

Syntax-Driven Semantic Frame Composition in Lexicalized Tree Adjoining Grammars

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Overview

1. Lexicalized Tree Adjoining Grammars
2. LTAG and Frame Semantics
3. Directed Motion Expressions
4. LTAG Analysis of Directional PPs
5. The Dative Alternation
6. Elementary Trees for DO and PO
7. MG Factorization
8. Semantic MG Decomposition
9. Summary

LTAG (1)

Tree Adjoining Grammars (TAG) [Joshi and Schabes, 1997]:

Tree-rewriting system: set of *elementary* trees with two operations:

Adjunction: replacing an internal node with a new tree.

Substitution: replacing a leaf with a new tree.

LTAG (1)

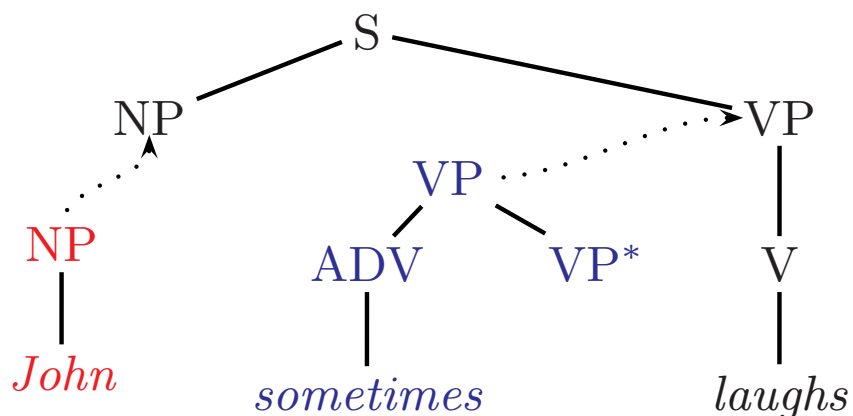
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Tree-rewriting system: set of *elementary* trees with two operations:

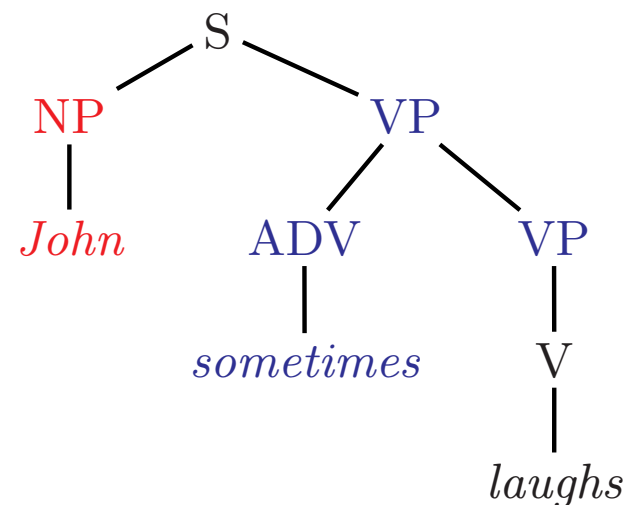
Adjunction: replacing an internal node with a new tree.

Substitution: replacing a leaf with a new tree.

(1) John sometimes laughs



derived tree:



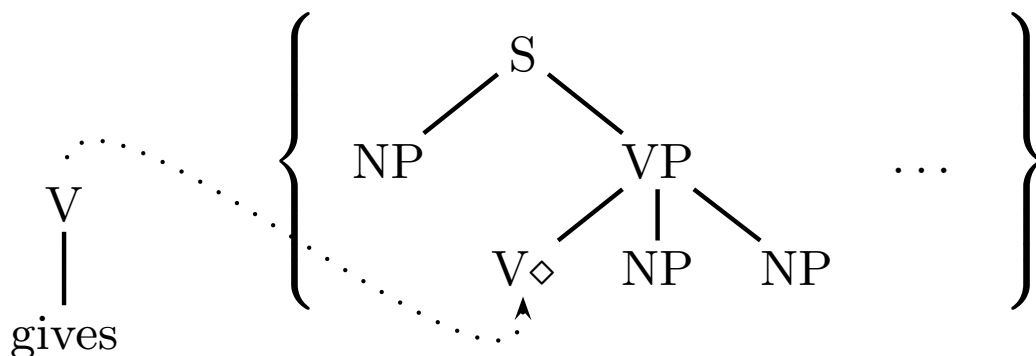
LTAG (2)

Important features of Lexicalized TAG (LTAG):

- Grammar is lexicalized;
- Recursive parts are put into separate elementary trees that can be adjoined (Factoring of recursion, FR)
- Elementary trees can be arbitrarily large, in particular (because of FR) they can contain elements that are far apart in the final derived tree (Extended domain of locality)
- The elementary tree of a lexical predicate contains slots (non-terminal leaves) for all arguments of the predicate, for nothing more.

LTAG (3)

- In an LTAG, the trees are organized in *tree families*.
Tree families group together trees belonging to the same subcategorization frame.
- The lexicon is further split into *unanchored tree families* and separate *lexical anchors* selecting for the tree families.



LTAG (4)

We use *Feature-structure based TAG (FTAG)*, [Vijay-Shanker/Joshi 1988].

Each node has a *top* and a *bottom* feature structure. Intuition:

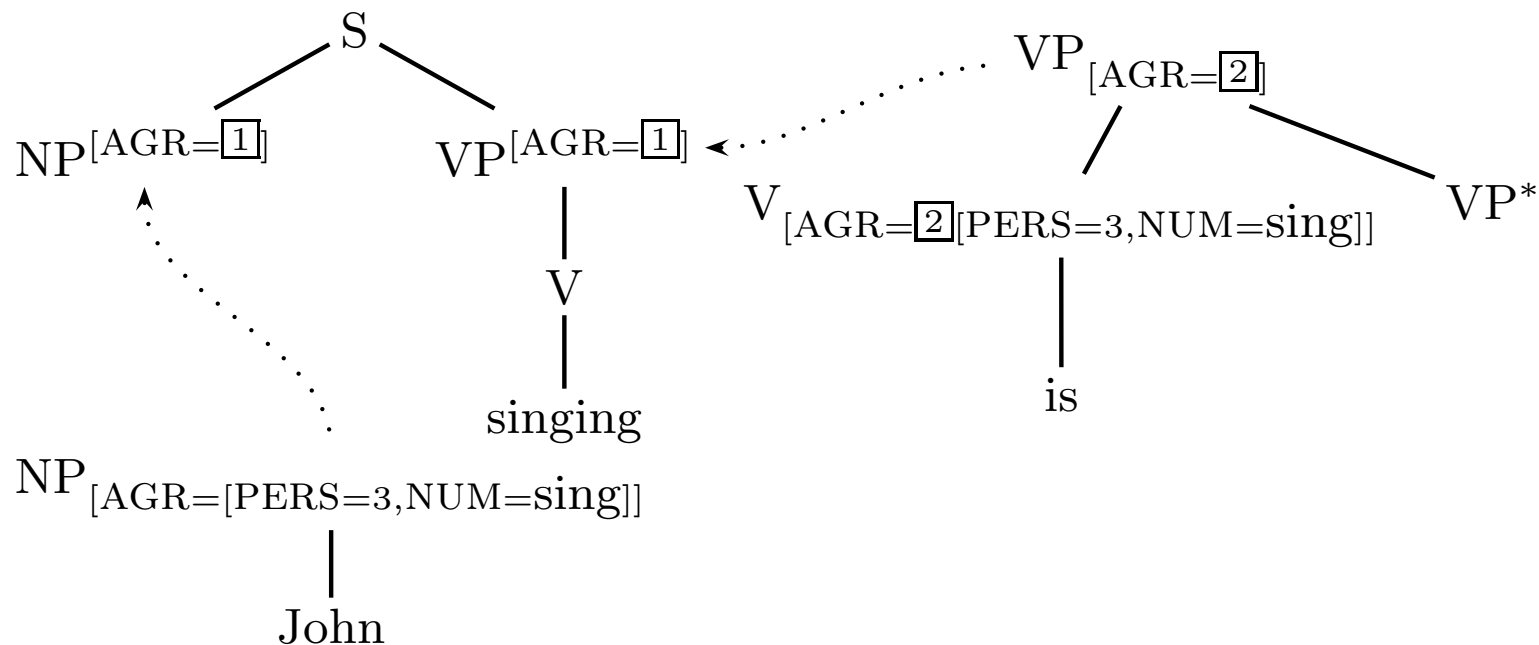
- The top feature structure tells us something about what the node presents within the surrounding structure, and
- the bottom feature structure tells us something about what the tree below the node represents.

In the final derived tree, both must be the same.

Substitutions and adjunctions trigger feature structure unifications on the nodes that are involved.

LTAG (5)

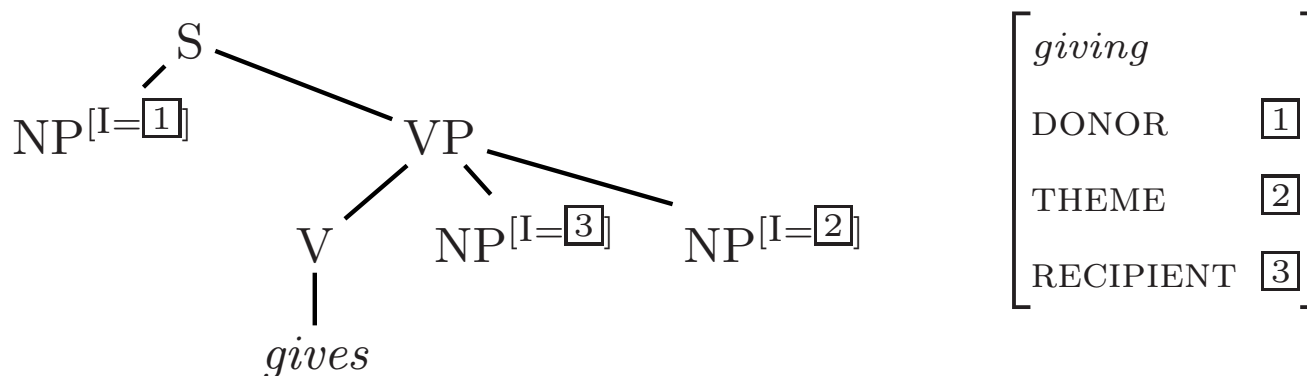
Example: percolation of agreement features



LTAG and Frame Semantics (1)

There are several reasons why LTAG seems a good candidate for a construction-based frame semantics:

- LTAG's **extended domain of locality** allows to access all the syntactic slots that correspond to the semantic roles specified within the frame of a predicate since they are part of the same elementary tree.



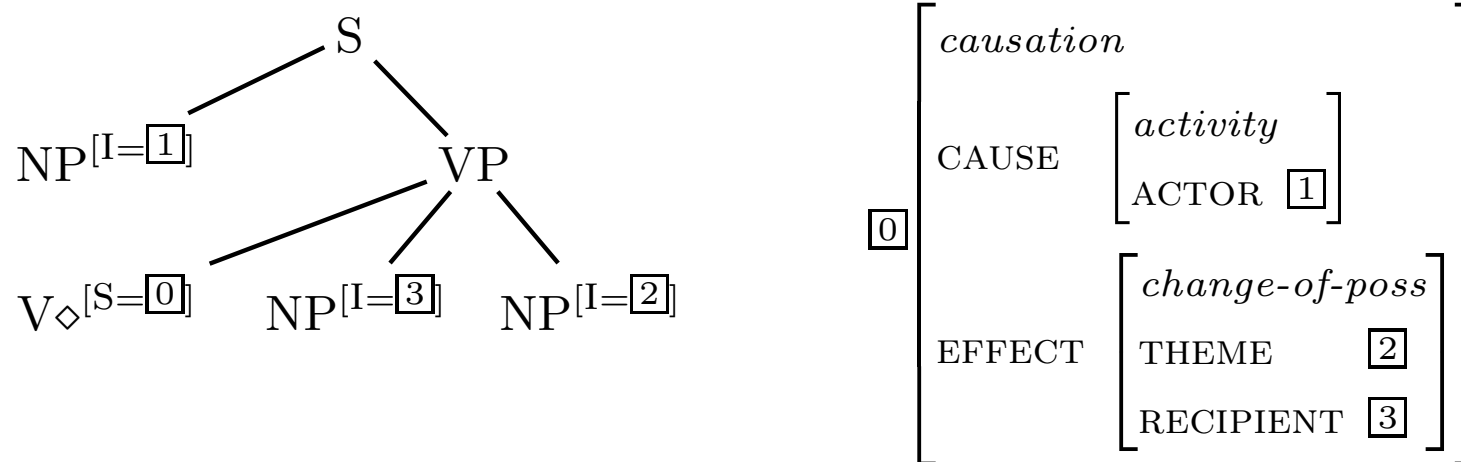
LTAG and Frame Semantics (2)

- LTAG's unanchored tree families can be regarded as constructional patterns.
- From a constructionist point of view, constructions by themselves can provide aspects of meaning [Goldberg, 1995, Van Valin and LaPolla, 1997].

LTAG and Frame Semantics (2)

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Example: DO construction \approx caused change of possession



LTAG and Frame Semantics (3)

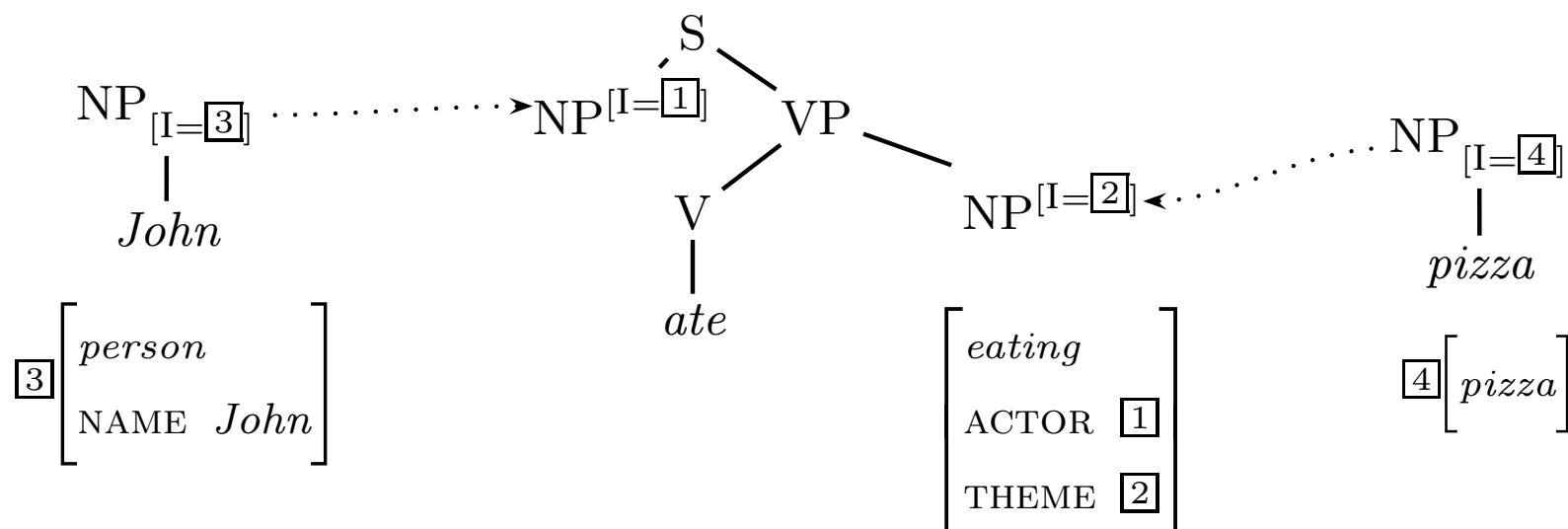
We assume a syntax-semantics interface where

- each elementary tree is linked to a semantic frame,
- semantic frames are typed feature structures with additional relations between their nodes, and
- semantic composition consists of unifications triggered by substitution and adjunction

LTAG and Frame Semantics (3)

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Directed Motion Expressions (1)

- (2) a. Mary walked to the house.
b. The ball rolled into the goal.
- (3) a. John threw/kicked the ball into the goal.
b. John pushed/pulled the cart to the station.
c. John rolled the ball into the hole.

Directional specifications are not restricted to goal expressions as in (2) and (3) but can also describe the source or the course of the path in more detail. Moreover, path descriptions can be iterated:

- (4) a. John walked through the gate along the fence to the house.
b. John threw the ball over the fence into the yard.

Directed Motion Expressions (2)

Question: Are directional expressions complements or adjuncts?

And, if they are complements, are they introduced by the construction or by the lexical item?

Distinction between *bounded* and *unbounded* directional PPs, which give rise respectively to telic (5-a) and atelic (5-b) event descriptions [Jackendoff, 1991, Verkuyl and Zwarts, 1992, Zwarts, 2005].

- (5) a. She walked to the brook (in half an hour/*for half an hour).
b. She walked along the brook (*in half an hour/for half an hour).

[Gehrke, 2008] argues that bounded directional PPs are complements of the verb while unbounded PPs are adjuncts.

Directed Motion Expressions (3)

Lexical semantics of some verbs of (caused) motion:

walk

<i>directed-motion-activity</i>		
ACTOR	[1
MANNER	<i>walking</i>	
PATH	[<i>path</i>
	STARTP	2
	ENDP	3

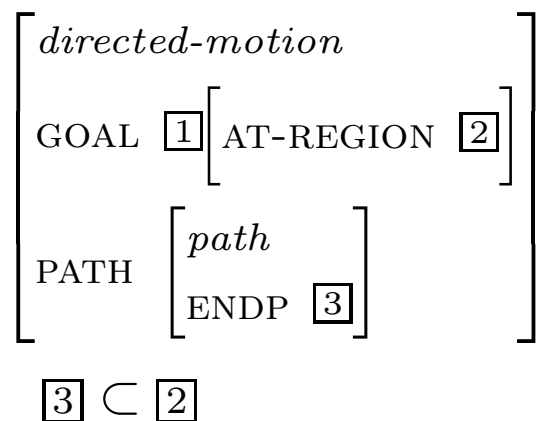
throw

<i>onset-causation</i>			
CAUSE	[<i>activity</i>	
	ACTOR	1	
	THEME	2	
	MANNER	<i>throwing</i>	
EFFECT	[<i>directed-motion</i>	
	THEME	2	
	PATH	[
		STARTP	3
		ENDP	4

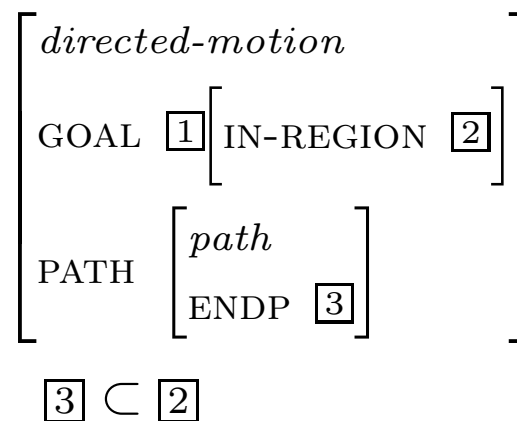
Directed Motion Expressions (4)

Lexical semantics of some directional prepositions:

to



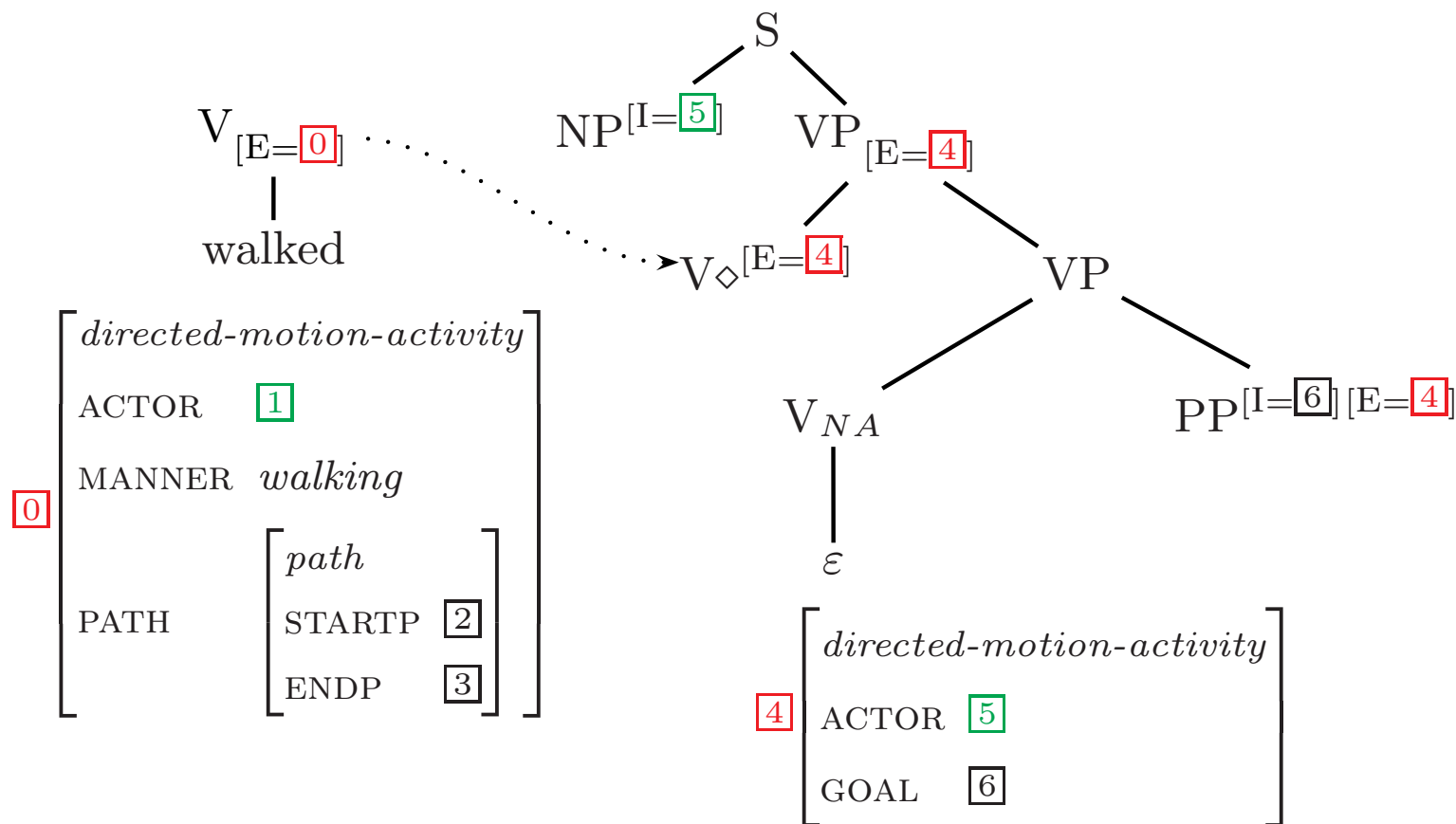
into



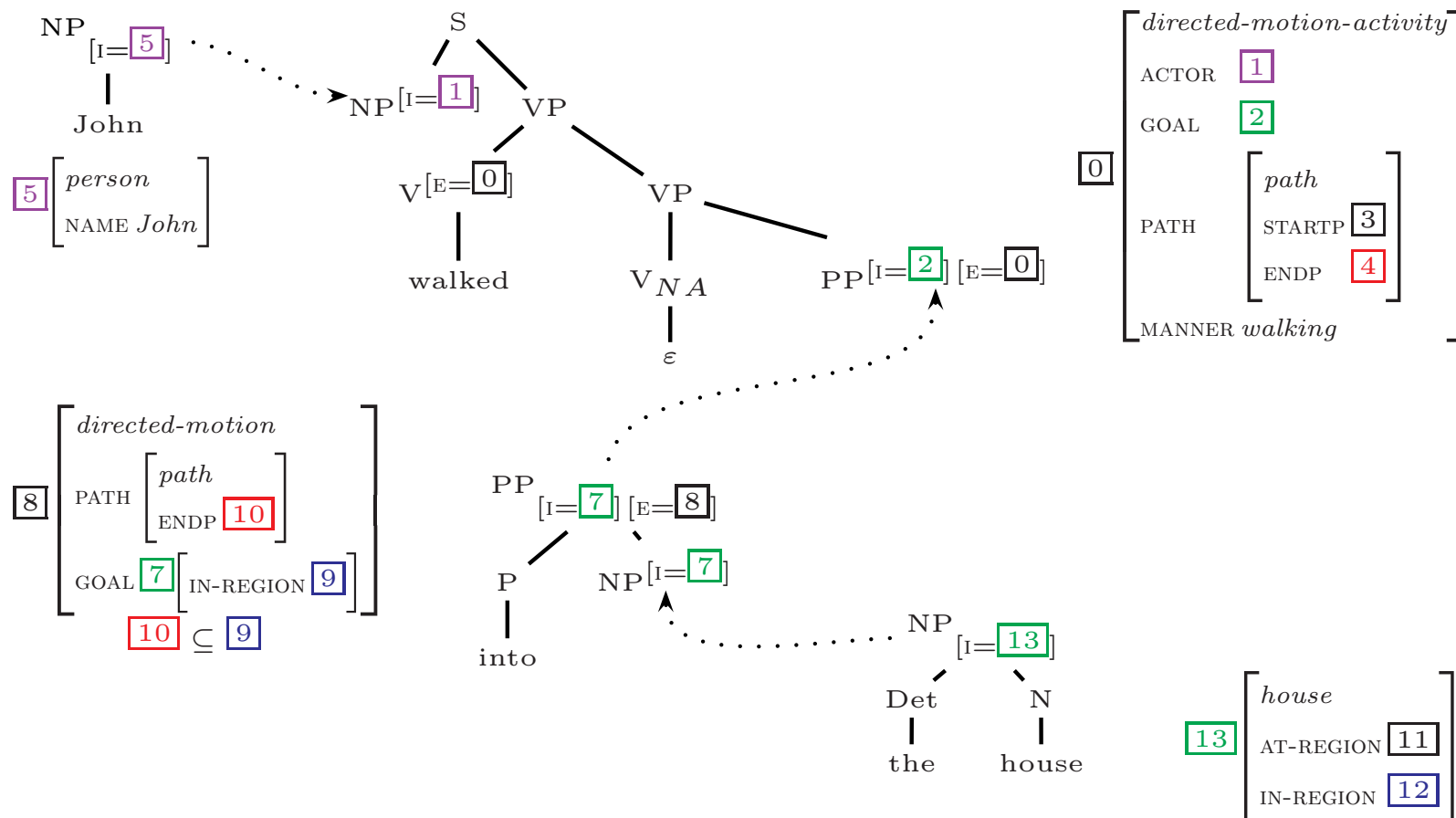
(*directed-motion* is a supertype of *directed-motion-activity*)

LTAG Analysis of Directional PPs (2)

Lexical anchoring:

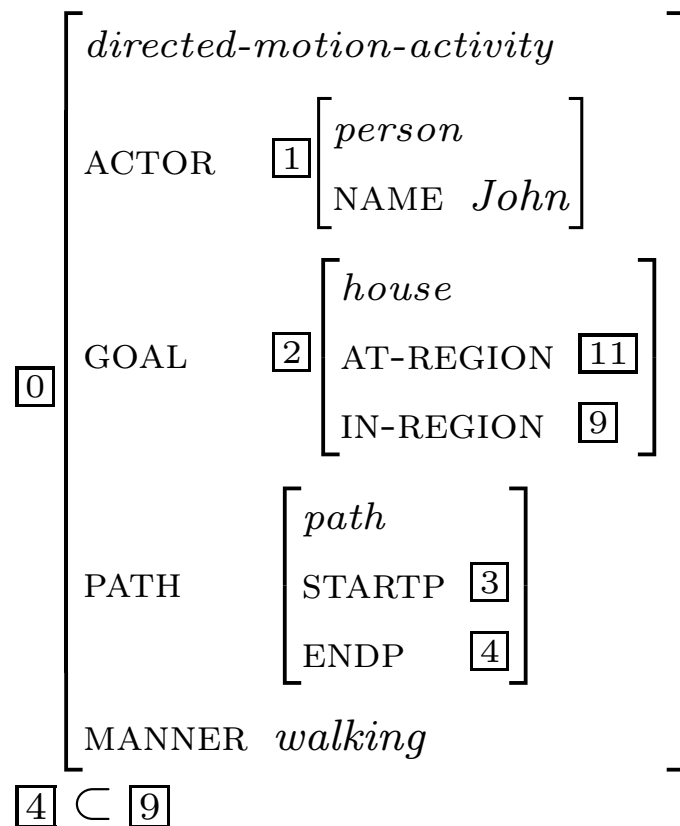


LTAG Analysis of Directional PPs (3)



LTAG Analysis of Directional PPs (4)

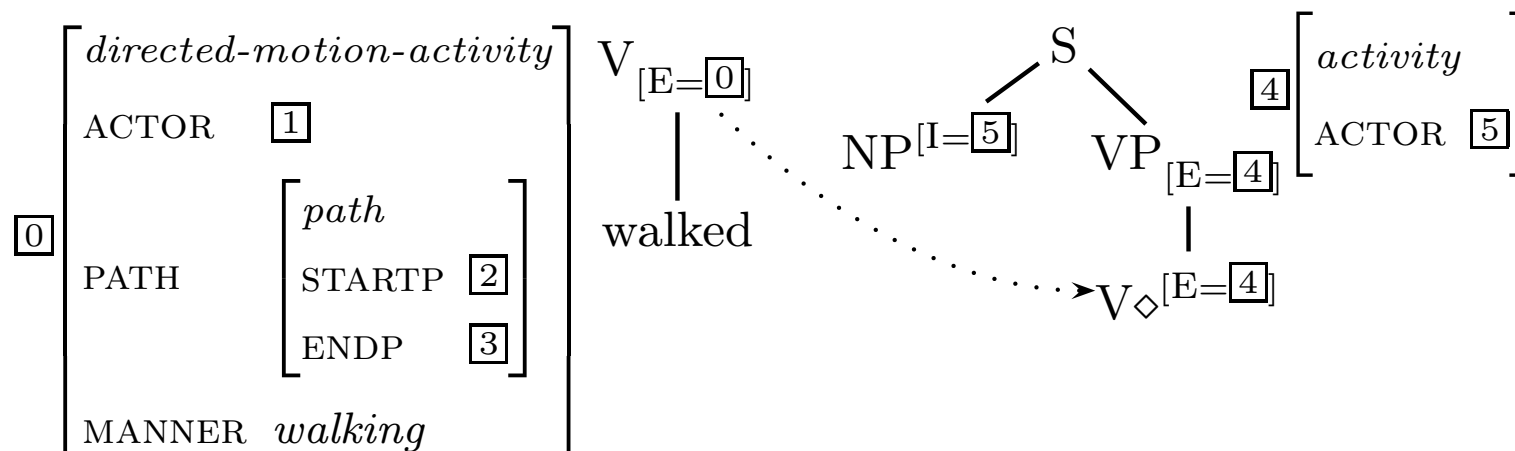
Resulting frame for *John walked into the house*



LTAG Analysis of Directional PPs (5)

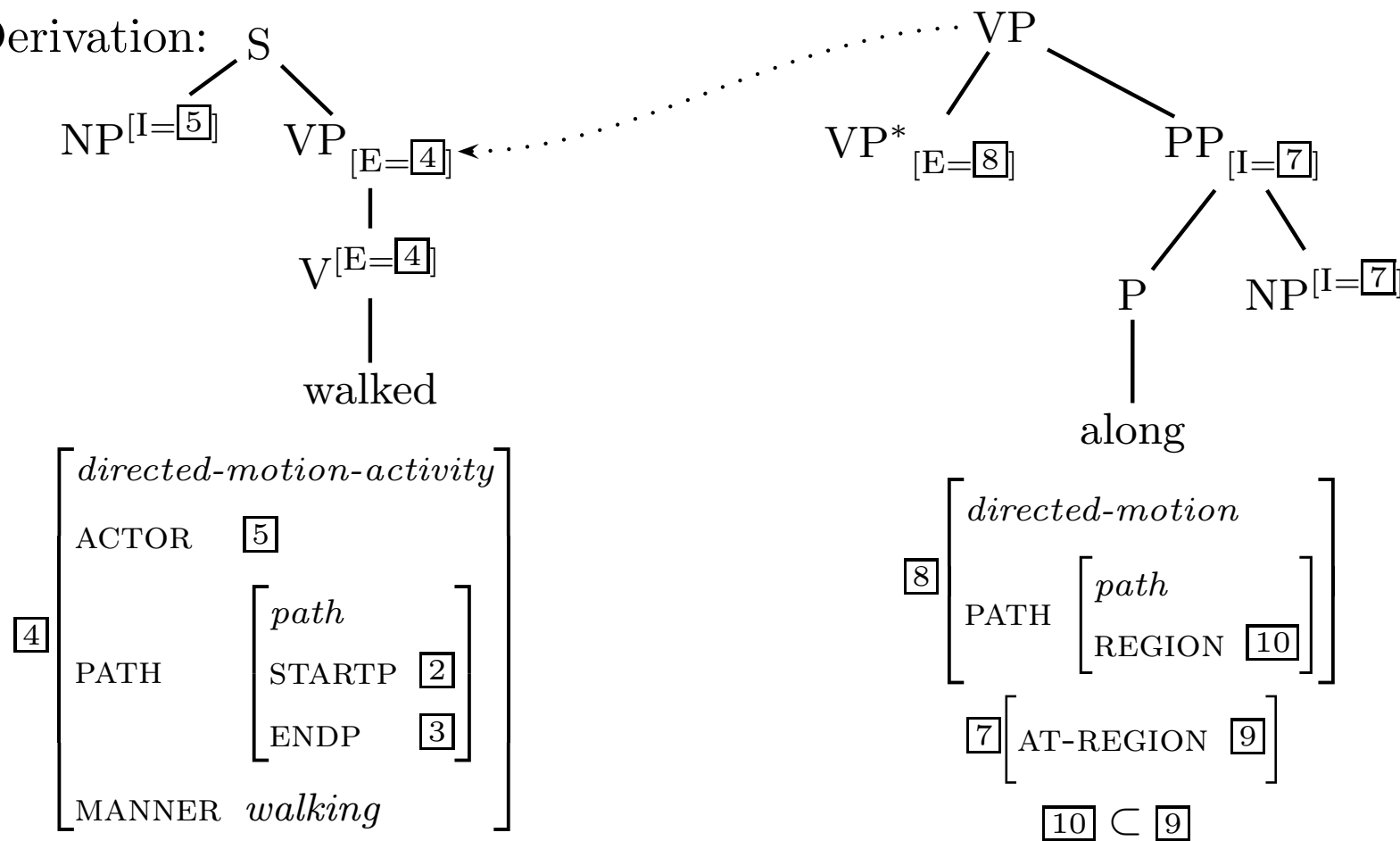
Path modification: *John walked along the brook*

Lexical anchoring for intransitive *walked*:



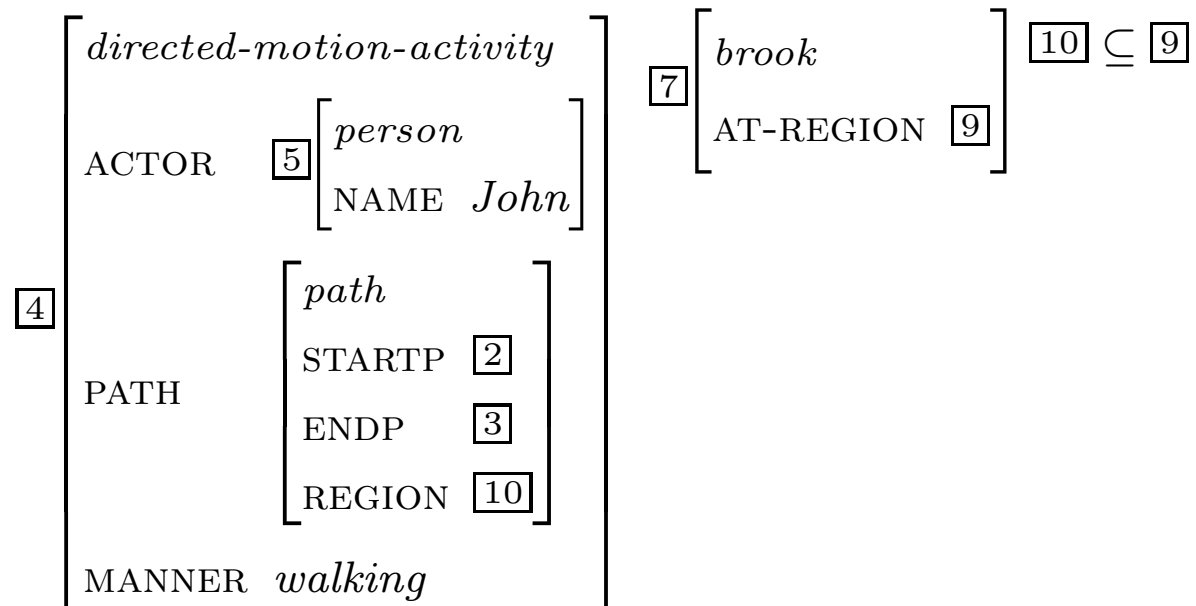
LTAG Analysis of Directional PPs (6)

Derivation:



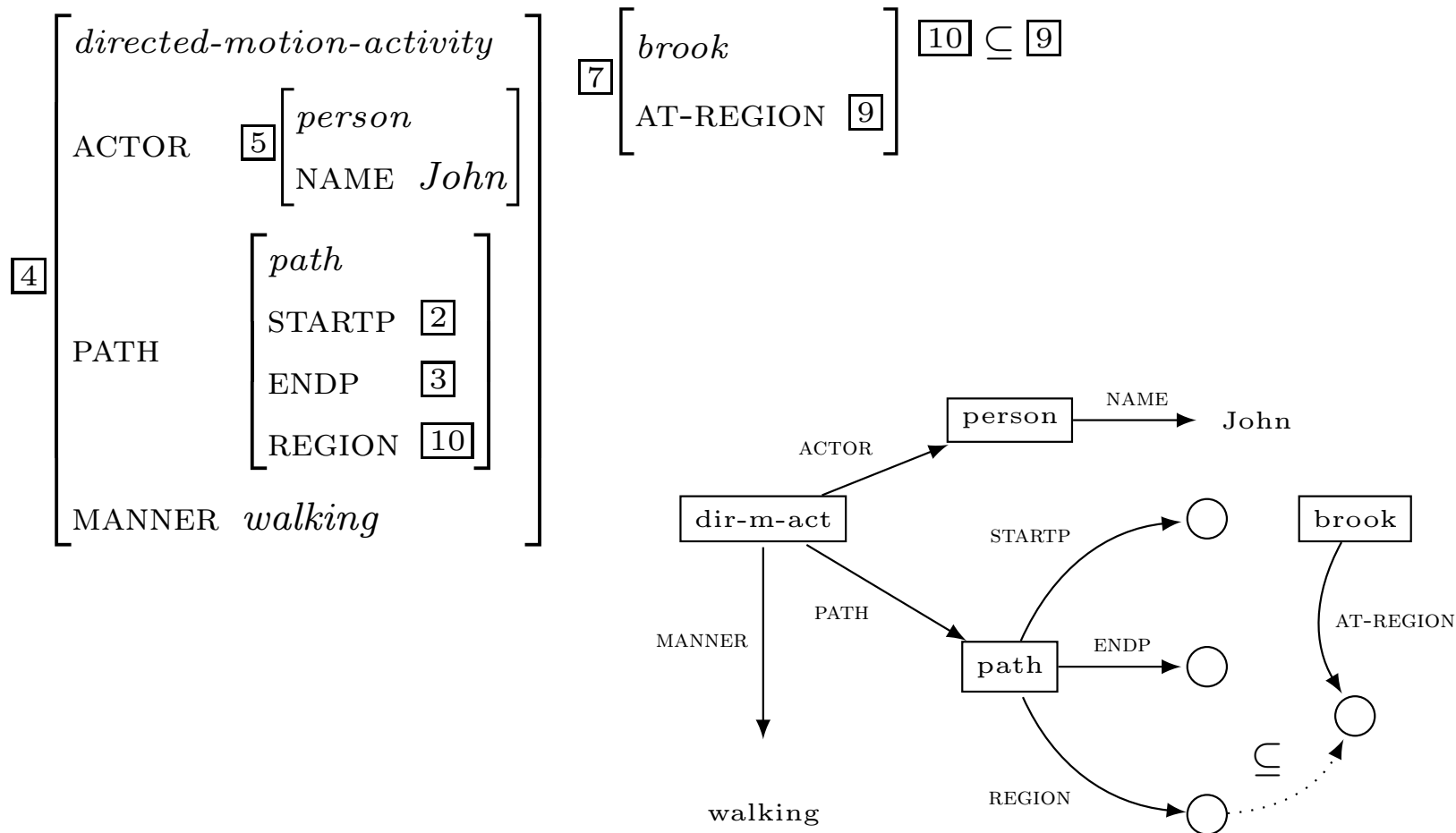
LTAG Analysis of Directional PPs (7)

Frame derived for *John walked along the brook*



LTAG Analysis of Directional PPs (7)

Frame derived for *John walked along the brook*



The Dative Alternation (1)

The English dative alternation is concerned with verbs like *give*, *send*, and *throw* which can occur in both the double object (DO) and the prepositional object (PO) construction.

- (6) a. John₁ sent Mary₃ the book₂. (DO)
b. John₁ sent the book₂ to Mary₃. (PO)

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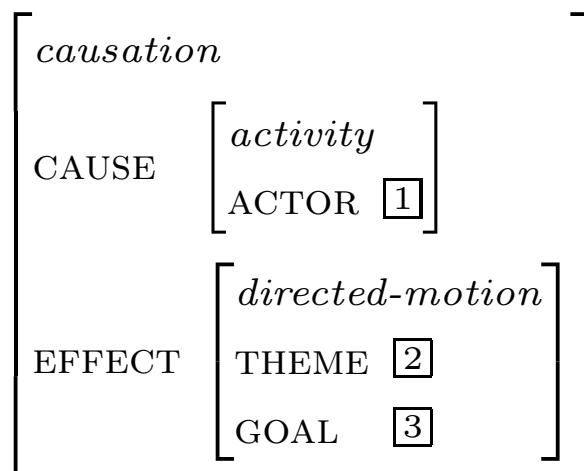
These constructions are traditionally associated with a ‘caused possession’ (7-a) and ‘caused motion’ (7-b) interpretation, respectively.

- (7) a. [[*x* ACT] CAUSE [*y* HAVE *z*]] (DO)
 b. [[*x* ACT] CAUSE [*z* GO TO *y*]] (PO)

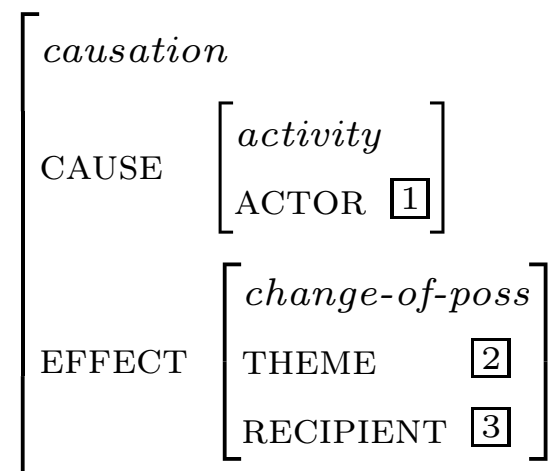
The Dative Alternation (2)

Frames for caused motion (PO) and caused change of possession (DO):

$[[x \text{ ACT}] \text{ CAUSE } [z \text{ GO TO } y]]$



$[[x \text{ ACT}] \text{ CAUSE } [y \text{ HAVE } z]]$



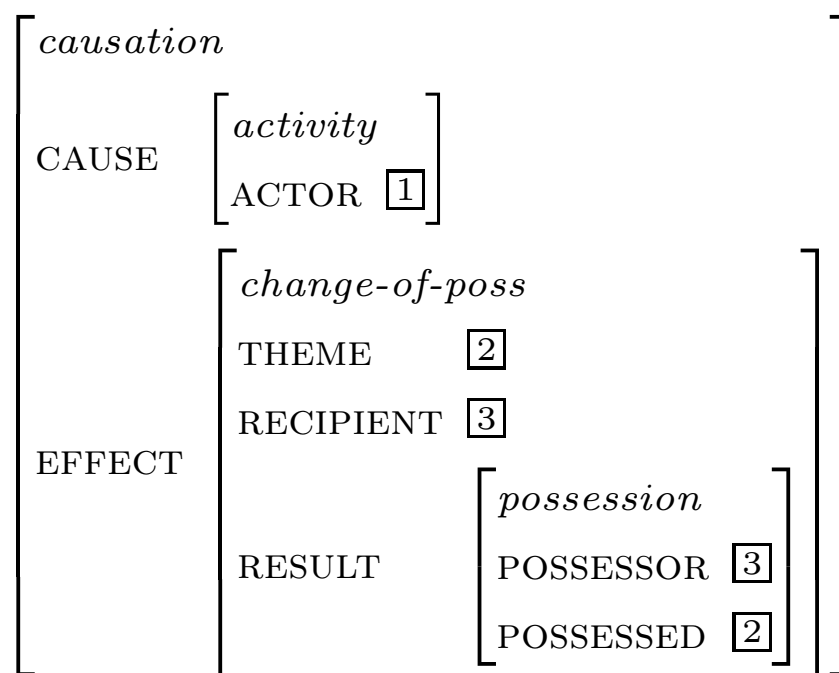
The Dative Alternation (3)

Semantic differences between ditransitive verbs like *give*, *send* and *throw* [Rappaport Hovav and Levin, 2008, Beavers, 2011]

- *give*: pure caused possession, no implication of motion.
- *hand*: caused possession and motion of the theme to the goal.
- *send*: caused motion towards a goal but not necessarily arrival.
- *throw*: caused motion, existence of goal is not lexicalized.

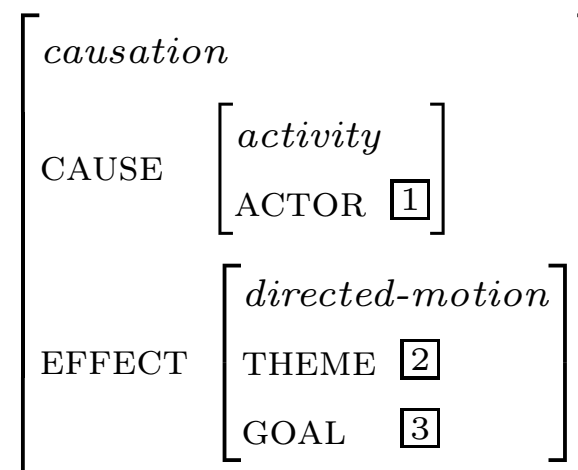
The Dative Alternation (4)

give: actual caused possession



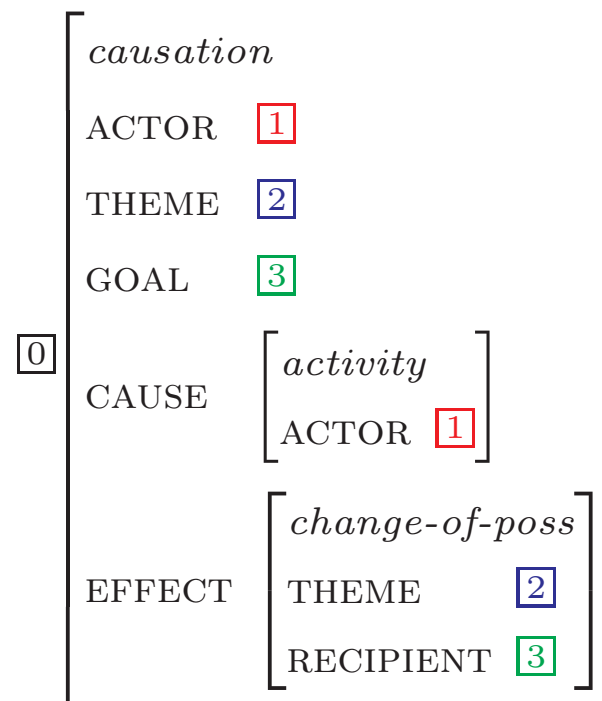
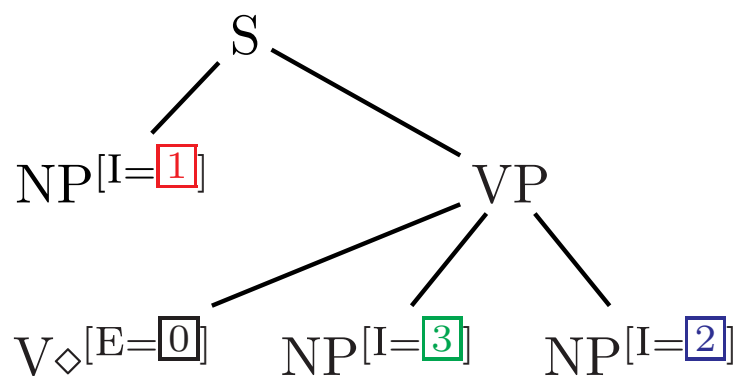
send: caused motion towards

a goal without necessarily arrival

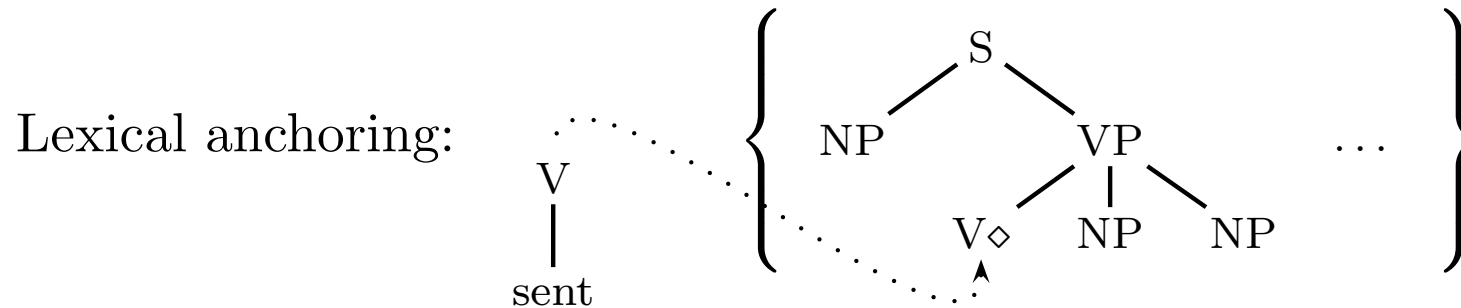


Elementary Trees for DO and PO (1)

Unanchored elementary tree for the DO construction:



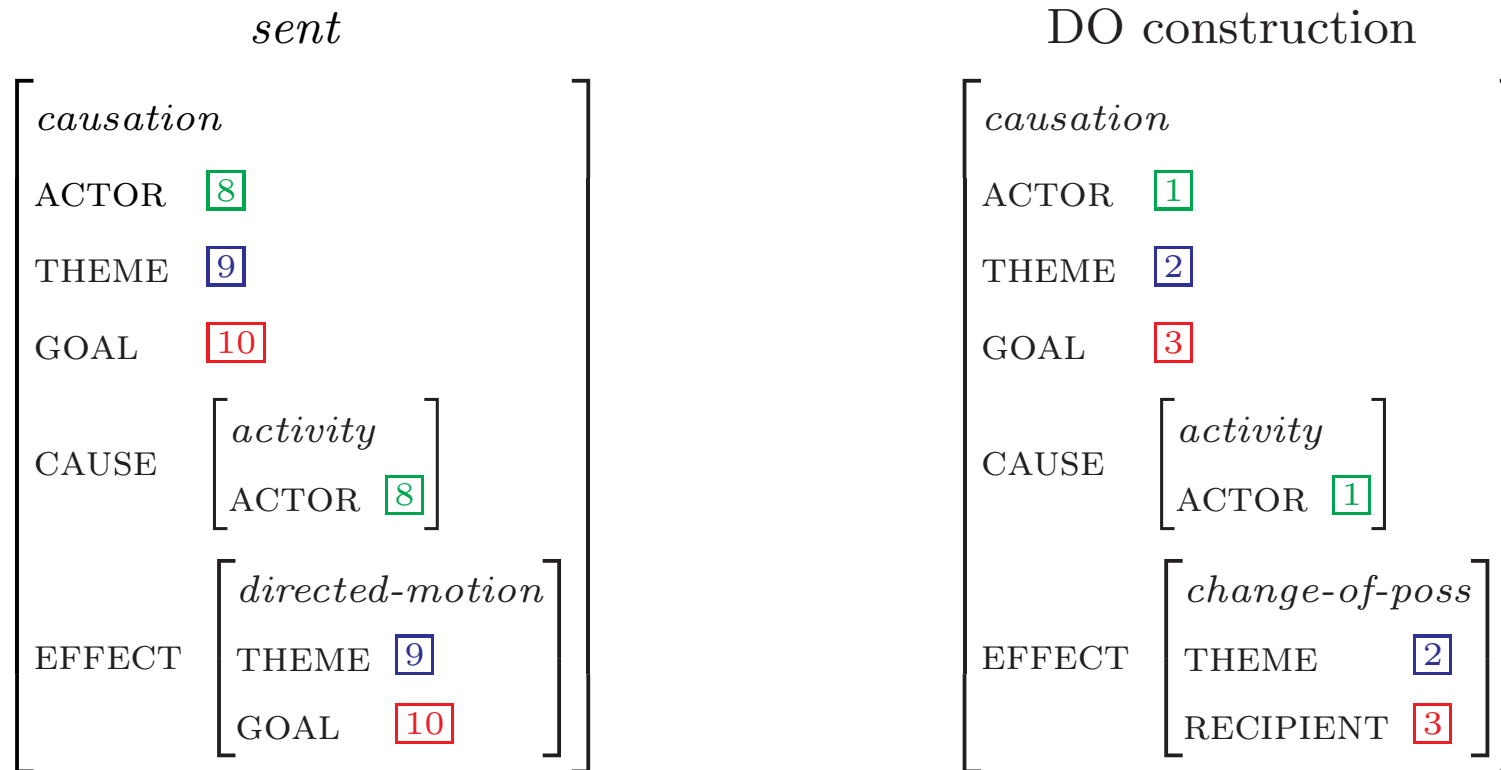
Elementary Trees for DO and PO (2)



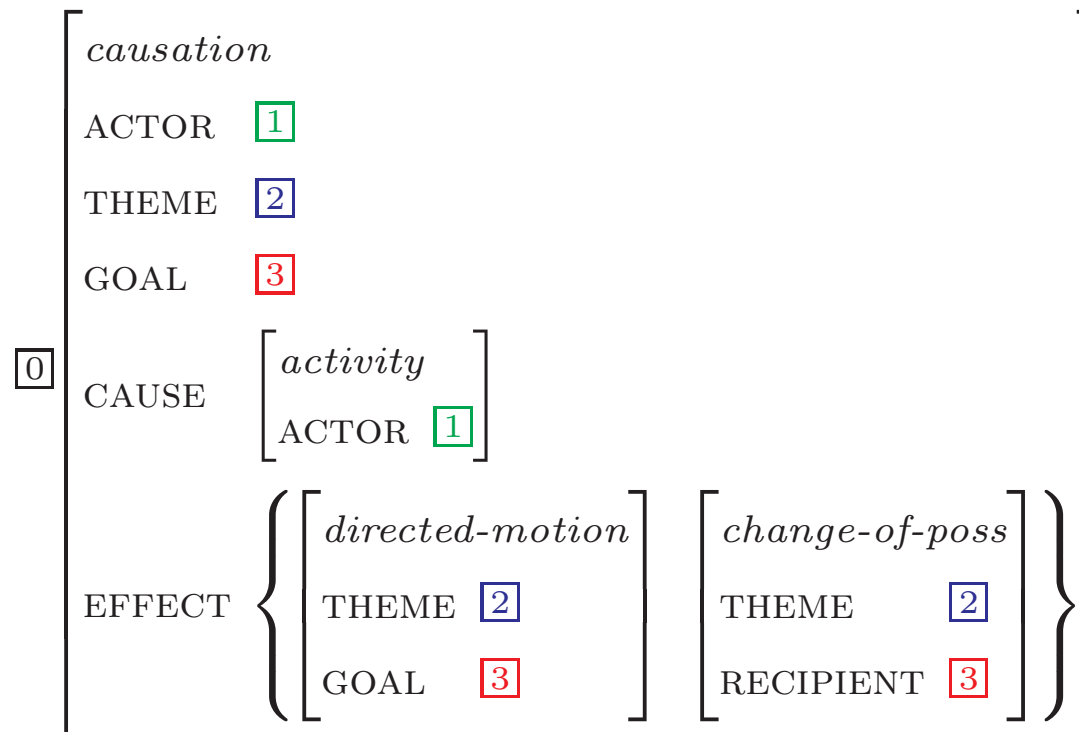
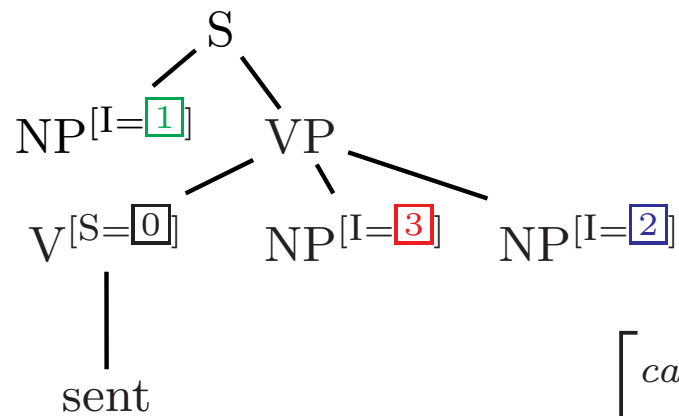
- Problem: *sent* expresses caused motion while the DO construction expresses caused change of possession.
- We do not use standard unification. Instead, we take the following approach: For two frames that are supposed to unify, if they are of the same type or one is of a subtype of the other, they must unify.

Otherwise, we take the two frames to describe different aspects that should be considered as a conjunction. We therefore combine them into a set (i.e., a list) of frames.

Elementary Trees for DO and PO (3)

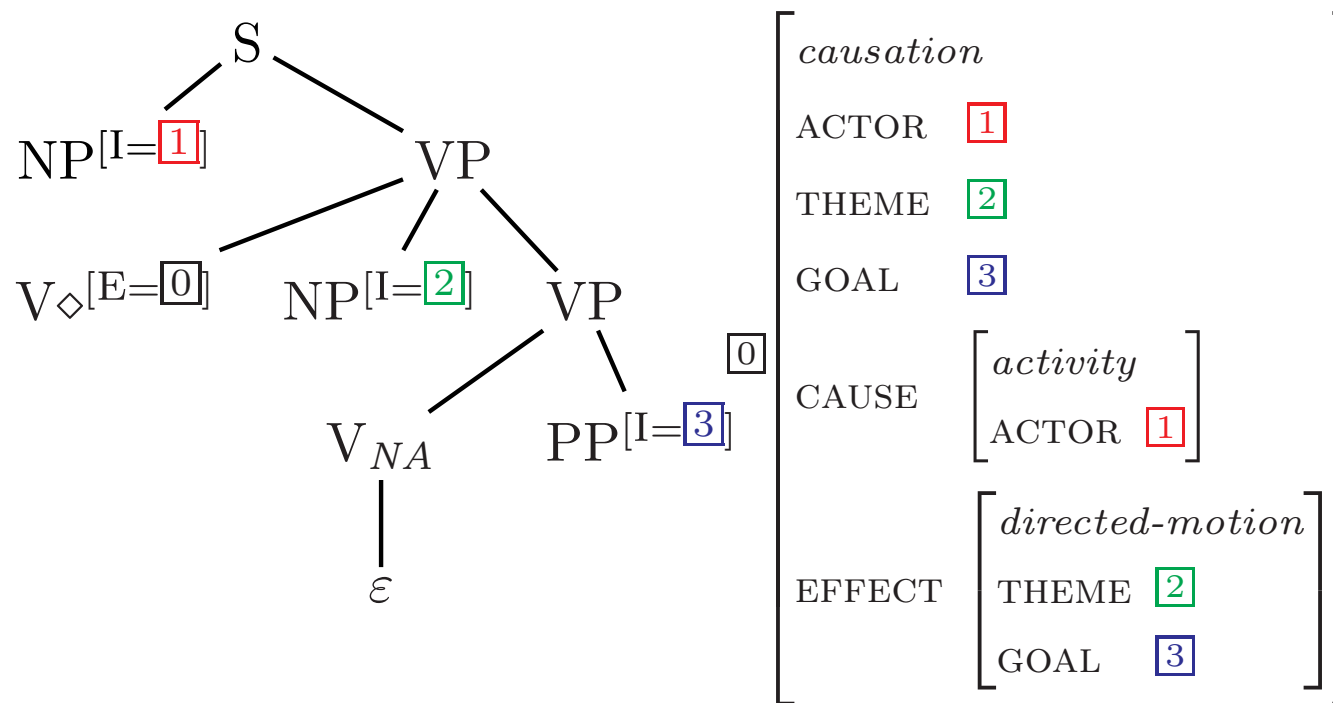


Elementary Trees for DO and PO (4)



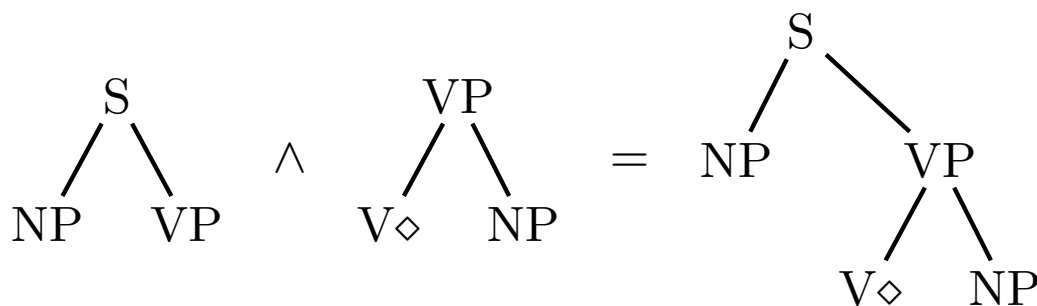
Elementary Trees for DO and PO (5)

Unanchored elementary tree for PO construction:

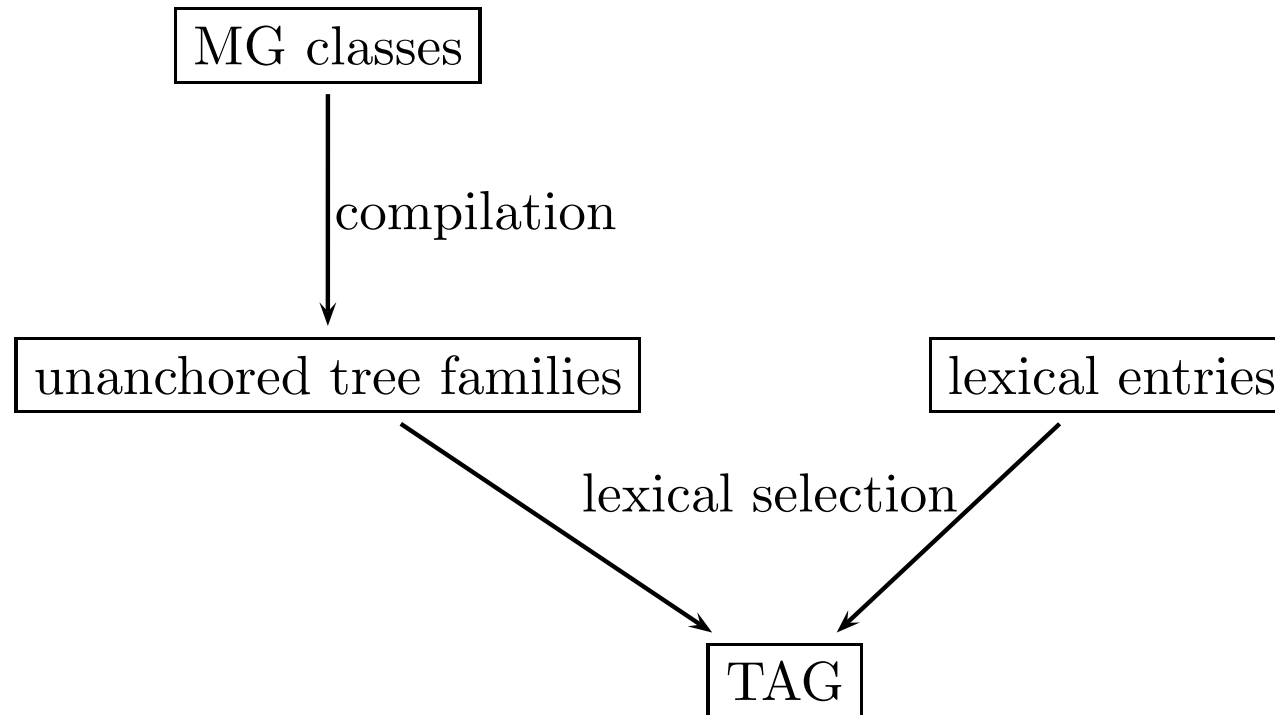


MG Factorization (1)

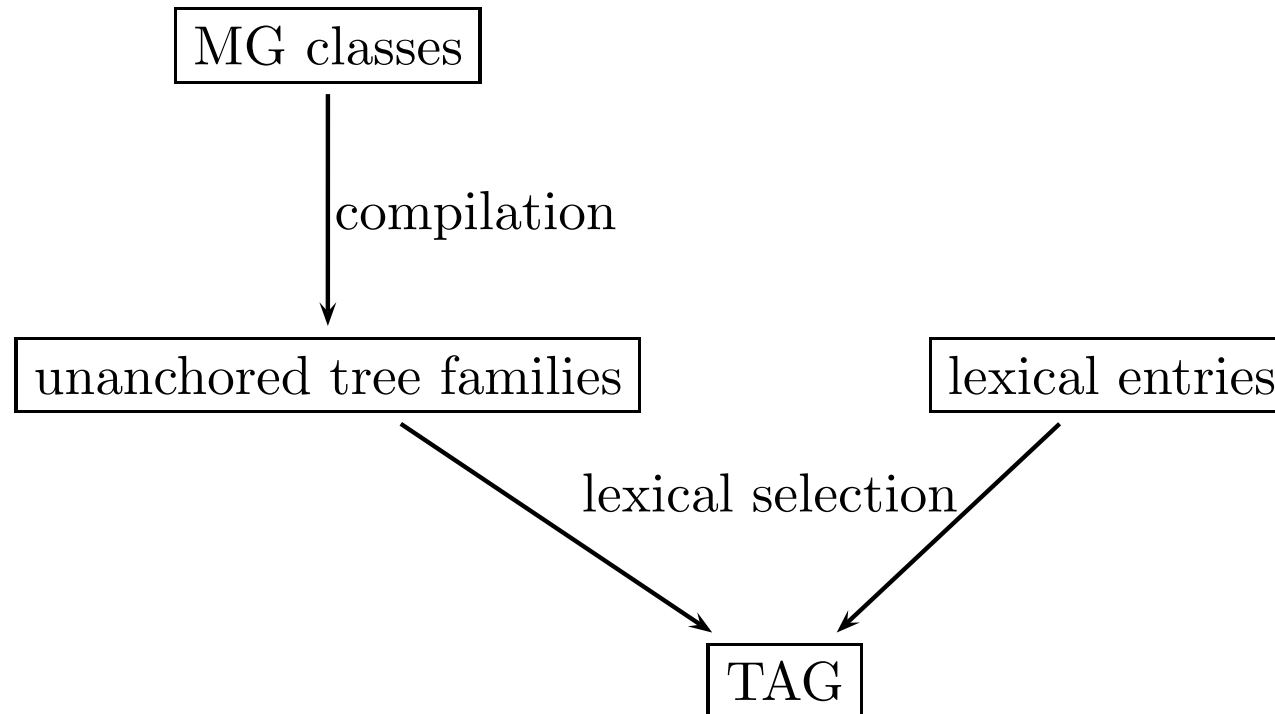
- In order to produce and maintain a consistent LTAG of a considerable coverage, one uses a metagrammar (MG) [Candito 1999, Crabbe/Duchier 2005].
- An MG contains factorized descriptions of unanchored elementary trees. It defines a set of tree fragments (MG classes) that can be used in other MG classes.
- This way, an unanchored elementary tree family is the denotation of an MG class that makes use of a series of other, smaller tree fragments in the MG.



MG Factorization (2)



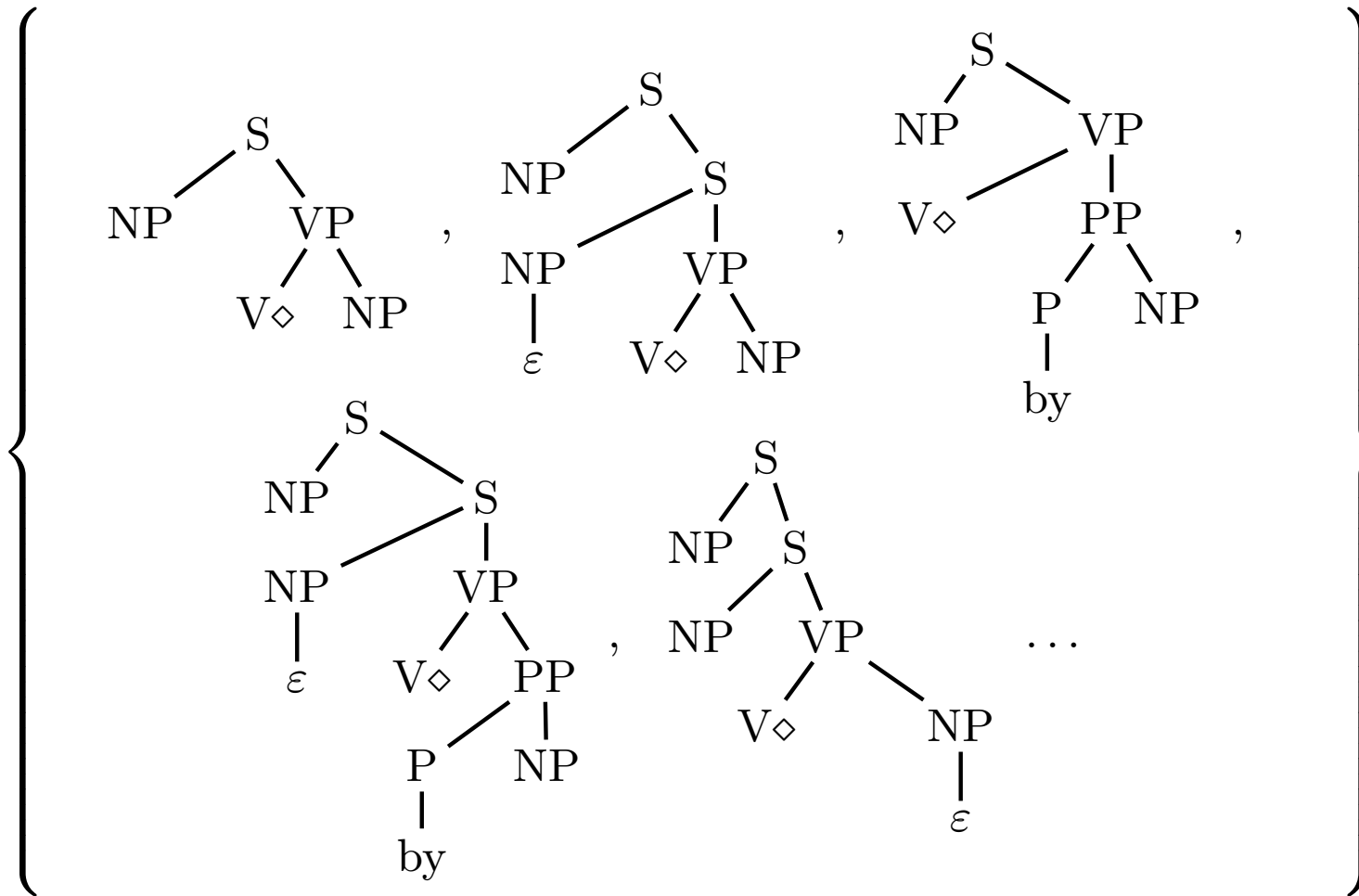
MG Factorization (2)



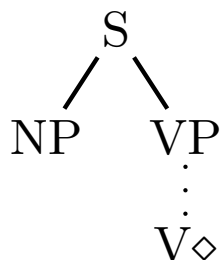
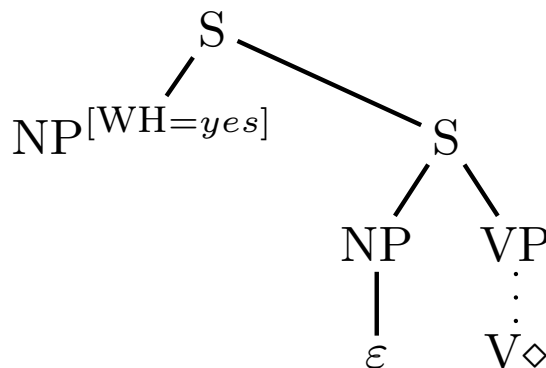
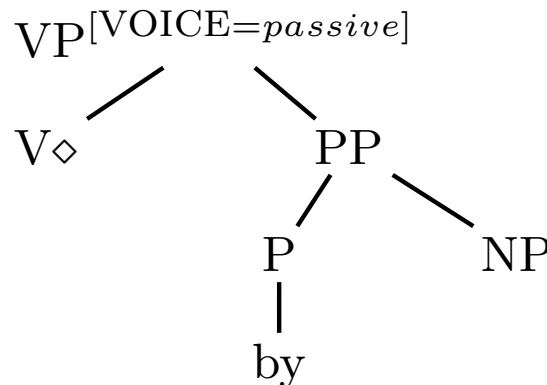
Advantage of MGs for TAG from a linguistic point of view: The MG allows to express and implement lexical generalizations.

MG Factorization (3)

Example: Unanchored family for transitive verbs:



MG Factorization (4)

Class *CanSubj*Class *ExtrSubj*Class *Subj* $CanSubj \vee ExtrSubj$ Class *ActV*VP[VOICE=*active*]Class *PassV*VP[VOICE=*passive*]Class *DirObj*Class *ByObj*Class *Transitive*

$$((Subj \wedge ActV) \vee ByObj \vee PassV) \wedge ((DirObj \wedge ActV) \vee (Subj \wedge PassV))$$

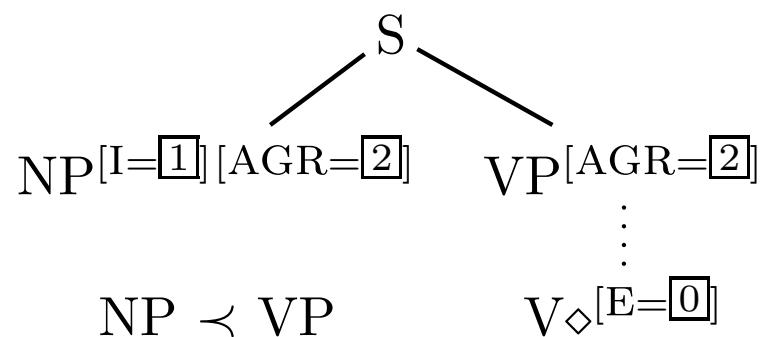
Semantic MG Decomposition (1)

Class *Subj*

export: e

identities: $e = \boxed{0}$

syntactic dimension



semantic dimension

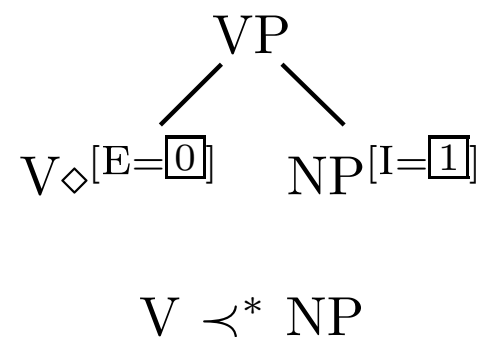


Class *DirObj*

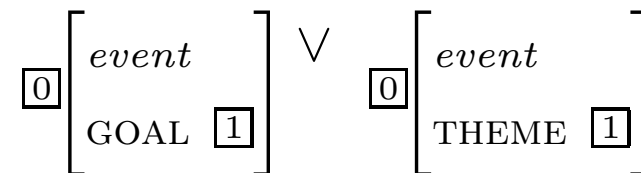
export: e

identities: $e = \boxed{0}$

syntactic dimension



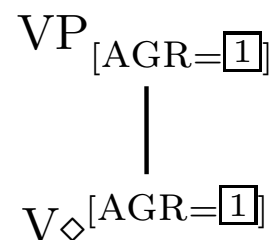
semantic dimension



Semantic MG Decomposition (2)

Class $VSpine$

syntactic dimension



Class $n0V$

export: e

use $V_1 = VSpine,$

$N_1 = \text{Subj}$

identities: $e = N_1.e,$

$V_1.V = N_1.V$

Class $n0Vn1$

export: e

use $V_1 = n0V$

$N_2 = \text{DirObj}$

identities: $e = N_2.e,$

$V_1.V = N_2.V$

Semantic MG Decomposition (2)

Class $VSpine$

syntactic dimension

$$\begin{array}{c} VP_{[AGR=\boxed{1}]} \\ | \\ V_{\diamond}[AGR=\boxed{1}] \end{array}$$

Class $n0V$

export: e

use $V_1 = VSpine,$

$N_1 = \text{Subj}$

identities: $e = N_1.e,$

$V_1.V = N_1.V$

Class $n0Vn1$

export: e

use $V_1 = n0V$

$N_2 = \text{DirObj}$

identities: $e = N_2.e,$

$V_1.V = N_2.V$

- Compilation of $n0Vn1$ yields unanchored trees of transitive verbs with a subject role ACTOR and a direct object role THEME or GOAL.
- These are not the only possible roles. A detailed linking theory is planned for future work.

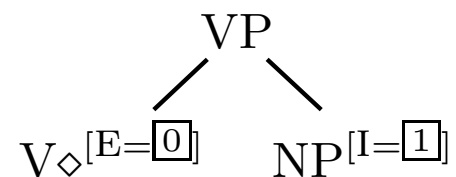
Semantic MG Decomposition (3)

Class *IndirObj*

export: e

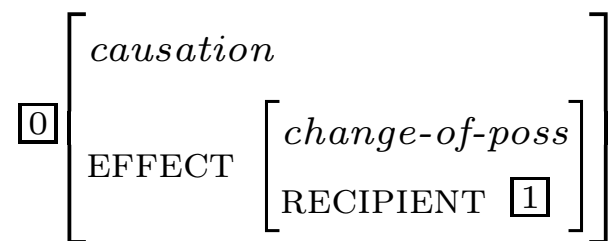
identities: $e = \boxed{0}$

syntactic dimension



$V \prec NP$

semantic dimension



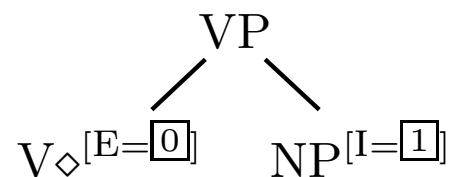
Semantic MG Decomposition (3)

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export: e

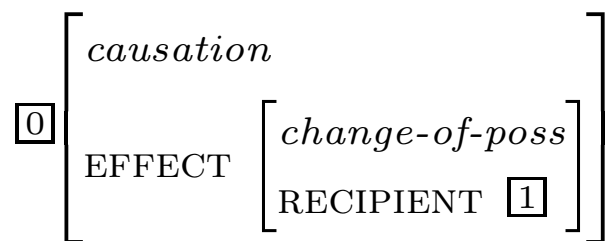
identities: $e = \boxed{0}$

syntactic dimension



$V \prec NP$

semantic dimension

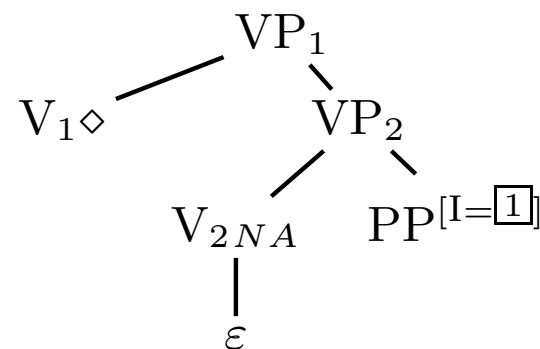


Class *DirPrepObj*

export: e

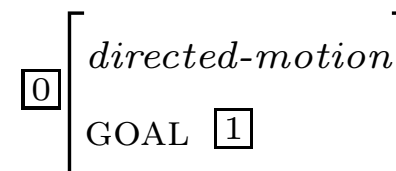
identities: $e = \boxed{0}$

syntactic dimension



$V_1 \prec^* \text{VP}_2, V_2 \prec \text{PP}$

semantic dimension



Semantic MG Decomposition (4)

Class *DOConstr*

use $V_1 = n0Vn1$, $N_3 = \text{IndirObj}$

identities: $V_1.V = N_3.V$

semantic dimension

	<i>causation</i>							
	ACTOR	1						
	THEME	2						
	GOAL	3						
$V_1.e$	CAUSE	<table style="border: none; margin-left: 20px;"> <tr> <td style="border: none;"><i>activity</i></td> <td style="border: none;"></td> </tr> <tr> <td style="border: none;">ACTOR</td> <td style="border: 1px solid black; text-align: center;">1</td> </tr> </table>	<i>activity</i>		ACTOR	1		
<i>activity</i>								
ACTOR	1							
	EFFECT	<table style="border: none; margin-left: 20px;"> <tr> <td style="border: none;"><i>change-of-poss</i></td> <td style="border: none;"></td> </tr> <tr> <td style="border: none;">THEME</td> <td style="border: 1px solid black; text-align: center;">2</td> </tr> <tr> <td style="border: none;">RECIPIENT</td> <td style="border: 1px solid black; text-align: center;">3</td> </tr> </table>	<i>change-of-poss</i>		THEME	2	RECIPIENT	3
<i>change-of-poss</i>								
THEME	2							
RECIPIENT	3							

Semantic MG Decomposition (4)

Class *DOConstr*

use $V_1 = n_0Vn_1$, $N_3 = \text{IndirObj}$

identities: $V_1.V = N_3.V$

semantic dimension

$$V_1.e \left[\begin{array}{l} \textit{causation} \\ \text{ACTOR} \quad \boxed{1} \\ \text{THEME} \quad \boxed{2} \\ \text{GOAL} \quad \boxed{3} \\ \text{CAUSE} \quad \left[\begin{array}{l} \textit{activity} \\ \text{ACTOR} \quad \boxed{1} \end{array} \right] \\ \text{EFFECT} \quad \left[\begin{array}{l} \textit{change-of-poss} \\ \text{THEME} \quad \boxed{2} \\ \text{RECIPIENT} \quad \boxed{3} \end{array} \right] \end{array} \right]$$

Class *POConstr*

use $V_1 = n_0Vn_1$, $N_3 = \text{DirPrepObj}$

identities: $V_1.V = N_3.V$

semantic dimension

$$V_1.e \left[\begin{array}{l} \textit{causation} \\ \text{ACTOR} \quad \boxed{1} \\ \text{THEME} \quad \boxed{2} \\ \text{GOAL} \quad \boxed{3} \\ \text{CAUSE} \quad \left[\begin{array}{l} \textit{activity} \\ \text{ACTOR} \quad \boxed{1} \end{array} \right] \\ \text{EFFECT} \quad N_3.e \quad \left[\begin{array}{l} \textit{dir.-motion} \\ \text{THEME} \quad \boxed{2} \\ \text{GOAL} \quad \boxed{3} \end{array} \right] \end{array} \right]$$

Semantic MG Decomposition (5)

Class $n0Vpp(dir)$

use classes $V_1 = n0V$, $N_2 = DirPrepObj$

identities: $N_2.e = V_1.e$, $V_1.V = N_2.V$

This yields the unanchored tree(s) for *walked in John walked into the house*.

Semantic MG Decomposition (5)

Class $n0Vpp(dir)$

use classes $V_1 = n0V$, $N_2 = DirPrepObj$

identities: $N_2.e = V_1.e$, $V_1.V = N_2.V$

This yields the unanchored tree(s) for *walked* in *John walked into the house*.

- Here, the directed motion event gets identified with the main verb event.
- In the case of *POConstr*, the directed motion event gets embedded under the effect of the causation.
- In both constructions, the same class can be used for the directional PP complement.

Summary

- We propose to integrate frame semantics into Lexicalized Tree Adjoining Grammars.
- LTAG's extended domain of locality facilitates linking.
- The distinction between unanchored elementary trees and lexical anchors allows to separate constructional meaning from lexical meaning.
- The flexibility owing to LTAG's decomposition in the metagrammar facilitates the decomposition of meaning depending on constructions and fragments of syntactic structure.
- This work is part of a larger project that is planned to include an implementation.

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