Advanced Natural Language Processing
Lecture 17
Dependency Grammar

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School of informatics

Dependency vs. Constituency

Why do our toy grammars for English begin S→NP VP ?

Because VP seems to be a constituent with its own properties, visible in

(1) a. I like ice cream. Do you ∅? (*VP ellipsis*)
b. I like ice cream and hate bananas. (*VP conjunction*)
c. I said I would hit Fred, and hit Fred I did. (*VP fronting*)

For a language like German, no VP constituent has been posited.

Accounting for syntactic patterns in English suggests a focus on structure and **constituency**.

Dependency vs. Constituency

But if we consider semantics, verbs like "likes", "hates", "hits", etc. appear to motivate two NPs, both in the same way

(2) a. an agent, found in *subject* position or with *nominative* inflection;
b. an object, found in *object* position or with *accusitive* inflection.

What NPs are motivated and what roles they play depend on the verb.

Accounting for semantic patterns suggests a focus on **dependency**.

Constituency focuses on the units; **Configuration** focuses on their patterning.

Accounting for languages that aren't as *configurational* as English also suggests a focus on dependency.

Dependency as Extreme Lexicalization

Dependencies express how words in a sentence depend on other words, motivating their presence in the sentence and what they are contributing.

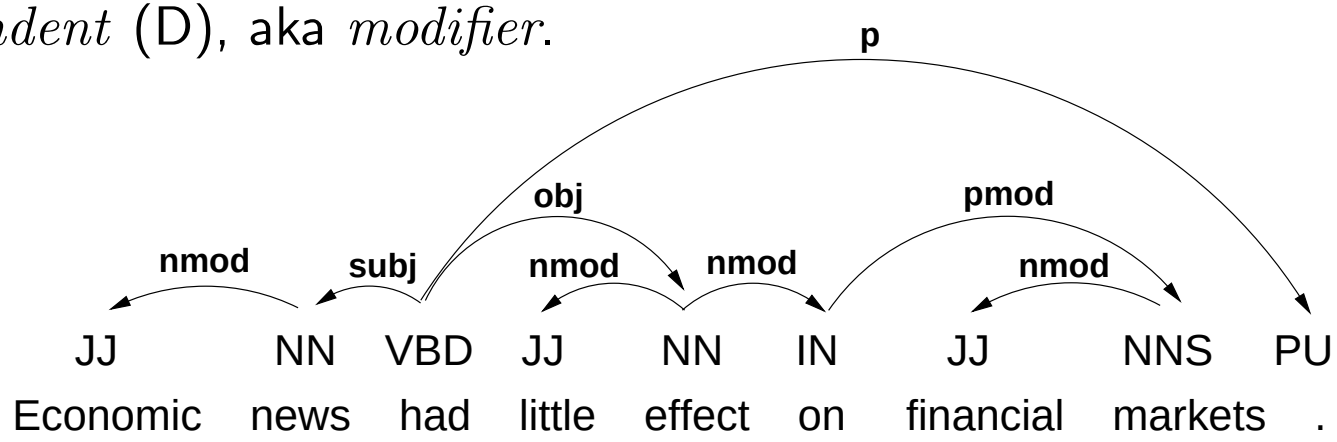
Linguistic analysis based on dependency is clearly going to be even more *lexicalized*, than in Tree Adjoining Grammar and CCG.

A dependency grammar attempts to directly account for patterns of dependencies between words, but will also have to provide some way of accounting for word order and configurational patterning.

Dependency Relations

Key to a Dependency Grammar are its *dependency relations*, all of which are binary and asymmetric. All relations hold between

- a *head* (H), aka *governor*, *regent*;
- a *dependent* (D), aka *modifier*.



[From Joakim Nivre, Dependency Grammar and Dependency Parsing]

How does one tell which is a *head* and which, its *dependent*?

Dependency Relations: Endocentric vs. Exocentric

All dependency relations form either *endocentric* or *exocentric* constructions. These differ in how their head relates to the rest of the construction:

- In an *endocentric* construction, the head (H) can replace the rest of the construction without damaging the grammaticality of the sentence.

  (3) Economic news had little effect on financial **markets**. (*endocentric*)

  (4) Economic news had little effect **on** financial markets. (*exocentric*, whether the preposition or the noun is the head)

- Sometimes it's hard to tell whether a construction is endocentric or exocentric.

  (5) Economic news had so **little** effect that people simply ignored it.

Can so replace so little? Or little replace so little? We'll come back to this.

Dependency Relations: Complements vs. Modifiers

The dependent in a dependency relation may serve its head as

- a *complement* – eg, both news and market serve as complements (ie arguments) to affected in

  (6) The news affected the market.

- a *modifier* (ie *adjunct*) – eg within a week modifies affected in

  (7) Within a week, the news affected the market.

- a *specifier* – eg the specifies market in

  (8) The news affected the market.

Dependency Relations: Valency

The number of complements (ie, arguments) that a head takes is its *valency* – ie, its *predicate-argument structure*, which is the basis for its meaning.

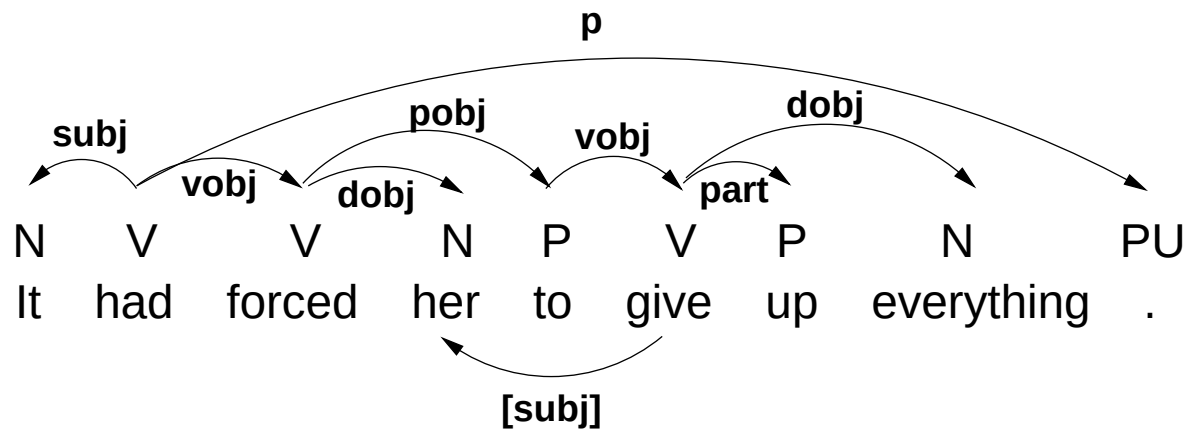
- sigh has valency = 1
- affect has valency = 2
- give and exchange both have valency = 3

While some constructions fit well into dependency relations, others like coordination, auxiliary verb constructions, and complementizers don't.

Nevertheless, **some** stand has to be taken, since the only thing a dependency parser can produce is a dependency structure!

Dependency Relations: One or more inventories

Dependency Grammars differ in their inventory of dependency relations, and in whether they produce a single analysis based on one inventory (a *monostratal theory*) or several analyses based on multiple inventories (a *multi-stratal theory*).



[from M. Buch-Kromann & Iorn Korzen, The unified annotation of syntax and discourse in the Copenhagen Dependency Treebanks, *Proceedings of the Fourth Linguistic Annotation Workshop*, Uppsala, July 2010.]

Dependency Relations: Syntactic or Semantic

Surface-oriented grammatical functions	Semantic-oriented role types
subject	agent
object	patient
nmodifier	goal
etc	etc

These may yield analyses that differ only in their labels, or different ones:

(9) I believe in the system

- Syntax-oriented: believe→in, in→system
- Semantics-oriented: believe→system, system→in

How about the analysis of "had forced" on the previous slide: Syn or Sem?

Dependency Graphs

The dependency representation of a sentence, consisting of its lexical elements linked by binary asymmetric relations, will comprise a (labelled or unlabelled) directed graph.

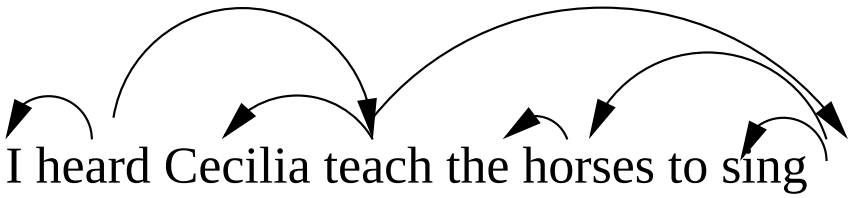
Properties of Dependency Graphs:

- Connected – Every node is related to at least one other node, and (through transitivity) to the root node.
- Single-headed – Every node is a dependent of at most one head.
- Acyclicity – The graph should not contain cycles of directed arcs.

Dependency Graphs: Projectivity

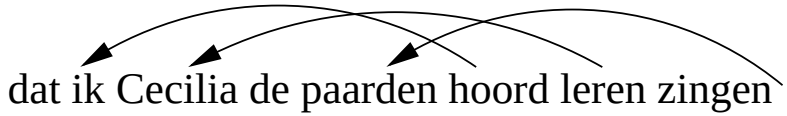
There may also be constraints relating dependency structures to linear realizations:

- "Projective" dependency graphs: A graph is projective w.r.t. a particular linear order of its nodes if, $\forall$ arcs $h \rightarrow d$ and node w, w occurs between h and d in linear order only if w is $dominated$ by h (ie, in the transitive closure of the arc relation).
  - I heard Cecilia teach the horses to sing.



Dependency Graphs: Projectivity

- "Nonprojective" dependency graph: w can occur between h and d in linear order without being dominated by h.
  - dat ik Cecilia de paarden hoord leren zingen.



that I Cecilia the horses heard teach sing

"That I heard Cecilia teach the horses to sing"

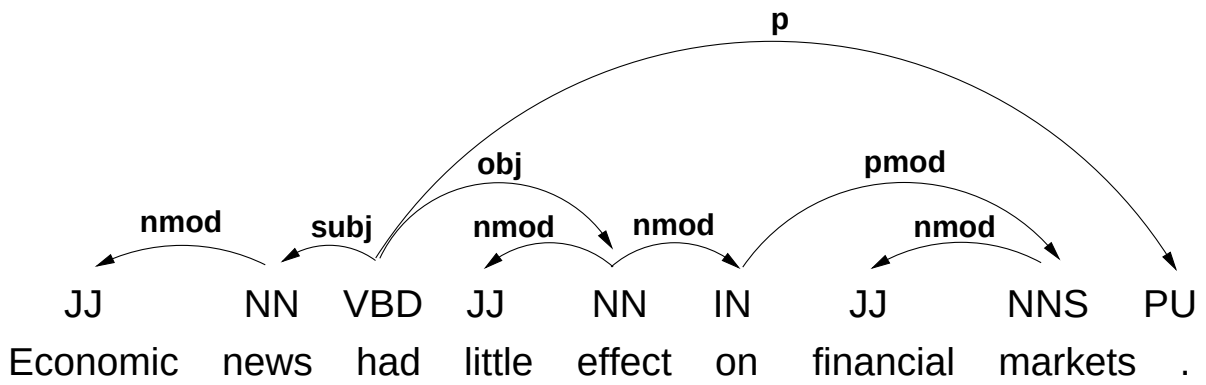
"Nonprojective" means "non-context free".

- Most practical systems for dependency parsing assume projectivity, though most dependency-based linguistic theories do not.

Class exercise: Dependency Analysis

(10) Economic news had so little effect on financial markets that people simply ignored it.

1. Should have some similarity with Nivre's analysis of related sentence.



2. Should reflect pattern *so* <Adj> <N> *that* <S> as unit of interpretation.

3. Should be connected, single-headed and acyclic. Projective? Nonprojective?