A Corpus-based Evaluation of Syntactic Locality in TAGs*

Fei Xia and Tonia Bleam

Institute for Research in Cognitive Science
University of Pennsylvania
Philadelphia, PA 19104,USA
{fxia/tbleam}@linc.cis.upenn.edu

Abstract

This paper presents a new methodology for examining cases of non-locality. The algorithm presented here allows us to extract from a large annotated corpus sentences that appear to require non-local MCTAG. We examine one such case, extraposition from NP, and argue that the dependency involved is not syntactic and therefore does not require non-local MCTAG.

1. Introduction

Mnch important work has been done to investigate the adequacy of local TAGs to account for various linguistic phenomena, see, e.g., (Heycock, 1987; Becker *et al.*, 1992; Abeillé, 1994; Bleam, 1994; Kulick, 1998; Joshi *et al.*, 2000). This paper presents a new methodology for doing this kind of research. The algorithm presented here allows us to extract from a large annotated corpus (the Penn Treebank) constructions that seem to require non-local[1] derivations. We propose that, in fact, these non-local dependencies should not be represented syntactically, and therefore do not constitute a problem for maintaining tree-local MCTAG.

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[1]By *non-local*, we mean *non-tree-local*.

2. Extracting MC sets from the Treebank

Extracting multi-component (MC) tree sets from Treebanks is one of the tasks performed by a grammar development system named LexTract, whose structure is shown in Figure 1, with the components relevant to the MC extraction task marked in bold. There are three main steps in the MC extraction procedure: first, a bracketed structure in a Treebank (*ttree*) is decomposed into a set of elementary trees (*etrees*); second, a derivation tree is built to show how the *etrees* are combined; third, any pair of *etrees* that coutain co-indexed components are placed in a trees set with the *etrees* that connect them in the derivation tree. If the size of the set is more than three, the relation between the co-indexed components is not tree-local, assuming the correctness of Treebank annotations. For lack of space, we will use an example to demonstrate these main steps without going into the details of the algorithms (see (Xia, 1999) for details).

2.1. *The extracted grammar*

To ensure that the extracted *etrees* are compact and linguistically sound, we require that each *etree* in the grammar fall into one of three types determined by the relations between the anchor of the *etree* and other nodes in the tree, as shown in Figure 2:

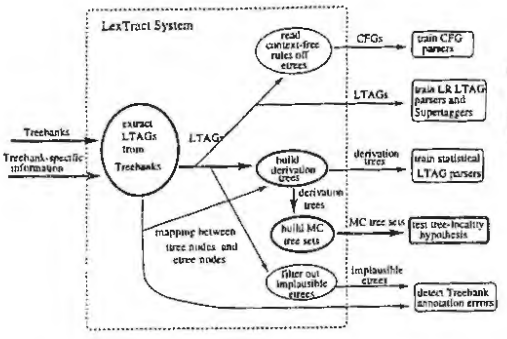

Figure 1: The structure of LexTract

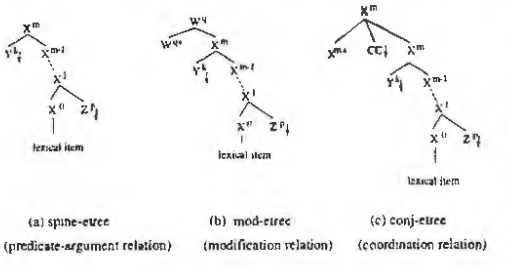

Figure 2: Forms of extracted *etrees*

2.2. *Extracting etrees from ttrees*

The first step of the MC extraction procedure is to extract *etrees* from *ttrees*. A *ttree* from Penn English Treebank is shown in Figure 3, where reference indices (e.g. -1 and -2) mark co-indexed constituents.

```
(S (NP-SBJ (NN supply) (NNS troubles))
   (VP (VBD were)
       (PP-LOC-PRD (IN on)
           (NP (NP (DT the) (NNS minds))
               (PP (IN of)
                   (NP (NP (NNP Treasury) (NNS investors))
                       (SBAR (-NONE- *ICH*-2) )))))
       (NP-TMP (RB yesterday))
       (, ,)
       (SBAR-2 (WHNP-1 (WP who) )
               (S (NP-SBJ (-NONE- *T*-1) )
                  (VP (VBD worried)
                      (PP-CLR (IN about)
                              (NP (DT the) (NN flood) ))))))
   (. .) ))
```

Figure 3: An example from the Treebank

The *ttrees* in the Treebank are partially bracketed in a way that does not explicitly distinguish arguments from adjuncts.

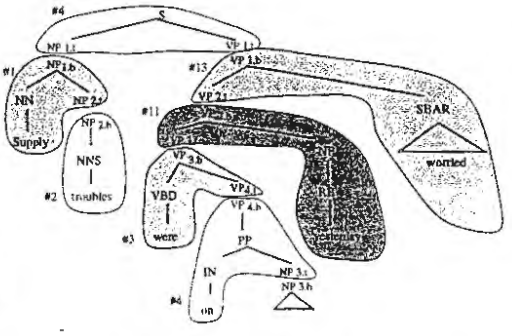

Figure 4: The *etree* set is a decomposition of the fully bracketed *ttree*.

In LTAGs, on the other hand, arguments and adjuncts are distinguished. To overcome this difference in notation, the algorithm first fully brackets *ttrees* by adding intermediate nodes so that *etrees* express one of three relations: a predicate-argument relation, a modification relation, or a coordination relation.

The next step is to extract the component *etrees* from a fully bracketed *ttree*. Recursive structures become mod-etrees or conj-etrees, and the remaining structures become spine-etrees. For instance, in the fully bracketed *ttree* in Figure 4,[2] along the path $S \rightarrow VP_1 \rightarrow VP_2 \rightarrow VP_3 \rightarrow VP_4 \rightarrow PP \rightarrow IN$, three adjuncts (the relative clause, the NP *yesterday* and the auxiliary verb *were*) are factored out and each forms a mod-*etree* (#13, #11 and #3 resp.), while the remaining structures become a spine-*etree* #4. The whole *ttree* yields the fifteen *etrees* shown in Figure 5.

[2]Some nodes in the *ttree* are numbered and split into the top and bottom pairs. Recall that when a pair of *etrees* are combined during parsing, the root of one *etree* is merged with a node in the other *etree*. Splitting nodes into top and bottom pairs during the decomposition of the fully bracketed *ttree* is the reverse process of merging nodes during parsing. For the sake of simplicity, we show the top and the bottom parts of a node only when the two parts will end up in different *etrees*.

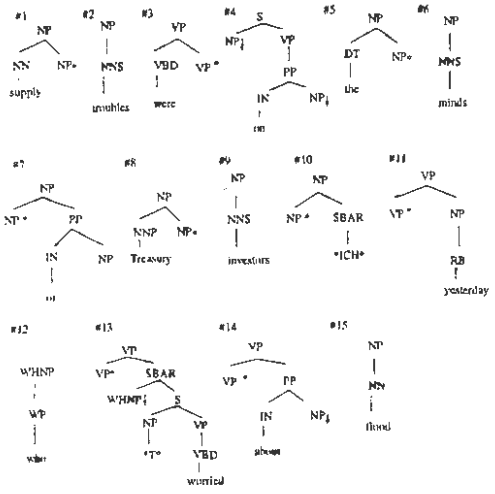

Figure 5: The extracted *etrees*

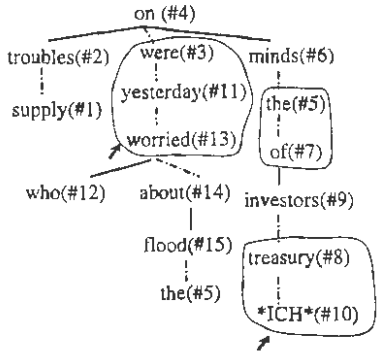

Figure 6: The derivation tree

2.3. *Building derivation trees*

Having extracted the *etrees* from a *ttree*, the next step for MC extraction is to build the derivation tree. Under the assumptions that no adjunctions are allowed at the foot nodes and at most one adjunction at any one node, and given the *etrees*, the mapping between the fully bracketed *ttree* and the derivation tree is one-to-one. The derivation tree for the *ttree* in Figure 4 is shown in Figure 6.

2.4. *Building MC tree sets*

We construct MC sets using the derivation trees and the reference indices in the *ttrees*. Given a pair of constituents that are co-indexed in a *ttree*, let e_g and e_f be the two *etrees* that the two constituents belong to. There exists a unique path that connects the two *etrees* in the derivation tree. The *etrees* on the path form a tree set.[3] If the size of the set is more than three, the relation between the co-indexed components is not tree-local, assuming the correctness of Treebank annotations. In our example, the relation between WHNP-1 and *T*-1 (both are in tree #13) is tree-local, whereas the relation between *ICH*-2 (in tree #10) and SBAR-2 (in tree #13) is not.

3. Experiments

We ran the algorithm on the Penn Treebank II (Marcus *et al.*, 1994). Table 1 gives the breakdown of MC sets by size. Out of 3151 MC sets, 999 sets (31.7%) had more than three *etrees* and were thus not tree-local. Table 2 shows the classifications of these non-local sets.

(1) That is [a skill]$_i$ Sony badly needs t_i and Warner is loath to lose t_i.

(2) It t_i would be my inclination [to advise clients not to sell]$_i$.

(3) Federal Express goes further t_i in this respect [than any company]$_i$.

(4) [Of all the ethnic tensions in America]$_i$, which t_i is the most troublesome right now ?

(5) [JMB officials are expected to be hired to represent the pension fund on the Santa Fe Pacific Realty board, Mr Roulac said t_i, to insulate the fund from potential liability problems.]$_i$

(6) The Diet doesn't normally even debate bills because the opposition parties are so often t_i opposed to whatever LDP does [that it would be a waste of time]$_i$.

[3] Notice if a list *etrees* E_i all modify the same *etree* E, E_i will form a chain in the derivation tree, as circled in Figure 6. Those intermediate mod-*etrees* are not included in the MC tree set.

size of MC sets	≤ 3 (tree-local sets)	4	5	6	7	8	subtotal	total
# of MC sets (type)	2152(68.3%)	874	94	26	4	1	999(31.7%)	3151
# of MC sets (token)	19994(91.3%)	1772	102	26	4	1	1905(8.7%)	21899

Table 1: Numbers of extended MC sets and their frequencies in PTB

PTB errors	LexTract errors	NP-EXP	extraction from coord.	*it*-EXP	comparative construction	*of*-PP	paren-thetical	*so .. that*	others
71	65	337	209	176	50	31	30	11	19

Table 2: Classification of 999 extended MC sets that look non-local

In each of these "non-local" cases, the Treebank notation establishes a dependence between two elements, as shown in (1) – (6). We suggest that, in fact, in all of the cases, the dependence is not syntactic, and so these examples do not constitute cases where non-local MCTAG would be required. Due to space considerations, however, we cannot address each case independently. Instead, we focus on one construction, that of Extraposition (EXP) from NP, both because this was the most common type of "non-local" example found by the algorithm and because it is potentially the strongest case against tree-locality. We will show that even for this difficult case, tree-locality can be maintained.

4. Extraposition

One example of EXP was discussed in Section 2 (cf. Figure 3-6). Further examples are illustrated in (7) and (8), where the bracketed prepositional phrase is construed as an argument (7) or a modifier (8) of the NP in bold.[4]

(7) Younkers rang up **sales** in 1988 [of $313 million].

(8) The company gave us **discounts** all last year [on their premium brands].

Most generative analyses of this phenomenon associate the extraposed phrase (EXP phrase) with a gap in the NP with which it is interpreted. See, e.g., (Guéron, 1980; Baltin, 1981; Pollard & Sag, 1994). These accounts can be referred to as "syntactic-dependence" analyses, since they require that the extraposed phrase and its "antecedent" noun be coindexed or associated *in the syntax*. This coindexation is shown in Figure 7. Other authors, on the other hand, argue for a semantic dependence, or non-gap analysis (Andrews, 1975; Culicover & Rochemont, 1990).

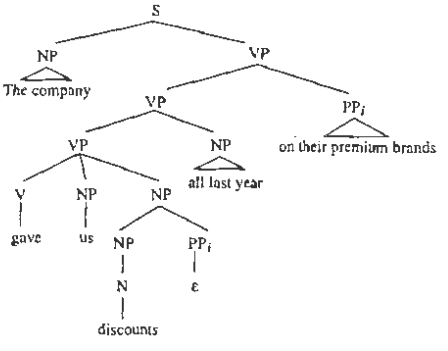

Figure 7: Gap analysis of Extraposition

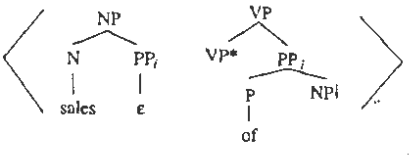

Figure 8: Gap analysis of argument EXP

Within TAG, the syntactic-dependence analysis can be modeled using MC tree sets (Kroch & Joshi, 1987), as in Figures 8 and

[4] Adjunct status was determined using two tests: *one*-substitution and *wh*-extraction.

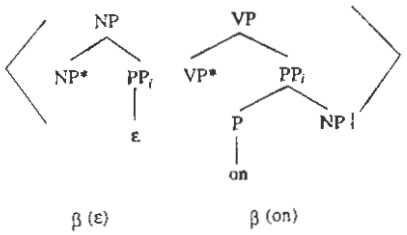

Figure 9: Gap analysis of adjunct EXP

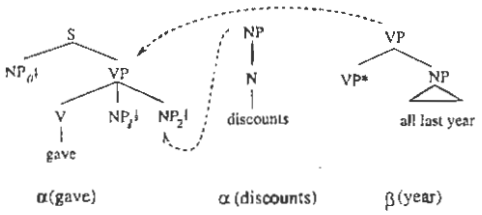

Figure 10: Elementary trees for (8)

9.[5] This approach works for argument EXP, but it faces two problems when applied to adjunct EXP. The first problem is that, given current assumptions, the derivation of even the simplest cases requires non-local MCTAG (Weir, 1988). The trees required to derive (8) are given in Figures 9 and 10. In this derivation $\beta(\varepsilon)$ adjoins to the NP of α(discounts), and β(on) adjoins to the VP node[6] in α(give).

A second problem with the gap analysis is pointed out by (Abeillé, 1994) citing (Gunnarson, 1982). Extraposed adjunct phrases (9) allow pronominalization of the head noun, something that is not allowed if the adjunct phrase is not extraposed (10). This is clear evidence that there is no movement since the putative underlying representation is impossible.

(9) John makes **lists** every day [with names of people who owe us money], and I make **them** every day [with names of people who we owe money to].

(10) * I make them with names of people every day.

(Abeillé, 1994) thus proposes that the relationship between adjunct extraposition and the head noun should be a semantic one rather than a syntactic one. These "base generated" cases are handled using synchronous TAG (S-TAG), where the syntax and semantics are represented by parallel TAG derivations. Representing the semantics with a TAG allows Abeillé to preserve the locality effects that we find in argument EXP, which do require a syntactic dependence. We refer to this locality property as *etree boundedness* (ETB). As Abeillé notes, her analysis predicts that EXP is *NP-bounded*; that is, the extraposed element "has to be a complement of the top N, and cannot be a dependent of an embedded N". While ETB holds of argument EXP, we have found that adjunct EXP does not obey this condition, and hence cannot be accounted for in the S-TAG analysis. (11) and (12) are examples from the Treebank of non-NP-bounded EXP. In (11), the extraposed relative clause *who worried...* is not associated with an argument of the *etree* to which it attaches, but rather to a more deeply embedded NP, thus violating ETB.

(11) Supply troubles were on the minds of **Treasury investors** yesterday [who worried about the flood of new government securities].

(12) Major rivals have been following a policy of continuous and **deep discounting** for at least the past 18 months [on their premium brands].

These examples show that the S-TAG analysis of the semantic dependence is too re-

[5] Notice that positing a dependence in the syntax would not necessarily require an explicit gap in the case of extraposition of an argument PP. When the extraposed phrase is an adjunct, however, syntactic dependence must be represented by adjoining a trace onto the head noun phrase (or alternatively coindexing with features).

[6] Alternatively, the extraposed element could adjoin to the S node. See (Kroch & Joshi, 1987; Culicover & Rochemont, 1990) for discussion.

strictive for adjunct EXP. Instead, we propose that the semantic dependency must be calculated post-derivationally, as, for example, in (Joshi & Vijay-Shanker, 1999), where the semantic representation is read off the derivation tree. The process of calculating this dependency must make reference to structure, but it does not adhere to the strict locality that the S-TAG analysis requires.

5. Conclusions

We have presented an algorithm to extract from the Penn Treebank constructions that seem to require non-local MCTAG. We propose that all these non-local dependencies should not be represented syntactically, and therefore do not require non-local MCTAG. One such example is NP-EXP, which has been previously argued to be a locally-bounded dependency. Our algorithm has revealed that adjunct EXP does not obey the locality constraints previously posited by linguists. If these examples are to be derived syntactically, they would require an LTAG more powerful than Tree-local MCTAG. We show, however, that the dependency between the head noun and the EXP phrase is not a syntactic one, but a semantic one. We conclude that extraposition does not constitute a case for using non-local MCTAG; tree-locality can be maintained.

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