scheffler: 2006, 'Binding of Anaphors in LTAG'. In: *Proceedings of the 8th International Workshop on Tree Adjoining Grammar and Related Formalisms*. Sydney, Australia, pp. 65–72.