Interpreting and defining connections in dependency structures

Sylvain Kahane
(Modyco, Université Paris Nanterre)

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Connection

- *connection* = dependency without the governor-dependent hierarchy

- We will not discuss the notion of *head*.

Questions ?

- Why are the dependencies **between words** in traditional dependency trees?
- Do we need to define the notion of word **before** defining the notion of dependency?
- More generally, how is the syntactic structure and how to define it?

Previous works

- K. Gerdes, S. Kahane (2011) Defining dependency (and constituency), *Proceedings of the 1st international conference on Dependency Linguistics* (*Depling*).
- S. Kahane, T. Osborne (2015) Translators' introduction, in L. Tesnière, *Elements of structural syntax*, John Benjamins, 49 p.
- Kahane S., Mazziotta N. (2015) Syntactic polygraphs: A formalism extending both constituency and dependency, *Proceedings of Mathematics of Langage* (*MOL*).
- Kahane S., K Gerdes (forthcoming) *Syntaxe théorique et formelle*.

Subjectal construction

- A first example of connection: the subjectal construction

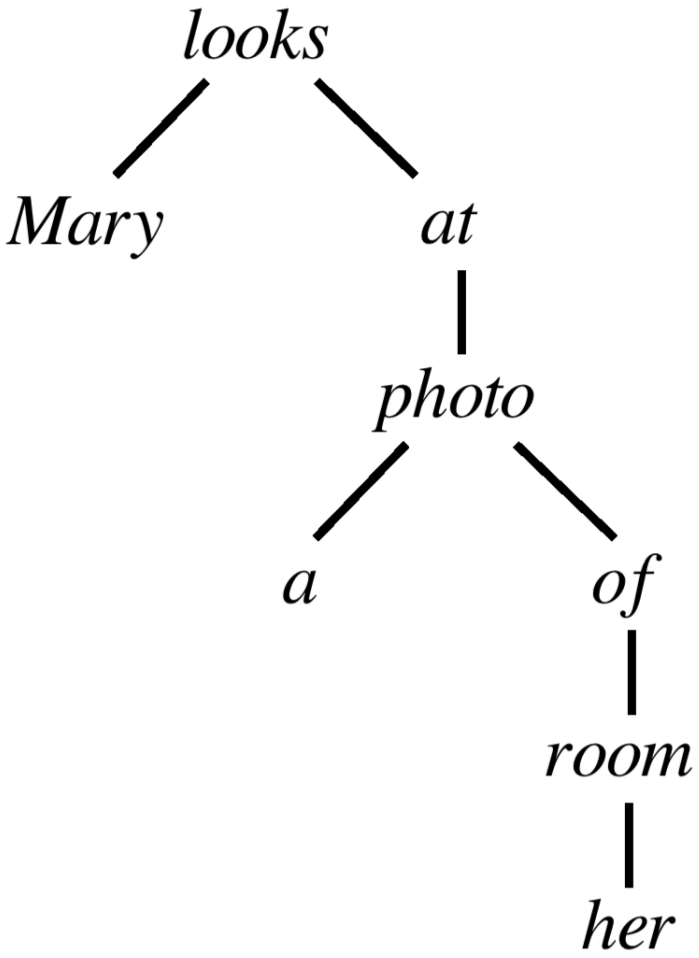
  (1) *A photo of her room is hanging on the wall.*

- All syntactic theories agree on the fact that there is a subjectal construction, but:
  - for PSG, combination NP/DP + VP (*a photo of her room* + *is hanging on the wall*)
  - for DG, combination between words (*photo* + *hanging* or *a* + *is* or *photo* + *is*)
  - for Tesnière, combination between nuclei (*a photo* + *is hanging*)
  - combination between chunks (Frazier & Fodor 1978, Abney 1991)
  - combination between the verb form and a constituent (*a photo of her room* + *is hanging*) (Beauzée 1765)

all these views
on syntactic combinations

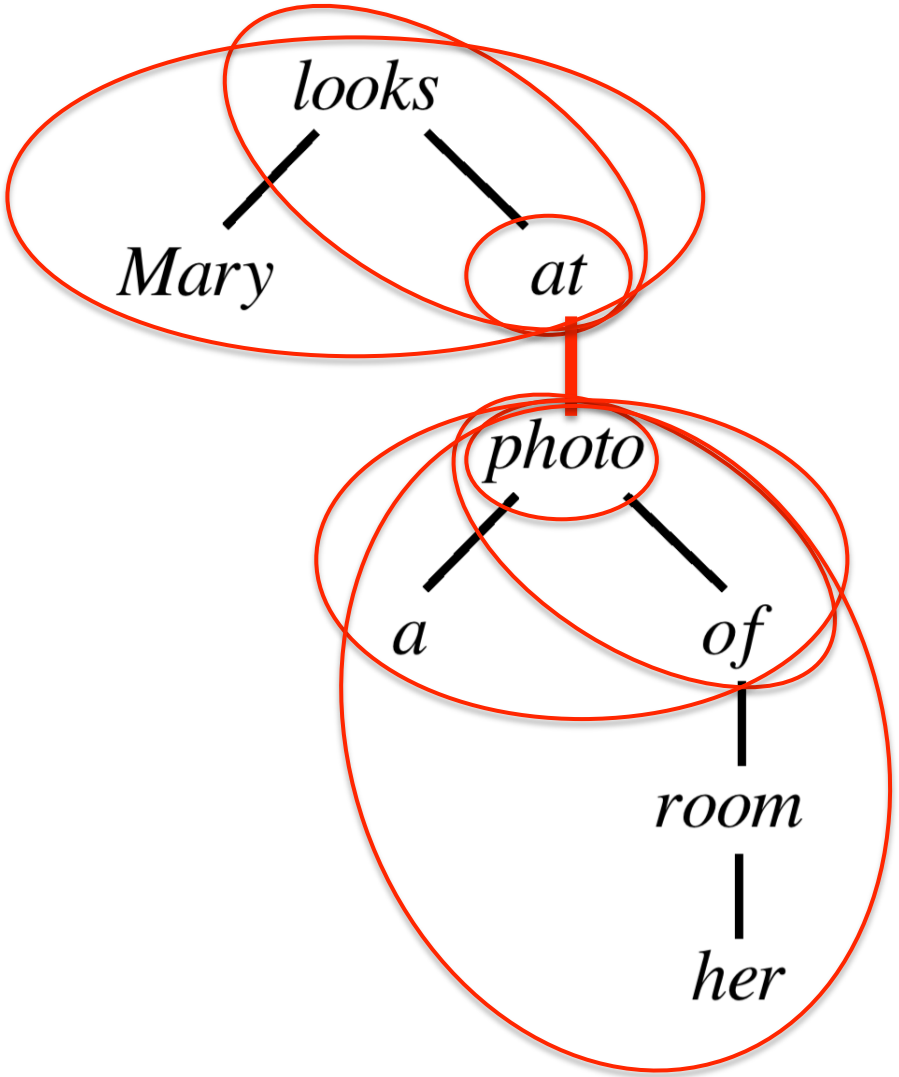
- define the same connection
- are compatible
  with dependency syntax

How to interpret a dependency tree



- connection ≠ combination
- combination = instance of a connection
- which **combinations** does a dependency tree define?

How to interpret a dependency tree



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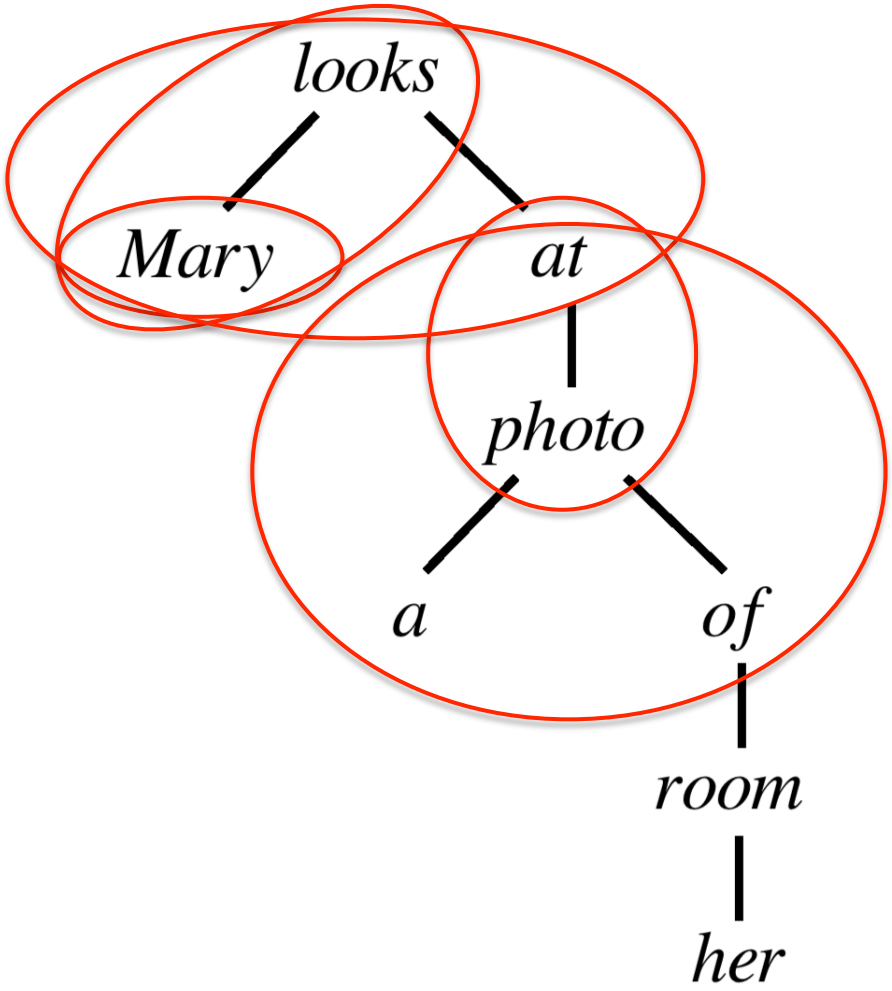
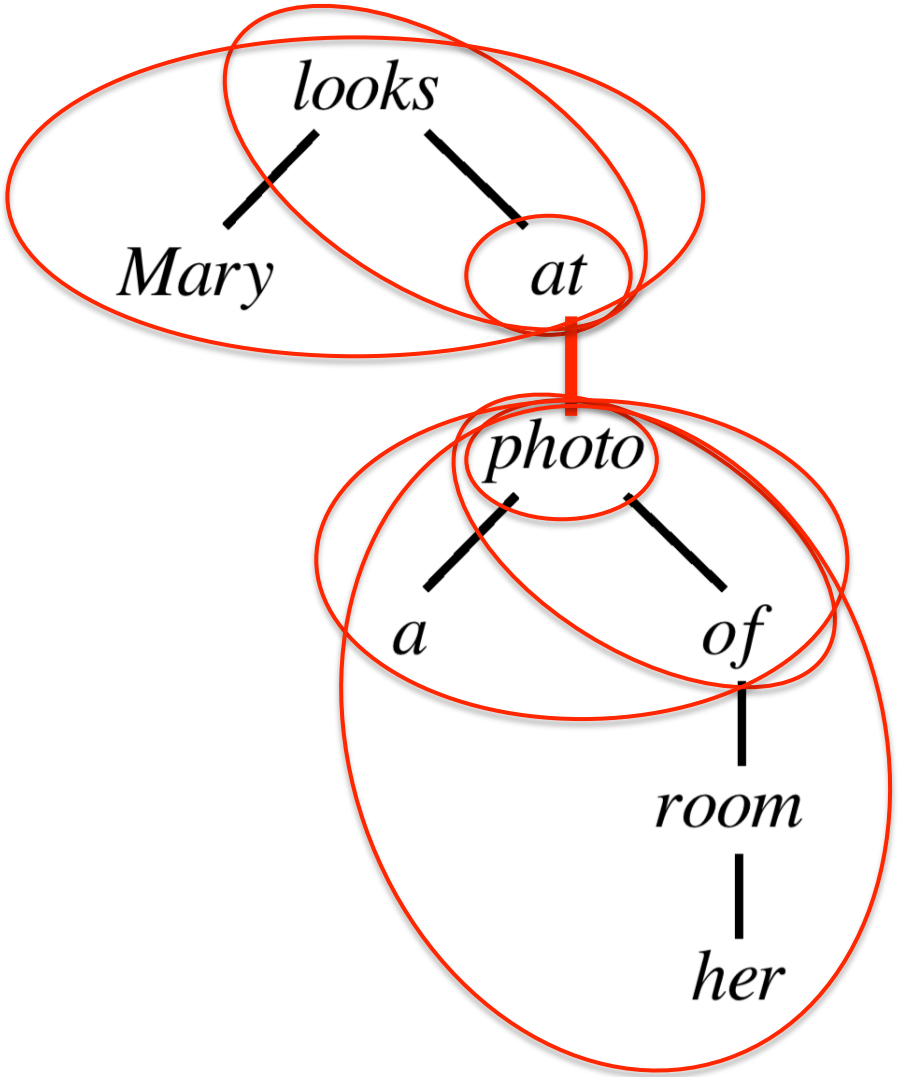
Catena



- *catena* = connected portion of a dependency tree

  (Osborne, Putnam, & Groß 2012)

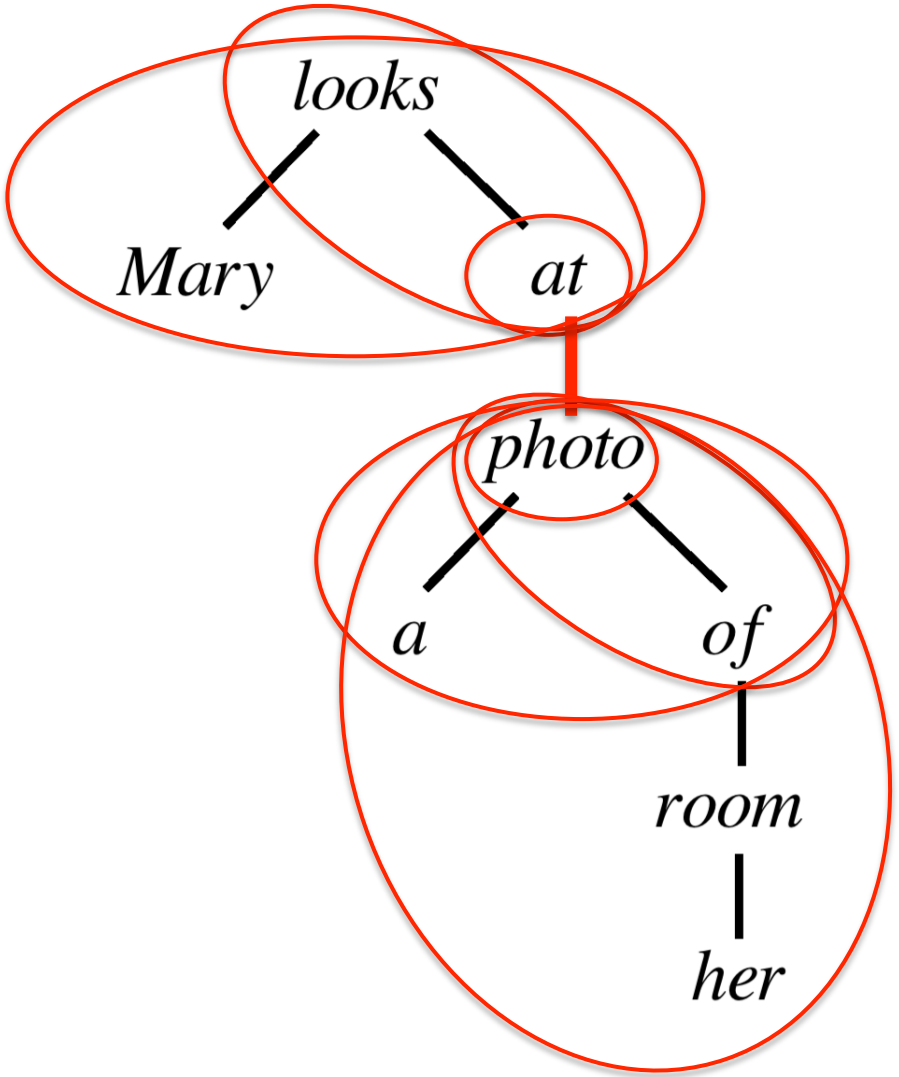
Connection



- *connection* = set of combinations of catenae

more formally,
how are
the connections
defined?

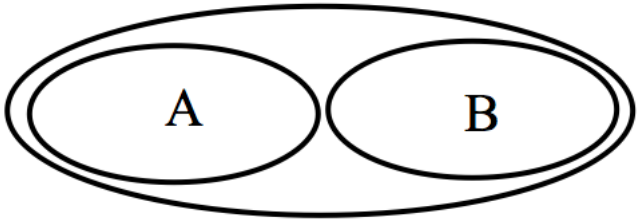
Combination



- a combination is a pair {A,B} of catenae such that A ∪ B is also a catena

Formal definition of connections

- We start with set U of units
  (for instance U = Catena(D))
- {A,B} is a **combination** on U if and only if
  - A, B, and A ∪ B are in U
  - A and B are disjoint (A ∩ B = ∅)

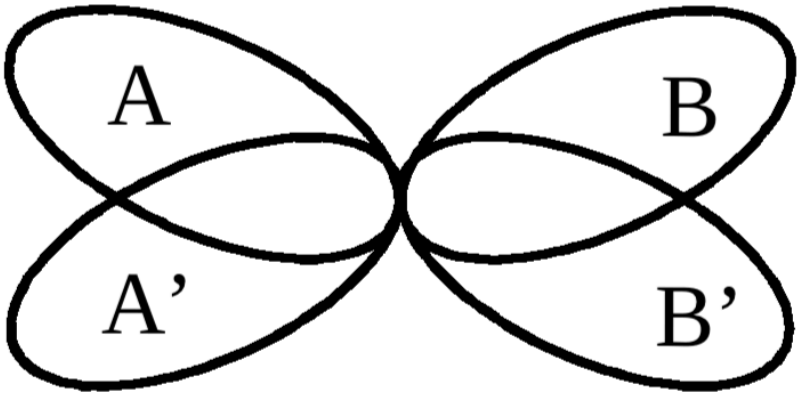


- Combi(U) = set of combinations on U

Formal definition of connections

- **connection** = set of compatible combinations

- Relation of **compatibility** "≈" between combinations
- {A,B} ≈ {A',B'} iff A ∩ A' and B ∩ B' are not empty
  and A ∪ A' and B ∪ B' are disjoint



Formal definition of connections

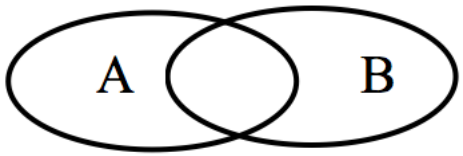
- ≈ is an **equivalence relation** as a consequence of the following properties of U:

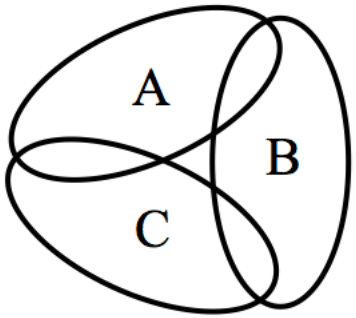
  (for every A, B, C in U)

  – **Intersection Property:**
  $A \cap B$ non empty $\Rightarrow A \cap B$ in U

  – **Sticking Property:**
  $A \cap B$ in U $\Rightarrow A \cup B$ in U.

  – **Acyclicity:**
  $A \cap B$, $B \cap C$, and $C \cap A$ non empty
  $\Rightarrow A \cap B \cap C$ non empty



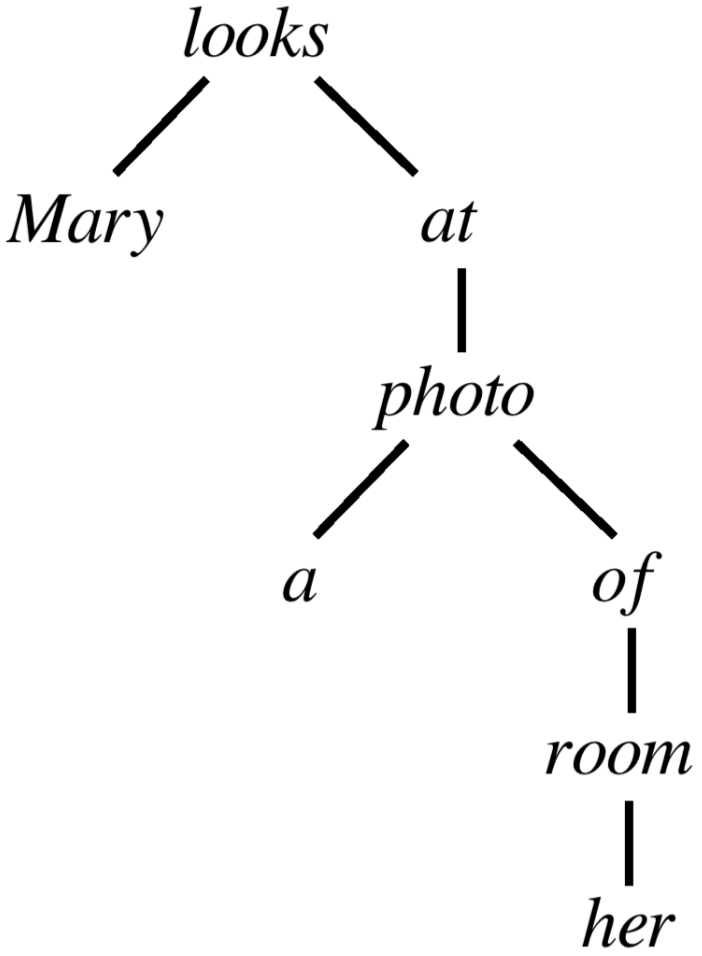


Formal definition of connections

- Connection(U)
  = Combi(U)/≈
  = **equivalence classes** of combinations
- Combinations are representatives of connections

- As a comparison: 1/2, 2/4, or 50/100 are **representatives** of the same rational number

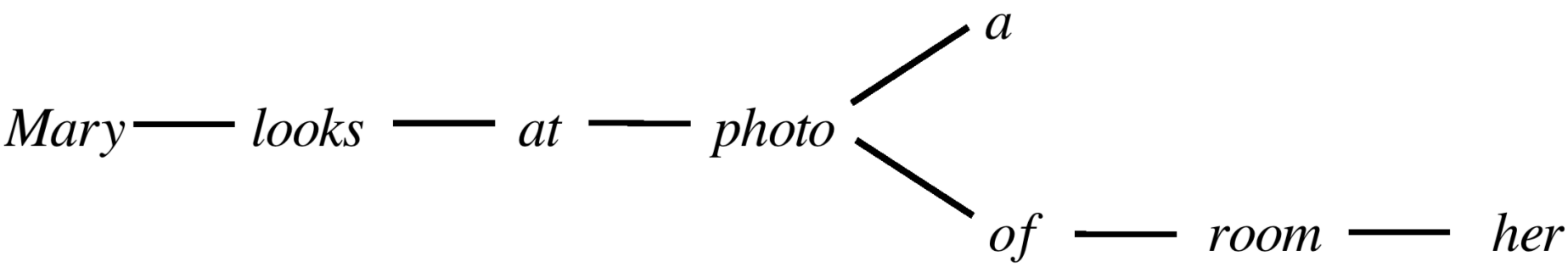
Connection structure



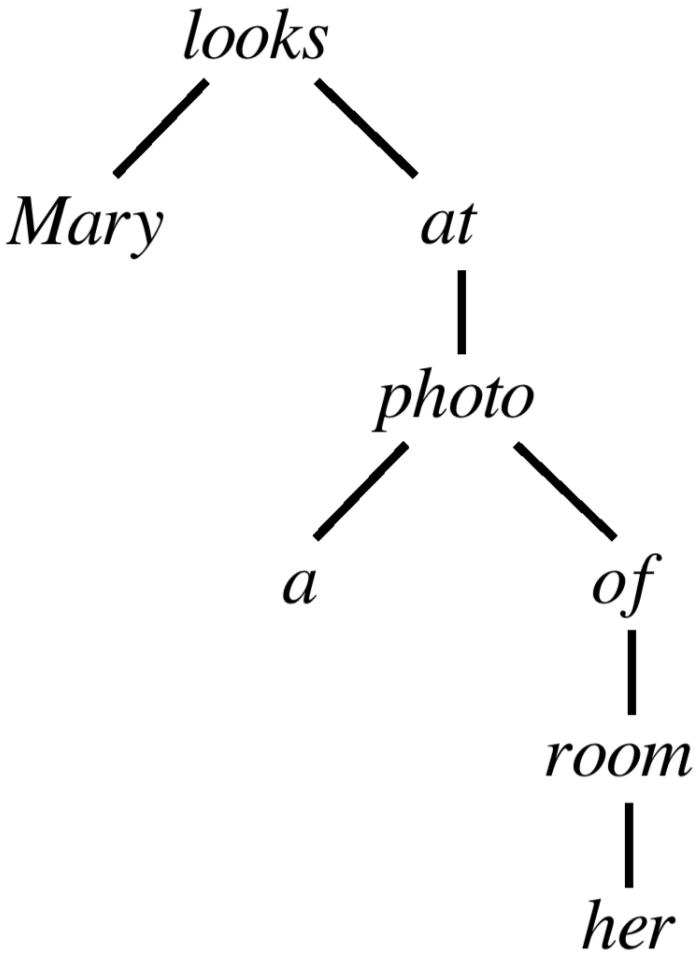
- U = Catena(D) = { *Mary, …, Mary looks, …, looks at room, …*}
- Combi(U) = { {*Mary, looks*}, {*Mary, looks at*}, {*looks,at*}, {*Mary looks,at*}, …}
- Connection(U) = Combi(U)/≈

Connection structure

- U = Catena(D) = { *Mary, …, Mary looks, …, looks at room, …*}
- Combi(U) = { {*Mary, looks*}, {*Mary, looks at*}, {*looks,at*}, {*Mary looks,at*}, …}
- Connection(U) = Combi(U)/≈
- Connection structure: choose a minimal representative in each connection



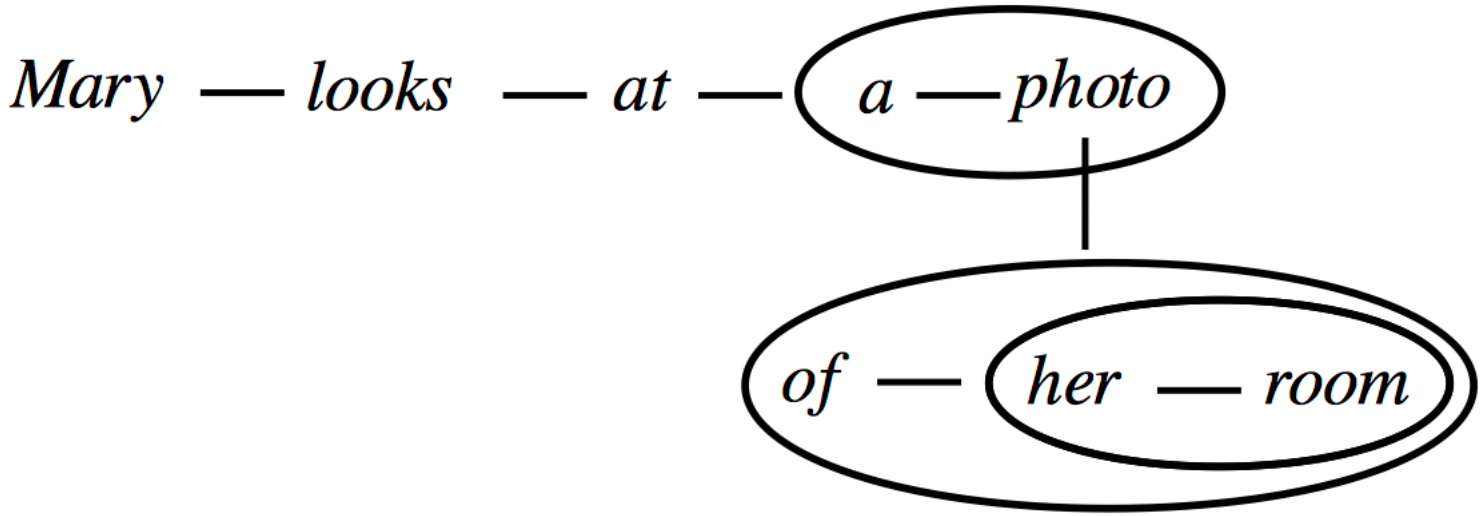
Other connection structures



- All catenae of a dependency tree are not relevant units:
  - **at photo*
  - **photo of*
  - **of room*

Other connection structures

- We can start only with relevant units
- Minimal combinations are not necessary between words => **bubble graph**



what are
the consequences
of such a view
on connections?

(connections as set of combinations)

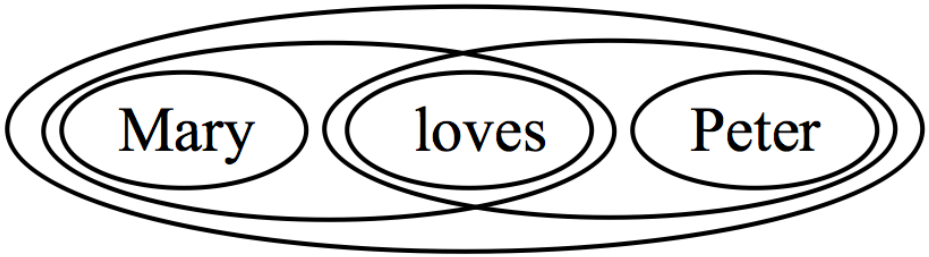
1.

phrase structure
from a dependency-based
point of view

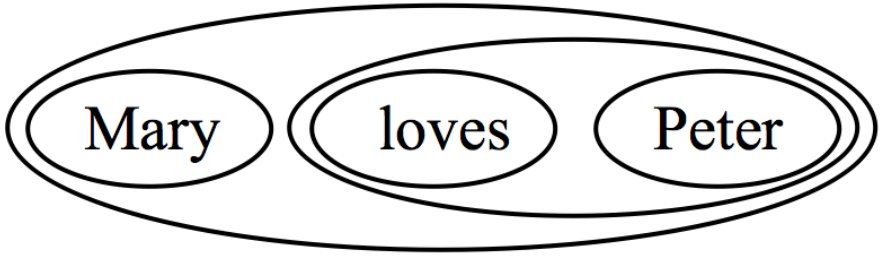
PSG vs DG

(3) *S = Mary loves Peter*

- DG: catenae = { S, *Mary, Peter, Mary loves, loves Peter* }
  - subject = { {*Mary,loves*}, {*Mary, loves Peter*} }
  - object = { {*loves,Peter*}, {*Mary loves,Peter*} }

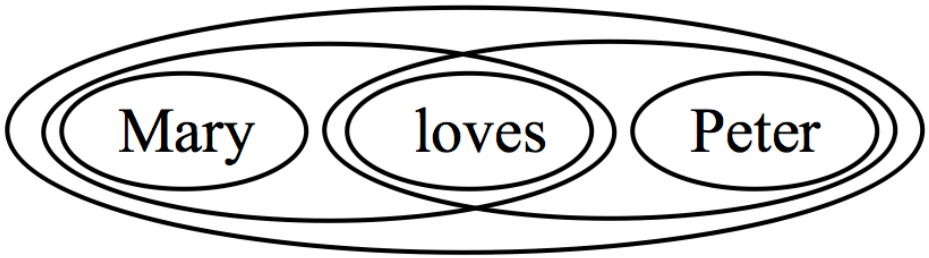


- PSG: constituents = { S, *Mary, Peter, loves Peter* }
  - subject = { {*Mary, loves Peter*} }
  - object = { {*loves,Peter*} }

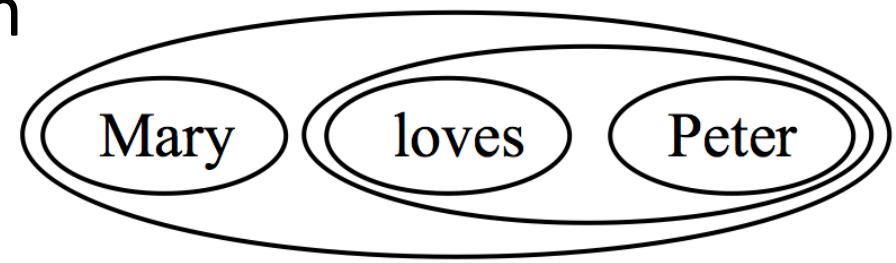


PSG vs DG

- DG: consider **more units** and combinations and choose a **minimal representative** for each connection (independently of one another)

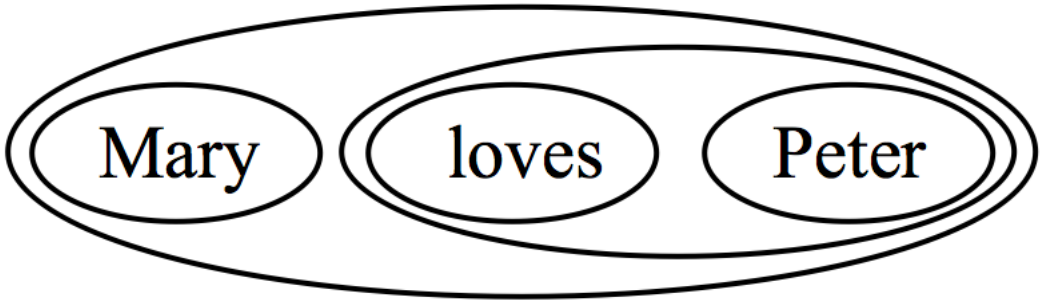


- PSG: choose a first connection (how?) and choose a **maximal representative** for this connection and so on



PSG vs DG

- Two weaknesses of PSG (towards DG):
  - PSG implies **stratification** (= **order** on connections) (Kahane 1997)
  - PSG choose only **one combination** for each connection (and moreover a maximal representative)



2. granularity and words

Granularity

- a same connection can be seen at various levels of granularity
  - lexemes and (inflectional) morphemes (cf. InflP)
  - words
  - chunks
  - full lexical units (-> deep syntactic structure)
- two connections (in two different structures) are compatible if they contain a common combination

Connections vs units

- connection strictly speaking is not subject to a particular level of granularity
- the notion of **connection** is an **abstraction** on the notion of combination
- combination is inseparable from the notion of unit, **but not connection**
- the definition of dependency structure is **not** subject to a **prior definition** of the **minimal units**, and in particular to the controversial notion of word
  - we need to consider units to start the definition of the syntactic structure, but the units we consider at the outset are not necessary determining

3.

cognitive and NLP
point of view

Cognition

- Between which units are the connections instantiated?
  - words?
  - morphemes?
  - chunks? (Frazier & Fodor 1978)
  - constituents?
- My guess: connections are instantiated at various levels; everything is possible, it all depends

NLP

- parsing:
  - dependency-based parser: connections between words
  - PS-based parser: connections between constituents
  - new possible strategies: fuzzy connections
- machine translation
  - alignment of units of various granularities
  - connections between these units must be maintained

Conclusion

- connection = set of combinations
  - combinations between words are possible representative, but not necessary the most relevant
  - no need to define the notion of word before defining the notions of connection and dependency
- DG considers more units and more combinations (than PSG) and do not order connections
- set of units (with some good properties) => connection structure