Tree Adjoining Grammars

TAG: Limits and extensions

Laura Kallmeyer & Benjamin Burkhardt

HHU Düsseldorf

WS 2017/2018

Outline

Overview (1)

1. Why extend LTAG?
   - **semantic reasons:**
     - The derivation tree does not always reflect the dependency tree / the predicate argument structure.
       (missing link problem, intersective modifiers)
   - **syntactic reasons:**
     - ellipsis (gapping, subject deletion, right node raising)
     - discontinuity (extraposition, extraction, scrambling)

       this lecture!

Overview (2)

2. How extend LTAG?
   - **Combinatorial operations**: flexible composition, multiple adjunction, segmented adjunction, contraction …
   - **Combinational operations and elementary trees**: Tree Description Grammars, …
   - **Elementary structures**: **this lecture!**
     - Multicomponent TAG (MCTAG): tree-local, set-local, non-local
     - variants of MCTAG: Vector MCTAG (V-TAG), MCTAG with shared nodes (SN-MCTAG), MCTAG with tree tuples and shared nodes (TT-MCTAG)

Why extend LTAG?

Discontinuity phenomena:

- Extraction out of subject raising verbs:

  (1) **To whom** does Gabriel **seem** to eat gnocchi?

- Extraction out of complex NPs:

  (2) **Which painting** did you see **a picture of**?
  Über Goethe las Peter **ein Buch**.

- Extraposed relative clauses:

  (3) **Somebody** lives nearby **[who has a CD-burner]**.

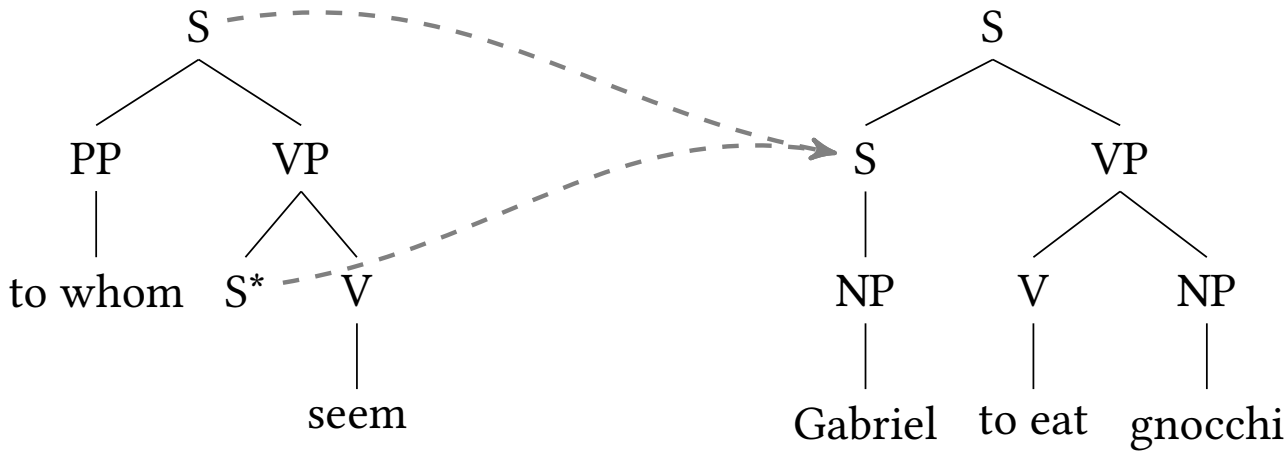
- Long-distance scrambling in German:

  (4) dass **den Kühlschrank** Peter heute **zu reparieren** versucht
  ('that Peter tries to repair the fridge today')

Extraction out of subject raising verbs

(5) **To whom** does **Gabriel seem to eat gnocchi**?

TAG-analysis:



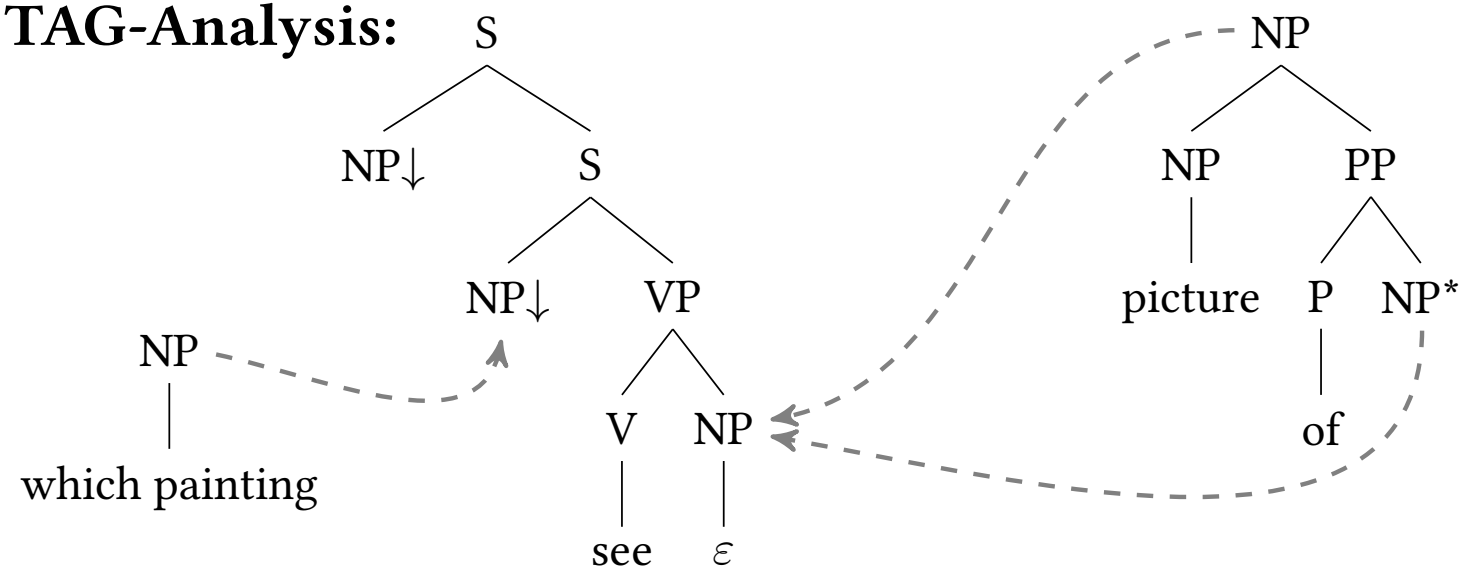
Problem: Not possible without changing the shape of the trees considerably!

Extraction out of complex NPs

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

Challenge: The wh-phrase is no complement of *see*, but of the preposition *of* that modifies the complement *a picture*.

TAG-Analysis:



- ⇒ The modifier *of* is part of the object NP-tree.
- ⇒ Contra θ-criterion: *which painting* is no semantic argument of *see*.

Extraposition of relative clauses

(7) **Somebody** lives nearby **[who has a CD-burner]**.

(8) Karl hat mir [von der Kopie [einer Fälschung [eines Bildes **[einer Frau]**]]] erzählt, **[die schon lange tot ist]**.

Relative clauses can appear:

- adjacent to the antecedent
- in the right periphery (Nachfeld) of the embedding sentence

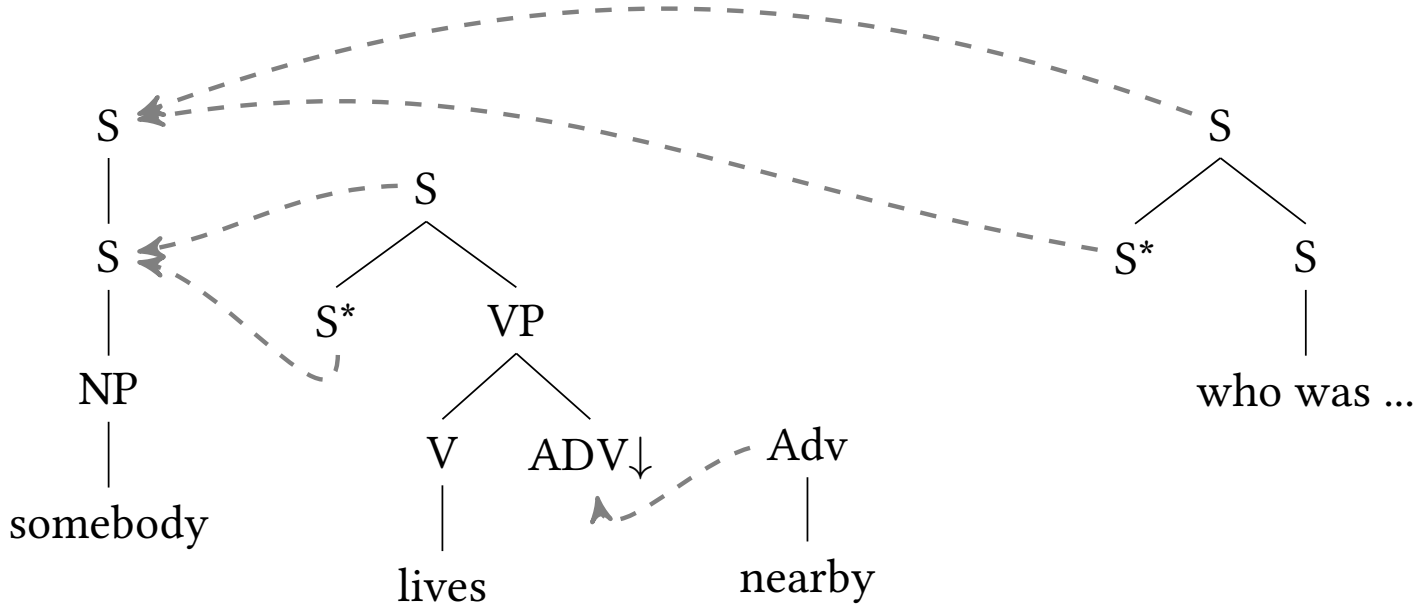
$\Rightarrow$ non-local, but not unbounded

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

Extraposition of relative clauses

Challenge: Relative clauses can modify non-adjacent nouns.

TAG-Analysis:



Problem: two extraposed relative clauses? embedded antecedents?

Scrambling

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

Challenge: Variability in word order.

TAG-Analysis:

- One elementary tree for every possible complement order.

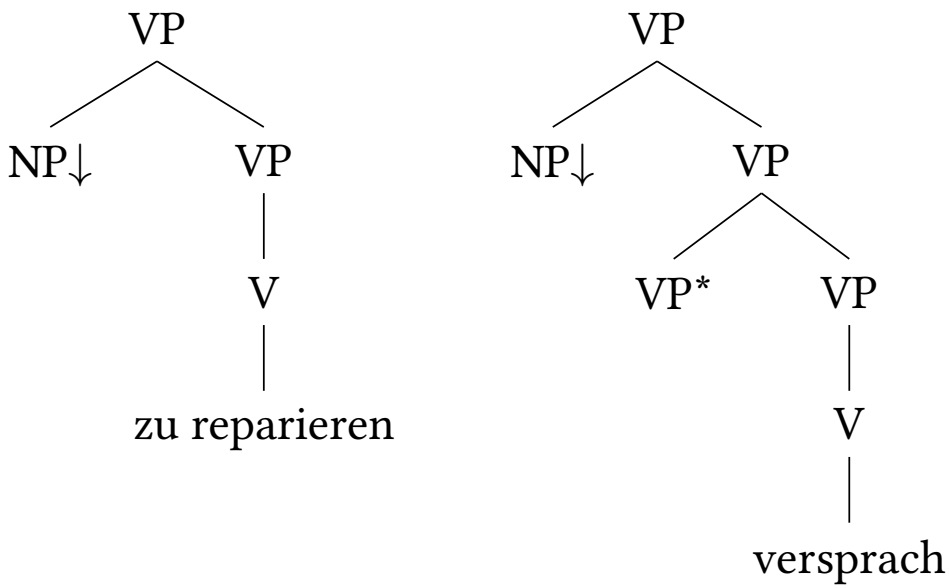
Problem: $n!$ elementary trees, where n is the number of arguments.

Long-Distance Scrambling in coherent constructions (1)

(10) dass **Peter** den Kühlschrank heute zu reparieren **versprach**
dass den Kühlschrank **Peter** heute zu reparieren **versprach**
...
('that Peter 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.



Long-Distance Scrambling in coherent constructions (2)

(11) dass **ihm Peter den Kühlschrank** heute **zu reparieren versprach**
dass **ihm den Kühlschrank Peter** heute **zu reparieren versprach**
...
('that Peter promised him to repair the fridge today')

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

TAG-Analysis:

- *zu reparieren* adjoins to *versprach*.
  $\Rightarrow$ contradicts θ-criterion
- *ihm* adjoins to *zu reparieren*.
  $\Rightarrow$ contradicts θ-criterion

Long-Distance Scrambling in coherent constructions (3)

(12) dass **des Verbrechens der Detektiv den Verdächtigen dem Klienten zu überführen versprach**
('that the detective promised the client to indict the suspect of the crime')

Problem: The trees of *versprach* 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**

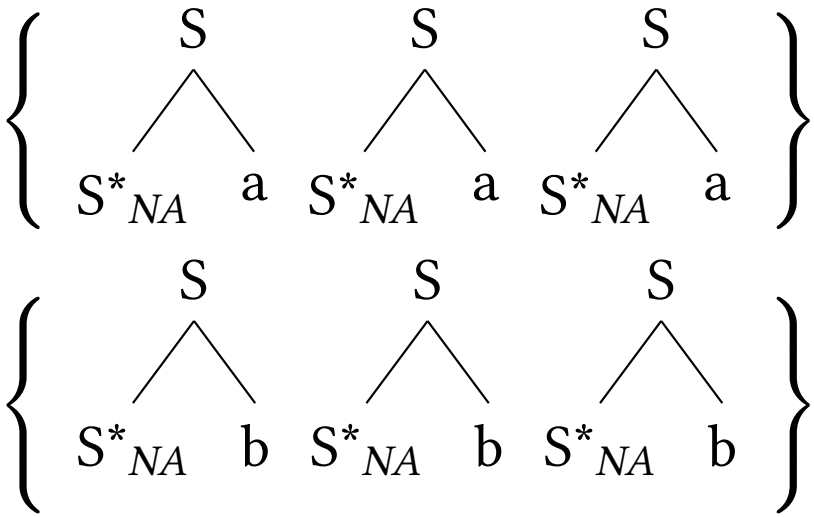
- that have two verbs and two complements each;
- that have more than two verbs with one complement each.

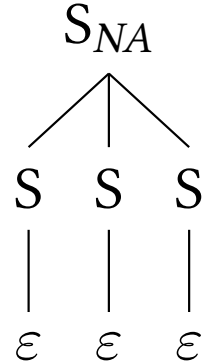
Becker et al. (1991), Becker et al. (1992), Joshi et al. (2000)

How extend LTAG?

- Multicomponent TAG (MCTAG): tree-local, set-local, non-local
- variants of MCTAG: Vector MCTAG (V-TAG), MCTAG with shared nodes (SN-MCTAG), MCTAG with tree tuples and shared nodes (TT-MCTAG)

Underlying idea: Split elementary structures into several trees (elementary multicomponent sets) that belong together but that can attach in different places.





MCTAG - Basics (1)

Definition

An MCTAG is a tuple $G =< N, T, I, A, O, C, \mathcal{A} >$ such that:

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

Restrictions on the application of an elementary tree set Γ:

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

MCTAG - Basics (2)

MCTAGs can be further restricted Weir (1988):

- **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).

Example: The MCTAG from slide 14 generates $\{\varepsilon, aaa, bbb\}$ in tree-local mode and $\{www \mid w \in \{a, b\}^*\}$ in set-local and also in non-local mode.

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

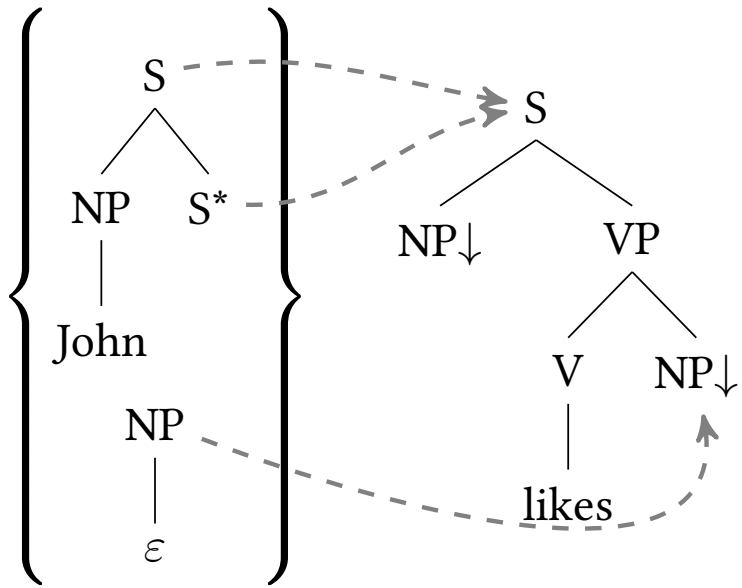
MCTAG - Expressivity and Complexity

- **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 movement-like analysis for extraction can be written down:

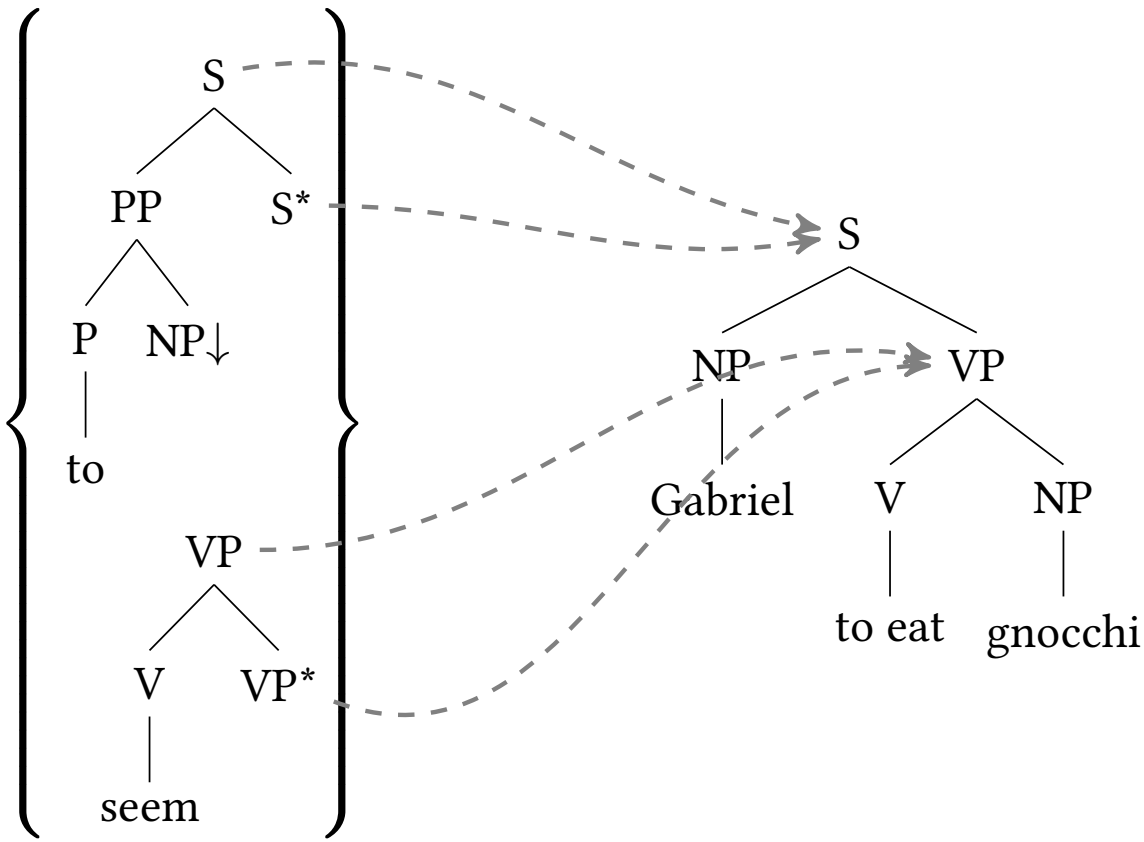
- tree sets for extracted complements
- one verbal tree for the base configuration



⇒ **Drawback(?):** do-support has to be part of the base configuration!

MCTAG - Analysis for extractions from raising verbs

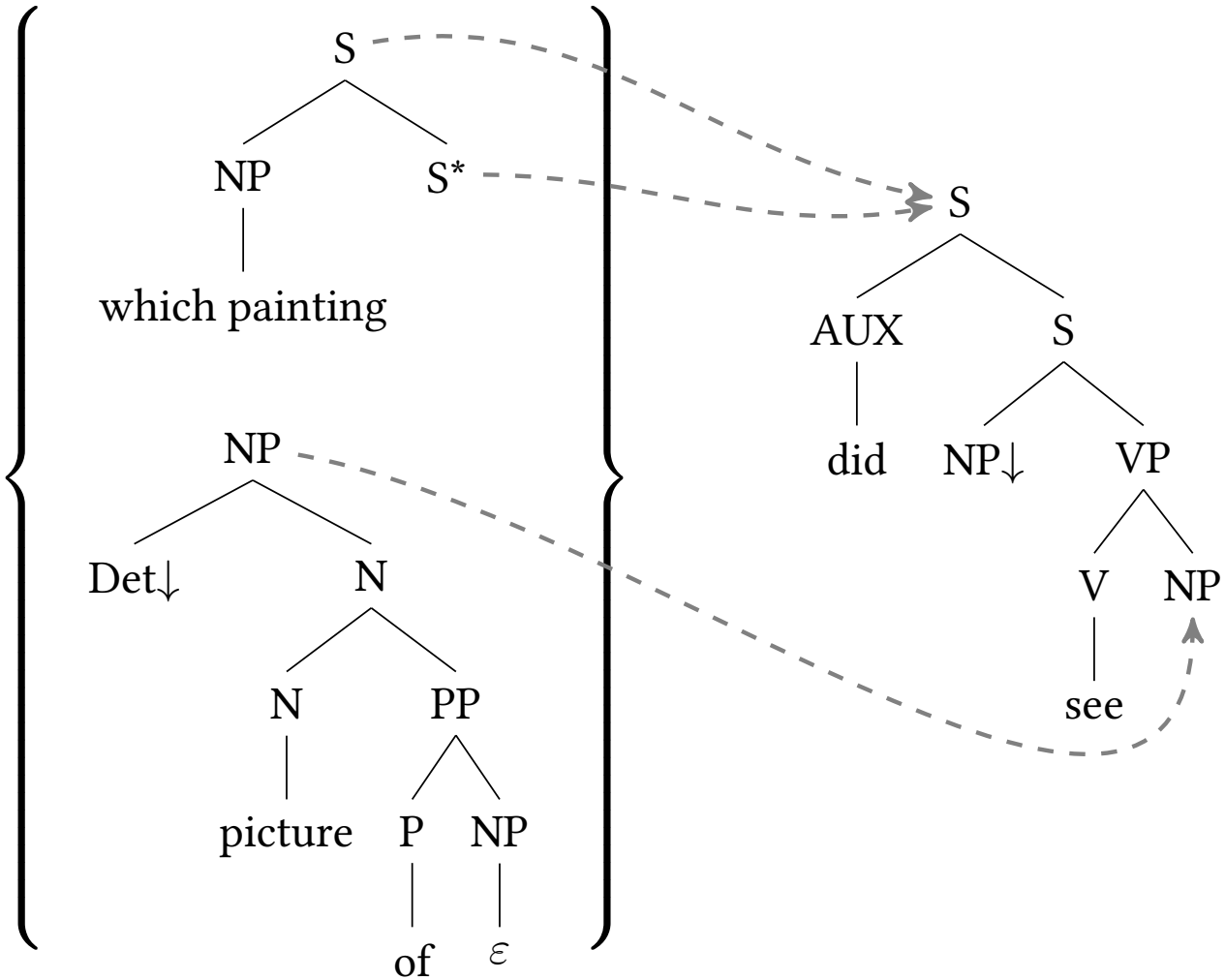
(13) **To whom** does **Gabriel seem to eat gnocchi**?



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

(14) **Which painting** did you see **a picture of** ?

(Kroch, 1989):



MCTAG - Analysis for extraction out of complex NPs (2)

- Unbounded character of extraction Kroch (1989):

  (15) **Which painting** did you see [a photograph of **[a copy of]**]

  ⇒ adjoin [*a photograph of*]
  ⇒ mismatch between derivation tree and predicate argument structure

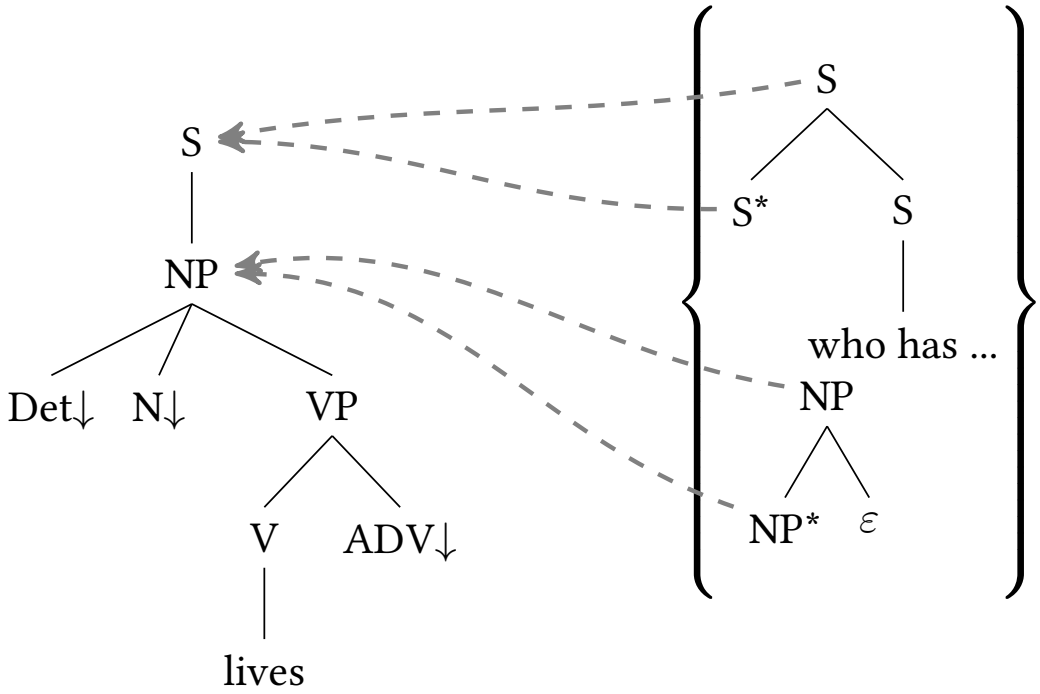
- Alternative accounts:

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

MCTAG - Analysis for extraposed relative clauses

(16) **Somebody** lives nearby **[who has a CD-burner]**.

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

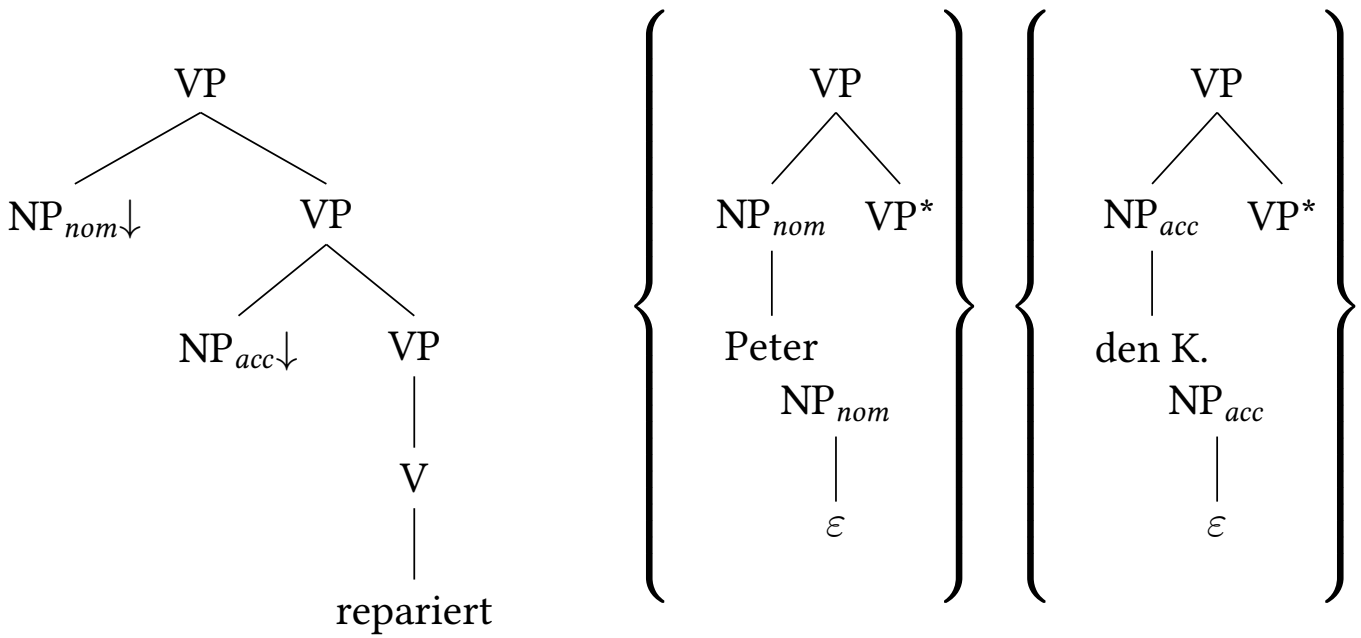


Drawbacks: a) NP-node has to be available!
b) Does not account for embedded antecedents:

(17) Karl hat mir [von der Kopie [einer Fälschung [eines Bildes **[einer Frau]**]]] erzählt, **[die schon lange tot ist]**.

MCTAG - Analysis for “simple” scrambling

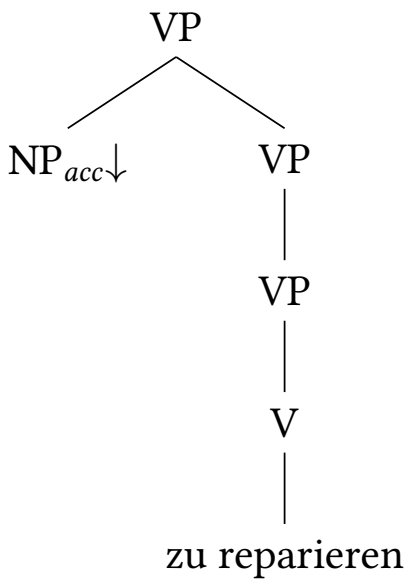
(18) dass Peter den Kühlschrank heute repariert
dass den Kühlschrank Peter heute repariert
dass den Kühlschrank **heute** Peter repariert
...
(’that Peter repairs the fridge today’)

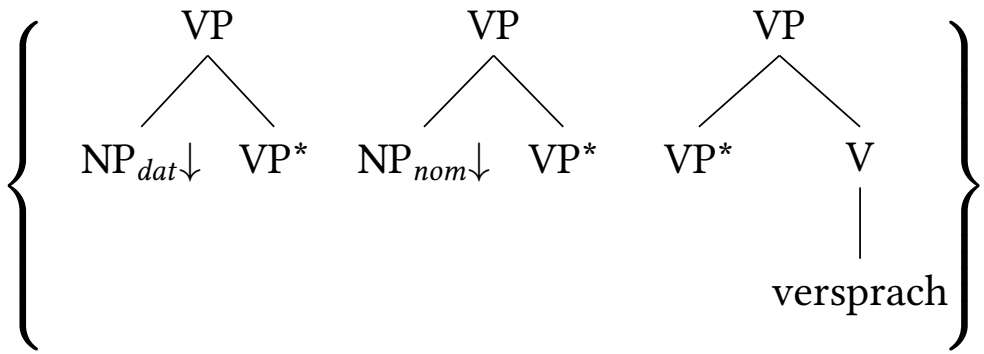


MCTAG - Analysis for long-distance scrambling (1)

Tree-local MCTAG can handle scrambling **up to two levels of embedding**, i.e. three verbs with one complement each forming a coherent construction. Joshi et al. (2000)

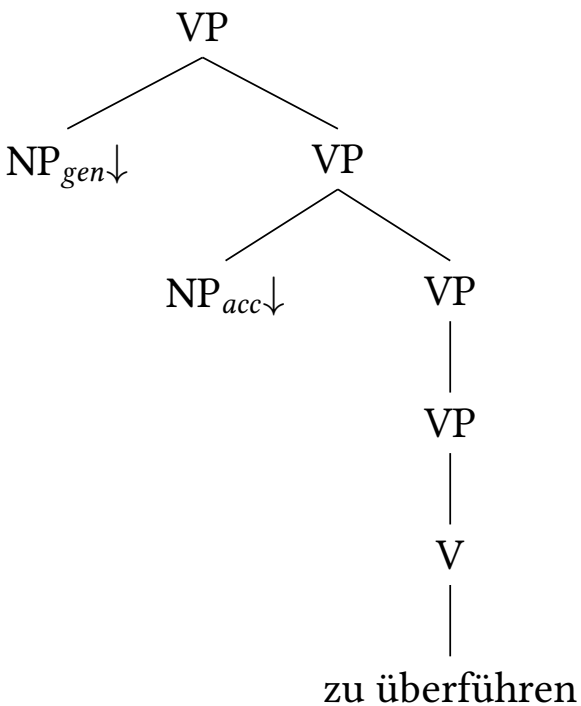
(19) dass **ihm** den Kühlschrank **Peter zu reparieren versprach**
('that Peter promised him to repair the fridge')

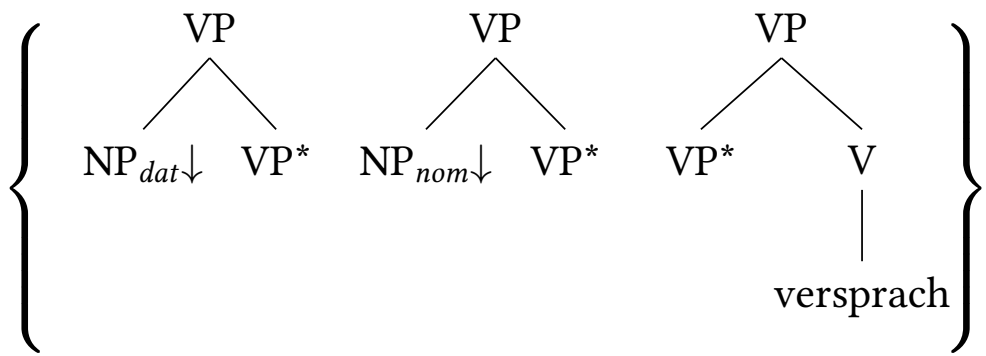




MCTAG - Analysis for long-distance scrambling (2)

(20) dass **des Verbrechens der Detektiv den Verdächtigen dem Klienten zu überführen versprach**
('that the detective promised the client to indict the suspect of the crime')





MCTAG - Analysis for long-distance scrambling (3)

Drawbacks wrt. tree design:

- Extra target nodes for modification:

(21) dass **den Kühlschrank Peter heute zu reparieren versprach**
('that Peter promised to repair the fridge today')

- Extra target nodes 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

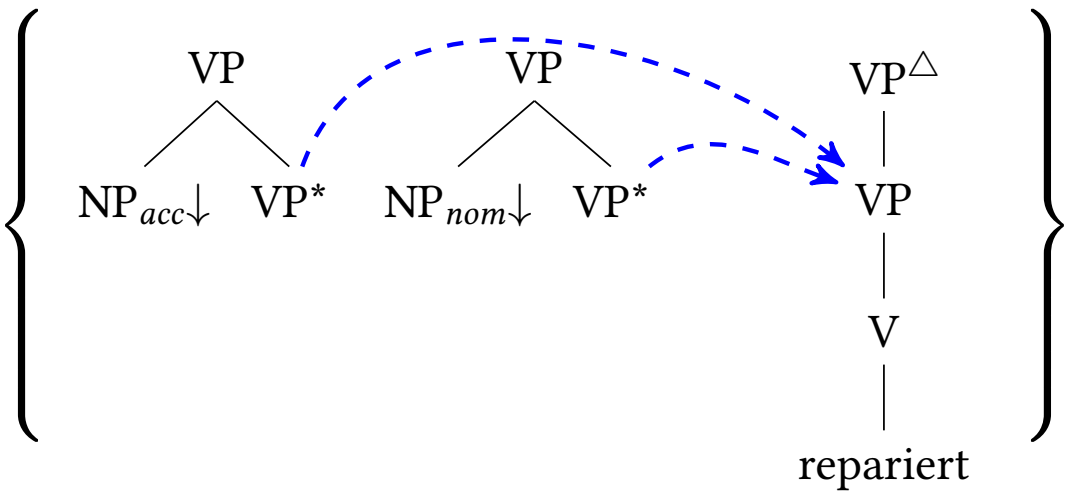
- Tree-local MCTAG is strongly equivalent to TAG.
- The design of elementary structures is more flexible. Hence, the options for providing a linguistically appealing grammar (including e.g. CETM) are more wide-ranging.
- **BUT:** TAG and tree-local MCTAG are not powerful enough to describe scrambling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

Extensions/variants of MCTAG

- Vector MCTAG (V-TAG) Rambow (1994)
  $\Rightarrow$ "limit non-locality"
- MCTAG with shared nodes (SN-MCTAG) Kallmeyer (2005)
  $\Rightarrow$ "extend tree-locality"
- MCTAG with tree tuples (TT-MCTAG) Lichte (2007)
  $\Rightarrow$ "extend tree-locality"

V-TAG basics

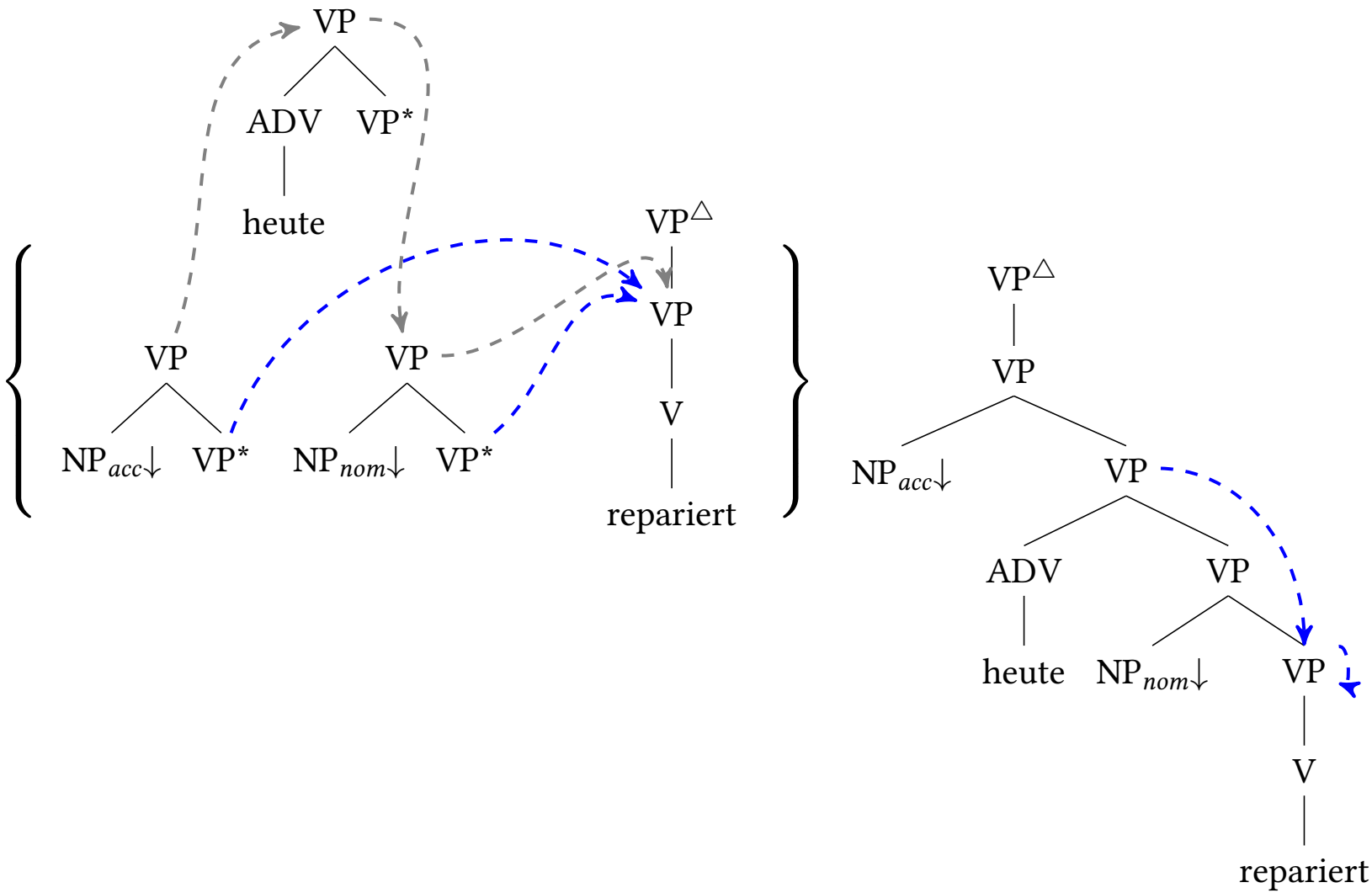
- non-local MCTAG
- non-simultaneity (⇒ polynomially tractable!)
- limitation of non-locality:
  dominance links (in blue) and integrity constraints (△)



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

V-TAG example

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



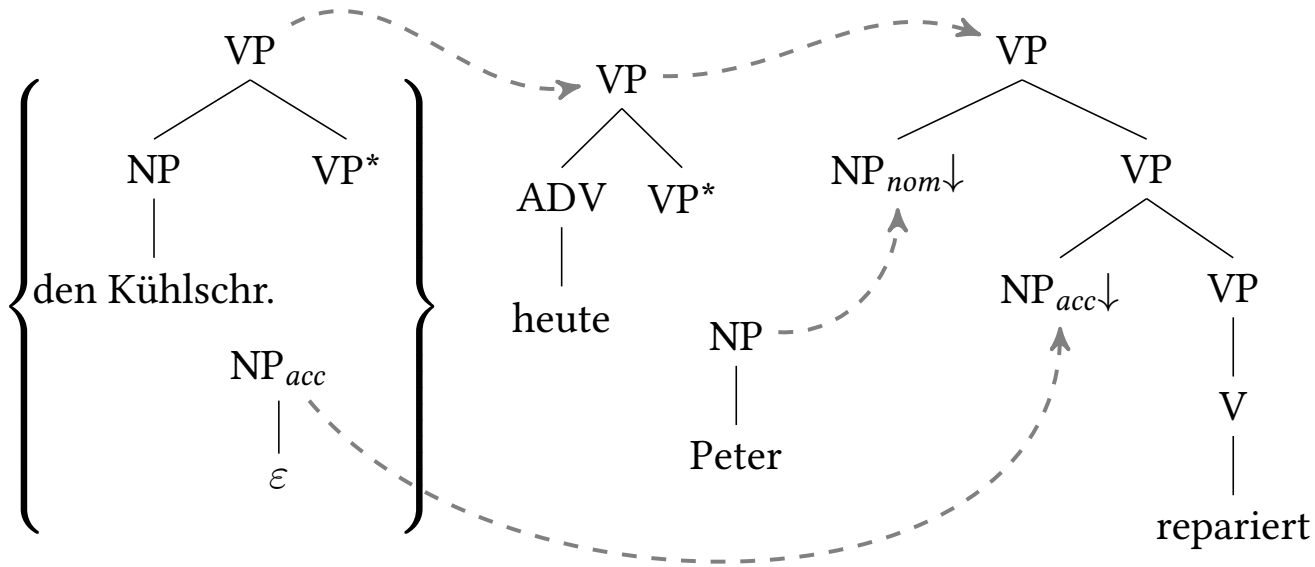
SN-MCTAG basics

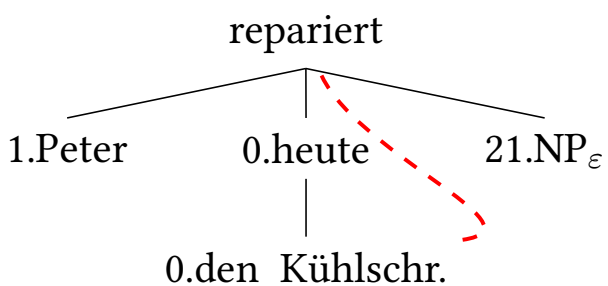
- MCTAG with extended notion of tree-locality
- Node sharing: after adjunction, the root node of the auxiliary tree is part of both, the auxiliary tree and the destination tree.
- $\Rightarrow$ adjoining γ at (the root of a tree that adjoins at)$^+$ α creates a direct link between γ and α
- Restrictions 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 apropriate analyses for scrambling
Contra: traces are inevitable.

SN-MCTAG example

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





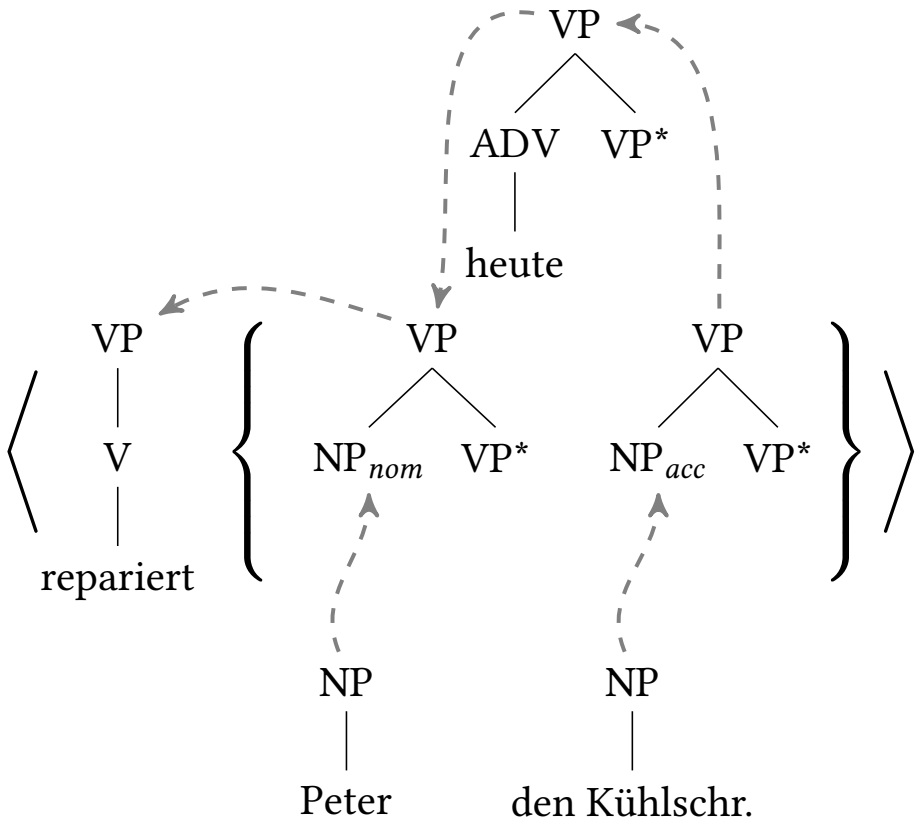
TT-MCTAG basics

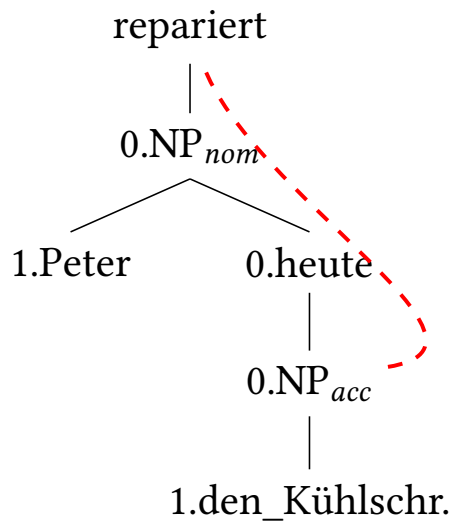
- MCTAG with shared-nodes locality
- Elementary structures are **tuples**:
  + a lexicalized elementary tree δ (the destination tree)
  + a tree set $\{\beta_1, \ldots \beta_n\}$
- During the derivation, the trees of the tree set have to attach to the destination tree **SN-locally**.
- Restrictions on 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 (Kallmeyer and Satta, 2009)

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

TT-MCTAG example

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





Outlook: Coherent constructions

(25) 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

(26) **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.

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