Introduction to Tree Adjoining Grammar

Natural Language Syntax with TAG

Timm Lichte

DGfS-CL Fall School 2011

2. week, 1. session

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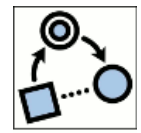


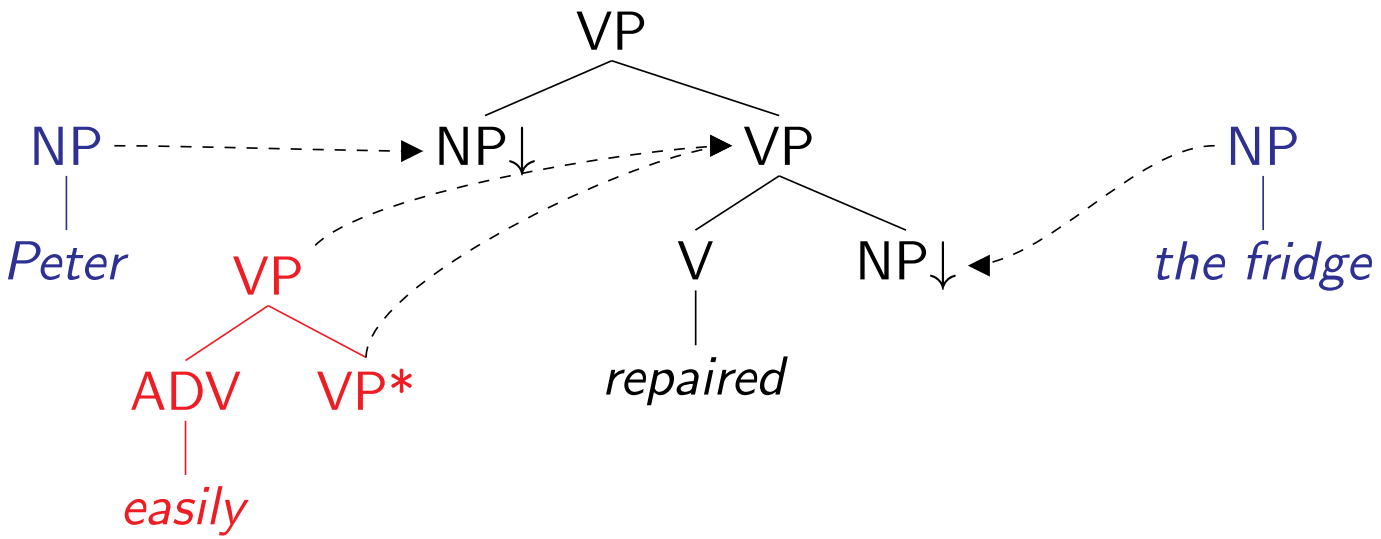
Outline

Overview over the second week

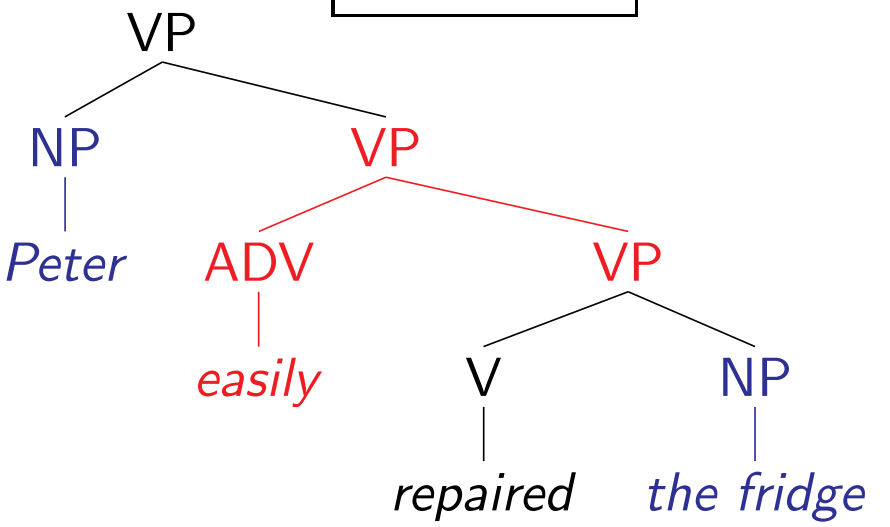
- **LTAG as a model for natural language syntax**
  - Principles underlying the shape of elementary trees (Monday)
  - XTAG-analyses of raising/control (Tuesday) and extraction (Wednesday)
- **How to do NLP with an LTAG?**
  - How to implement an LTAG? (Thursday)
  - How to run and test an LTAG? (Friday)

Outline

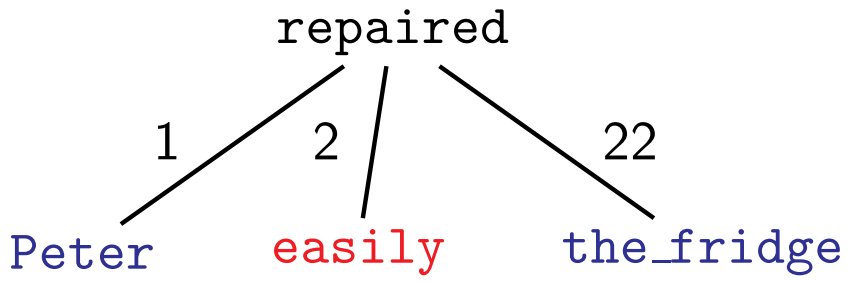
Elementary trees, derived tree, derivation tree



derived tree



derivation tree



Outline

Design principles for elementary trees

What is an elementary tree, and what is its shape?

elementary trees $\overset{?}{\Longleftarrow}$ syntactic/semantic properties of linguistic objects

$\Rightarrow$ Syntactic design principles from [Frank, 2002]:

- Lexicalization
- Fundamental TAG Hypothesis (FTH)
- Condition on Elementary Tree Minimality (CETM)
- θ-Criterion for TAG

$\Rightarrow$ Semantic design principles [Abeillé and Rambow, 2000]

$\Rightarrow$ Design principle of economy

Design principles (1): Lexicalization

Each elementary tree has at least one non-empty lexical item, its lexical **anchor**.

$\Rightarrow$ All widely used grammar formalisms support some kind of lexicalization!

Reasons for lexicalization: [Joshi and Schabes, 1991], [Schabes and Joshi, 1990]

- **Formal properties:** A finite grammar has finitely many analyses per string (finitely ambiguous).
- **Linguistic properties:** Idiosyncrasies of lexical items can be accounted for more directly.
- **Parsing:** The search space can be delimited (grammar filtering).

Design principles (2): Fundamental TAG Hypothesis

Fundamental TAG Hypothesis (FTH)

Every syntactic dependency is expressed locally within an elementary tree. [Frank, 2002]

"syntactic dependency"

- valency/subcategorization
- modification
- binding
- ...

"expressed within an elementary tree"

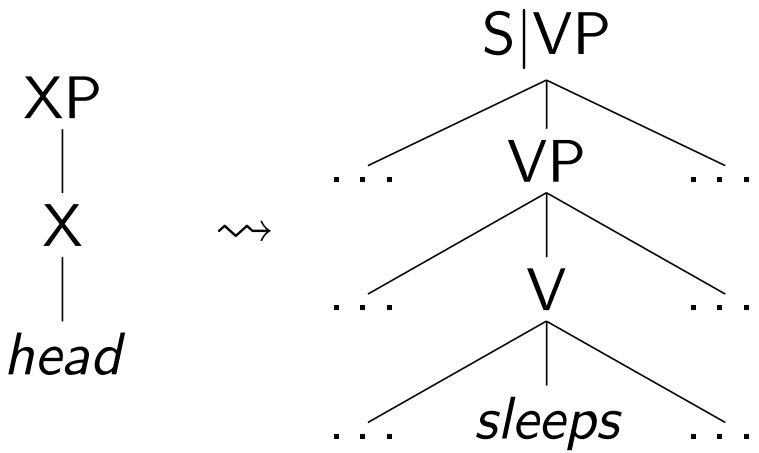
- terminal leaf (i.e. lexical anchor)
- nonterminal leaf (substitution node and footnode)
- marking an inner node for obligatory adjunction

Design principles (3): Condition on Elementary Tree Minimality

Condition on Elementary Tree Minimality (CETM)

The syntactic heads in an elementary tree and their projections must form the extended projection of a single lexical head. [Frank, 2002]

Note: We only use simple, non-extended projections!



Design principles (4): θ-Criterion for TAG

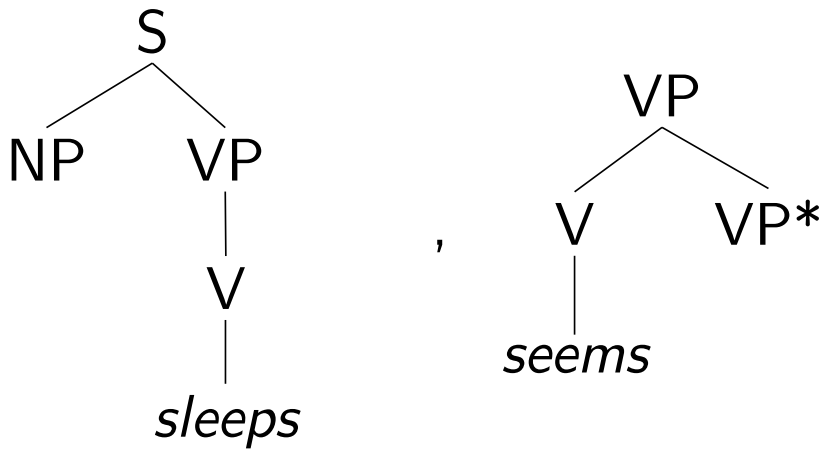
θ-Criterion (TAG version)

a. If H is the lexical head of an elementary tree T, H assigns all of its θ-roles in T.

b. If A is a frontier non-terminal of elementary tree T, A must be assigned a θ-role in T.

[Frank, 2002]

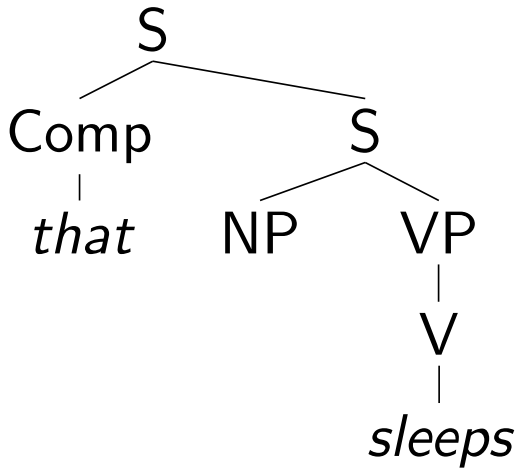
$\Longrightarrow$ Valency/subcategorization is expressed only with nonterminal leaves!

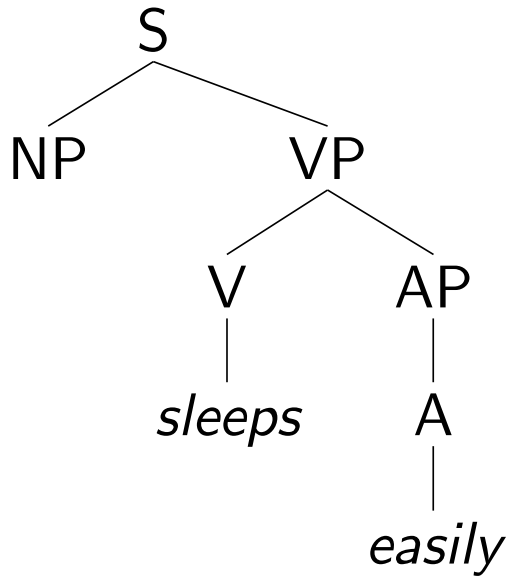


Modification and functional elements

How to insert **modifiers** (*easily*) and **funtional elements** (complementizers, determiners, do-auxiliaries, ...)?

- Either by separate auxiliary trees (e.g., XTAG grammar),
- or as co-anchor in the elementary tree of the lexical item they are associated with.





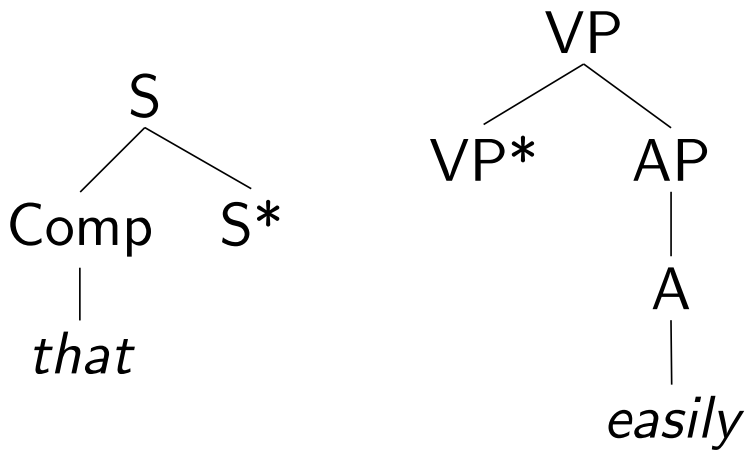
Modification and functional elements

In XTAG, modifiers and functional elements are generally represented by auxiliary trees.

⇒ Footnodes/Adjunctions indicate both complementation and modification.

⇒ Enhancement of the CETM: (see [Abeillé and Rambow, 2000])

core tree (following CETM) + spine



Principles related to semantics

See [Abeillé and Rambow, 2000].

Predicate-argument cooccurrence:

Each elementary tree associated with a predicate contains a non-terminal leaf for each of its arguments.

Semantic anchoring:

Elementary trees are not semantically void (*to*, *that*.)

Compositional principle:

An elementary tree corresponds to a single semantic unit.

Design principle of economy

Design principle of economy

The elementary trees are shaped in such a way, that the size of the elementary trees and the size of the grammar is minimal.

Outline

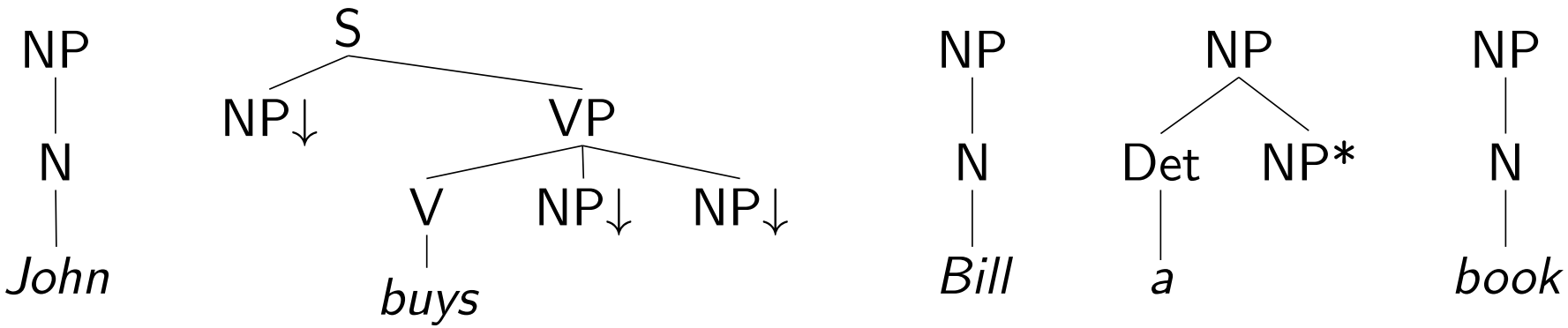
Sample derivations

- **Complementation**
  with NPs, PPs, adjectives, clauses (raising, controlling), ...
- **Modification**
  with PPs, adjectives, particles, temporal clauses, relative clauses, ...

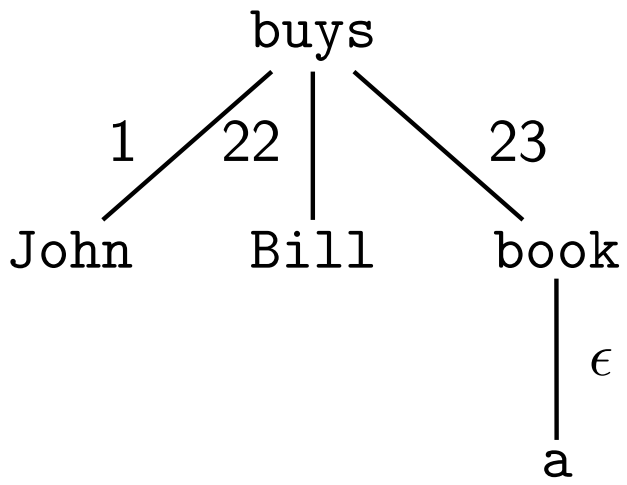
Sample derivations: NP complements

(1) John buys Bill a book.

Elementary trees:



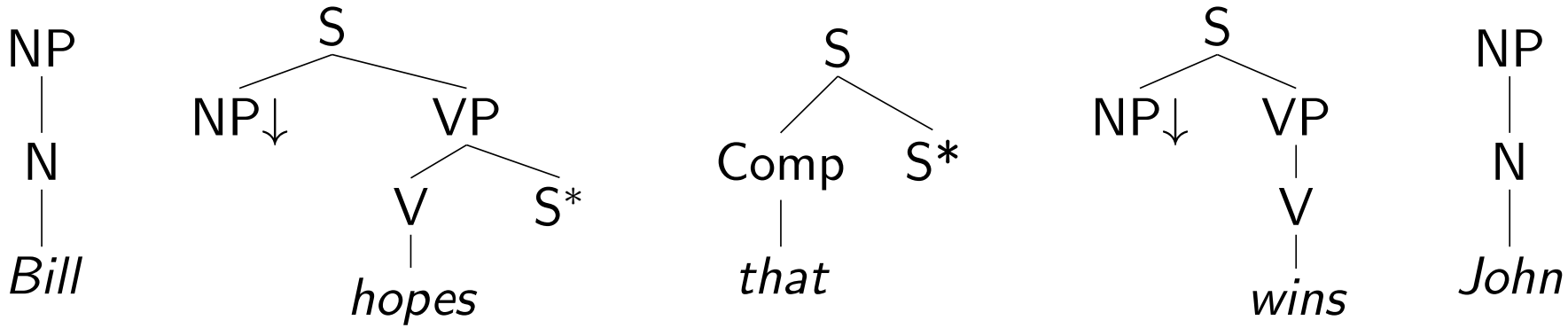
Derivation tree:



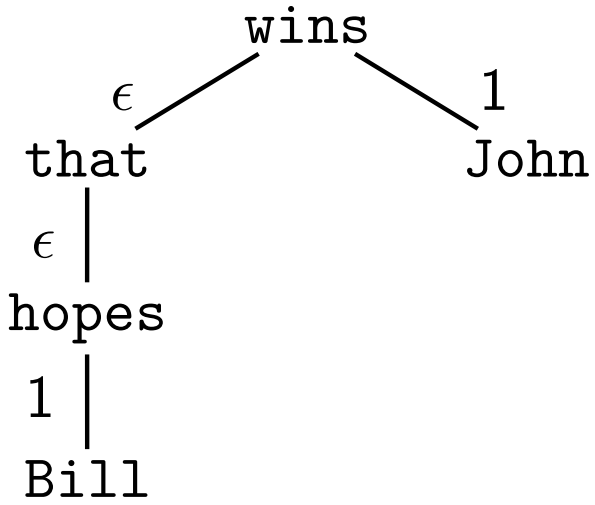
Sample derivations: Sentential complements (1)

(2) Bill hopes that John wins.

Elementary trees:



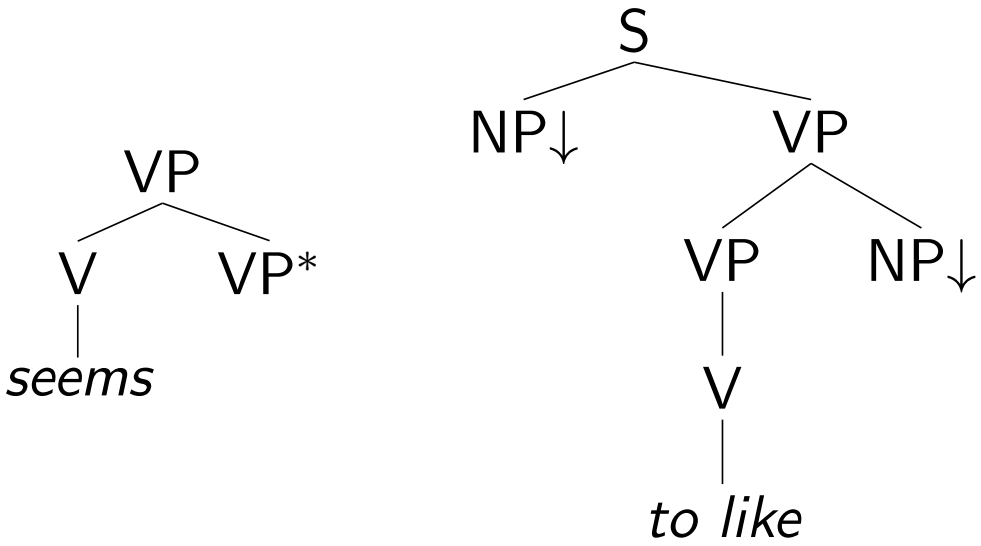
Derivation tree:



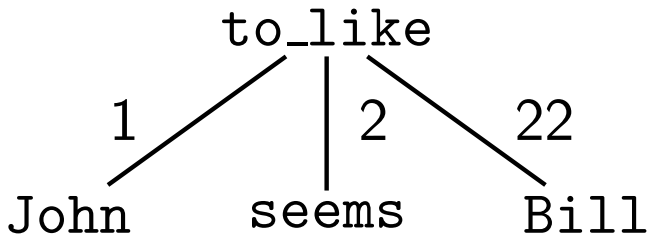
Sample derivations: Sentential complements (2)

(3) John seems to like Bill.

Elementary trees:



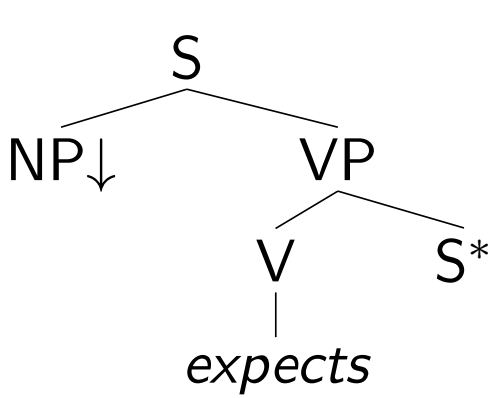
Derivation tree:

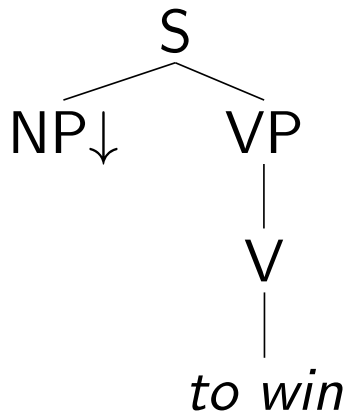


Sample derivations: Sentential complements (3)

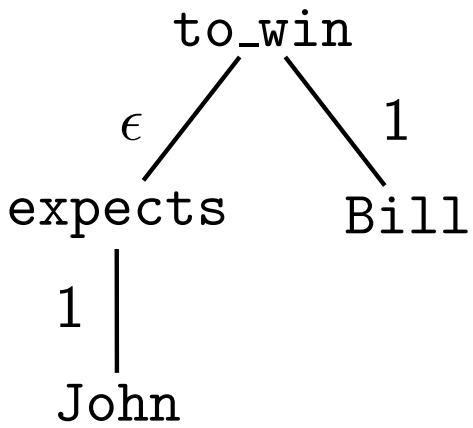
(4) John expects [Bill to win].

Elementary trees:





Derivation tree:



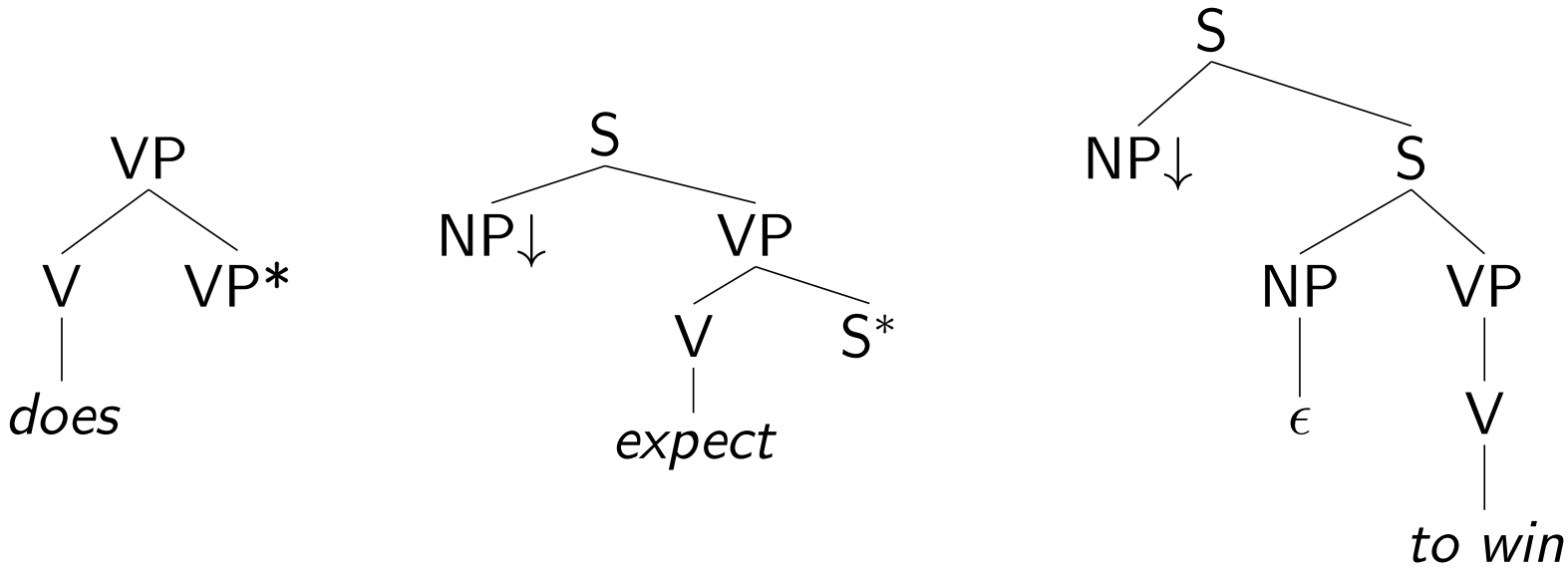
Sample derivations: Sentential complements (4)

Question: Why is the sentential object represented as a footnode?

The sentential object is realised as a foot node in order to allow extractions:

(5) **Who** does John expect **to win**?

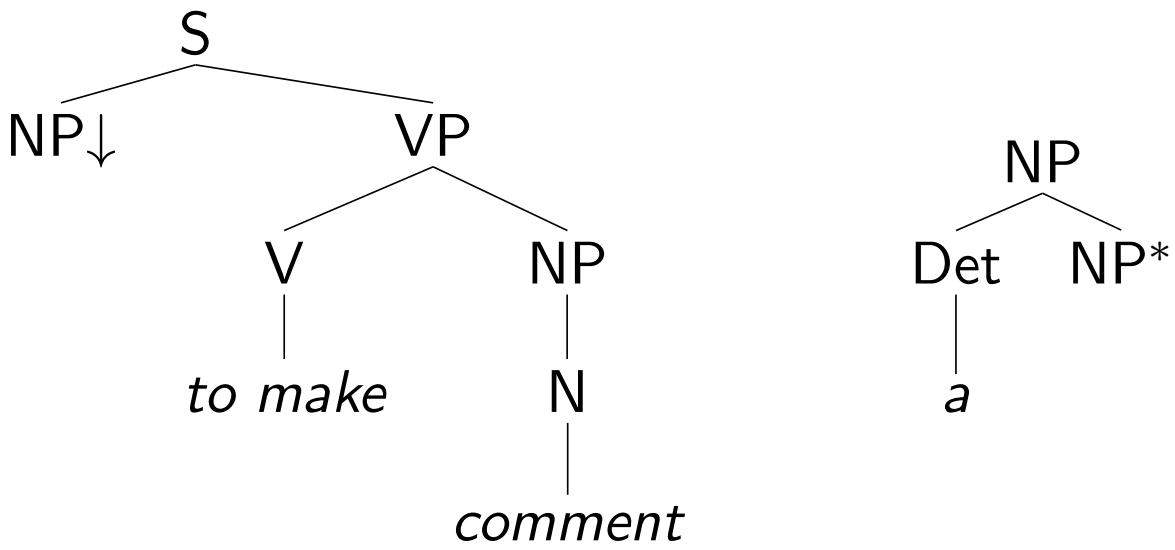
Elementary trees:



Sample derivations: Multiple anchors

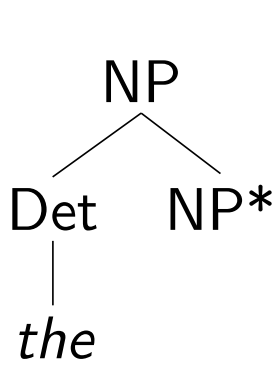
Multiword expressions and light verb constructions can be represented by elementary trees with multiple anchors:

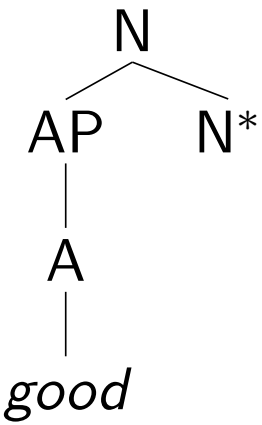
(6) John expected [Mary to make a comment].

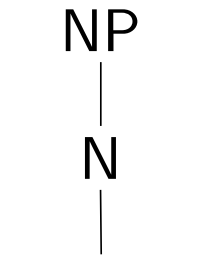


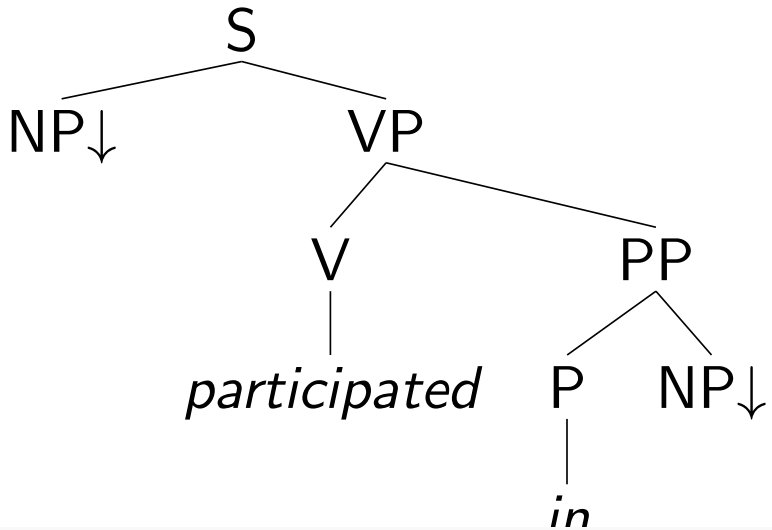
Sample derivations: Modifiers

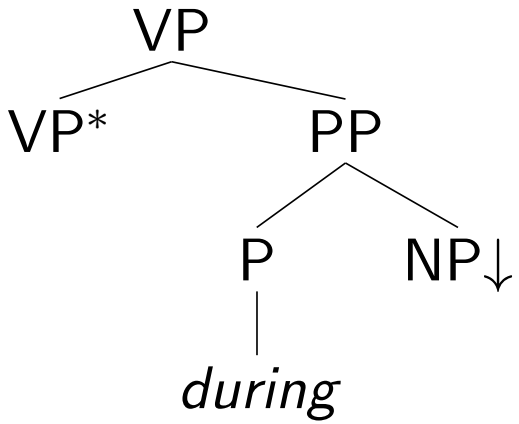
(7) The good student participated in every course during the semester.





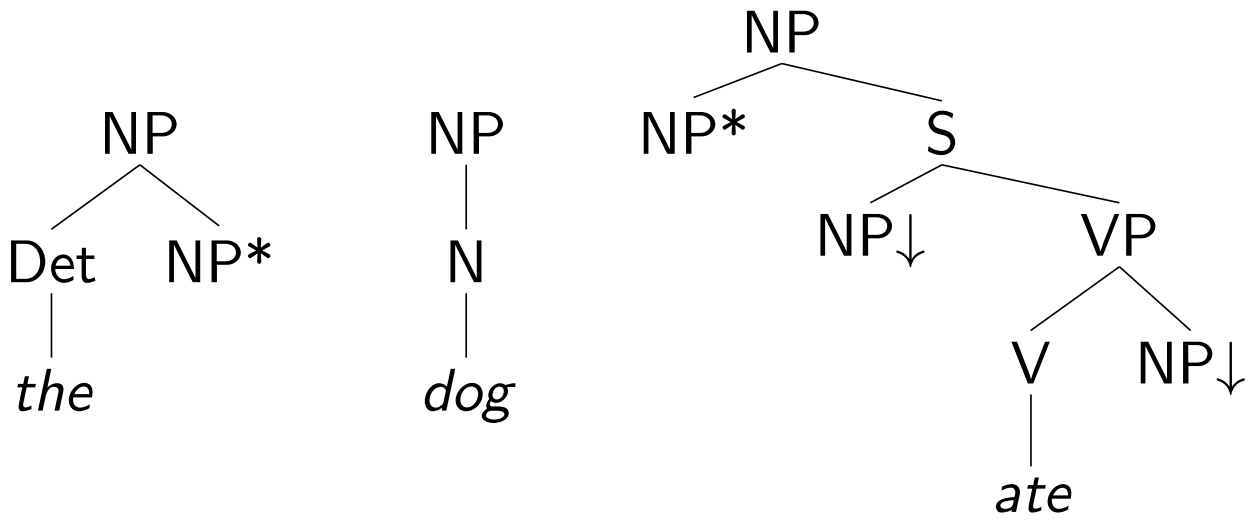






Sample derivations: Relative clauses

(8) The dog [who ate the cake].



Problem: Extraposed relative clauses:

(1) Somebody$_i$ lives nearby [who$_i$ has a CD-burner].

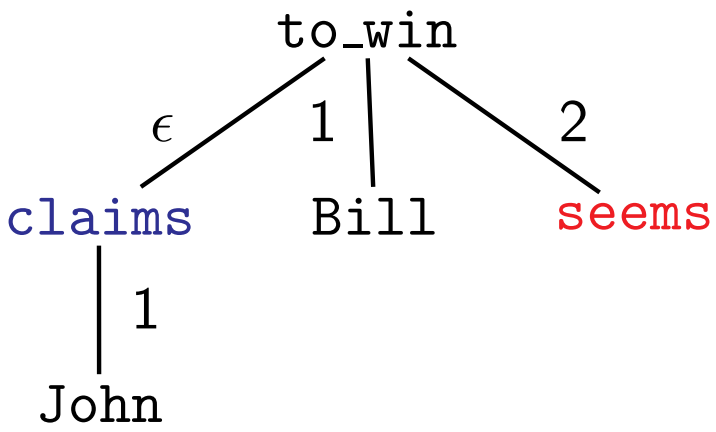
Derivation trees = Semantic dependency structure ?

The derivation tree is not always the semantic dependency structure, due to:

- indiscernibility of complementation and modification in adjunction, and
- missing links.

Example for a missing link:

(2) John claims [Bill seems to win]



Summary

- TAG derivations are described by derivation trees.
- In LTAG, elementary trees for lexical predicates contain slots for all arguments of these predicates, for nothing else. Recursion is factored away.
- The derived tree describes the constituent structure while the derivation tree is close to a semantic dependency graph.

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Abeillé, A. and Rambow, O. (2000).

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In Abeillé, A. and Rambow, O., editors, Tree Adjoining Grammars: Formalisms, Linguistic Analyses and Processing, volume 107 of CSLI Lecture Notes, pages 1–68. CSLI Publications, Stanford.

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