Dependency Grammars: Dependency and Non-Dependency Relations; Free Word Order

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Phrase structure vs. dependency tree

Bernard returned late from the dinner with Yolande and Paul.

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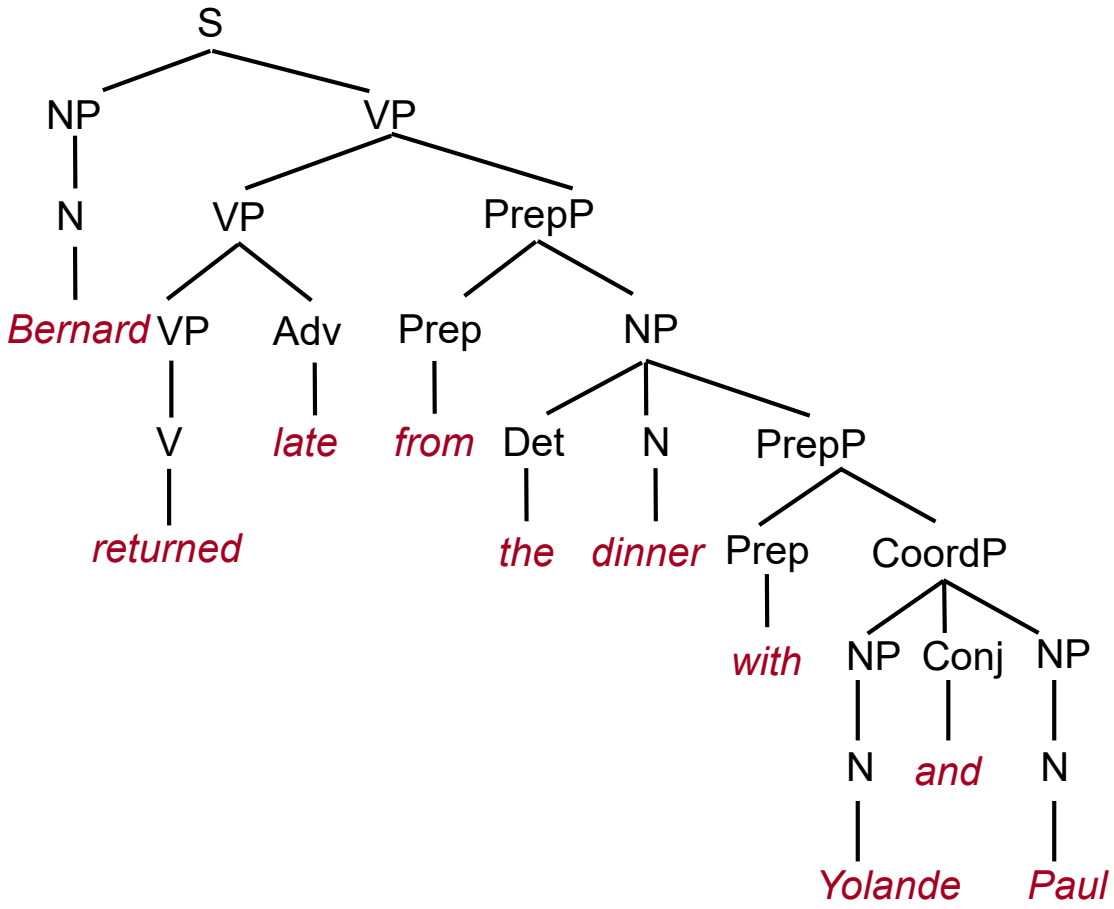

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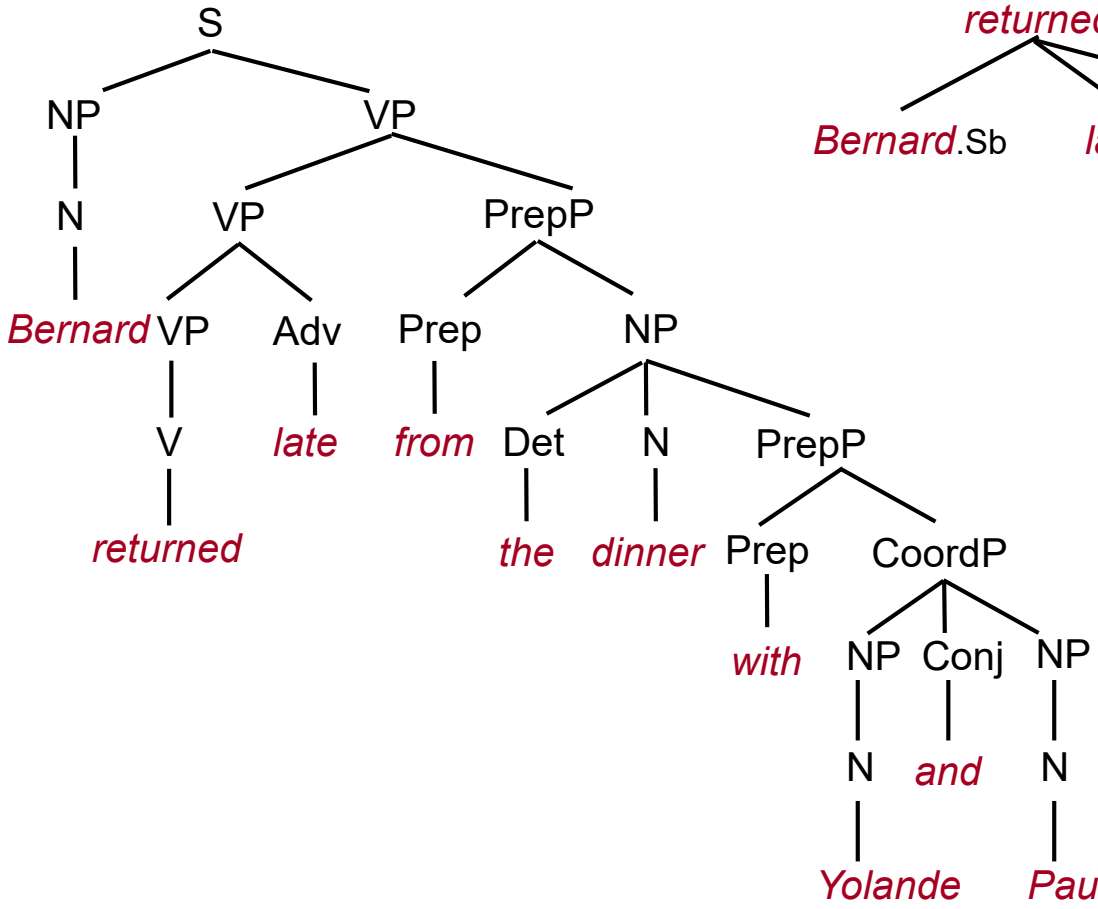

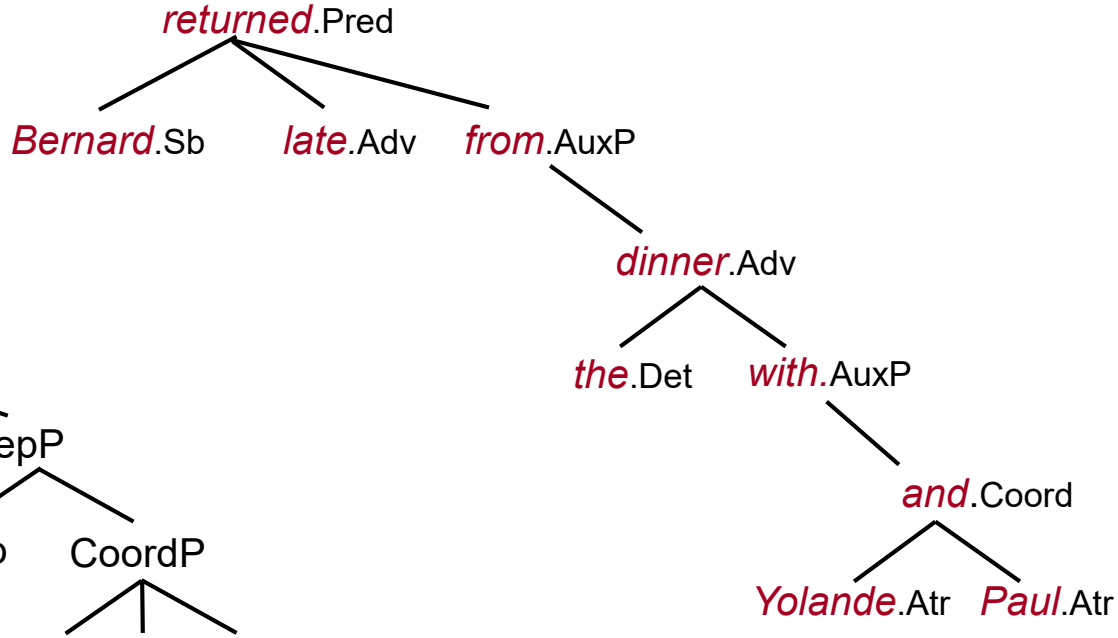

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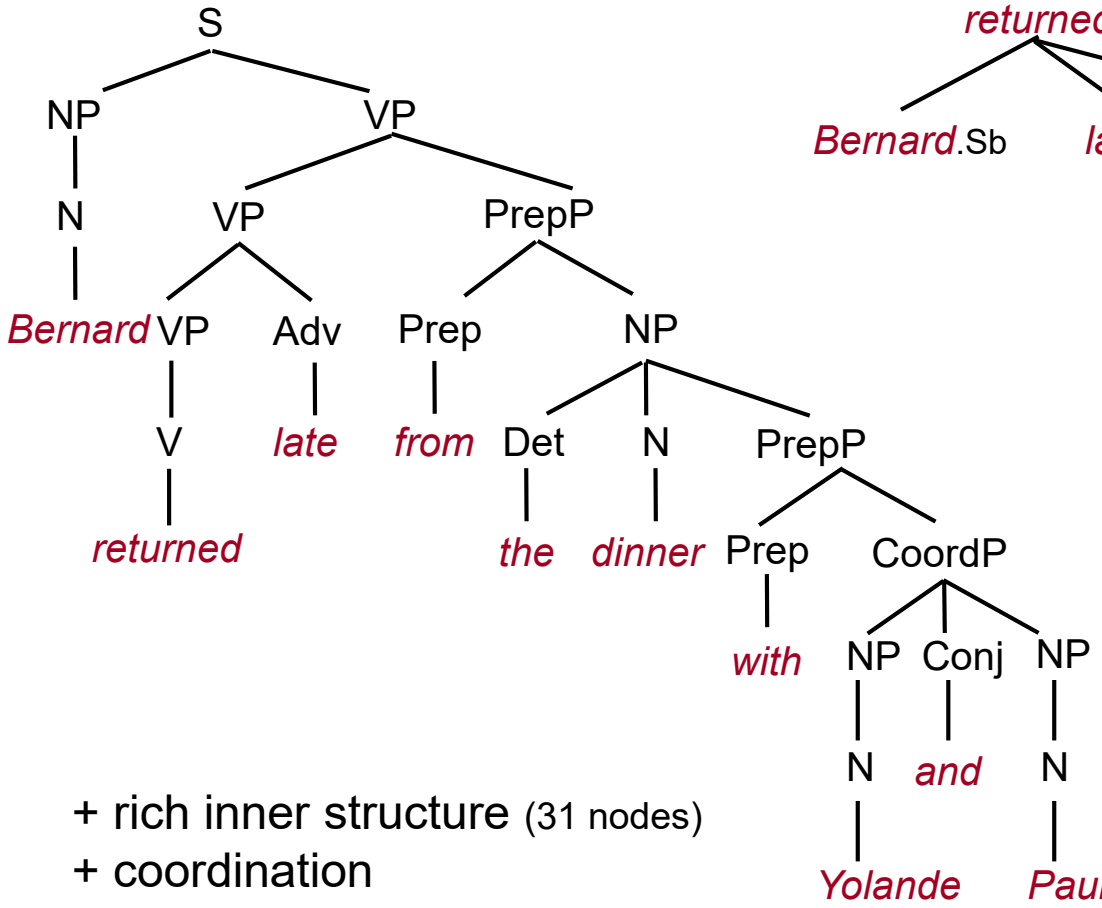
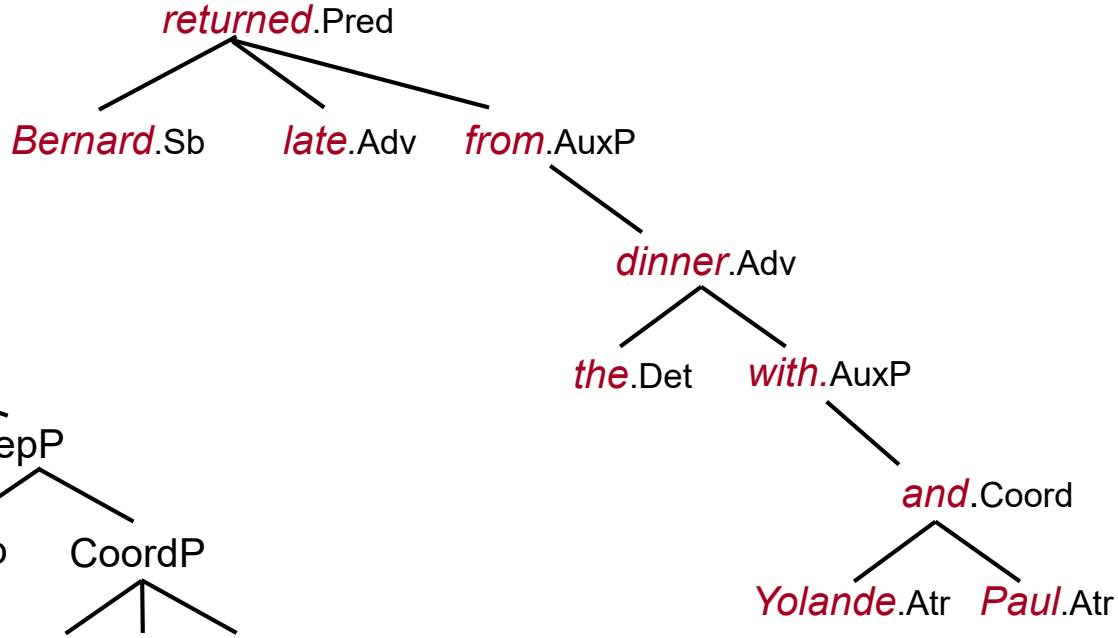




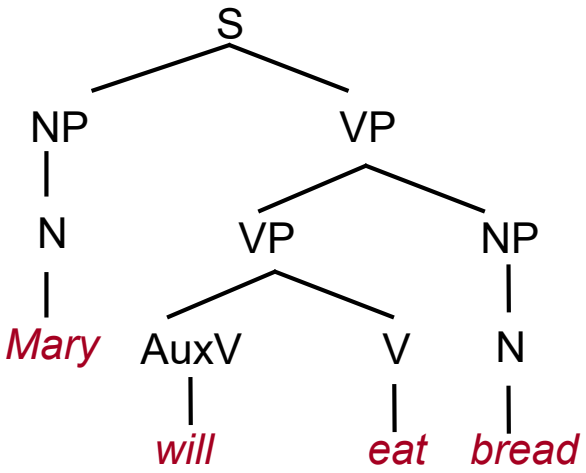
+ rich inner structure (31 nodes)
+ coordination
– free word order

+ heads (10 nodes)
– coordination
+ free word order

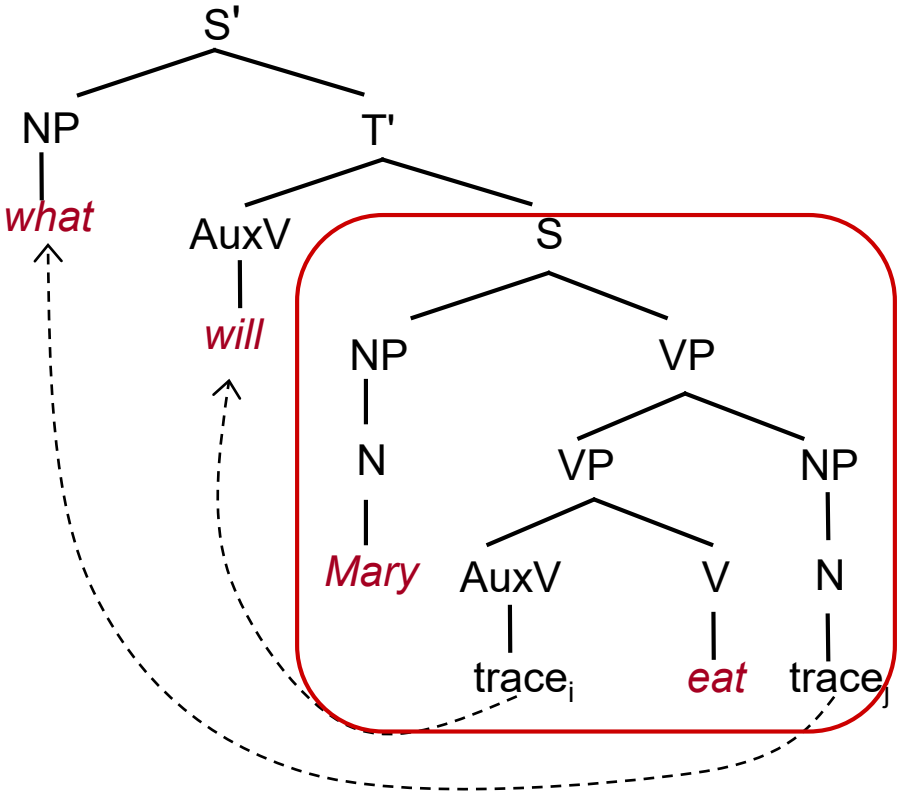
Phrase structure vs. dependency tree

discontinuous ‘phrases’: solution for English

Mary will eat bread.



What will Mary eat?



Syntactic Dependencies

- principle of lexicalization
- based on dependencies as an asymmetric binary relations between language units

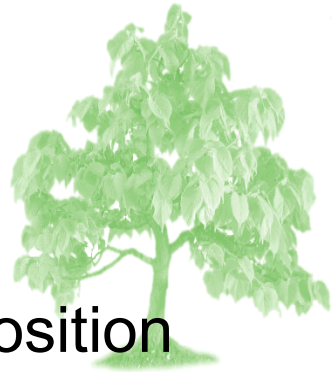
  → detecting heads: not commonly agreed criteria
    - possible reduction criterion
    - constituent-based criterion
    - criterion of maximal parallelism between languages

  → (finite) verb as the structural center of clause structure

  → a single "position" in a tree for a single syntactic function
  (subject, direct object, indirect object, …)

  → problem with coordination and other non-dependency relations

Non-Dependency Relations



coordination … "multiplication" of a single syntactic position

- different referents
- coordination of sentence members / sentences

  My sister Mary and John came late.
  Mary came in time but John was late.
  I can't leave since it hasn't stopped raining yet.
  Nemohu odejít, neboť ještě nepřestalo pršet.

- coordination may be embedded

  nice and romantic towers and castles
  krásné a romantické hrady a zámky

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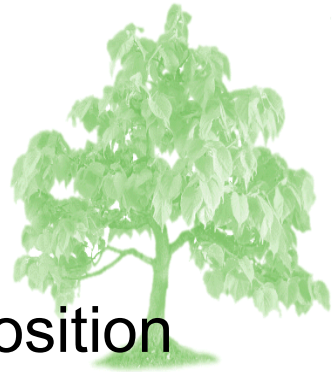

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- coordination may be embedded

  nice and romantic towers and castles
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apposition … "multiplication" of a single syntactic position

- identical referent

  Charles IV, Holy Roman Emperor
  The Hobbit, or There and Back Again
  George Washington, the first president of the United States

Non-Dependency Relations

coordination … "multiplication" of a single syntactic p

- different referents
- coordination of sentence members / sentences
- coordination may be embedded

apposition … "multiplication" of a single syntactic position

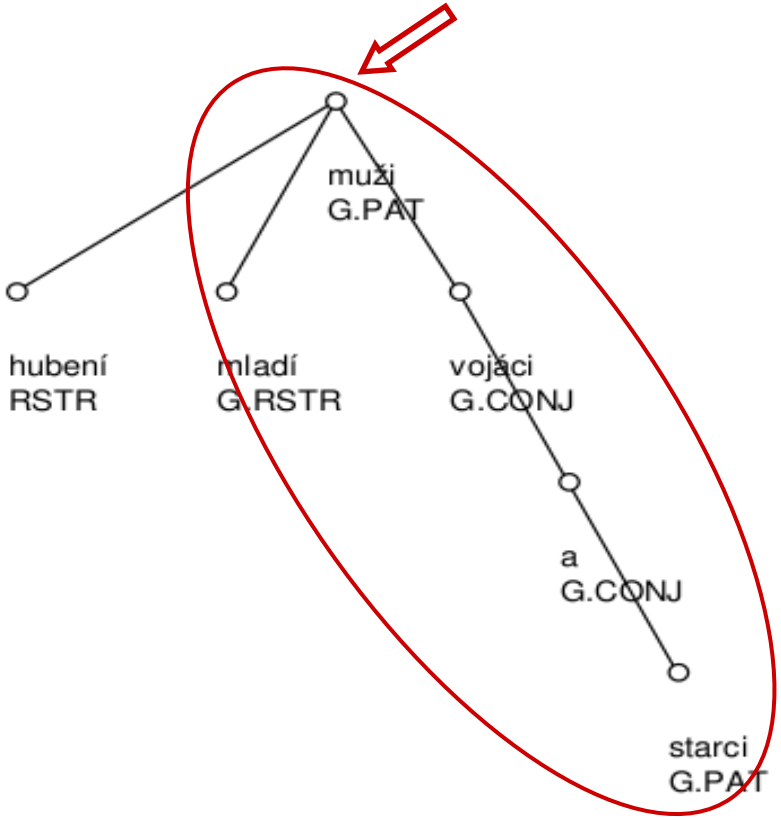
- identical referent

⇨ cannot be represented by dependency edges
necessary to enrich the data structure

Coordination in Dependency Trees I

Mel'čuk (1988):

- ‘grouping’ (G) … treating the first conjunct as the head
- problem:
  shared modification
  vs. modification of a single member



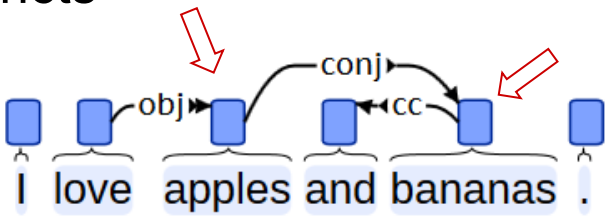
Hubení ((mladí muži) , vojáci a starci)
[Thin young men, soldiers and old-men]

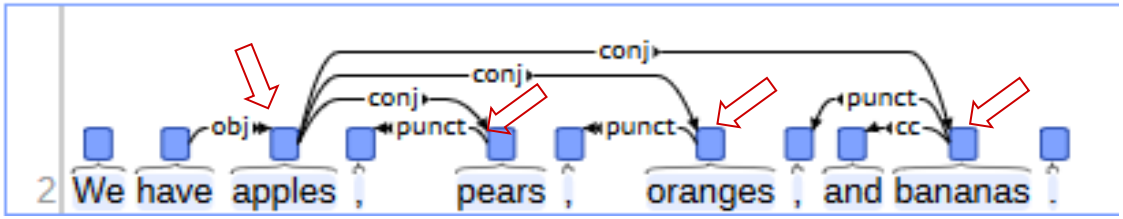
Coordination in Dependency Trees II

Universal Dependencies:
version 2 (2016):

- the *first conjunct* ~ the head of all following conjuncts

  i.e., "left-headed" principle





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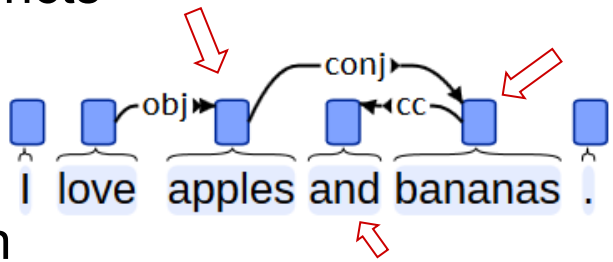
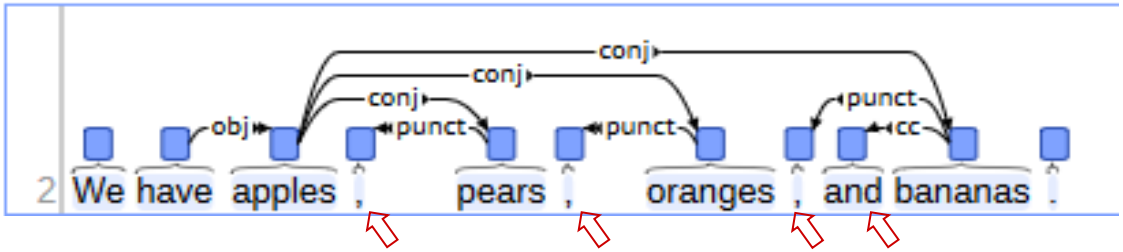


- attach coordinating conjunctions and punctuation
  to the immediately succeeding conjunct



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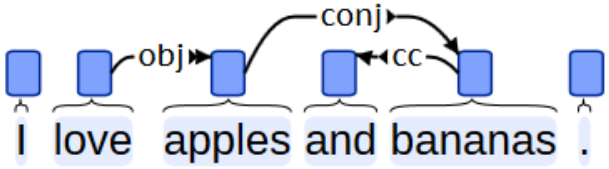

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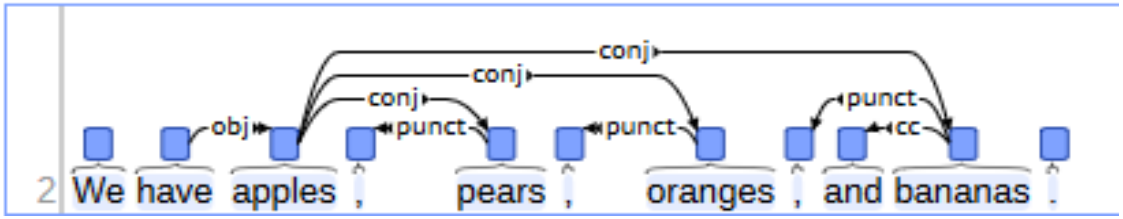
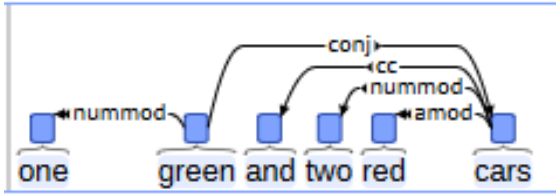


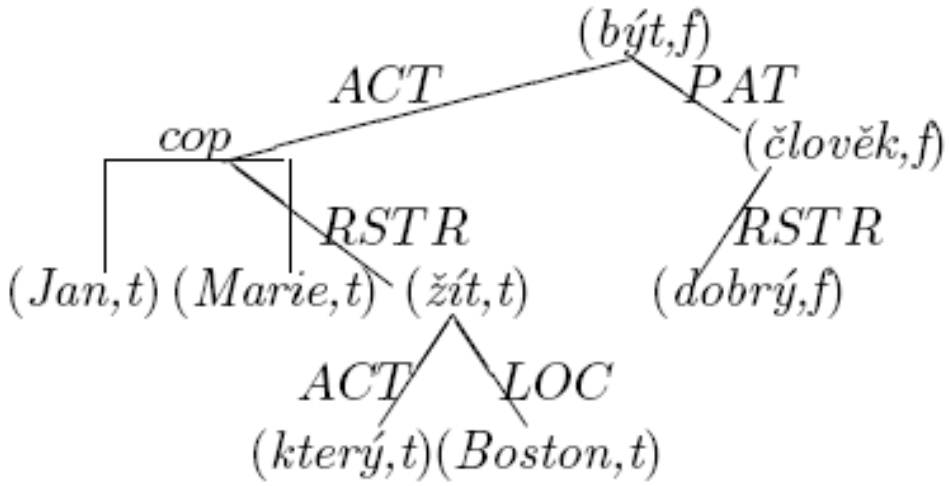
- BUT: right-headed constructions
  e.g., *one green and two red* ***cars***
  green as a (promoted) head (and *cars* as dependent)



Coordination in Dependency Trees III

Petkevič (1995) … formal representation of FGD
two types of brackets for tree linearization:

- ⟨ ⟩ for dependencies
- [ ] for coordination



$\langle[(Jan,t);\ (Marie,t)]_{cop}\ _{RSTR}\langle\langle(který,t)\rangle_{ACT}\ (žít,t)\ _{LOC}\langle(Boston,t)\rangle\rangle_{ACT}\ (být,f)\ _{PAT}\langle\langle(dobrý,f)\rangle_{RSTR}\ (člověk,f)\rangle$

John and Mary, who live in Boston, are good people.

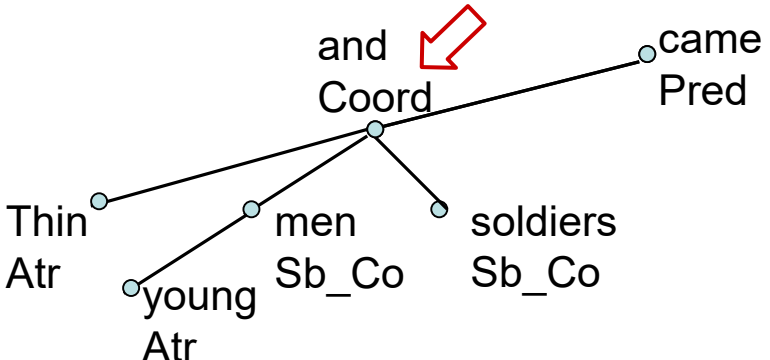
Coordination in Dependency Trees IV

PDT 2.0:

'connecting' constructions ~ coordination, apposition (, OPER)

specific types of nodes and edges:

- *connecting node* = node for coordinating / appositing conjunction



Coordination in Dependency Trees IV

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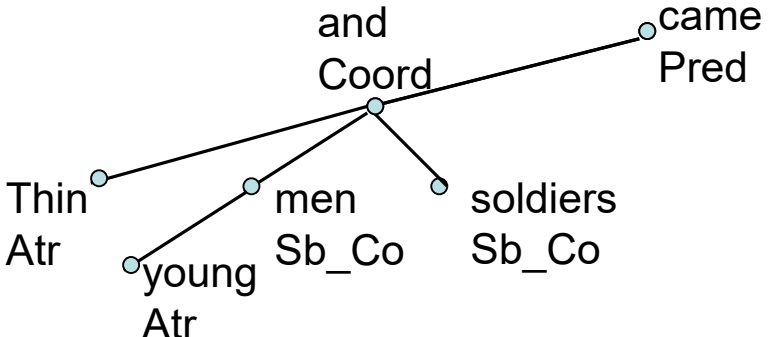
- *connecting node* = node for coordinating / appositing conjunction
- *members of a connecting construction* = nodes that are coordinated / are in apposition
  - `is_member`
- *effective parent* = node for governing node, i.e. node modified by the whole construction, 'linguistic parent'
- *effective child(ren)* … modification(s) of the individual member of the connecting construction **+** common/shared modifier(s)



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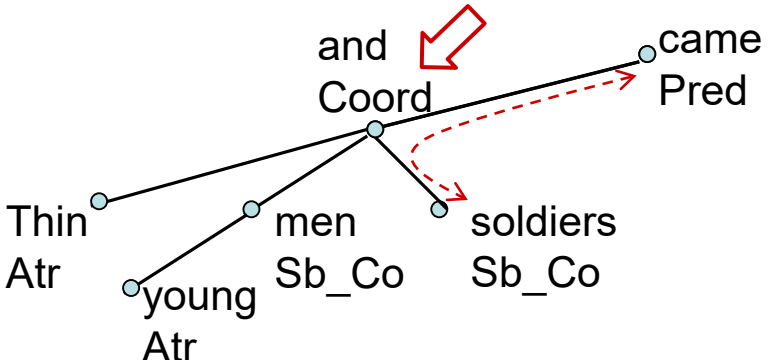
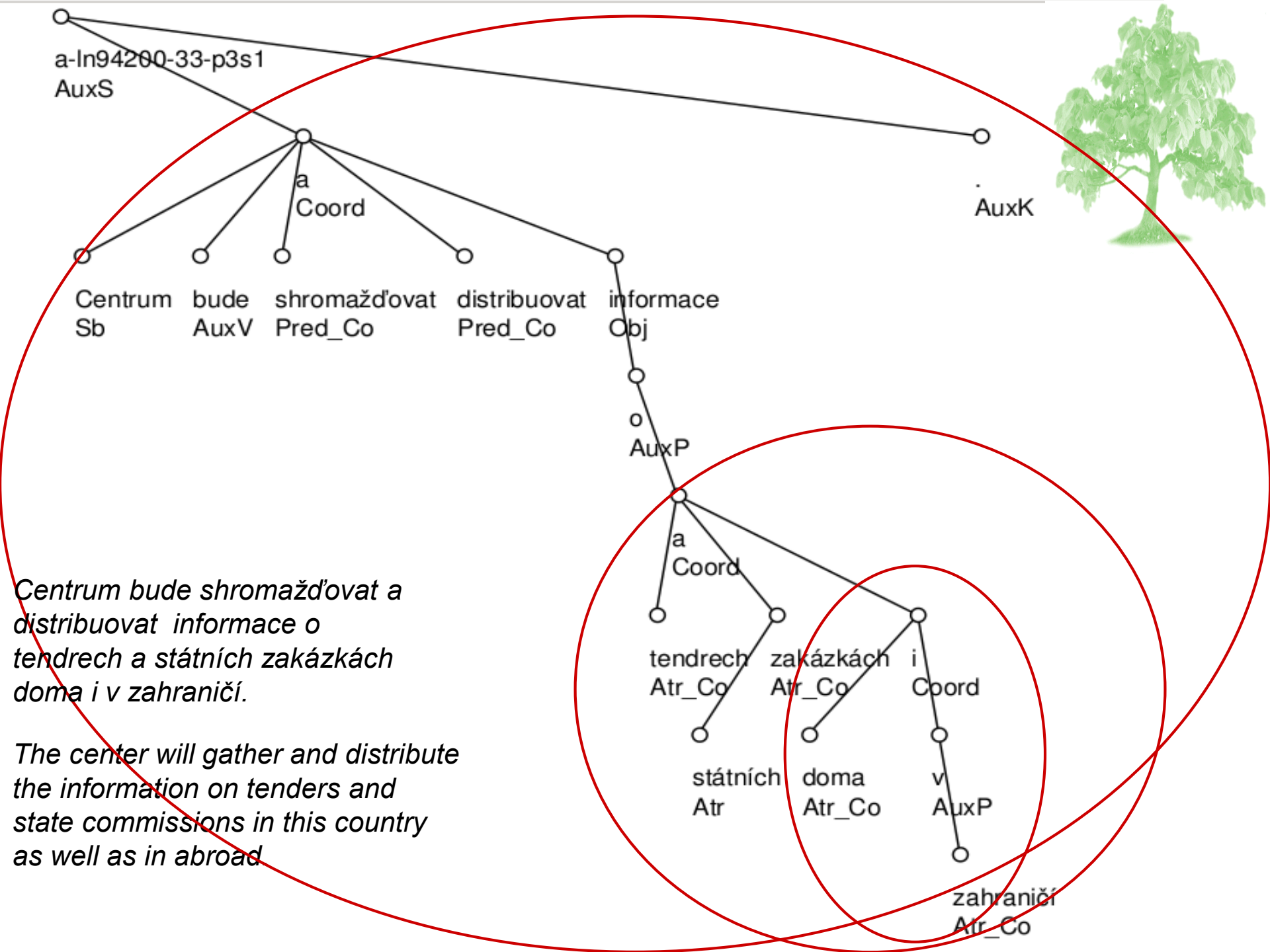
- *"pass-through" nodes*





Centrum bude shromažďovat a distribuovat informace o tendrech a státních zakázkách doma i v zahraničí.

The center will gather and distribute the information on tenders and state commissions in this country as well as in abroad.

Coordination in Dependency Trees IV

PDT 2.0:

- embedded connecting constructions ⇨ recursivity

- *TrEd* (Tree Editor, Pajas):

functions `GetEChildren, GetEParents`

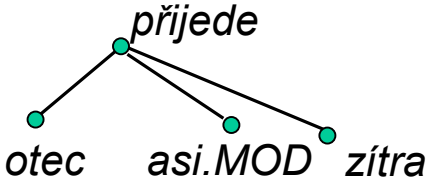
Dependency and non-dependency relations

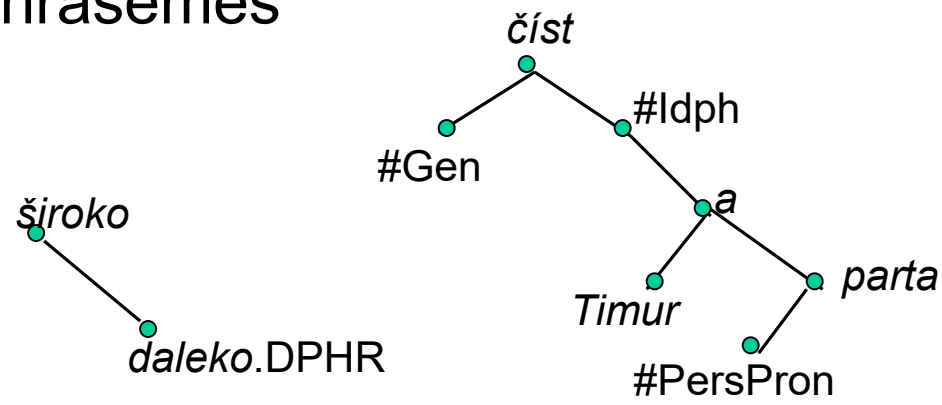
other non-dependency relations in PDT:

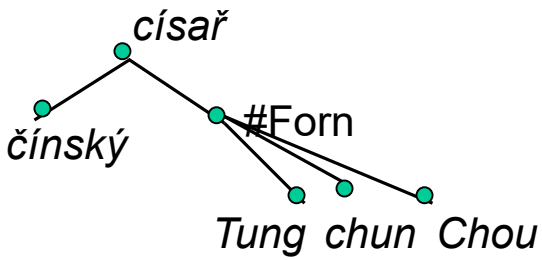
- technical root – effective root of a sentence
- syntactically unclear expressions

  rhematizers; sentence, linking and modal adverbial expressions, conjunction modifiers
- list structures

  names, foreign expressions
- phrasemes





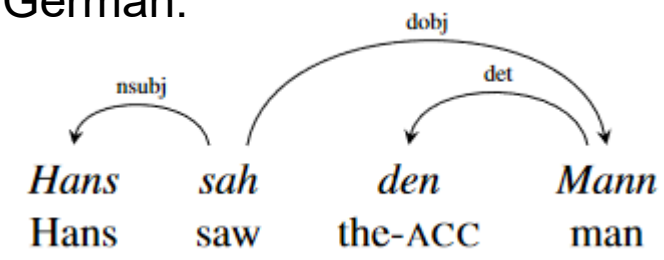


Problem with Free Word Order

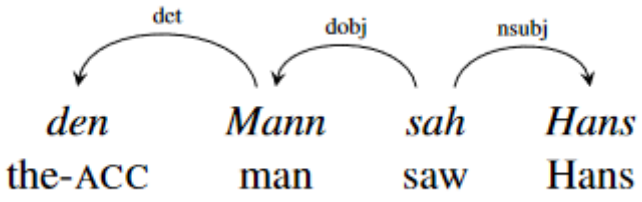
free word order:

- freedom of word order of dependents within a <u>continuous</u> 'head domain' (i.e., substring of head + its dependents)

German:



stolen from (Futrell et al., 2015)



Czech:

Hans.nom *viděl* *toho*.acc *člověka*.acc

toho.acc *člověka*.acc *viděl* *Hans*.nom

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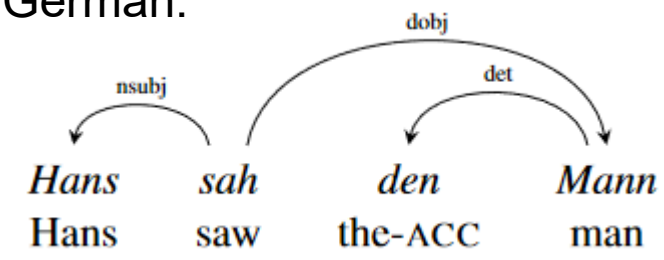

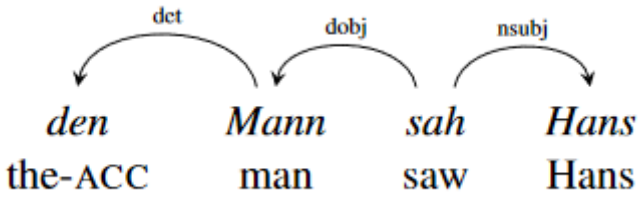

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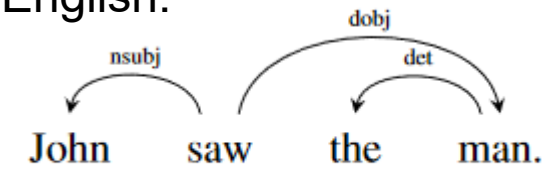
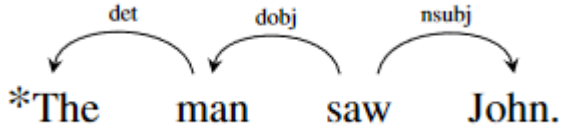
English:





→ *The man was seen by John*

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free word order:

- relaxation of continuity of a head domain

English: long-distance unbounded dependency

John, Peter thought that Sue said that Mary loves.

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to-Mary PART Peter that book decided not-buy
'Peter decided not to buy that book to Mary.'

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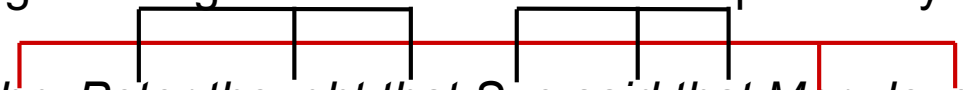

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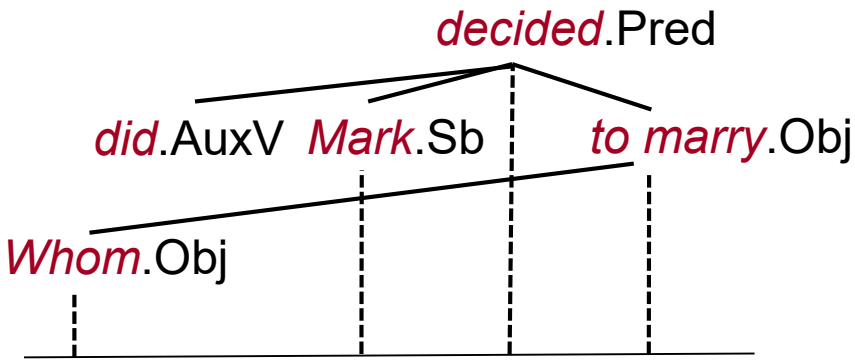
German:

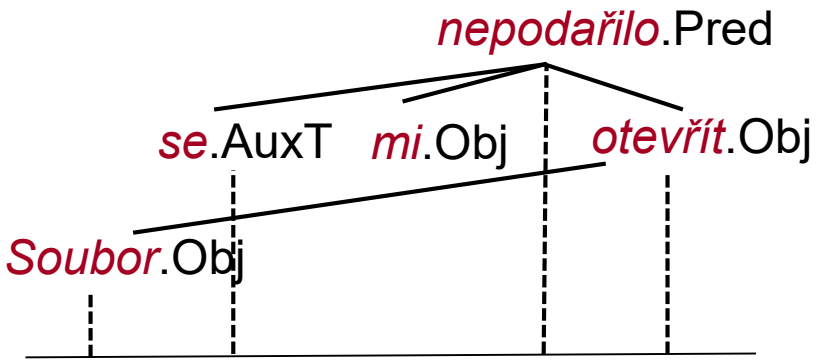
Maria hat einen Mann kennengelernt der Schmetterlinge sammelt.
Mary has a man met the butteries collects
'Mary has met a man who collects butteries.'

Projectivity and non-projectivity (definition)

Whom did Mark decided to marry?



Soubor se mi nepodařilo otevřít. (Oliva)

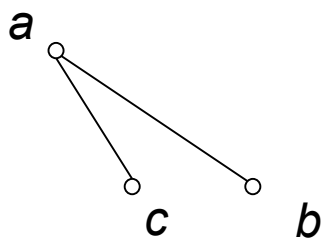


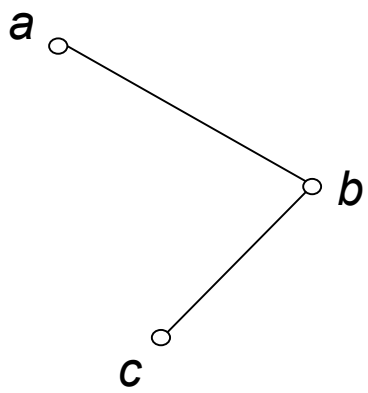
Projectivity and non-projectivity (definition)

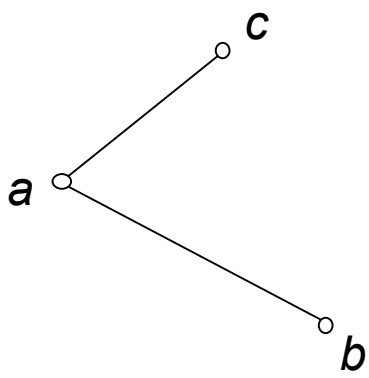
(Marcus, 1965), (Harper & Hays)

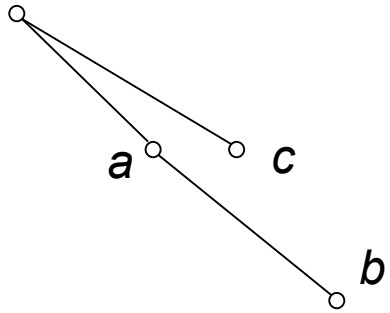
A subtree *S* of a rooted dependency tree *T* is *projective* iff for all nodes *a*, *b* and *c* of the subtree *S* the condition holds:

$$(a \leq_D b) \;\&\; [(a <_{WO} c <_{WO} b) \;\vee\; (b <_{WO} c <_{WO} a)] \Rightarrow (a <_D^* c)$$





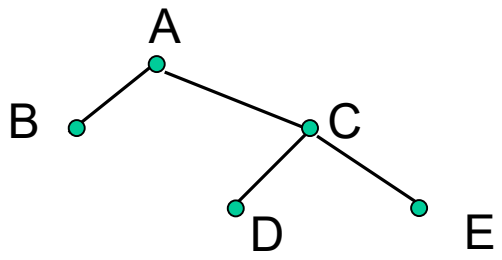




Projectivity and non-projectivity

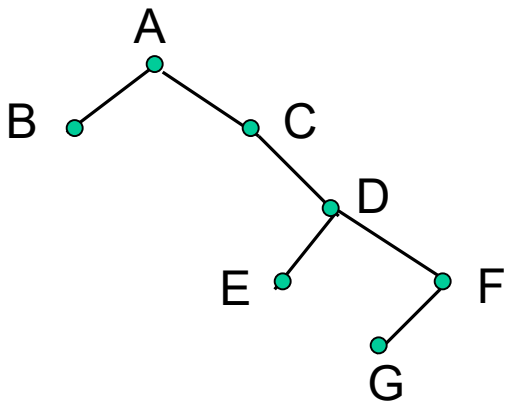
Projective dependency trees can be encoded by *linearization*:

- string of nodes, edges ~ brackets



A (B C (D E)) without WO ordering

(B) A ((D) C (E)) with WO



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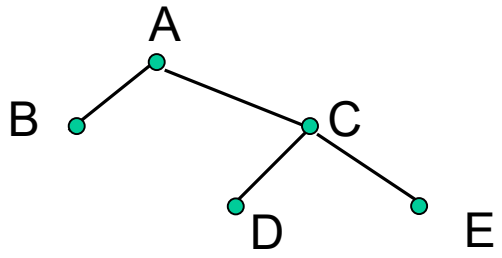

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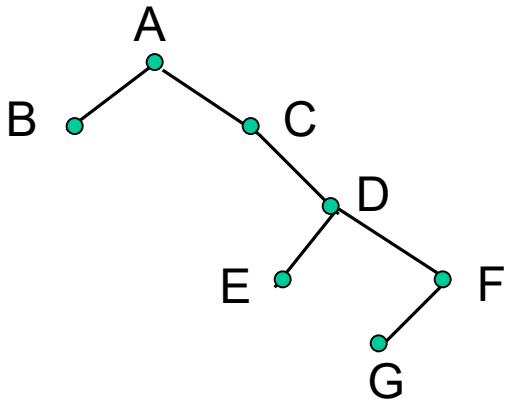


A (B C (D (E F (G)))) without WO

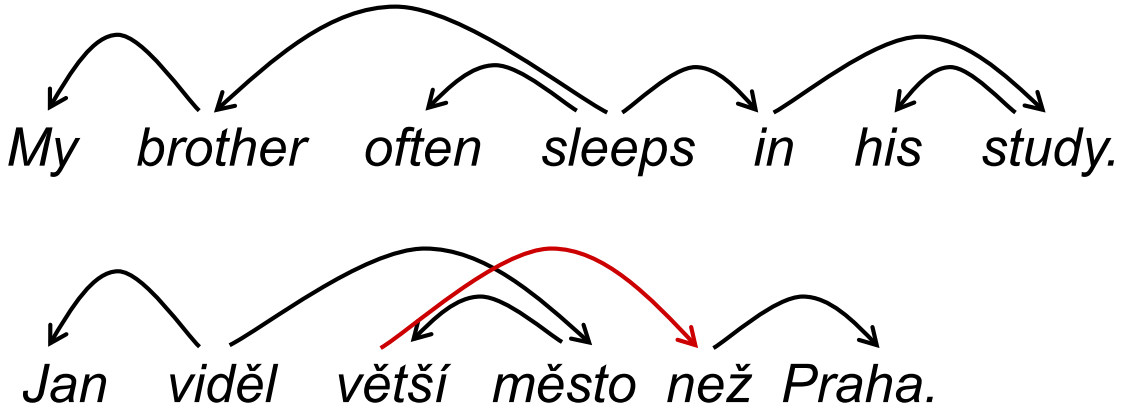
(B) A (C ((E) D ((G) F))) with WO

Planarity

A dependency graph *T* is *planar*, if it does *not* contain nodes *a, b, c, d* such that:

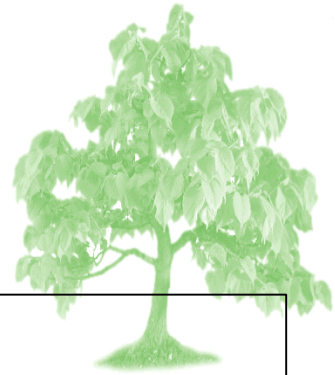
$$linked(a,c) \;\&\; linked(b,d) \;\&\; a <_{WO} b <_{WO} c <_{WO} d$$

linked(i,j) … 'there is an edge in *T* from *i* to *j*, or vice versa'



Informally, a dependency graph is planar, if its edges can be drawn above the sentence without crossing.

Planarity vs. projectivity



projectivity $\Rightarrow$ planarity

projectivity $\overset{?}{\Leftarrow}$ planarity

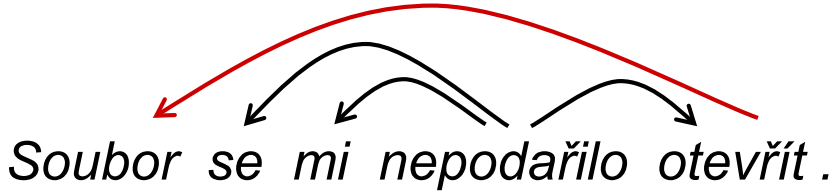
(Kuhlmann, M., Nivre, J., 2006)

Planarity vs. projectivity

projectivity $\Rightarrow$ planarity

projectivity $\not\Leftarrow$ planarity

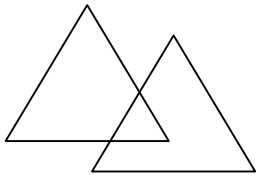
(Kuhlmann, M., Nivre, J., 2006)



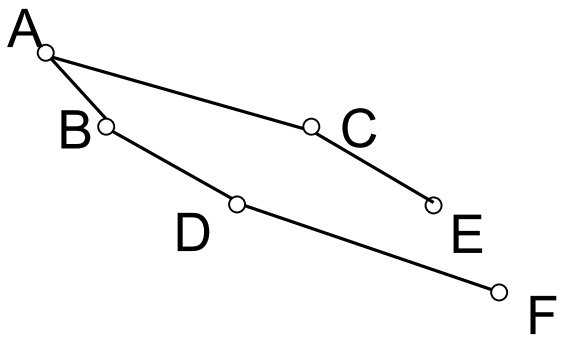
‘Well-Nestedness’

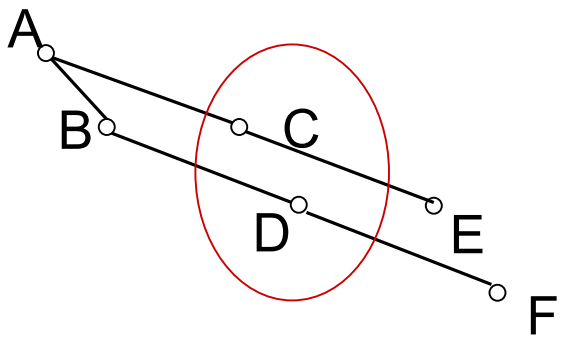
Two subtrees T_1, T_2 *interleave*, if there are nodes l_1, $r_1 \in T_1$ and l_2, $r_2 \in T_2$ such that

$$l_1 <_{wo} l_2 <_{wo} r_1 <_{wo} r_2$$



A dependency graph is *well-nested*, if no two of its disjoint subtrees interleave.’



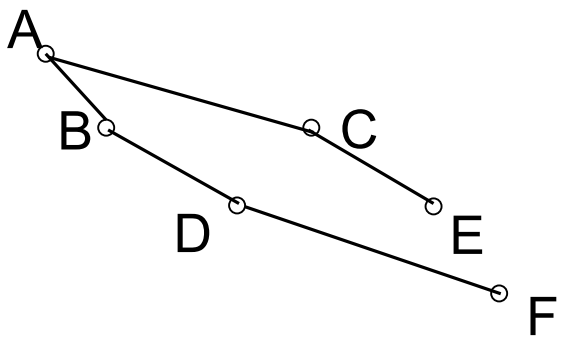


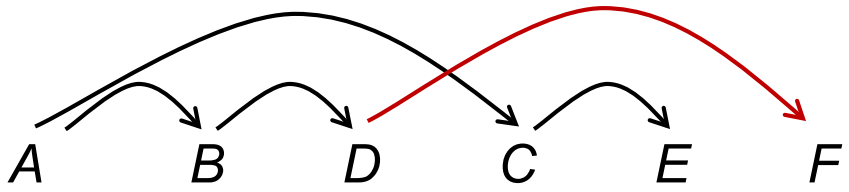
Planarity vs. projectivity

projectivity $\Rightarrow$ planarity $\Rightarrow$ well-nestedness

projectivity $\not\Leftarrow$ planarity $\not\Leftarrow$ well-nestedness

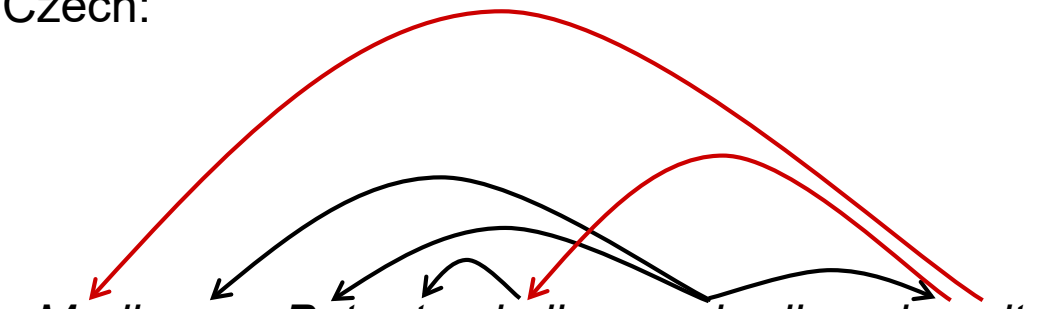
(Kuhlmann, M., Nivre, J., 2006)





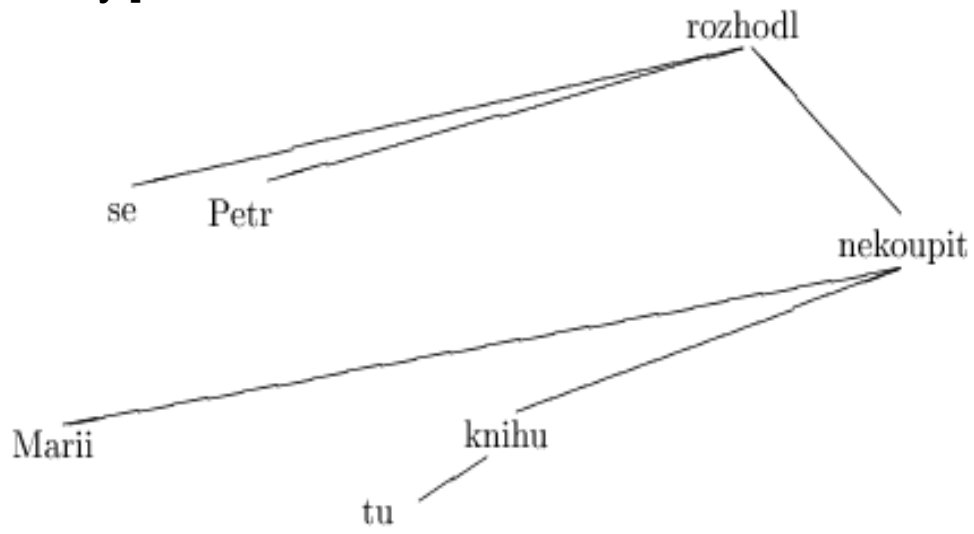
Projectivity and free word order

Czech:

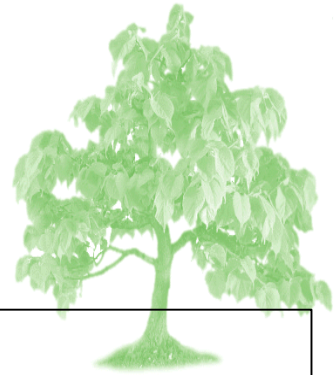


to-Mary PART Peter that book decided not-buy

[Peter decided not to buy that book to Mary.]



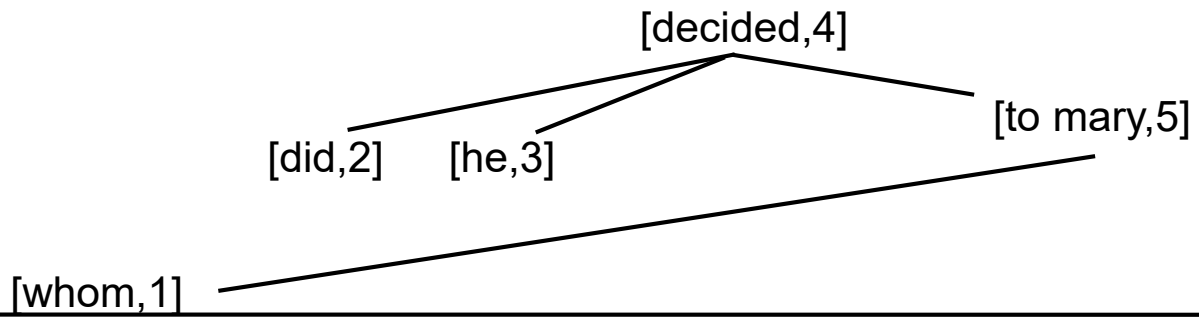
Gap Degree *gd(T)*



Coverage of a node $u \in T$

$Cov(u,T) = \{ i \mid i$ - word order position of $v \in T$ such that, $u \leq_D v \}$

$Cov(u_1,T)=\{1\}$; $Cov(u_2,T)=\{2\}$; $Cov(u_3,T)=\{3\}$; $Cov(u_4,T)=\{1,2,3,4,5\}$; $Cov(u_5,T) = \{1,5\}$



Gap Degree *gd(T)*

Coverage of a node $u \in T$

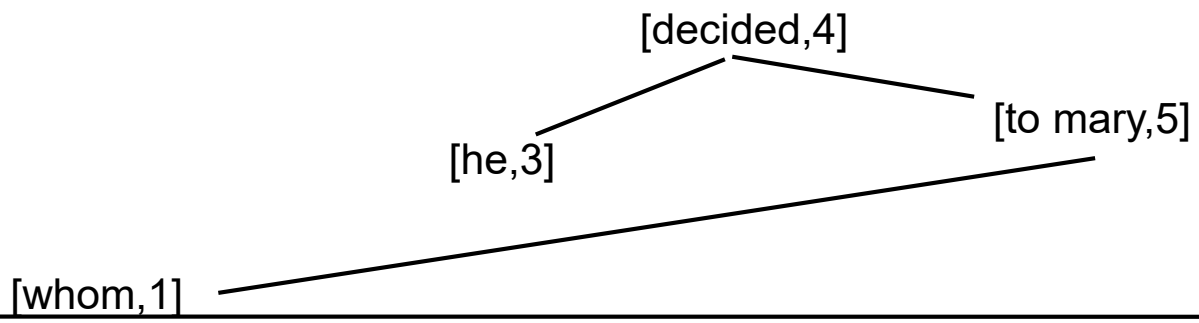
$Cov(u,T) = \{ i \mid i$ - word order position of $v \in T$ such that, $u \leq_D v \}$

Gap in Coverage of a node $u \in T \Leftrightarrow_{def} Cov(u,T)$ is not an interval

$gd(u,T)$ … *number of Gaps* in $Cov(u,T)$

Tree Gap Degree $gd(T) = \max \{gd(u,T) \mid u \in T \}$

$Cov(u_1,T)=\{1\}$; $Cov(u_2,T)=\{2\}$; $Cov(u_3,T)=\{3\}$; $Cov(u_4,T)=\{1,2,3,4,5\}$; $Cov(u_5,T) = \{1,5\}$

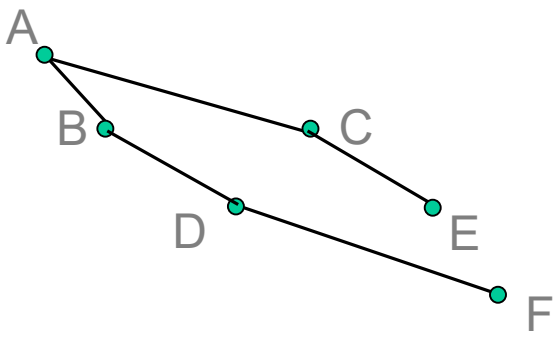


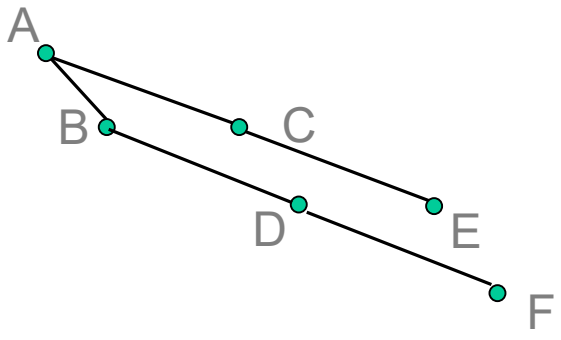
Edge Degree *ed(T)*

Let $T = (N, E)$ dependency tree, $e = [i, j]$ an edge in E, T_e the subgraph of T induced by the nodes contained in the span of e.

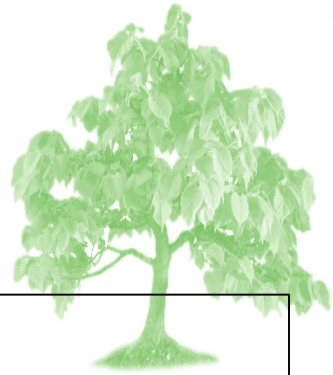
Degree of an edge $ed \in E$, ***ed(e)***, is the number of connected components c in T_e such that the root of c is not dominated by the head of e.

Edge degree of T, ed(T) … $\max \{ed(e) | e \in T\}$





Planarity vs. projectivity



projectivity $\Rightarrow$ planarity $\Rightarrow$ well-nestedness

projectivity $\not\Leftarrow$ planarity $\not\Leftarrow$ well-nestedness

$gd(T) = 0 \Leftrightarrow ed(T) = 0 \Leftrightarrow$ projectivity

well-nestedness … independent from gap/edge degree

$\forall\ d > 0$ well-nested and non-well-nested trees exist such that $gd(T) = d$ and $ed(T) = d$

(Kuhlmann, M., Nivre, J., 2006)

property	DDT		PDT	
all structures	$n = 4393$		$n = 73088$	
gap degree 0	3732	84.95%	56168	76.85%
gap degree 1	654	14.89%	16608	22.72%
gap degree 2	7	0.16%	307	0.42%
gap degree 3	–	–	4	0.01%
gap degree 4	–	–	1	< 0.01%
edge degree 0	3732	84.95%	56168	76.85%
edge degree 1	584	13.29%	16585	22.69%
edge degree 2	58	1.32%	259	0.35%
edge degree 3	17	0.39%	63	0.09%
edge degree 4	2	0.05%	10	0.01%
edge degree 5	–	–	2	< 0.01%
edge degree 6	–	–	1	< 0.01%
projective	3732	84.95%	56168	76.85%
planar	3796	86.41%	60048	82.16%
well-nested	4388	99.89%	73010	99.89%
non-projective structures only	$n = 661$		$n = 16920$	
planar	64	9.68%	3880	22.93%
well-nested	656	99.24%	16842	99.54%

Kuhlmann, M., Nivre, J. (2006)

References

- Osborne, T. (2019) *A Dependency Grammar of English*. John Benjamins Publishing Company, Amsterdam/Philadelphia
- Mel'čuk, I. (1988) *Dependency Syntax: Theory and Practice.* State University of New York Press, Albany
- Sgall, P., Hajičová, E., Panevová, J. (1986) *The Meaning of the Sentence in Its Semantic and Pragmatic Aspects*. D. Reidel Publishing Company, Dordrecht/Academia, Prague
- Hajičová, E., Panevová, J., Sgall, P. (2002) Úvod do teoretické a počítačové lingvistiky, sv. I. Karolinum, Praha
- Petkevič, V. (1995) A New Formal Specification of Underlying Structure. *Theoretical Linguistics*, vol. 21, No.1
- Štěpánek, J. (2006) *Závislostní zachycení větné struktury v anotovaném syntaktickém korpusu*. PhD Thesis, MFF UK
- Universal Dependencies https://universaldependencies.org
- Prague Dependency Treebank http://ufal.mff.cuni.cz/pdt3.5