Why extend LTAG? (1)

The reasons:
- appeal to intuition / to a certain favoured analysis (CETM, co-occurrence constraint)
- smaller grammar
- enlarged expressive power
- better tractability

Why extend LTAG? (2)

The phenomena:
- Extracted complements of subject raising verbs:
  1. To whom does Gabriel seem to eat gnocchi? (Frank et al., 2000)
- Extraction out of complex NPs
  2. Which painting did you see a picture of?
- Extraposited relative clauses
  3. Somebody lives nearby [who has a CD-burner].
- Scrambling
  4. dass den Kühlschrank Peter heute repariert ('that Peter repairs the fridge today')
Extracted complements of subject raising verbs

(5) To whom does Gabriel seem to eat gnocchi?
(Frank et al., 2000)

Problem:

\[
\begin{array}{c}
\text{PP} \\
\text{To whom} \\
\text{VP} \\
\text{seems} \\
\text{S*} \\
\text{NP} \\
\text{Gabriel} \\
\text{VP} \\
\text{to eat} \\
\text{NP} \\
\text{gnocchi}
\end{array}
\]

TAG-Analysis: Not possible without changing the shape of the trees considerably (see the trees for the copy language!)

Extraction out of complex NP

(6) Which painting did you see a picture of __?

Problem: The wh-phrase is no complement of see, but of the preposition of that modifies the complement a picture. The constituent [which painting ... of] is called discontinuous.

TAG-Analysis:

\[
\begin{array}{c}
\text{WH} \\
\text{which painting} \\
\text{S} \\
\text{VP} \\
\text{to see} \\
\text{NP} \\
\text{a picture} \\
\text{PP} \\
\text{of} \\
\text{NP*}
\end{array}
\]

⇒ of is part of the object NP-tree
⇒ non-compositional analysis?

Extraposed relative clauses (1)

(7) a. Somebody lives nearby [who has a CD-burner].
   b. Karl hat mir [von der Kopie [einer Fälschung [eines Bildes einer Frau ____]]] erzählt, [die schon lange tot ist].

(8)* That someone would come became certain [who could help].

Relative clauses can appear:
- adjacent to the antecedent
- in the right periphery (Nachfeld) of the embedding sentence
- not unbounded, but non-local dependency

All kinds of constituents can undergo extraposition (especially in German): sentential complements, PPs, NPs

Extraposed relative clauses (2)

(9) a. Somebody lives nearby [who has a CD-burner].
   b. Karl hat mir [von der Kopie [einer Fälschung [eines Bildes einer Frau ____]]] erzählt, [die schon lange tot ist].

Problem: Relative clauses are modifiers that can be placed in non-adjacent position wrt. the modified NP. The NP thus is discontinuous.

TAG-Analysis:
- Feature hacking

⇒ contradicts extended domain of locality
Scrambling

(10) dass Peter den Kühlschrank heute repariert
dass den Kühlschrank Peter heute repariert
... ('that Peter repairs the fridge today')

Problem: Variablity in word order.

TAG-Analysis:
- One elementary tree for every possible complement order.

⇒ elegant?

Long-Distance Scrambling in coherent constructions (1)

(11) dass Peter den Kühlschrank heute zu reparieren versprochen hat
dass den Kühlschrank Peter heute zu reparieren versprochen hat
... ('that Peter has promised to repair the fridge today')

Coherent Constructions (Bech, 1955)
Complements (and adjuncts) of different verbs intermingle. These verbs are connected via "Statusrektion" and subcategorization.

TAG-Analysis:

Long-Distance Scrambling in coherent constructions (2)

(12) dass ihm Peter den Kühlschrank heute zu reparieren versprochen hat
dass ihm den Kühlschrank Peter heute zu reparieren versprochen hat
... ('that Peter has promised him to repair the fridge today')

Problem: If ihm is considered to be an argument/complement of versprochen hat, the tree of versprochen hat has to split into three pieces when conjoined with the tree of zu reparieren.

TAG-Analysis:
- zu reparieren adjoins to versprochen hat.
  ⇒ contradicts elementary tree minimality
- ihm adjoins to zu reparieren.
  ⇒ contradicts co-occurrence constraint

Long-Distance Scrambling in coherent constructions (2)

(13) dass des Verbrechens der Detektiv den Verdächtigen dem Klienten zu überführen versprochen hat
('that the detective has promised the client to indict the suspect of the crime')

Problem: The trees of versprochen hat and zu überführen split into 3 pieces each, while adjunction can yield at most 5 pieces.

Under the co-occurrence constraint, TAG does not have sufficient expressive power to handle coherent constructions
- that have two verbs and two complements each;
- that have more than two verbs
(Becker et al., 1991), (Becker et al., 1992), (Joshi et al., 2000)
### MCTAG - Basics (1)

**Definition**

An MCTAG is a tuple $G = \langle N, T, I, A, O, C, A \rangle$ such that:

- $G_{\text{TAG}} = \langle N, T, I, A, O, C \rangle$ is a TAG with adjunction constraints, and
- $A \subseteq P(I \cup A)$ is a set of subsets of $I \cup A$, the set of elementary tree sets.

Restrictions on the application of an elementary tree set $\Gamma$:

- **(MC)** using $\Gamma$ implies the application of all the elementary trees of $\Gamma$.
- **(SIM)** all trees of $\Gamma$ have to be used simultaneously.

### MCTAG - Basics (2)

MCTAGs can be further restricted:

- **tree-local**: (MC)+(SIM) and all $\gamma_i \in \Gamma$ have to attach to the same elementary tree.
- **set-local**: (MC)+(SIM) and all $\gamma_i \in \Gamma$ have to attach to the same elementary tree set.
- **non-local**: (MC)+(SIM).

Mainly tree-local MCTAG are considered for natural language grammars due to complexity issues.

### MCTAG - Expressivity and Complexity

- **tree-local MCTAG** is strongly equivalent to TAG.
- BUT: the universal recognition problem for tree-local MCTAG is NP-complete!
- **set-local MCTAG** is weakly equivalent to LCFRS and simple RCG. Polynomially parsable.
- **non-local MCTAG**: the fixed recognition problem is NP-complete (even with lexicalization and dominance links).

### MCTAG - Analysis for extraction

Using tree-local MCTAG, a more concise analysis for extraction can be written down:

- tree sets for extracted complements
- one verbal tree for the base configuration

$$
\begin{align*}
S & \rightarrow S^* \\
& \rightarrow \text{NP [John] NP} \\
& \rightarrow \text{VP [likes] NP} \\
\end{align*}
$$

$\Rightarrow$ **Drawback(?):** do-support has to be part of the base configuration!
MCTAG - Analysis for extractions from raising verbs

(14) To whom does Gabriel seem to eat gnocchi? (Frank et al., 2000)

⇒ does has to be part of the PP-complement! That, however, contravenes the CETM!

MCTAG - Analysis for extraction out of complex NPs (1)

(15) [Which painting] did you see a picture of __? 

Kroch (1989):

Unbounded character of extraction (Kroch, 1989):

(16) [Which painting], did you see [a photograph of [a copy of ___]]

⇒ adjoin [a photograph of]

Alternative accounts:

• setlocal MCTAG + multiple adjunctions (Nesson and Shieber, 2007)
• the complex NP adjoins to the wh-phrase, and the rest is added (Kahane et al., 2000).

MCTAG - Analysis for extraposed relative clauses

(17) Somebody, lives nearby [who has a CD-burner].

Along the lines of the analysis of Kroch and Joshi (1987):

⇒ Drawbacks: (1) NP-node has to be available! (2) Does not account for embedded antecedents:

(18) Karl hat mir [von der Kopie [einer Fälschung [eines Bildes [einer Frau ___]]]] erzählt, [die schon lange tot ist].
MCTAG - Analysis for “simple” scrambling

(19) dass Peter den Kühlschrank heute repariert
dass den Kühlschrank Peter heute repariert
dass den Kühlschrank heute Peter repariert...

(‘that Peter repairs the fridge today’)

MCTAG - Analysis for long-distance scrambling (1)

Under the co-occurrence constraint, tree-local MCTAG can handle scrambling up to two levels of embedding, i.e. three verbs in a coherent construction. (Joshi et al., 2000)

(20) dass ihm den Kühlschrank Peter zu reparieren versprochen hat

(‘that Peter has promised him to repair the fridge today’)

MCTAG - Analysis for long-distance scrambling (2)

(21) dass des Verbrechens der Detektiv den Verdächtigen dem Klienten zu überführen versprochen hat

(‘that the detective has promised the client to indict the suspect of the crime’)

MCTAG - Analysis for long-distance scrambling (3)

Drawbacks wrt. tree design:
- Extra structure for modification:

(22) dass den Kühlschrank Peter heute zu reparieren versprochen hat

(‘that Peter has promised to repair the fridge today’)

- Extra structure for the complements of embedding verbs

- The subcategorization frame is implemented nonuniformly, namely either via substitution nodes in an elementary tree, or via elementary trees in a tree set.
Summary for tree-local MCTAG

- Tree-local MCTAG is strongly equivalent to TAG.
- The design of elementary structures is more flexible. Hence, the options for providing a linguistically appealing grammar (including e.g. CETM) are more wide-ranging.
- **BUT**: TAG and tree-local MCTAG are not powerful enough to describe scrambling of a certain complexity!
- **BUT**: Tree design still suffers from structural overhead!

Extensions of MCTAG

- **Vector MCTAG (V-TAG)** (Rambow,1994) ⇒ “limit non-locality”
- **MCTAG with shared nodes (SN-MCTAG)** (Kallmeyer,2005) ⇒ “extend tree-locality”
- **MCTAG with tree tuples (TT-MCTAG)** (Lichte,To appear) ⇒ “extend tree-locality”

V-TAG basics

- non-local MCTAG
- non-simultaneity (⇒ polynomially tractable!)
- limitation of non-locality: dominance links and integrity constraints (△)

**Pro**: linguistically appropriate analyses for scrambling
**Contra**: rather TAG-alien integrity constraints and dominance links

V-TAG example

(23) dass den Kühlschrank **heute** Peter repariert
(“that Peter repairs the fridge today”)

Extensions of TAG

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SN-MCTAG basics

- MCTAG with extended notion of tree-locality
- Node sharing: after adjunction, the root node of the auxiliary tree is part of both, the auxiliary tree and the destination tree.
- Restrictions for SN-MCTAG:
  - RSN-MCTAG: one tree of a tree set has to attach immediately to the destination tree.
  - RSN-MCTAG with fixed arity $k$: there are at most $k$ crossing node sharing relations.
- RSN-MCTAG[$k$] is polynomially tractable.

Pro: linguistically appropriate analyses for scrambling
Contra: traces are necessary.

TT-MCTAG basics

- MCTAG with shared-nodes locality
- Elementary structures are tuples:
  - a lexicalized elementary tree $\delta$ (the destination tree)
  - a tree set $\{ \beta_1, \ldots, \beta_n \}$
- During the derivation, the trees of the tree set have to attach to the destination tree SN-locally.
- Restrictions on TT-MCTAG:
  - fixed maximum on the size of the tree set
  - fixed maximum on the number of concurrently active tree tuples during derivation
- restricted TT-MCTAG is polynomially tractable ???

Pro: linguistically appropriate analyses for scrambling
Contra: extra multi-componential structure

SN-MCTAG example

(24) dass den Kühlschrank heute Peter repariert
("that Peter repairs the fridge today")

TT-MCTAG example

(25) dass den Kühlschrank heute Peter repariert
("that Peter repairs the fridge today")
Outlook: Diversity of data

(26) a. dass Peter ihm das Fahrrad zu reparieren versprochen hat
dass Peter ihm das Fahrrad zu reparieren hat versprochen
dass Peter ihm das Fahrrad hat zu reparieren versprochen
b. dass Peter ihm das Fahrrad versprochen hat zu reparieren
dass Peter das Fahrrad versprochen hat ihm zu reparieren
c. dass Peter das Fahrrad zu reparieren ihm versprochen hat

(27) Das Fahrrad hat Peter ihm zu reparieren versprochen.
Zu reparieren versprochen hat ihm Peter das Fahrrad.
Das Fahrrad zu reparieren hat Peter ihm versprochen.
Zu reparieren hat ihm Peter das Fahrrad versprochen.

Puzzle:
Give a linguistically appealing, preferably minimal TAG that is tractable in polynomial time. Also an appealing transition from syntax to semantics should be within reach.