Grammar Implementation with Lexicalized Tree Adjoining Grammars and Frame Semantics

Putting things together

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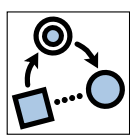
University of Düsseldorf

DGfS CL Fall School, September 14, 2017



Outline of today's course

1. Combining LTAG with frame semantics
   - Overall architecture
   - Elements of the syntax-semantics interface
2. Case studies
   - Directed motion construction
   - Dative alternation
3. Outlook: factorization of elementary constructions in the metagrammar
4. Summary and outlook

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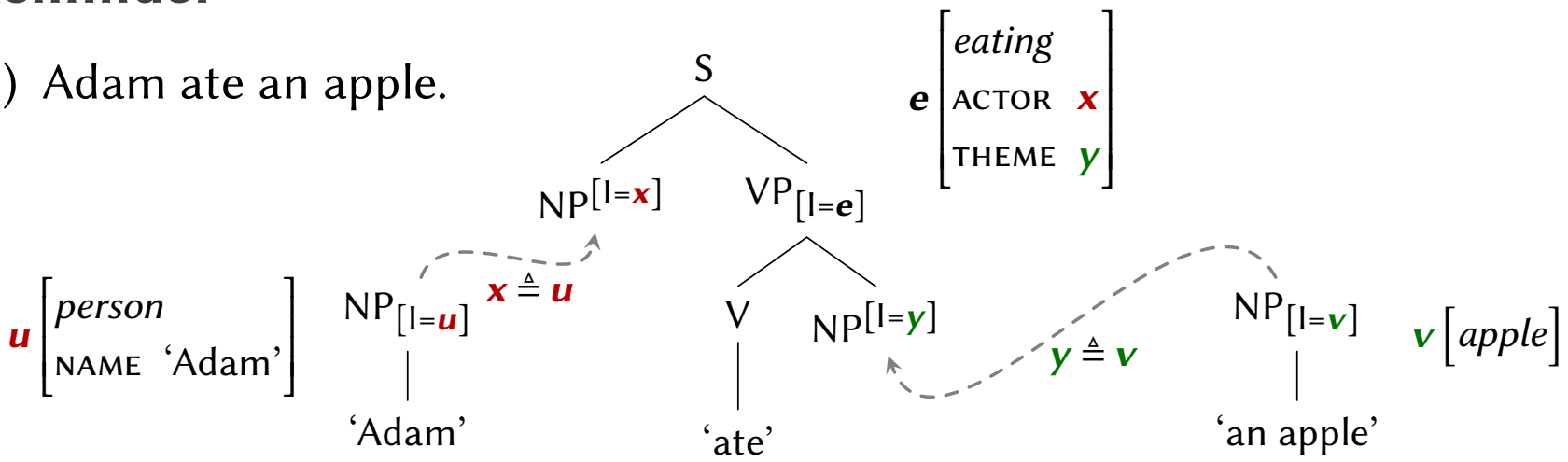
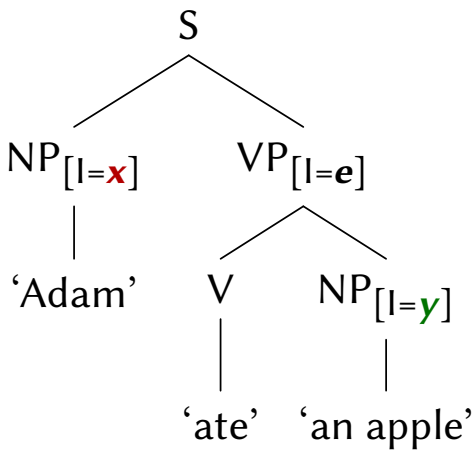
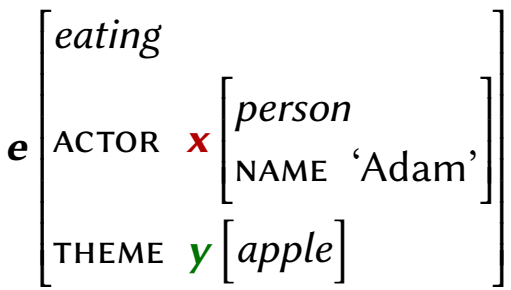
LTAG & frame semantics

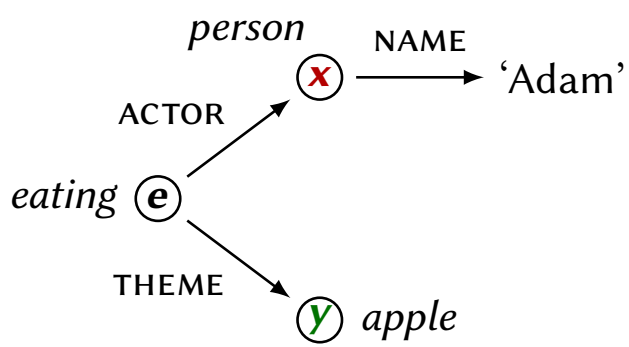
Reminder

(1) Adam ate an apple.

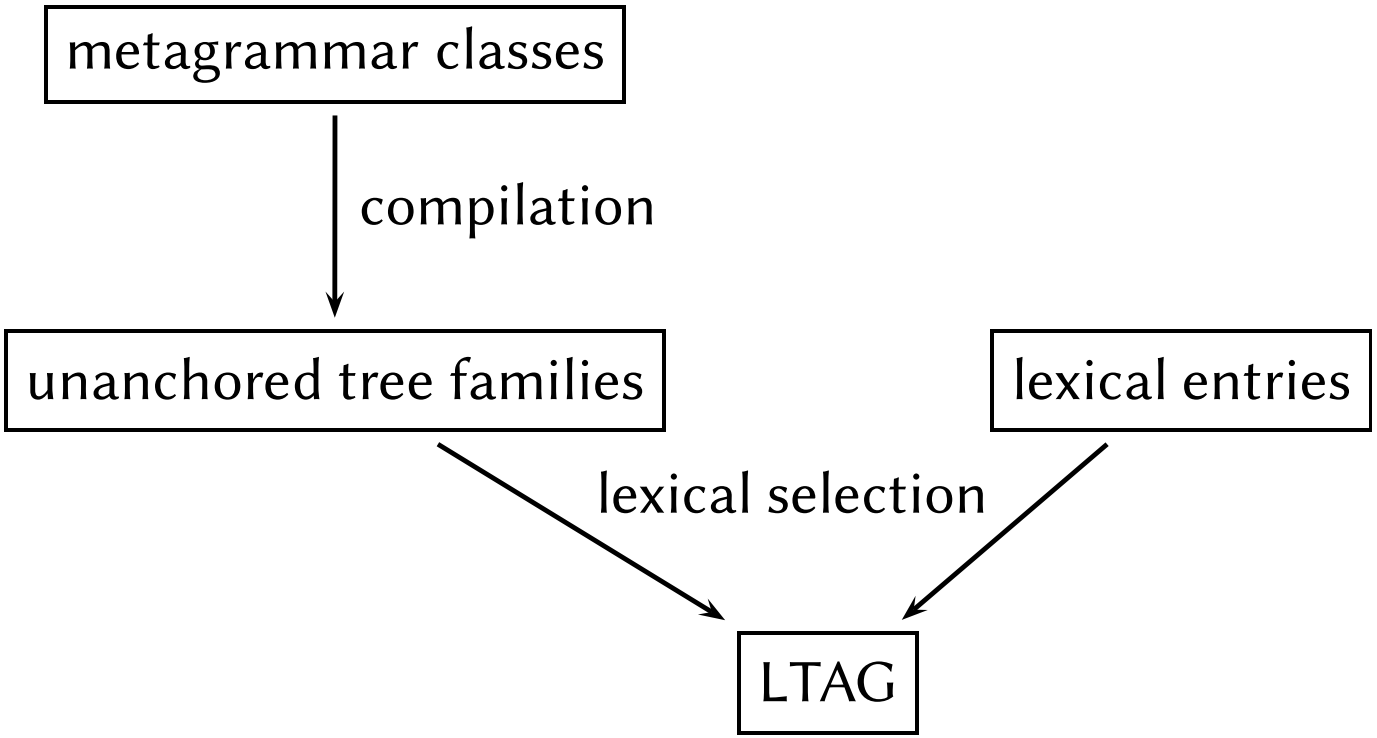








Overall architecture (reminder)



LTAG & frame semantics

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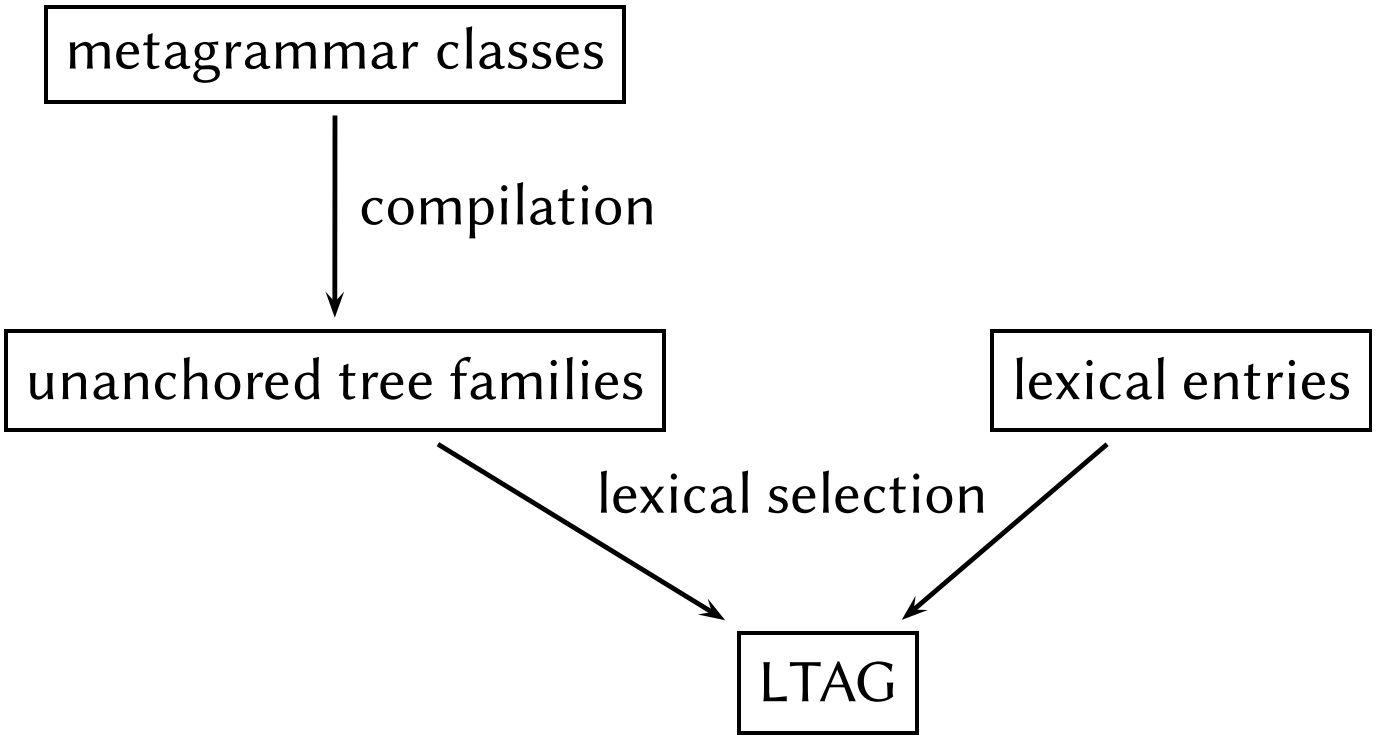
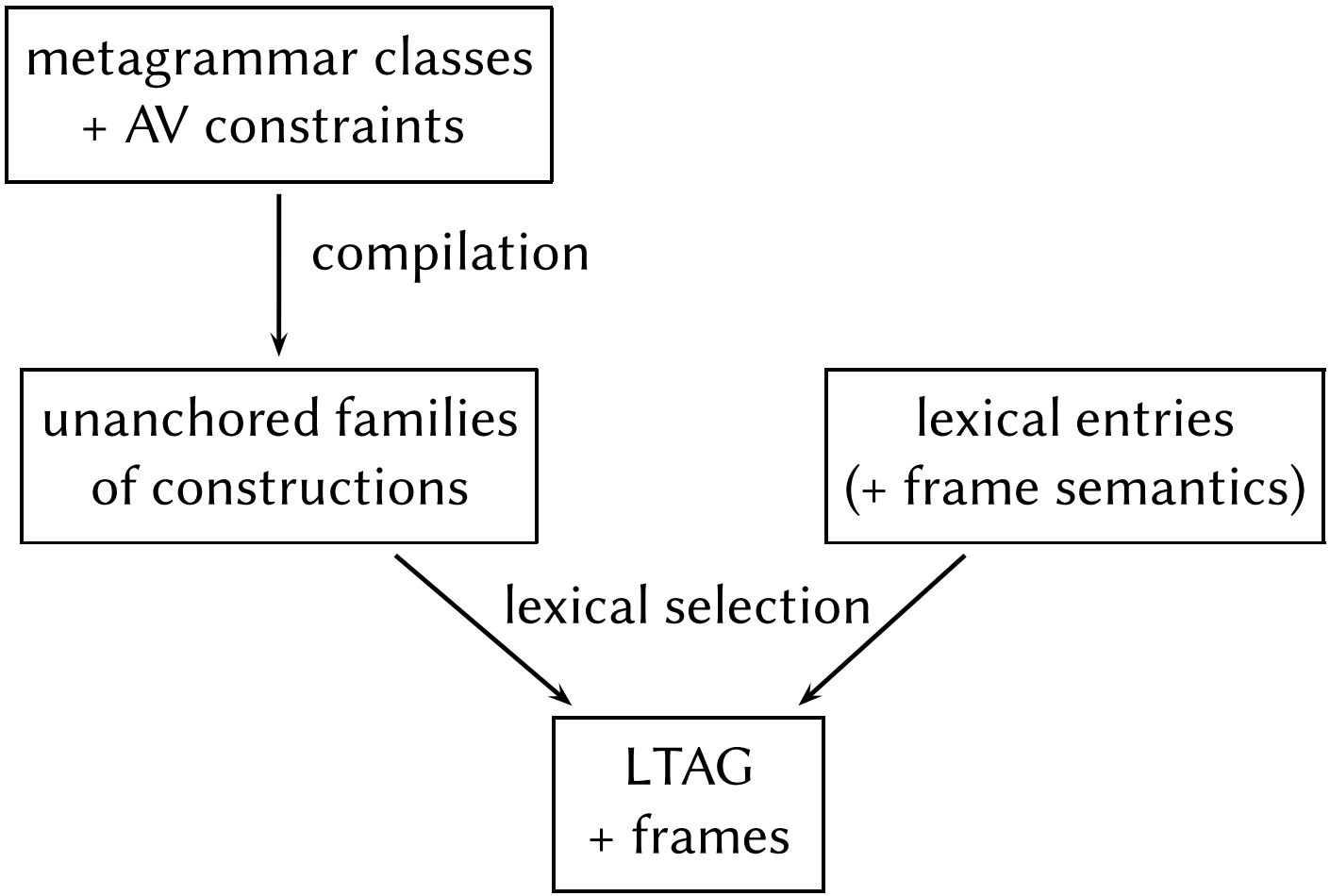


Next step: Add (frame) semantics to all components and link syntax to semantics.

LTAG & frame semantics

Overall architecture (syntax + semantics)



LTAG & frame semantics

Elements of the syntax-semantics interface

- **Elementary construction:**

  elementary tree
  + semantic frame
  + linking of frame node variables to interface features in the tree

- Specification in the metagrammar:

  classes of tree constraints
  + sets of attribute-value constraints
  + linking of variables to interface features

  Note: Regularities about **argument linking** are expressed in the metagrammar. [Kallmeyer/Lichte/Osswald/Petitjean 2016]

- Semantic **composition** $\approx$ frame unification via identification of interface variables during substitution and adjunction.

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Case study: directed motion construction

Intransitive:

(2) a. Mary walked to the house.
b. The ball rolled into the goal.

Case study: directed motion construction

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(2) a. Mary walked to the house.
b. The ball rolled into the goal.

Transitive:

(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.

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Directional specifications are not restricted to **goal** expressions but can also describe the **source** or the **course of the path** in more detail.

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Directional specifications are not restricted to **goal** expressions but can also describe the **source** or the **course of the path** in more detail. Moreover, path descriptions can be **iterated** to some extent:

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

Case study: directed motion construction

Question: Syntactic treatment of directional PPs?

- Construction ($\rightsquigarrow$ elementary tree)
- Syntactic composition ($\rightsquigarrow$ adjunction)

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Arguments for treating goal (or **bounded**) PPs constructionally, in contrast to path (or **unbounded**) PPs:

- Goal PPs cannot be iterated.

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Question: Syntactic treatment of directional PPs?

- Construction ($\rightsquigarrow$ elementary tree)
- Syntactic composition ($\rightsquigarrow$ adjunction)

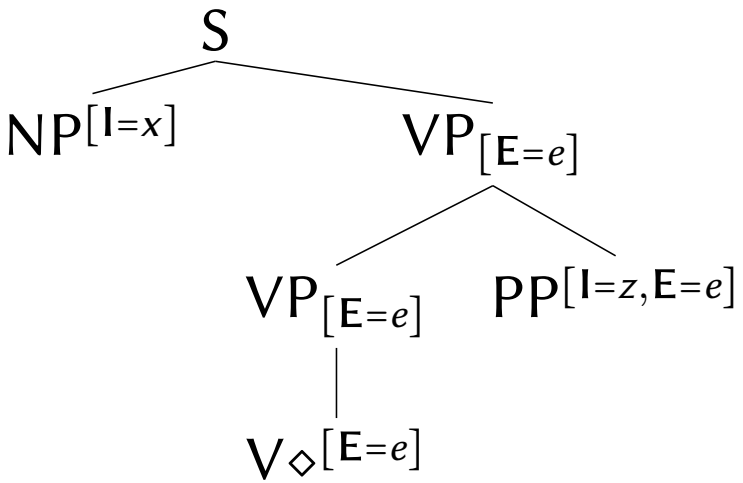
Arguments for treating goal (or **bounded**) PPs constructionally, in contrast to path (or **unbounded**) PPs:

- Goal PPs cannot be iterated.
- They affect the Aktionsart of the expression:

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

Case study: directed motion construction

Unanchored construction for intransitive directed motion (*n0Vpp(dir)*):



$$e\begin{bmatrix} \textit{bounded-translocation} \\ \textsc{mover} & x \\ \textsc{goal} & z \\ \textsc{path} & [\textit{path}] \end{bmatrix}$$

Case study: directed motion construction

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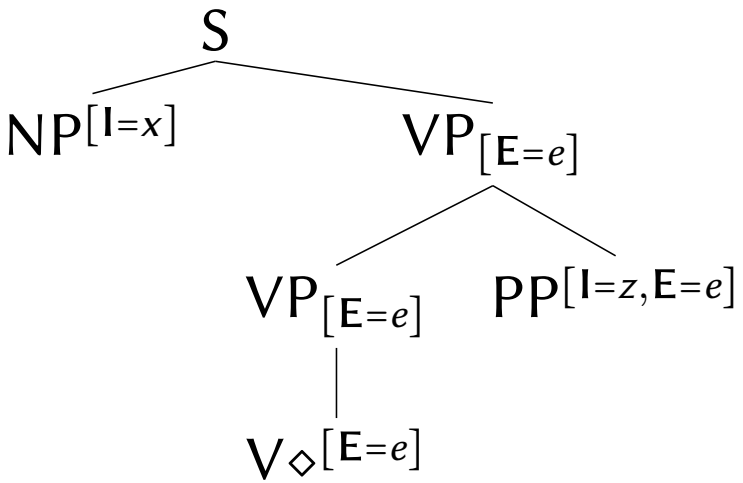
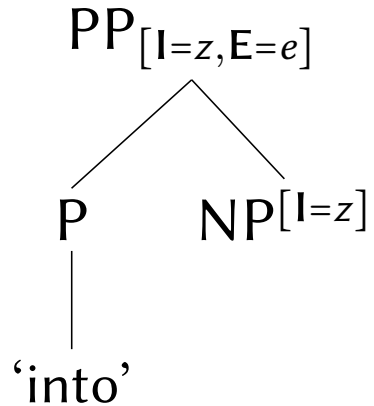


$$e\begin{bmatrix} \textit{bounded-translocation} \\ \textsc{mover} & x \\ \textsc{goal} & z \\ \textsc{path} & [\textit{path}] \end{bmatrix}$$

Elementary tree for ‘into’:



$$e\begin{bmatrix} \textit{bounded-translocation} \\ \textsc{path} & \begin{bmatrix} \textit{path} \\ \textsc{endp} & \boxed{1} \end{bmatrix} \end{bmatrix}$$

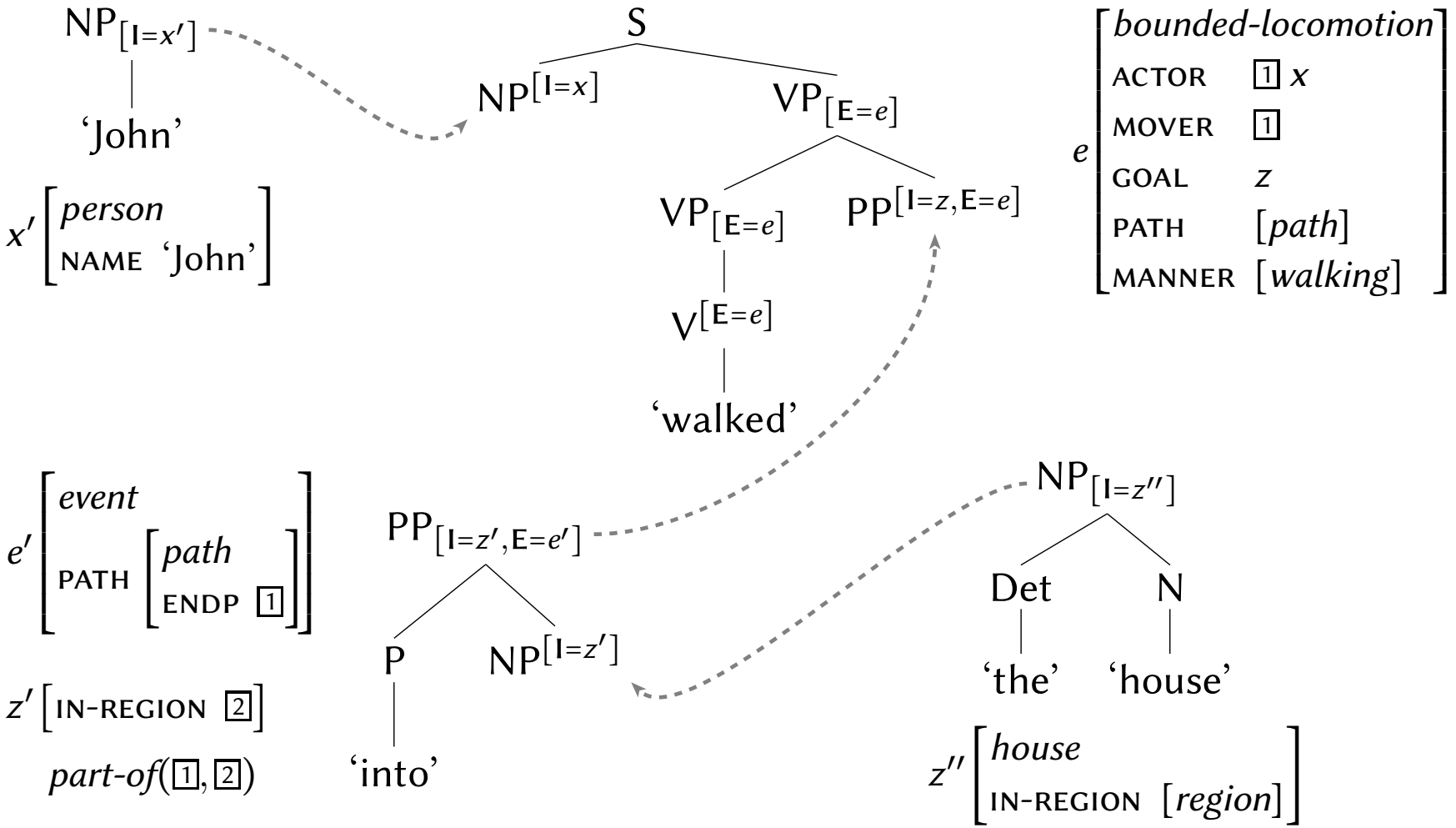
$$z\begin{bmatrix} \textsc{in-region} & \boxed{2} \end{bmatrix}$$

$$\textit{part-of}(\boxed{1}, \boxed{2})$$

Case study: directed motion construction

Example (intransitive directed motion)

(6) John walked into the house.



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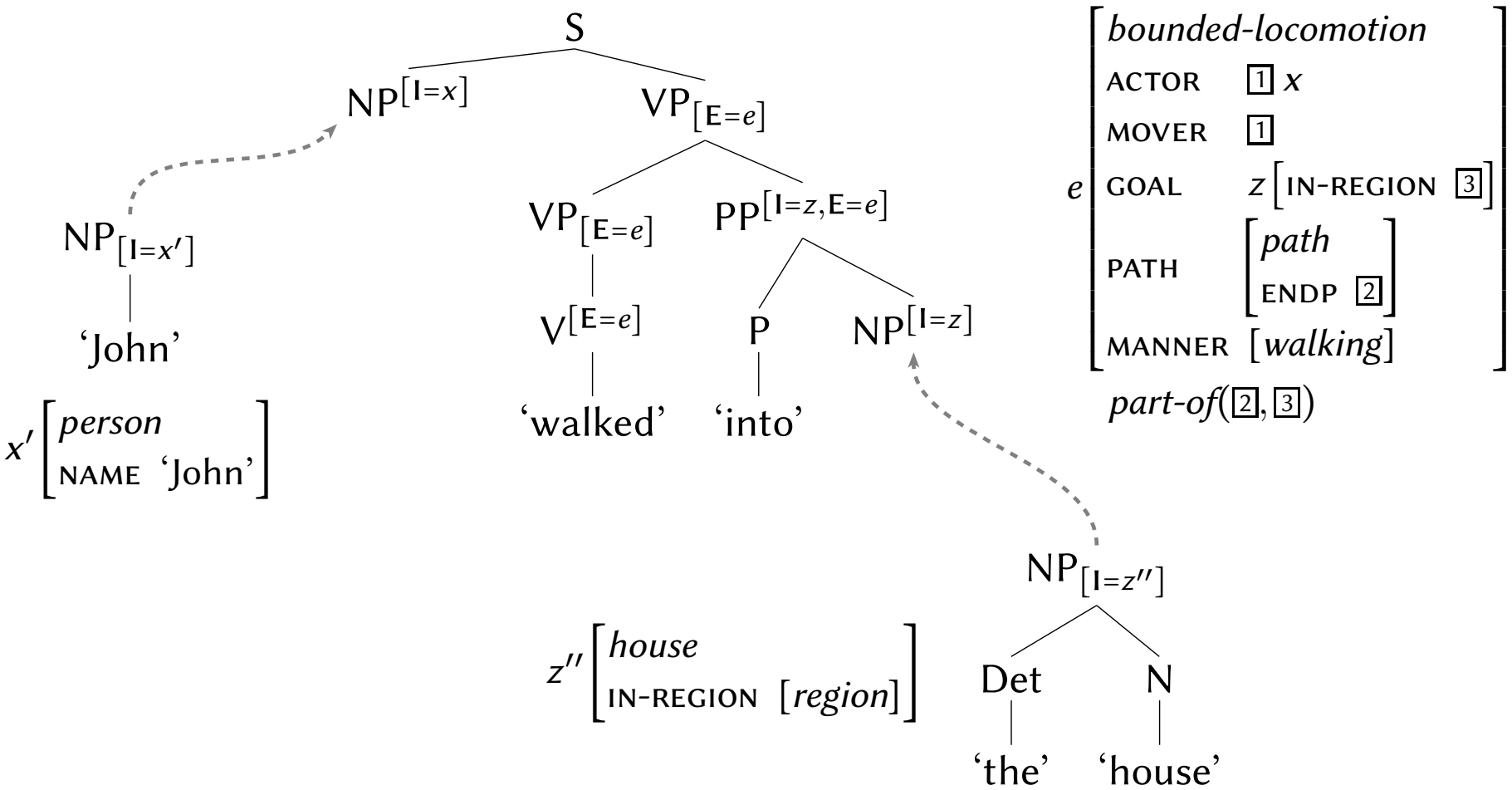

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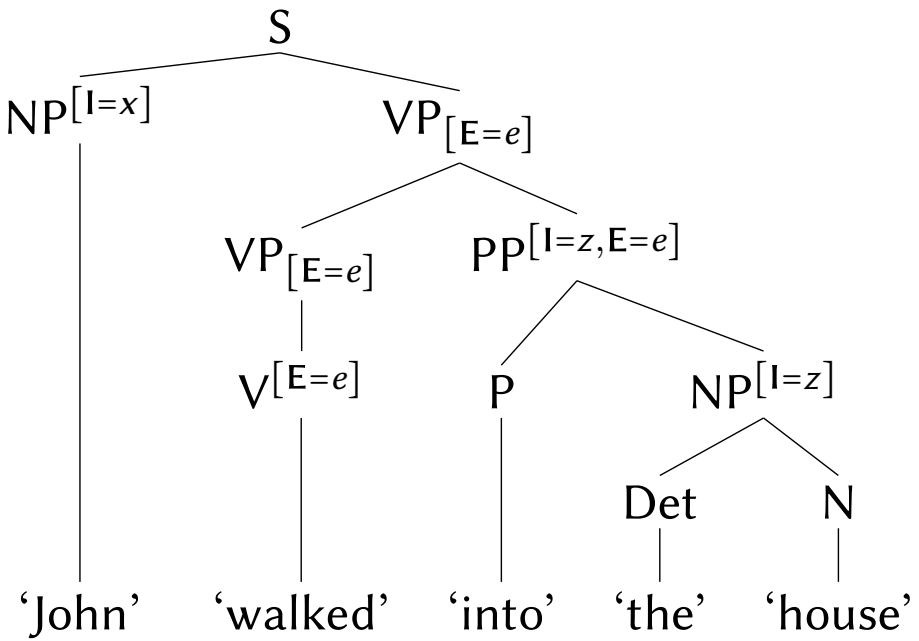

$$e\begin{bmatrix} \textit{bounded-locomotion} \\ \textsc{actor} \quad \boxed{1}\, x\begin{bmatrix} \textit{person} \\ \textsc{name} \ \text{'John'} \end{bmatrix} \\ \textsc{mover} \quad \boxed{1} \\ \textsc{goal} \quad z\begin{bmatrix} \textit{house} \\ \textsc{in-region} \ \boxed{3}\ [\textit{region}] \end{bmatrix} \\ \textsc{path} \quad \begin{bmatrix} \textit{path} \\ \textsc{endp} \ \boxed{2} \end{bmatrix} \\ \textsc{manner} \ [\textit{walking}] \end{bmatrix}$$

$$\textit{part-of}(\boxed{2}, \boxed{3})$$

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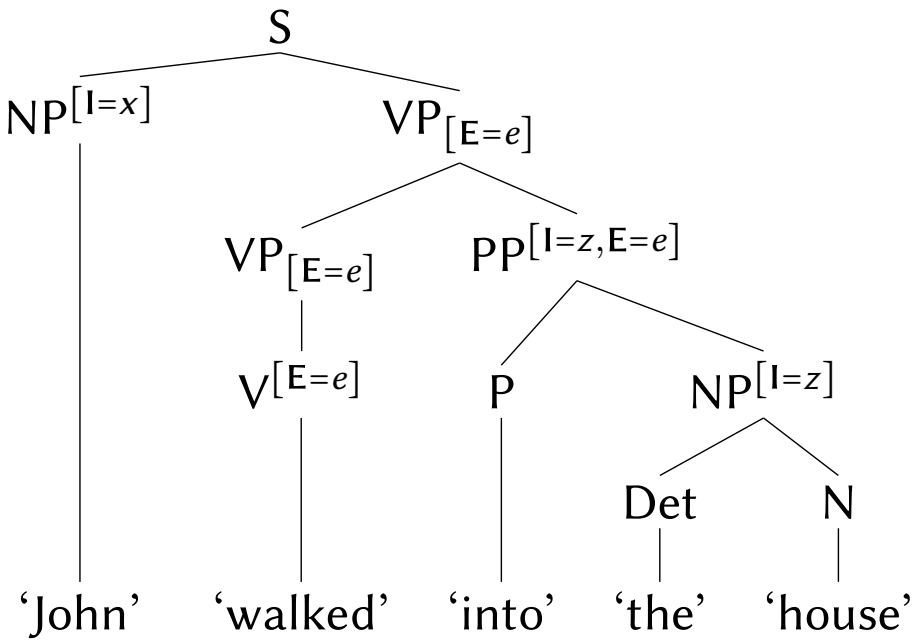

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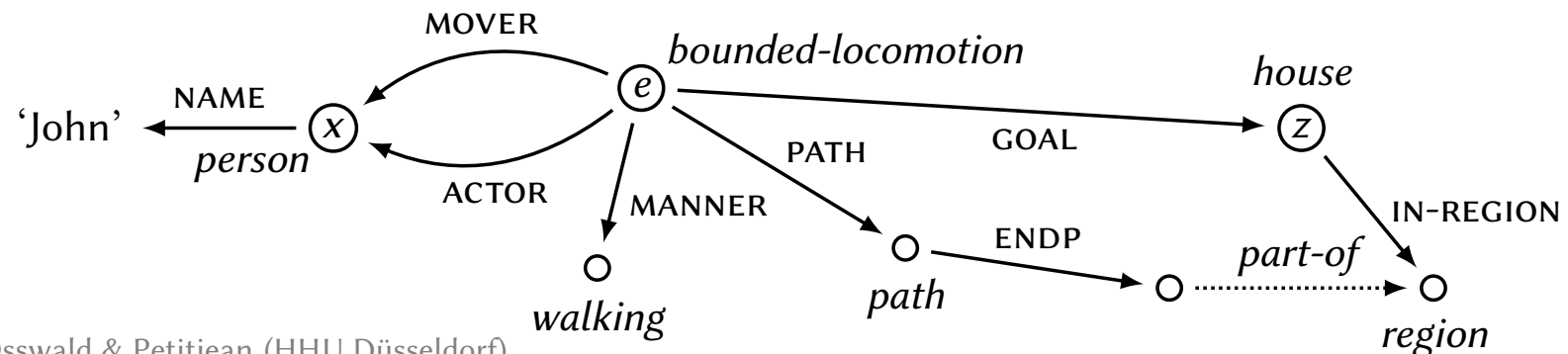


Case study: directed motion construction

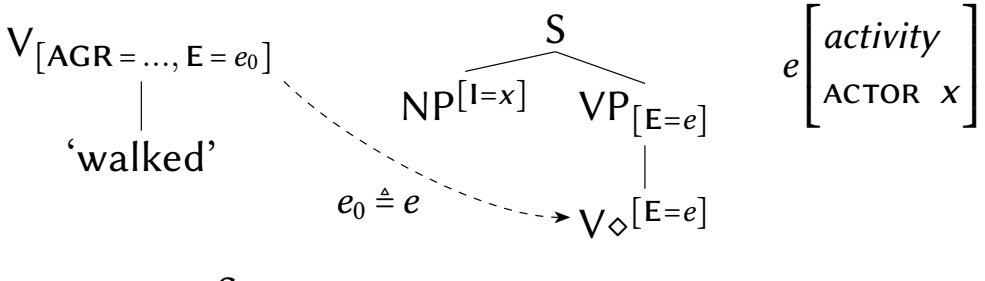
Lexical anchoring (non-directed case)

morph entry +
'walked'
pos: V
Syn_1:
$\left[\text{AGR} = \left[\begin{array}{l}\text{PERS} = 3\\ \text{NUM} = sg\end{array}\right]\right]$
lemma: walk

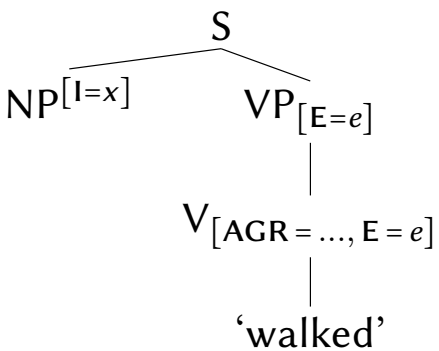
lemma entry +
walk:
FAM: n0V, …
Syn_2:
$\left[\text{E} = e_0\right]$
Sem:
$e_0\left[\begin{array}{ll}\textit{locomotion}\\ \text{MANNER} & [\textit{walking}]\end{array}\right]$

Constraints:
locomotion $\Rrightarrow$ *activity* $\wedge$ *translocation*
translocation $\Rrightarrow$ *motion* $\wedge$ PATH : *path*
activity $\Rrightarrow$ ACTOR : $\top$
motion $\Rrightarrow$ MOVER : $\top$
activity $\wedge$ *motion* $\Rrightarrow$ ACTOR $\doteq$ MOVER

$\rightsquigarrow$ $e_0\left[\begin{array}{ll}\textit{locomotion}\\ \text{ACTOR} & \boxed{1}\\ \text{MOVER} & \boxed{1}\\ \text{PATH} & [\textit{path}]\\ \text{MANNER} & [\textit{walking}]\end{array}\right]$



$\rightsquigarrow$ $e\left[\begin{array}{ll}\textit{locomotion}\\ \text{ACTOR} & \boxed{1}\ x\\ \text{MOVER} & \boxed{1}\\ \text{PATH} & [\textit{path}]\\ \text{MANNER} & [\textit{walking}]\end{array}\right]$



Case study: directed motion construction

Example

(7) John walked along the brook.

Case study: directed motion construction

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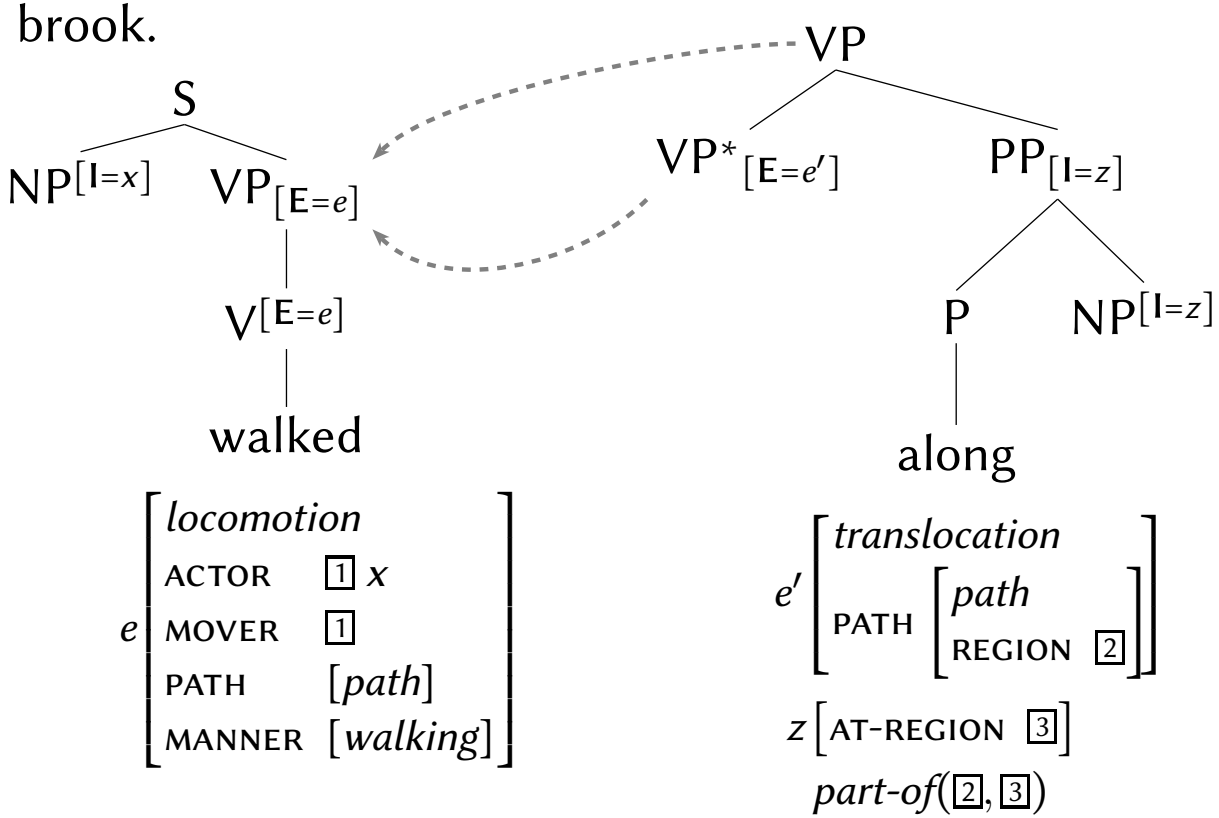

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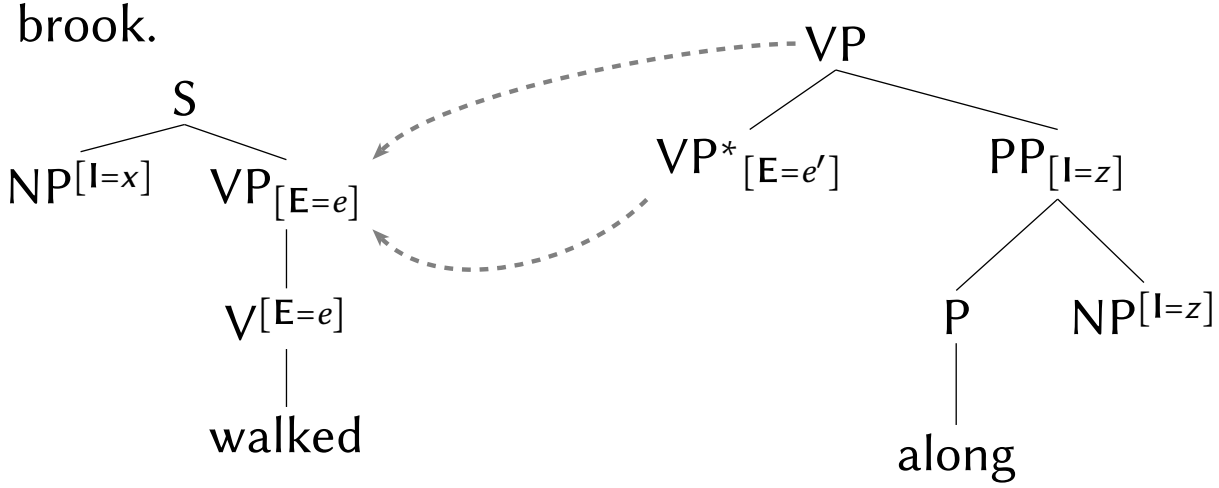
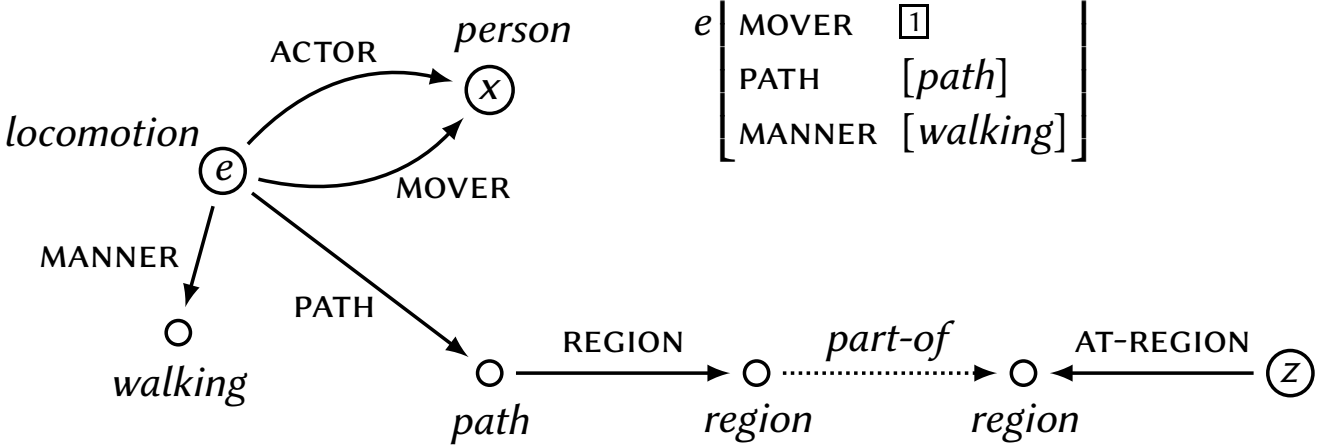


$$e\begin{bmatrix} \textit{locomotion} \\ \text{ACTOR} & \boxed{1}\ x \\ \text{MOVER} & \boxed{1} \\ \text{PATH} & [\textit{path}] \\ \text{MANNER} & [\textit{walking}] \end{bmatrix}$$

$$e'\begin{bmatrix} \textit{translocation} \\ \text{PATH} & \begin{bmatrix} \textit{path} \\ \text{REGION} & \boxed{2} \end{bmatrix} \end{bmatrix}$$

$$z\left[\text{AT-REGION}\ \boxed{3}\right]$$

$$\textit{part-of}(\boxed{2}, \boxed{3})$$



Case study: directed motion construction

Example (causative directed motion)

(8) Mary threw/kicked/rolled the ball into the room.

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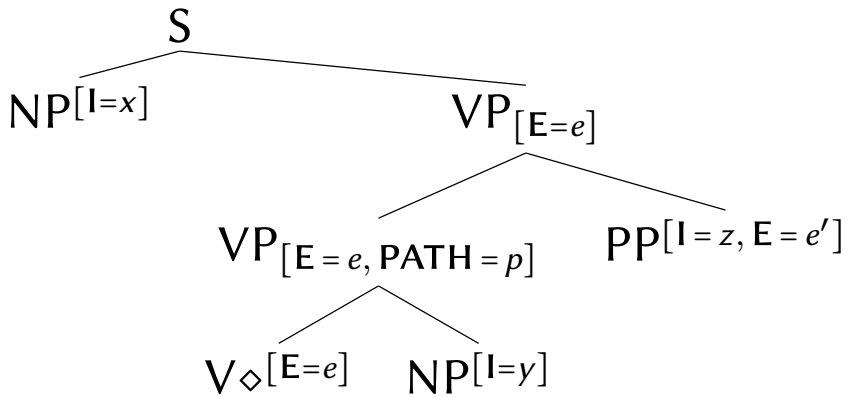
Unanchored construction (*n0Vn1pp(dir)*):



$$e\begin{bmatrix} \textit{causation} & \\ \textsc{cause} & \begin{bmatrix} \textit{activity} & \\ \textsc{actor} & x \\ \textsc{theme} & y \end{bmatrix} \\ \textsc{effect} & e'\begin{bmatrix} \textit{bounded-translocation} & \\ \textsc{mover} & y \\ \textsc{goal} & z \\ \textsc{path} & p \end{bmatrix} \end{bmatrix}$$

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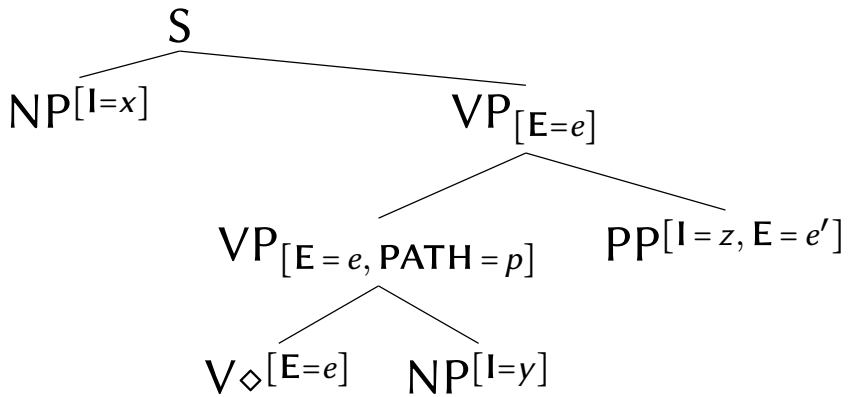

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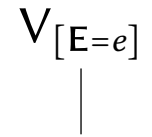
(Partial) lexical entry for ‘threw’:



$$e\begin{bmatrix} \textit{onset-causation} & \\ \textsc{cause} & \begin{bmatrix} \textit{activity} \\ \textsc{actor} & \top \\ \textsc{theme} & \boxed{1} \\ \textsc{manner} & [\textit{throwing}] \end{bmatrix} \\ \textsc{effect} & \begin{bmatrix} \textit{translocation} \wedge \textit{undergoing} \\ \textsc{theme} & \boxed{1} \\ \textsc{mover} & \boxed{1} \end{bmatrix} \end{bmatrix}$$

Case study: dative alternation

Sketch

[→ Kallmeyer/Osswald 2013]

(9) a. John sent Mary the book. (double object construction)
b. John sent the book to Mary. (prepositional object construction)

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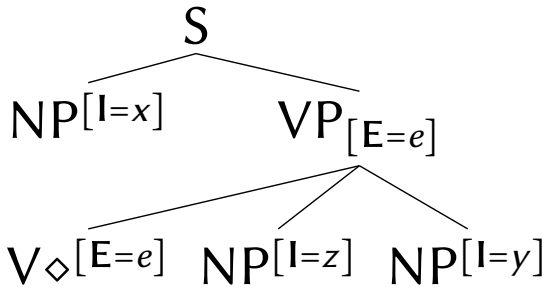
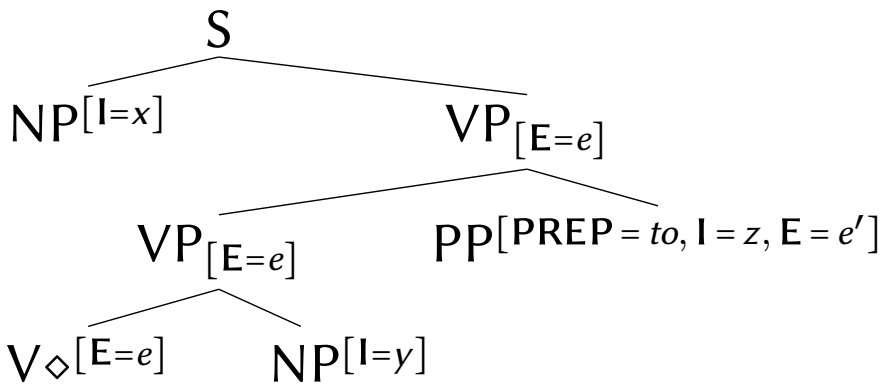
a)



$$e\begin{bmatrix}\textit{causation} & \\ \textsc{cause} & \begin{bmatrix}\textit{activity} \\ \textsc{actor} \quad x\end{bmatrix} \\ \textsc{effect} & \begin{bmatrix}\textit{change-of-possession} \\ \textsc{theme} \quad y \\ \textsc{recipient} \quad z\end{bmatrix}\end{bmatrix}$$

b)



$$e\begin{bmatrix}\textit{causation} & \\ \textsc{cause} & \begin{bmatrix}\textit{activity} \\ \textsc{actor} \quad x\end{bmatrix} \\ \textsc{effect} \quad e' & \begin{bmatrix}\textit{bounded-translocation} \\ \textsc{mover} \quad y \\ \textsc{goal} \quad z\end{bmatrix}\end{bmatrix}$$

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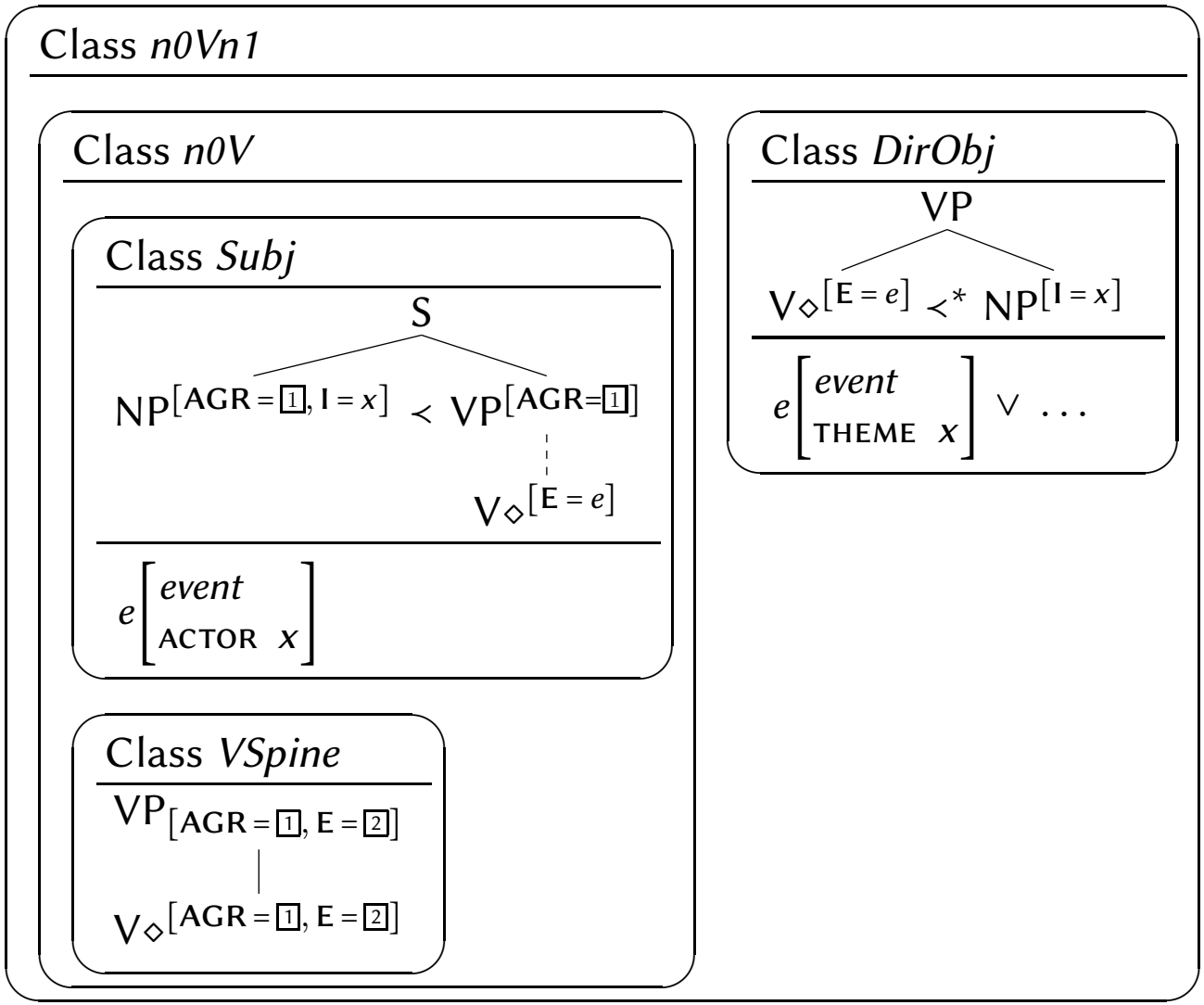
Outlook: Factorization in the metagrammar

Metagrammar classes (syntax + semantics)



Outlook: factorization in the metagrammar

Metagrammar classes (syntax + semantics)

Class *DirPrepObj*

export: e, x

$\mathrm{VP}_{[\mathrm{PATH}=p]}$

$\mathrm{VP}^{[\mathrm{PATH}=p]}$ $\prec$ $\mathrm{PP}^{[\mathrm{I}=x,\mathrm{E}=e]}$

$\mathrm{V}\diamond$

$$e\begin{bmatrix} \textit{bounded-translocation} \\ \textsc{goal} & x \\ \textsc{path} & p \end{bmatrix}$$

Class *n0Vpp(dir)*

identities: $C_1.e = C_2.e$

Class C_1 =*n0V*

export: e

…

Class C_2 =*DirPrepObj*

export: e, x

…

Class *n0Vn1pp(dir)*

identities: $C_1.e = e$, $C_2.x = z$, $C_2.e = e'$

Class C_1 =*n0Vn1*

export: e

…

Class C_2 =*DirPrepObj*

export: e, x

…

$$e\begin{bmatrix} \textit{causation} & & \\ \textsc{actor} & x\,\boxed{1} & \\ \textsc{theme} & y\,\boxed{2} & \\ \textsc{cause} & \begin{bmatrix} \textit{activity} \\ \textsc{actor} & \boxed{1} \\ \textsc{theme} & \boxed{2} \end{bmatrix} & \\ \textsc{effect} & e'\begin{bmatrix} \textsc{mover} & \boxed{2} \\ \textsc{goal} & z \end{bmatrix} & \end{bmatrix}$$

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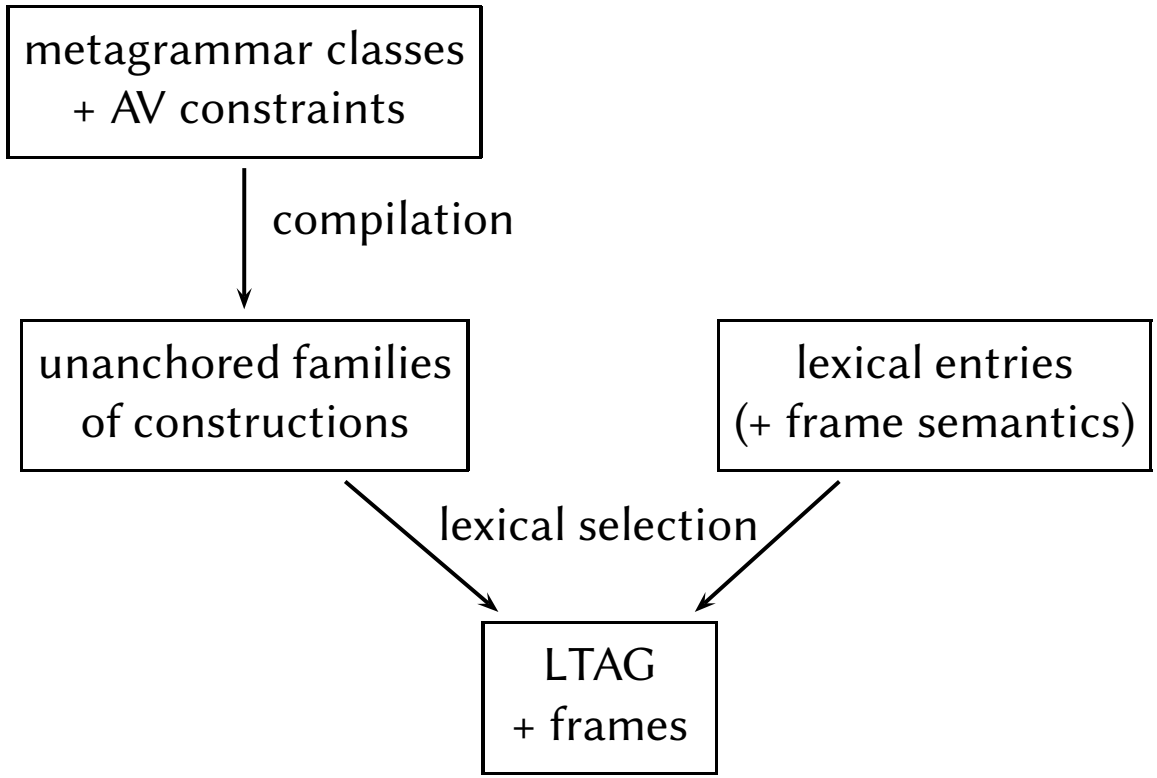
Summary & outlook

Summary



Summary & outlook

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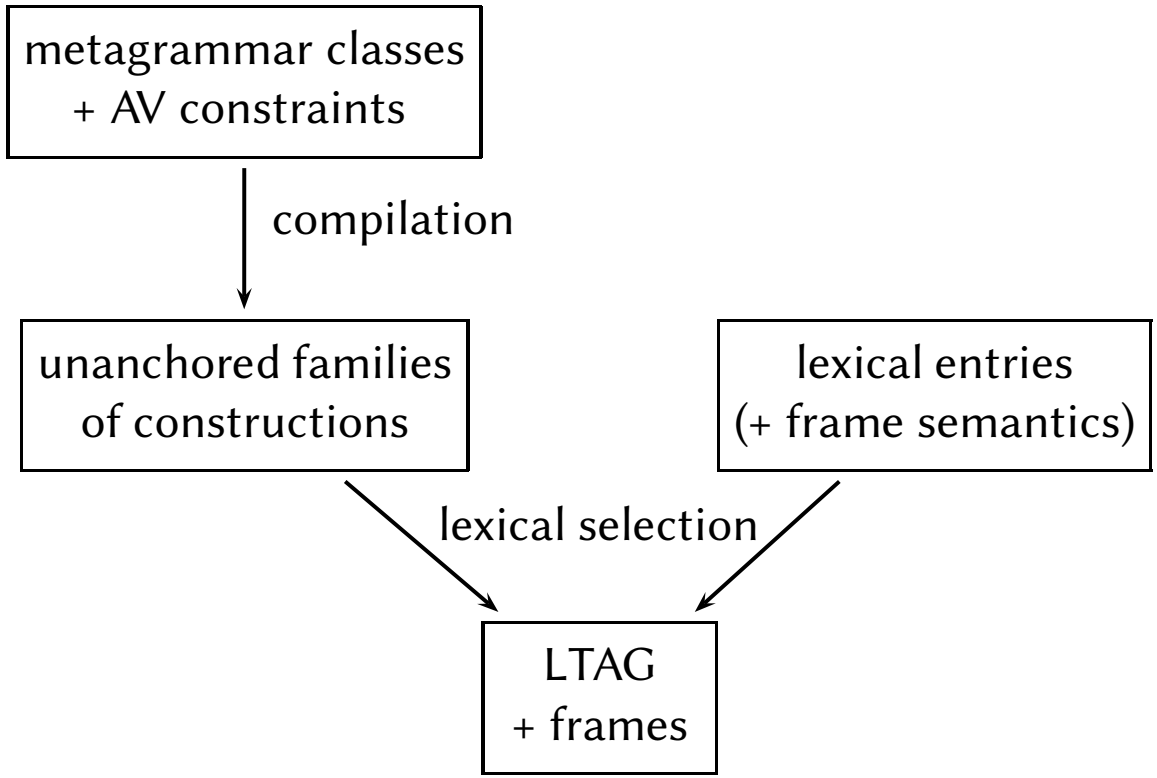

Next week (≠ Tomorrow !)

- Grammar engineering and XMG (eXtensible MetaGrammar)
- Implementing LTAG syntax and frame semantics with XMG
- Parsing implemented grammars with TuLiPA

References

Kallmeyer, Laura, Timm Lichte, Rainer Osswald & Simon Petitjean. 2016. Argument linking in LTAG: A constraint-based implementation with XMG. In **Proceedings of the 12th International Workshop on Tree Adjoining Grammars and related formalisms (TAG+12)**, 48–57.

Kallmeyer, Laura & Rainer Osswald. 2013. Syntax-driven semantic frame composition in Lexicalized Tree Adjoining Grammars. **Journal of Language Modelling** 1(2). 267–330.