A high-level approach to language description

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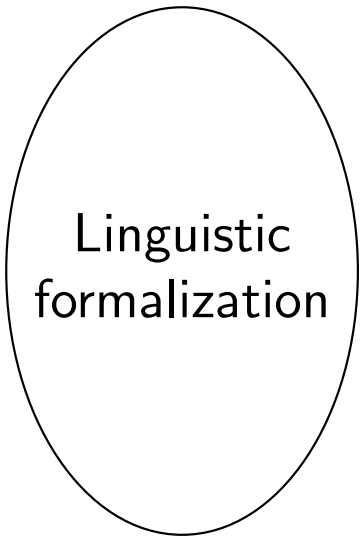
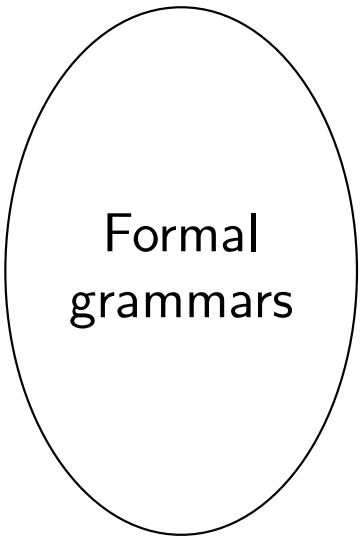
Polymnie meeting

12 Mars 2014

Context and motivation





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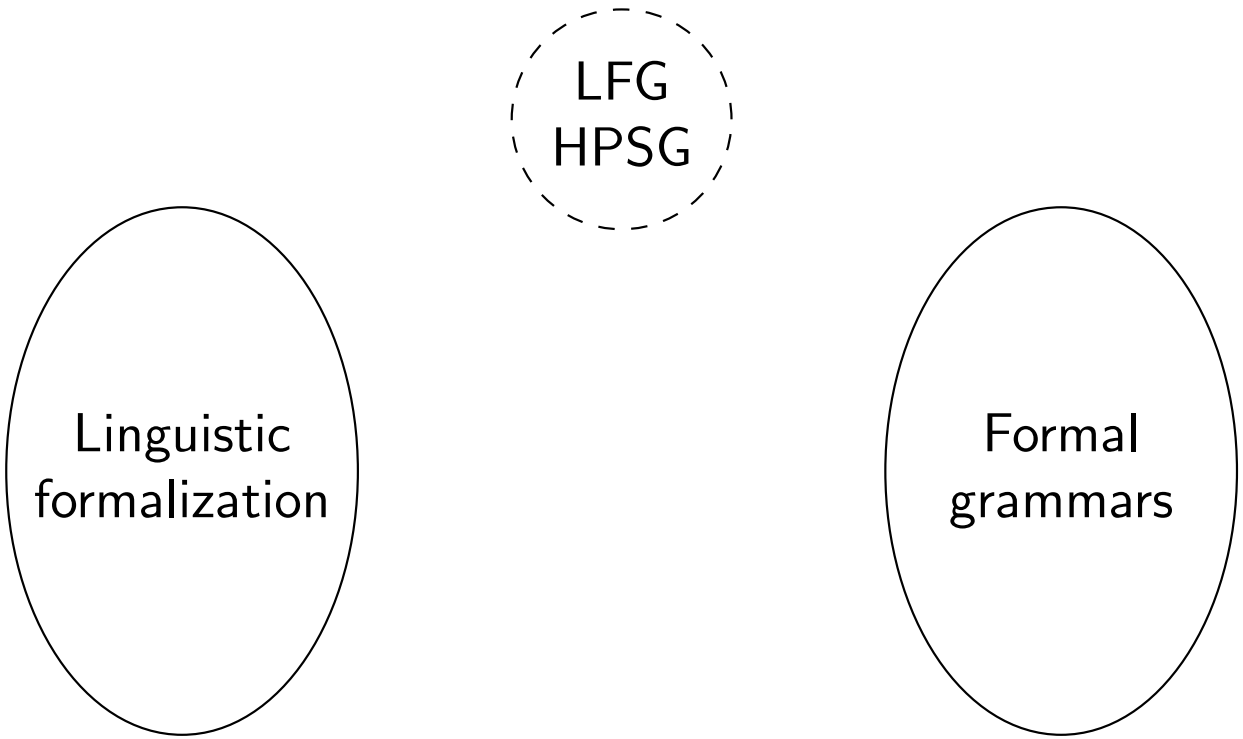

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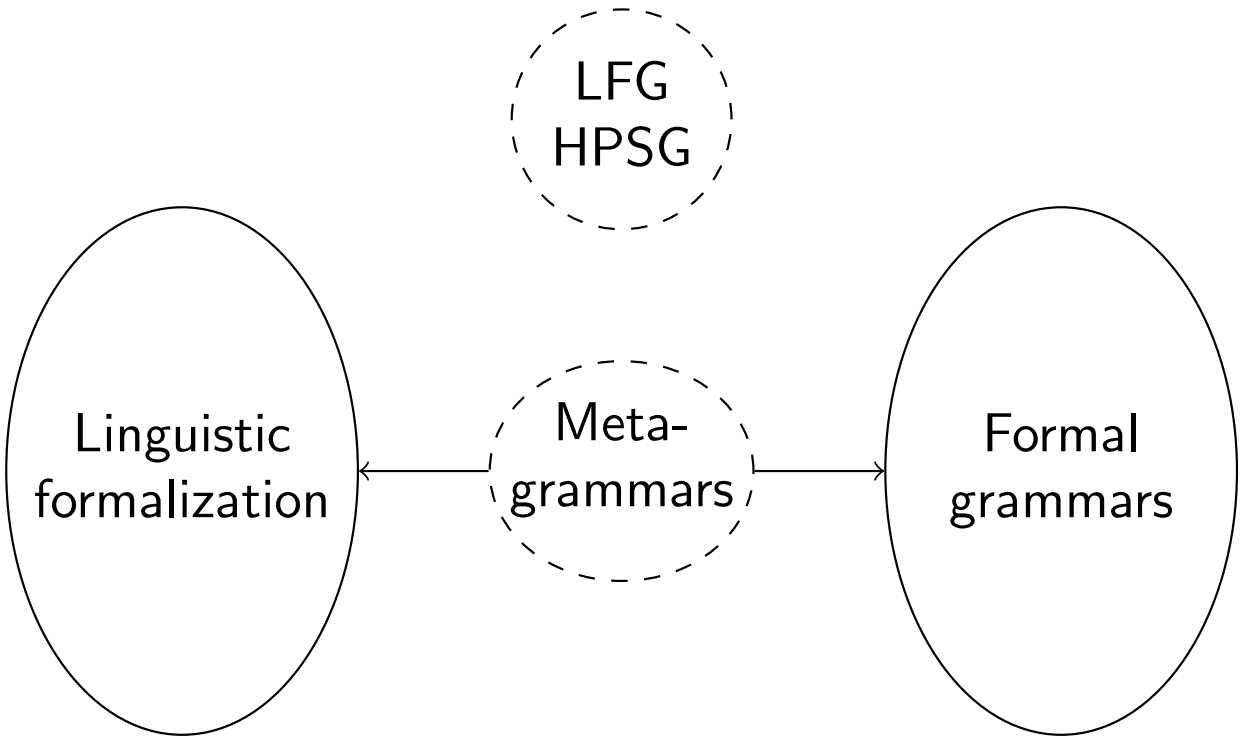

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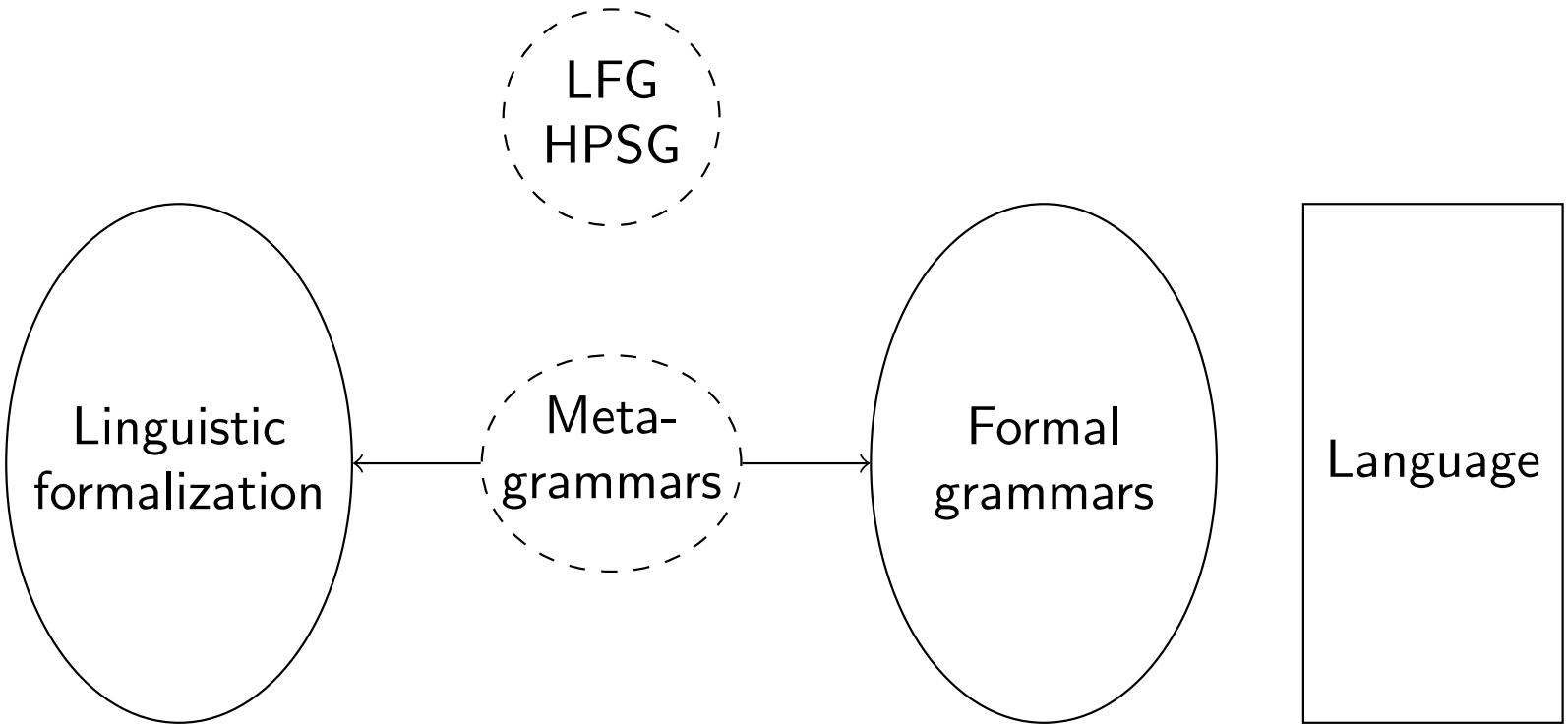

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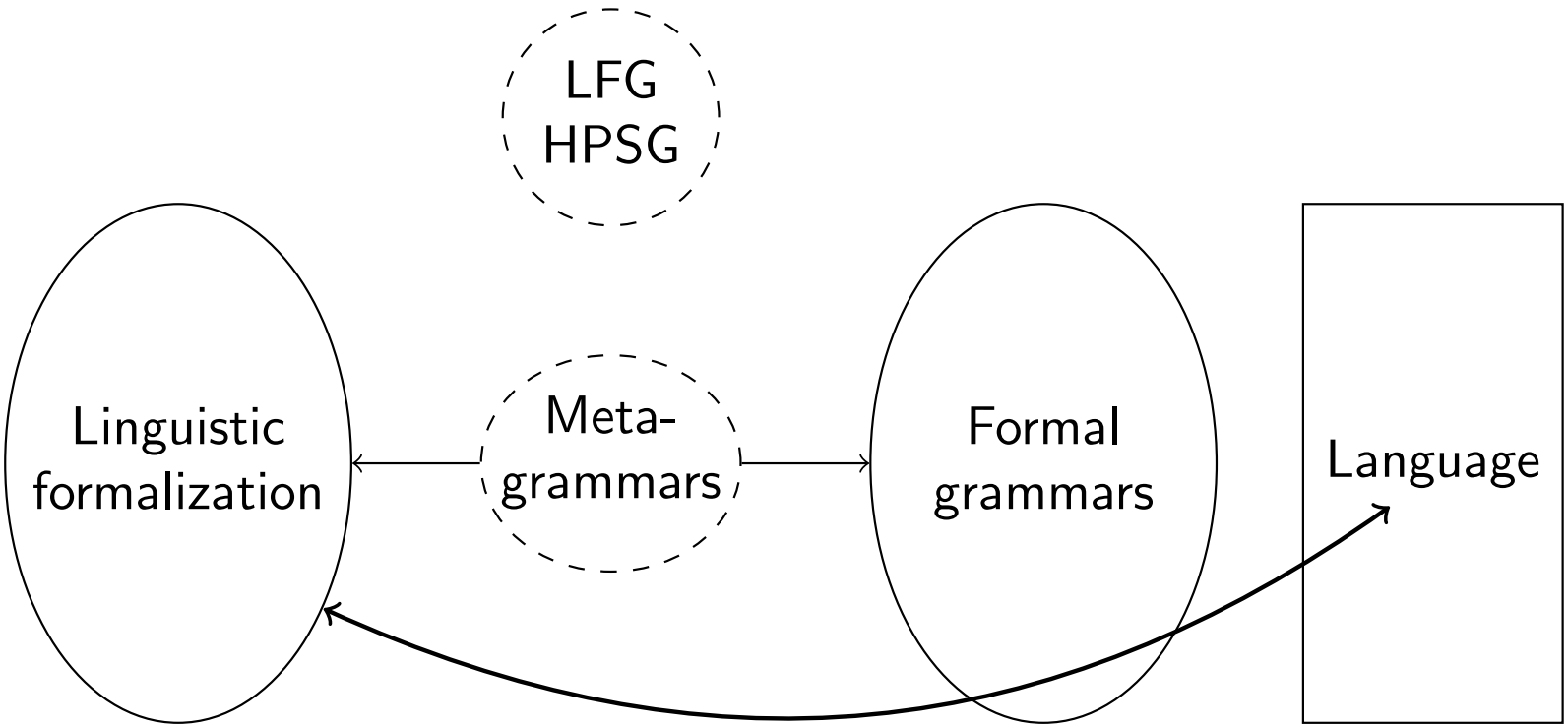

Goals on both ends

Linguistic formalization

- High-level description of natural languages

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Target class of languages

- Mildly Context Sensitive Languages
- $\Rightarrow$ Polynomial parsability

Working hypotheses

Abstract Categorial Grammar:

Abstract language (syntactic structure)

$\updownarrow$

Object language (word order)

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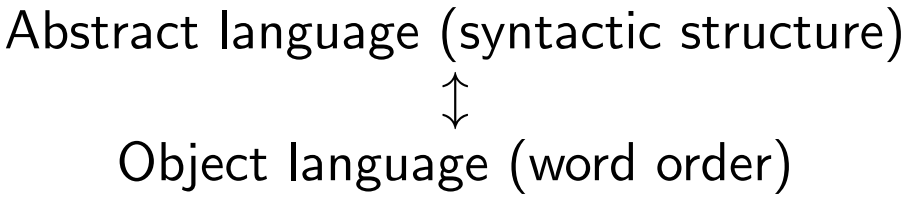

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- Non-local phenomena → logical long-distance relations
- Also helps defining the linearization

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- Non-local phenomena $\rightarrow$ logical long-distance relations
- Also helps defining the linearization

Linearization: mapping from abstract to surface structures
= linear composition of lexical entries

Existing tools and results

Base tools

- Logic (MSO or weaker on trees)
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B. Courcelle and J. Engelfriet. (HR are closed by MSO transductions)
A logical characterization of the sets of hypergraphs defined by hyperedge replacement grammars.
Mathematical Systems Theory, 28(6):515–552, 1995.

S. Salvati. ($HR \cap T \rightarrow 2\,ACG_{lin} \cap T$)
Encoding second order string acg with deterministic tree walking transducers.
In S. Wintner, editor, *Proceedings FG 2006: the 11th conference on Formal Grammars*, FG Online Proceedings, pages 143–156. CSLI Publications, 2007.

Example grammar

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Enrich the grammar to include

- Relative clauses as modifiers
- Complement clauses (for long distance wh-movement)
- Island constraints

Abstract structures

Abstract language = set of *abstract structure* trees

Trees have:

- Unlabelled internal nodes
- Labelled edges (bounded arity)
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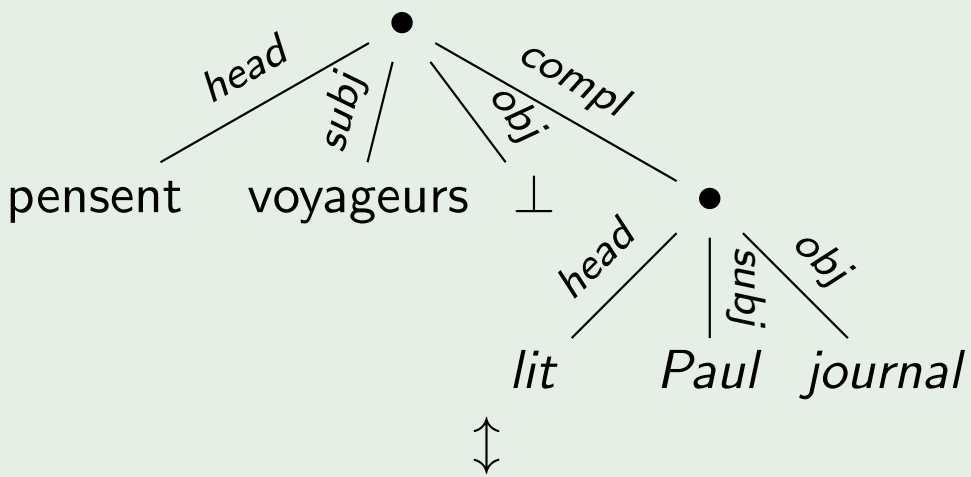

Des voyageurs pensent que Paul lit le journal.

Lexical entries

Lexical entries decorate leaves in the abstract structure tree

Each entry has a set of associated properties (from a finite set)

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A lexicon

Entry	Properties
le journal	*noun*, *def* , *masculine*, *singular*
des voyageurs	*noun*, *indef* , *masculine*, *plural*
Paul	*proper noun*, *masculine*, *singular*
lit	*verb*, *transitive*, *intransitive*, *singular* , *3rd pers*
lisent	*verb*, *transitive*, *intransitive*, *plural* , *3rd pers*
marche	*verb*, *intransitive*, *singular* , *3rd pers*

Regular backbone

Definition of abstract structures by a regular tree grammar (over-approximation)

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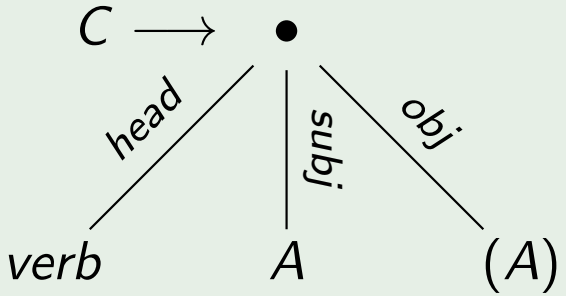
A simple over-approximation RTG



$$A \longrightarrow noun \mid proper\ noun$$

Terminals are POS properties (any lexical entry with the right POS tag)

Some arguments may be optional (between parentheses): $(T) \rightarrow T \mid \bot$

Logical vocabulary (1/2)

Variables ($x, y, z, \dots$): positions in the tree

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Used to restrict the set of valid abstract structures:

- Sub-categorization, selection restrictions, etc.
- Regexps allow long-distance constraints

Logical vocabulary (2/2)

Linguistic formalization by building additional predicates and relations

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Agreement relations

$$numb\_agr(x,y) := singular(x) \wedge singular(y) \vee plural(x) \wedge plural(y)$$

$$gend\_agr(x,y) := masculine(x) \wedge masculine(y) \vee feminine(x) \wedge feminine(y)$$

$$third\_pers(x) := 3rd\ pers(x) \vee \neg(1st\ pers(x) \vee 2nd\ pers(x))$$

$$pers\_agr(x,y) := 1st\ pers(x) \wedge 1st\ pers(y) \vee 2nd\ pers(x) \wedge 2nd\ pers(y) \vee third\_pers(x) \wedge third\_pers(y)$$

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Subject-verb agreement relation

$$sv\_agr(x,y) := numb\_agr(x,y) \wedge pers\_agr(x,y)$$

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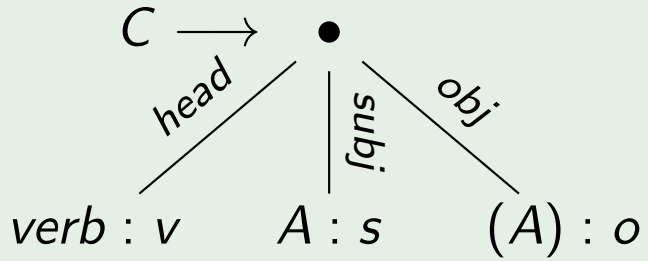
Enforcing subject-verb agreement and valency



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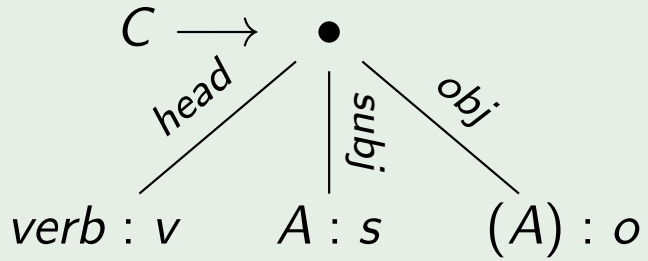

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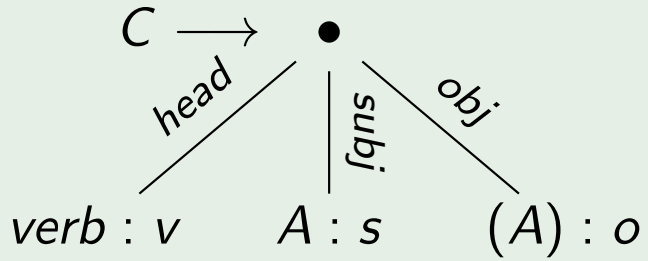

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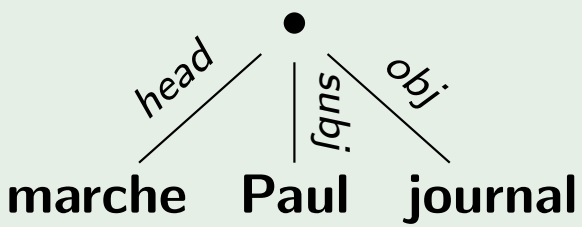

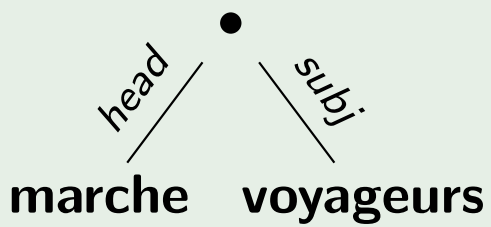

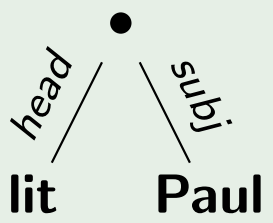

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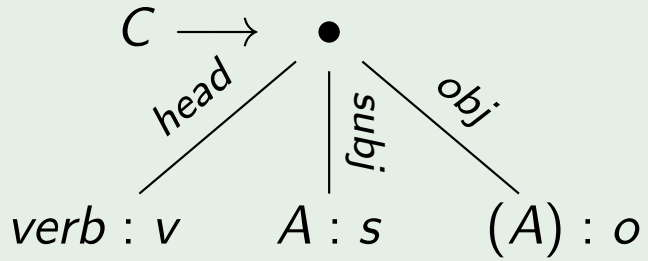

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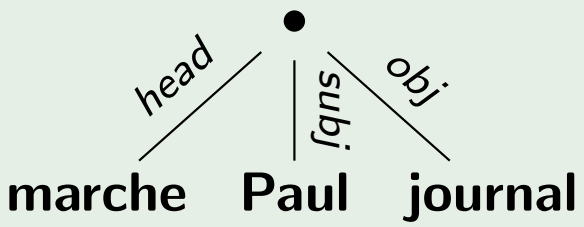

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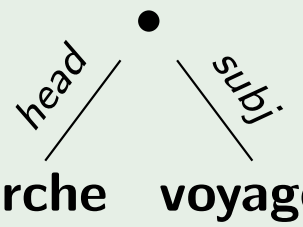

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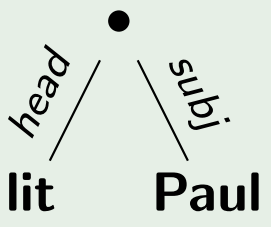

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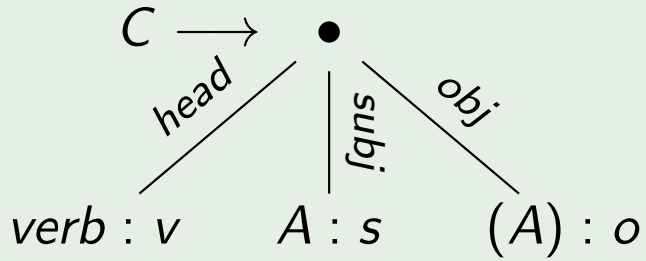

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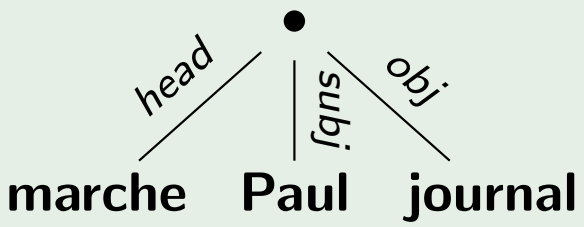

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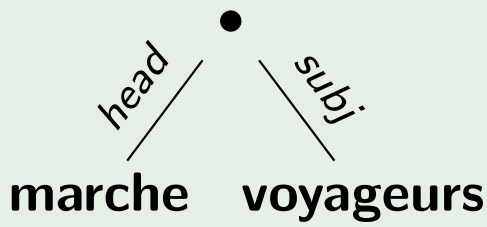

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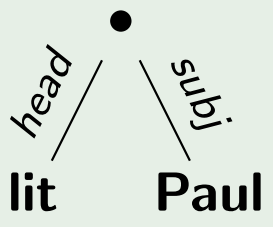

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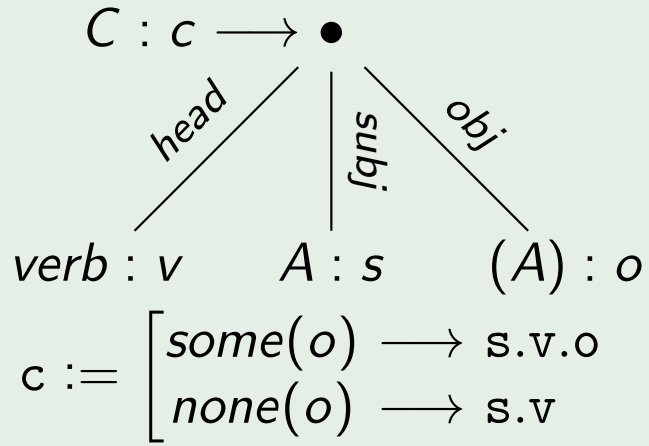

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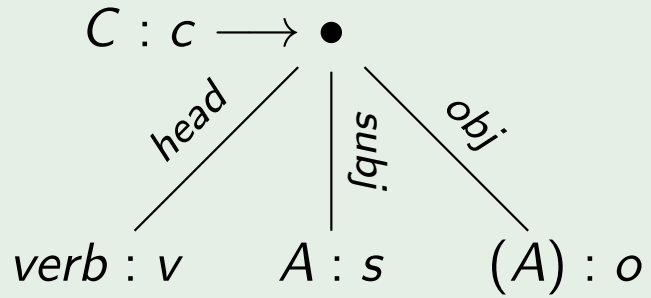

$\mathtt{c} := \mathtt{s.v.o}$ $\quad$ $(lin(\bot) := \varepsilon)$

Adding relative clauses (1/3)

We enrich the previous grammar to include relative clauses

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Lexical entries for french relative pronouns

Entry	Properties
qui	*pronoun*, *rel_pro*, *masculine*, *feminine*, *singular*, *plural*, *1st*, *2nd*, *3rd pers.*, *nom*
que	*pronoun*, *rel_pro*, *masculine*, *feminine*, *singular*, *plural*, *1st*, *2nd*, *3rd pers.*, *acc*

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Logical vocabulary for wh-movement and agreement in relatives

$$wh\_path(x, y) := subj(x, y) \vee obj(x, y)$$

$$ext(x) := rel\_pro(x)$$

$$rel(r) := \exists np.mod(np, r) \wedge \exists v.verb(v) \wedge head(r, v)$$

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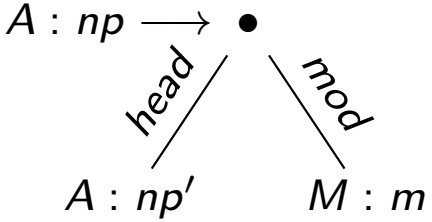
Adding relative clauses (2/3)



$A : a \longrightarrow pronoun : p$

$M : m \longrightarrow C : r$

$\mathtt{np} := \mathtt{np}'.\mathtt{m}$

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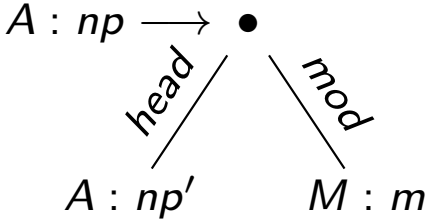

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$\neg rel\_pro(np')$

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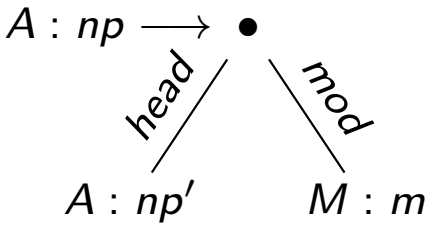


$A : a \longrightarrow pronoun : p$

$M : m \longrightarrow C : r$

$\neg rel\_pro(np')$

$\mathtt{np} := \mathtt{np}'.\mathtt{m}$

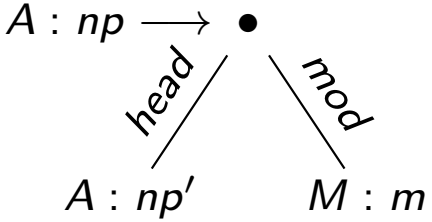
$\mathtt{a} := \mathtt{p}$

$\mathtt{m} := wh\_path(r, \mathbf{p}) \wedge ext(\mathbf{p}) \longrightarrow \mathbf{p}.\mathtt{r}$

Filtered out sentences - [NP+MOD] (SUJ+VB+OBJ)

*[la pomme ([qui (que regarde Paul)] tombe)]

Adding relative clauses (2/3)



$A : a \longrightarrow pronoun : p$

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$$rel\_pro(p) \Rightarrow \exists r.rel(r) \wedge wh\_path(r,p) \wedge \exists a.antecedent(a,p) \wedge ap\_agr(a,p)$$

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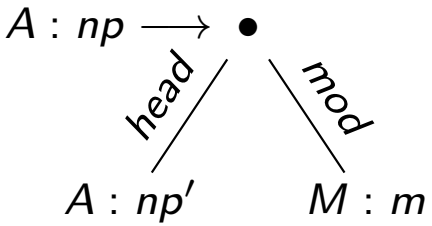

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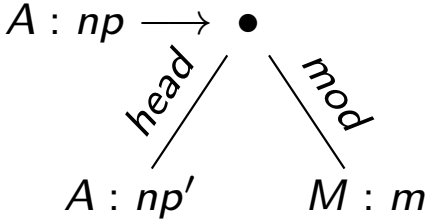

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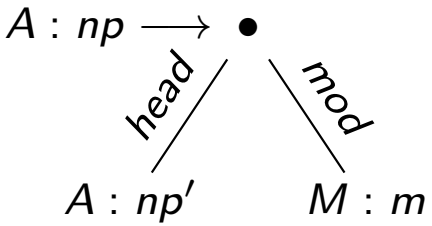

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*[la pomme ([qui (que regarde Paul)] tombe)]
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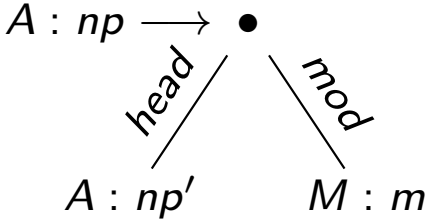

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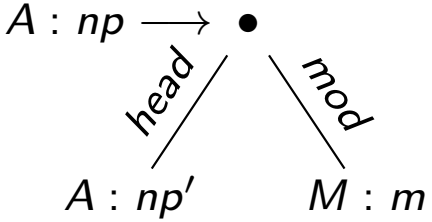

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Filtered out sentences - [NP+MOD] (SUJ+VB+OBJ)

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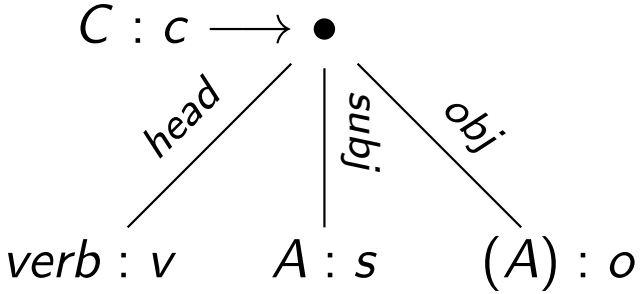
*(qui tombe)
*[la pomme (que tombe)] ; *[la pomme (qui Paul regarde)]
*[la pomme (Paul regarde Marie)] ; *[Paul (qui que regarde)]

Adding relative clauses (3/3)



$$M : m \longrightarrow C : r$$

$$\mathtt{c} := \begin{bmatrix} ext(s) & \longrightarrow & \mathtt{v.o} \\ ext(o) & \longrightarrow & \mathtt{s.v} \\ else & \longrightarrow & \mathtt{s.v.o} \end{bmatrix}$$

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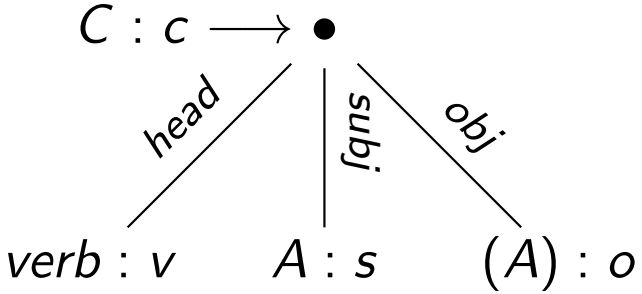

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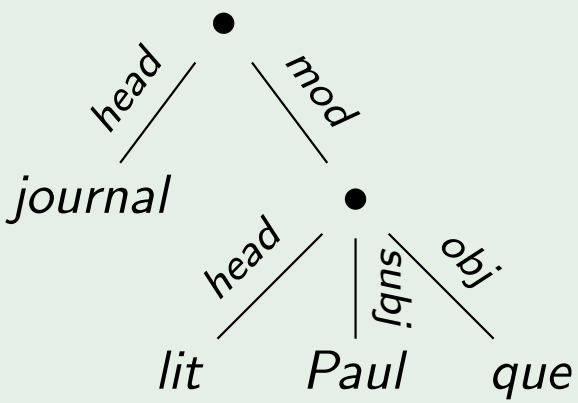
Wh- movement account



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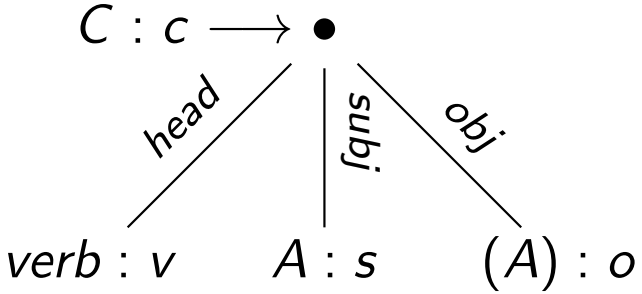

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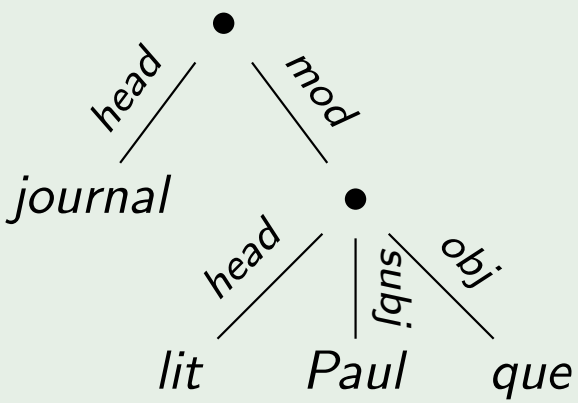

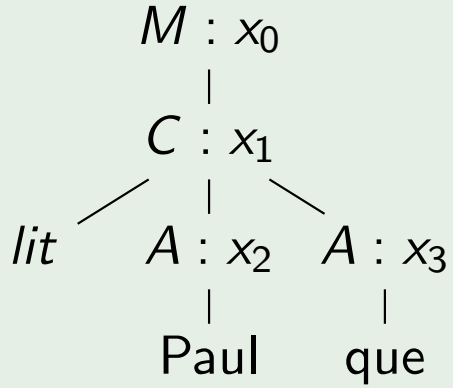

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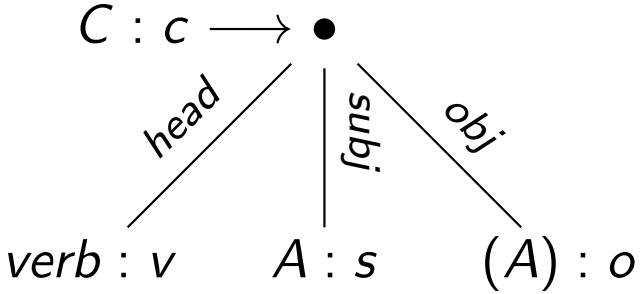

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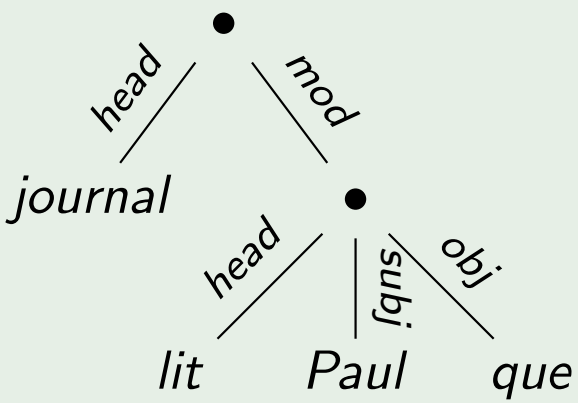
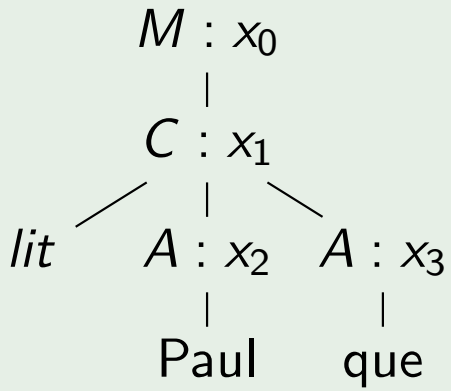
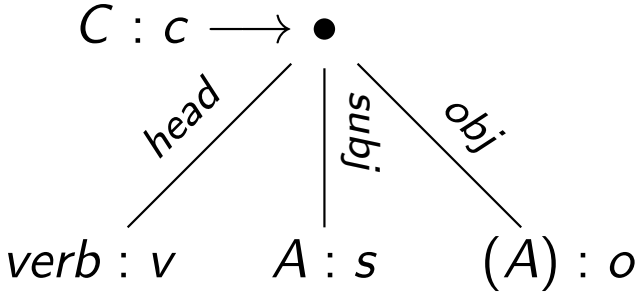




$$\mathtt{x}_2 = \mathtt{Paul}$$
$$\mathtt{x}_3 = \mathtt{que}$$

Adding relative clauses (3/3)



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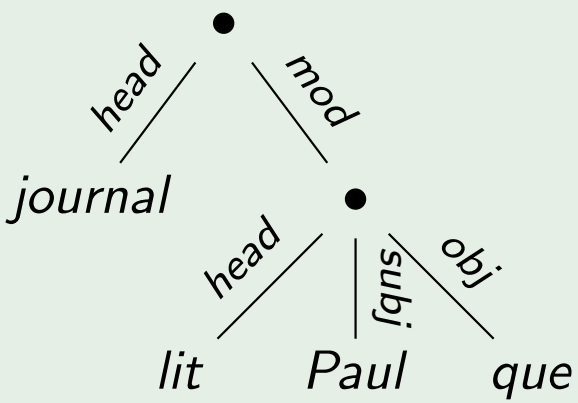
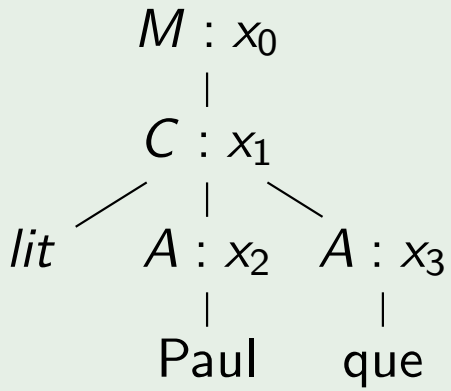
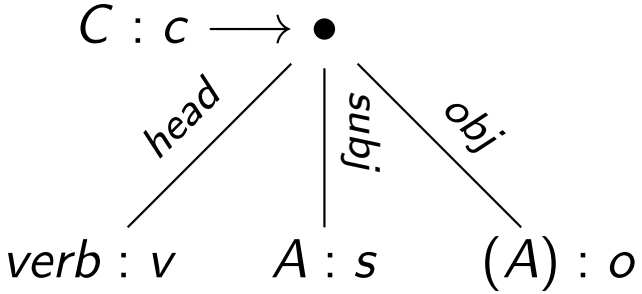




$$\mathtt{x}_1 = \mathtt{Paul.lit}$$

$$\mathtt{x}_2 = \mathtt{Paul}$$
$$\mathtt{x}_3 = \mathtt{que}$$

Adding relative clauses (3/3)



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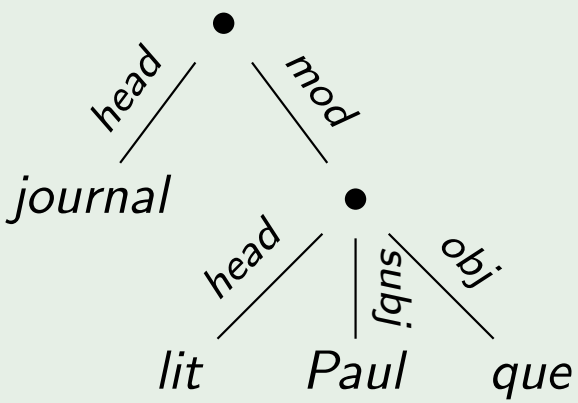

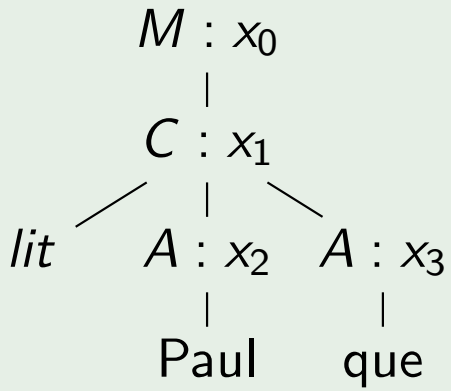

$$\mathtt{x}_0 = \mathtt{que.Paul\ lit}$$

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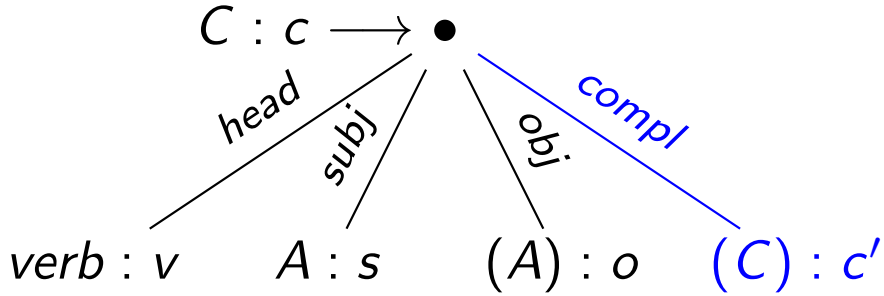
Adding complement clauses (1/2)



$$some(o) \Rightarrow transitive(v)$$
$$none(o) \Rightarrow intransitive(v)$$
$$sv\_agr(s, v)$$
$$some(c') \Leftrightarrow compl\_cl(v)$$

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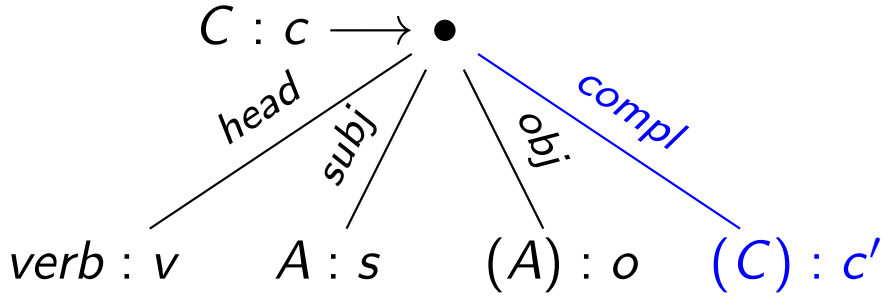

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Addition to the lexicon

Entry	Properties
dit	*verb*, *intransitive*, *compl_cl*, *singular*, *3rd pers*
disent	*verb*, *intransitive*, *compl_cl*, *plural*, *3rd pers*

Adding complement clauses (2/2)

Updated logical definition of *wh_path* (Island constraints)

$$wh\_path(x, y) := subj(x, y) \vee compl^{*}\, obj(x, y)$$

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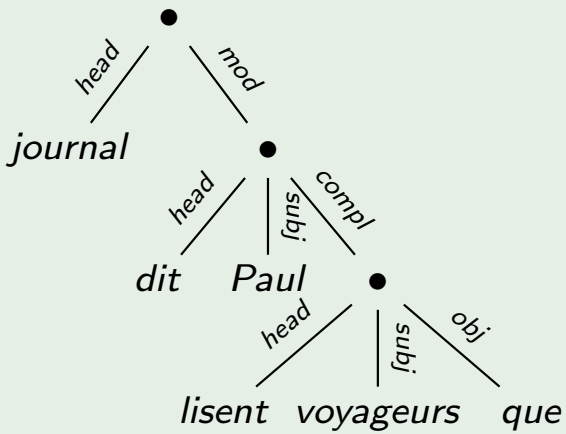
Final linearization example



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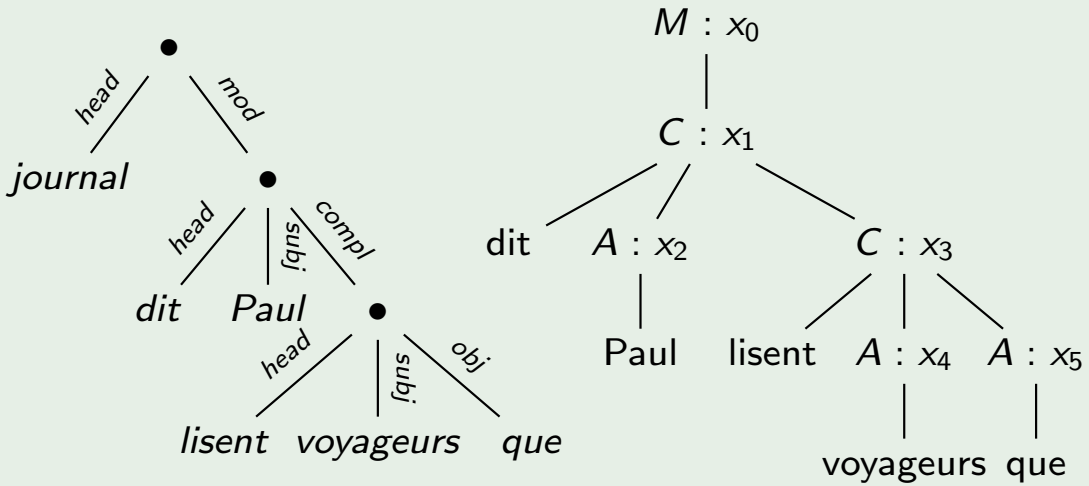

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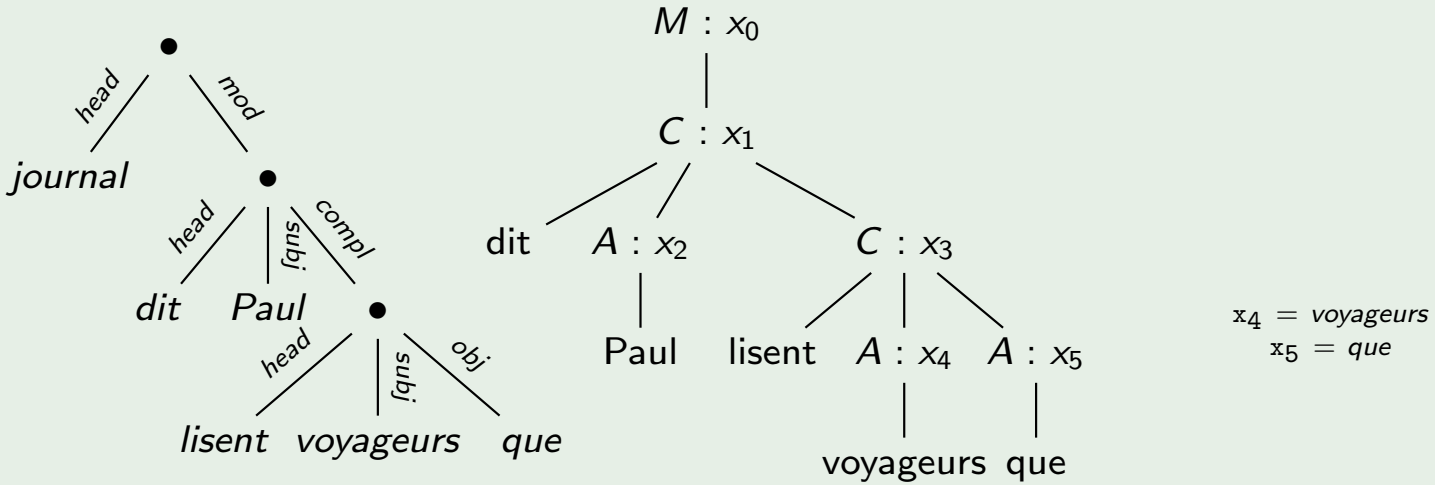

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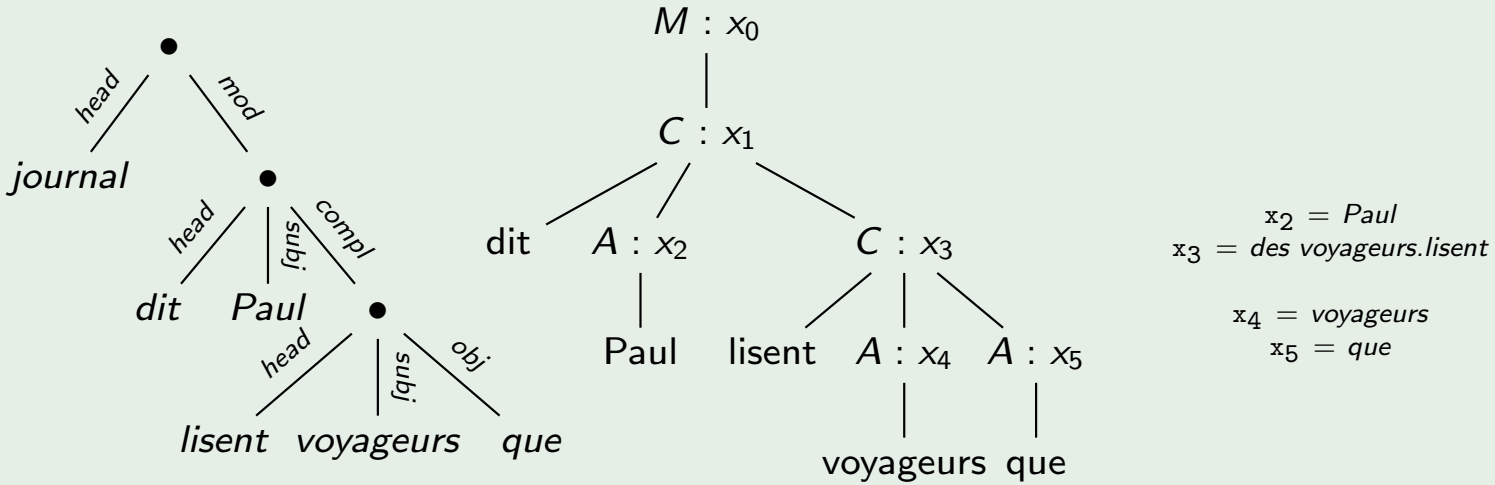

x_2 = *Paul*
x_3 = *des voyageurs.lisent*

x_4 = *voyageurs*
x_5 = *que*

Adding complement clauses (2/2)

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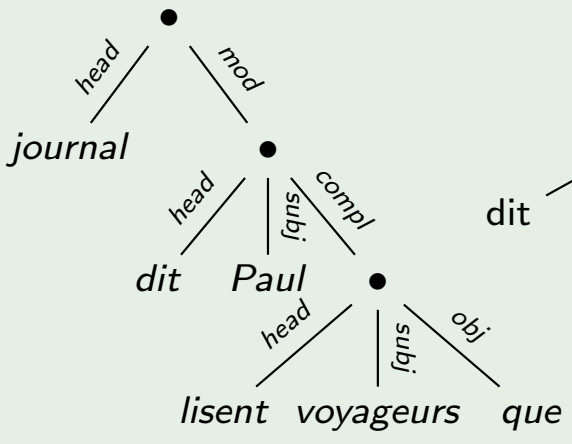

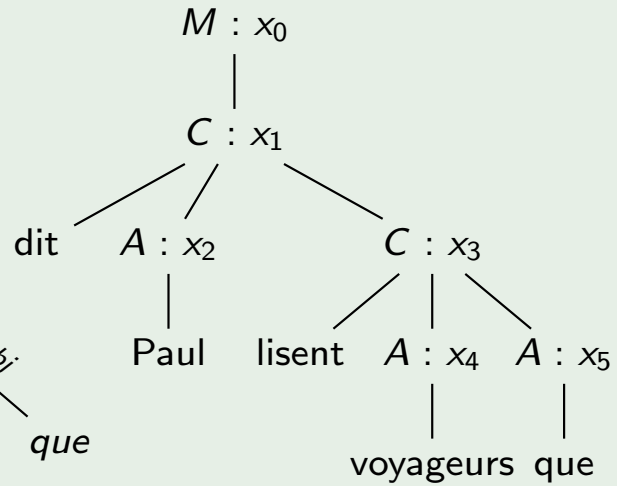

x_1 = *Paul.dit.que.des voyageurs lisent*

x_2 = *Paul*
x_3 = *des voyageurs.lisent*

x_4 = *voyageurs*
x_5 = *que*

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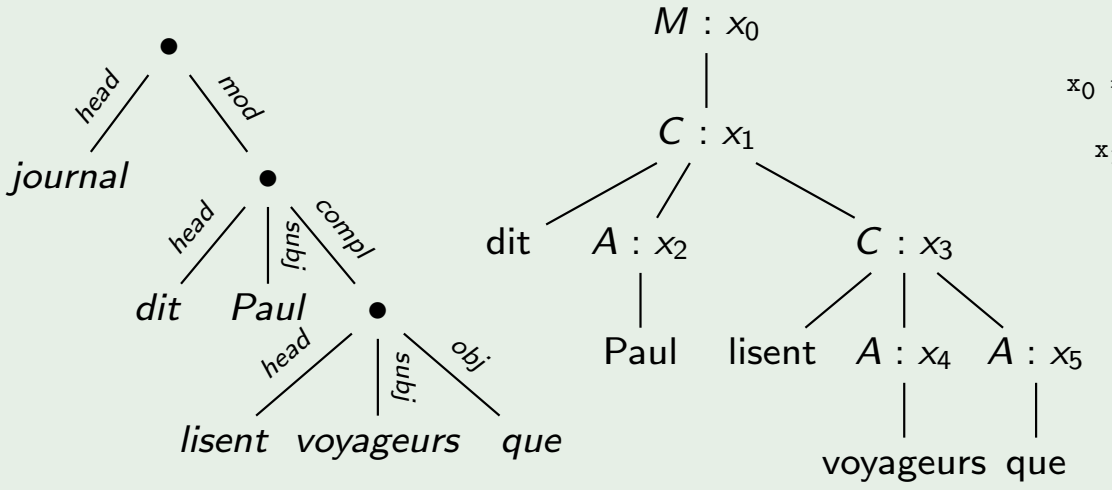

x_0 = *que.Paul dit que des voyageurs lisent*

x_1 = *Paul.dit.que.des voyageurs lisent*

x_2 = *Paul*
x_3 = *des voyageurs.lisent*

x_4 = *voyageurs*
x_5 = *que*

Conclusion

In summary, we have :

- Provided a logic-based toolset for linguistic description
- Demonstrated possible uses for it through a simple grammar
- Hinted at an effective procedure to compile the descriptions

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- Provided a logic-based toolset for linguistic description
- Demonstrated possible uses for it through a simple grammar
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Possible directions :

- Work towards a usable implementation
- Improve mapping to language semantics
- Implement linguistic knowledge into larger grammars