Dynamic Syntax in Type Theory with Records

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2009-1569, Semantic analysis of interaction and coordination in dialogue (SAICD);
2016-01162, Incremental Reasoning in Dialogue (IncReD);
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Outline

DS in TTR

Using TTR contents in DS

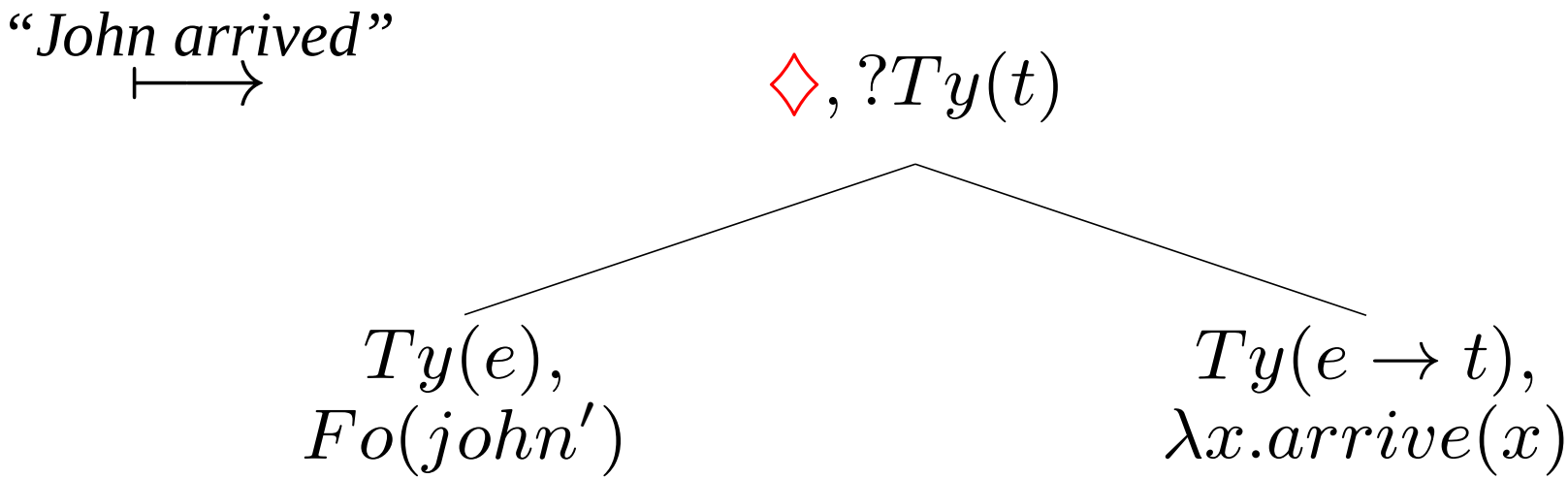
Adding speech events

Outline

Relating DS and TTR

- DS (Kempson *et al.*, 2001)
- TTR (Cooper, in prep, 2012; Cooper and Ginzburg, 2015)
- adding TTR for semantic representation (Eshghi, 2015)
- What might it look like to do everything in TTR?
- Is it even possible?

John arrived in DS



Tree nodes

Nodes seem to contain records of the type:

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That is, in official notation:

$$\begin{bmatrix} \text{type} & : & \mathit{Type} \\ \text{cont} & : & \langle \lambda v{:}\mathit{Type}.v, \langle \text{type} \rangle \rangle \end{bmatrix}$$

Daughters

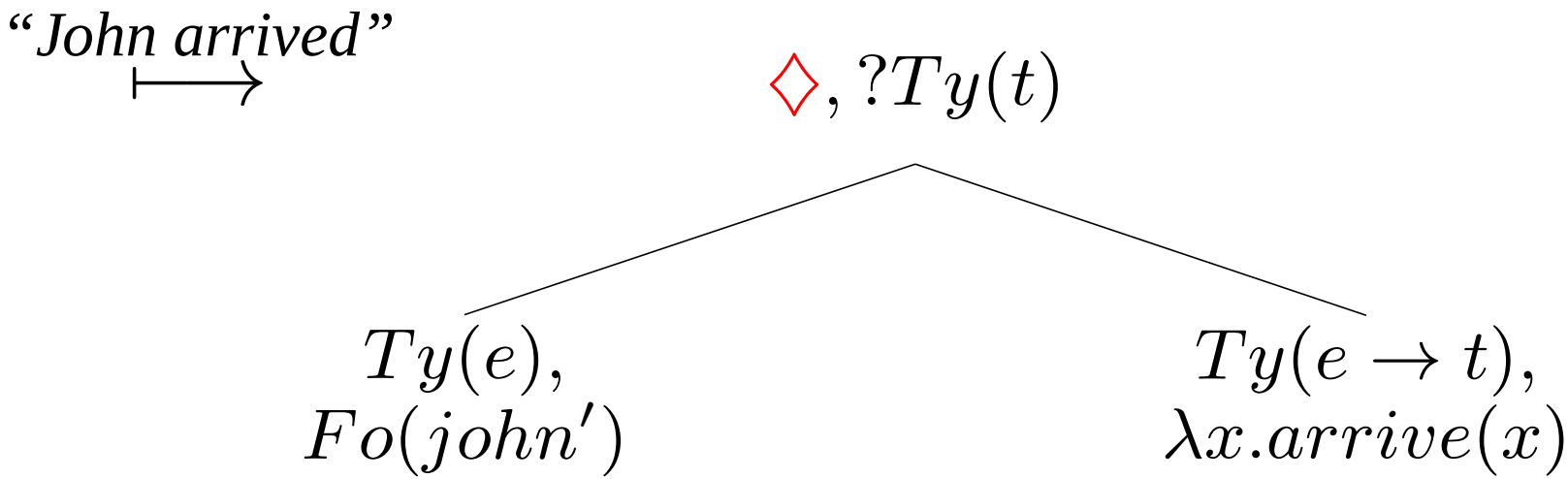
But tree nodes may have daughters.

Therefore we define a (basic, recursive) type *Tree* such that

$$a{:}\mathit{Tree} \text{ iff } a{:}\begin{bmatrix} \text{type} & : & \mathit{Type} \\ \text{cont} & : & \text{type} \\ \text{daughters} & : & \mathit{Tree}* \end{bmatrix}$$

*Tree** is the type of strings of trees (*cf.* Kleene-*) including the empty string, ϵ

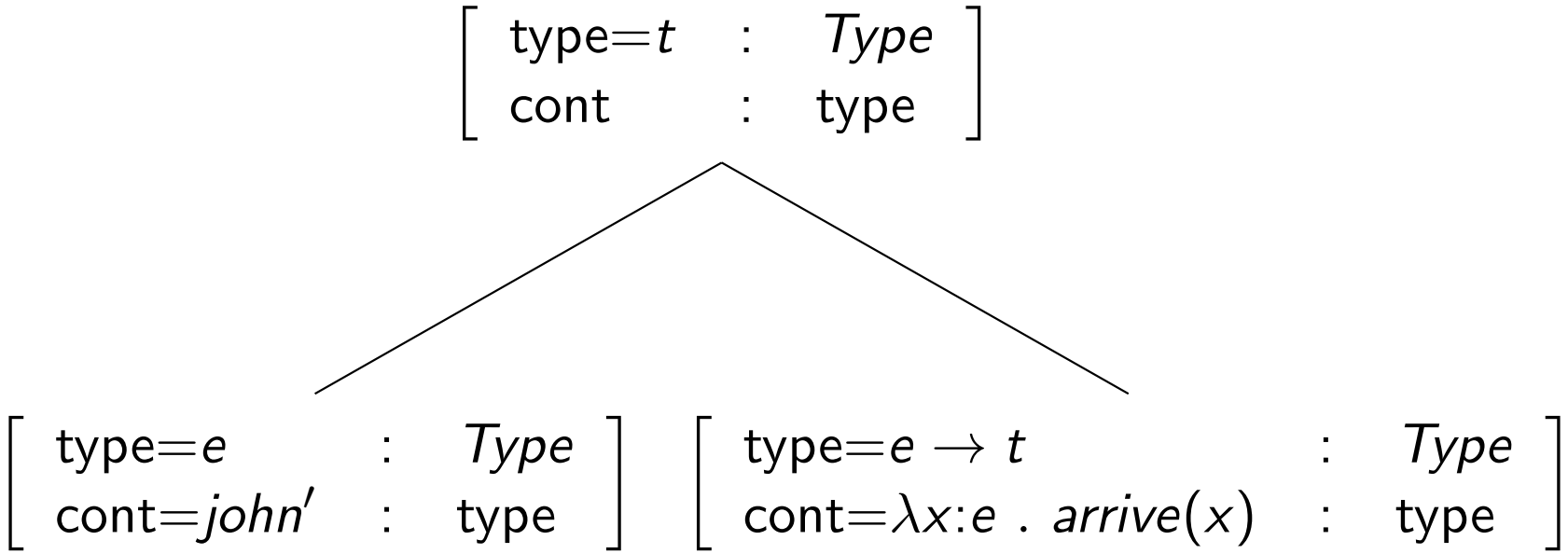
John arrived in DS (again)



Type for the tree for *John arrived*

$$\left[\begin{array}{lcl}
\text{type}{=}t & : & \mathit{Type} \\
\text{cont} & : & \text{type} \\
\text{daughters} & : & \left[\begin{array}{lcl}
\text{type}{=}e & : & \mathit{Type} \\
\text{cont}{=}\mathit{john}' & : & \text{type} \\
\text{daughters}{=}\epsilon & : & \mathit{Tree}^*
\end{array}\right]^\frown \\
 & & \left[\begin{array}{lcl}
\text{type}{=}e \rightarrow t & : & \mathit{Type} \\
\text{cont}{=}\lambda x{:}e\ .\ \mathit{arrive}(x) & : & \text{type} \\
\text{daughters}{=}\epsilon & : & \mathit{Tree}^*
\end{array}\right]
\end{array}\right]$$

or more diagrammatically . . .



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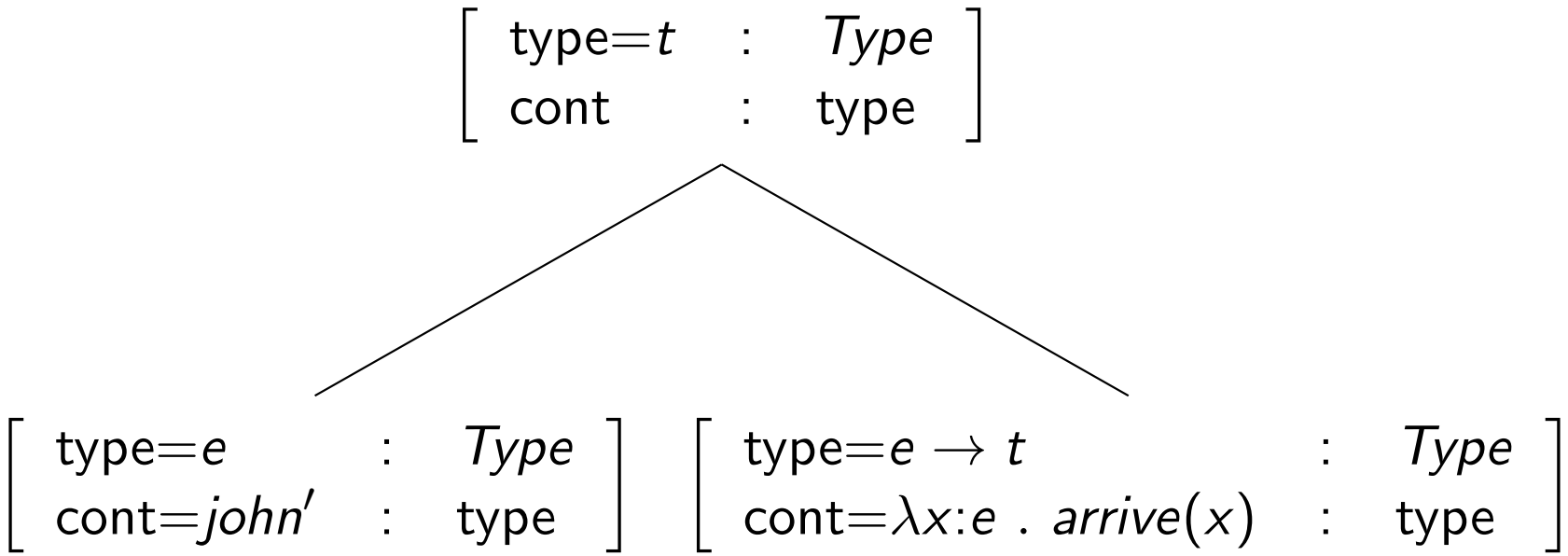

- Note that this represents a tree *type*, not a tree

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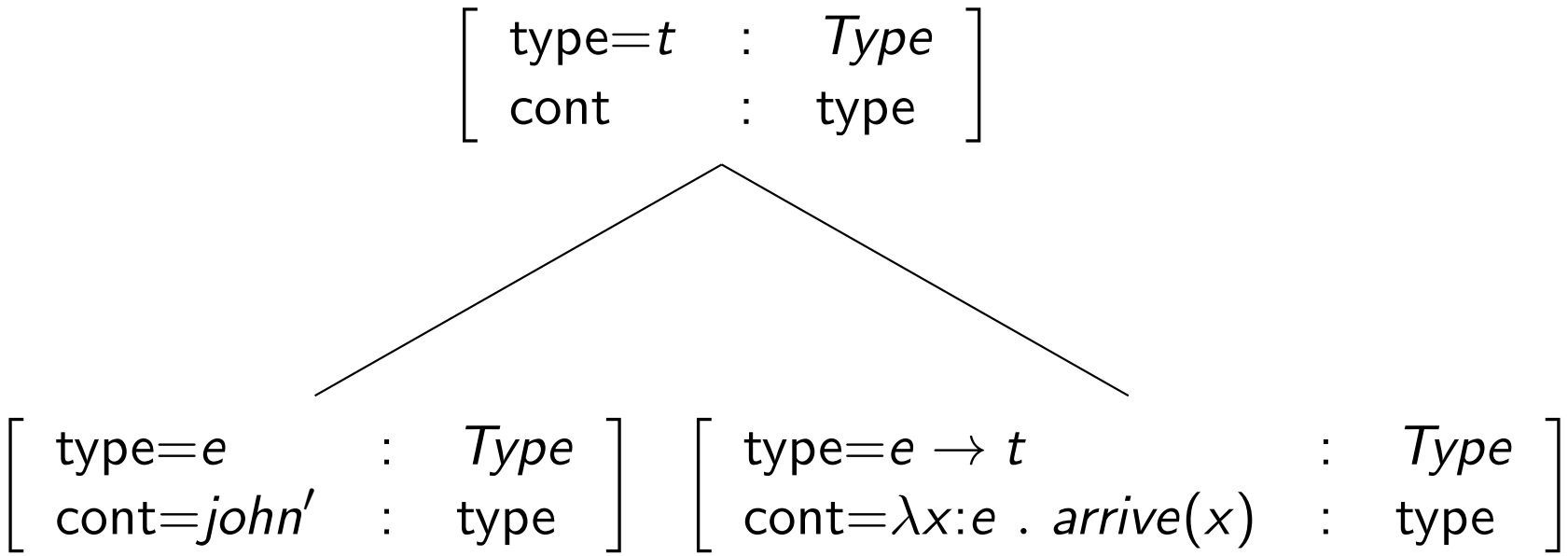

- Note that this represents a tree *type*, not a tree
- cf underspecified trees

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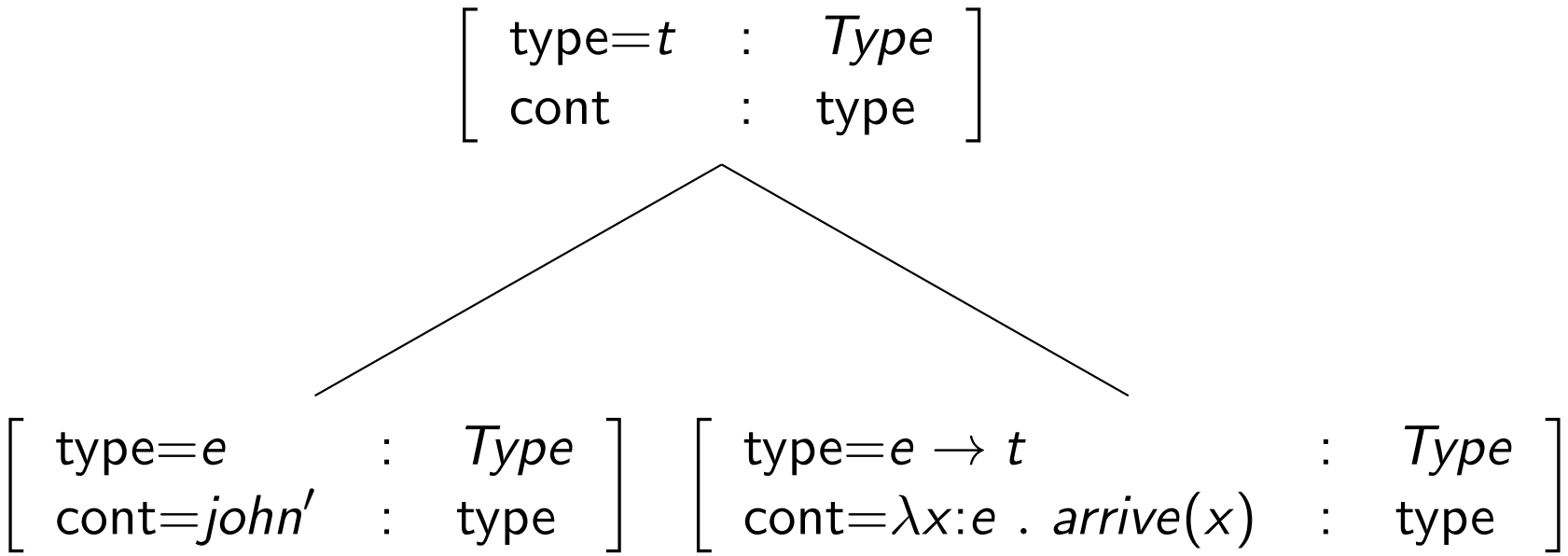

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- a record type is *fully specified* iff all its fields are manifest

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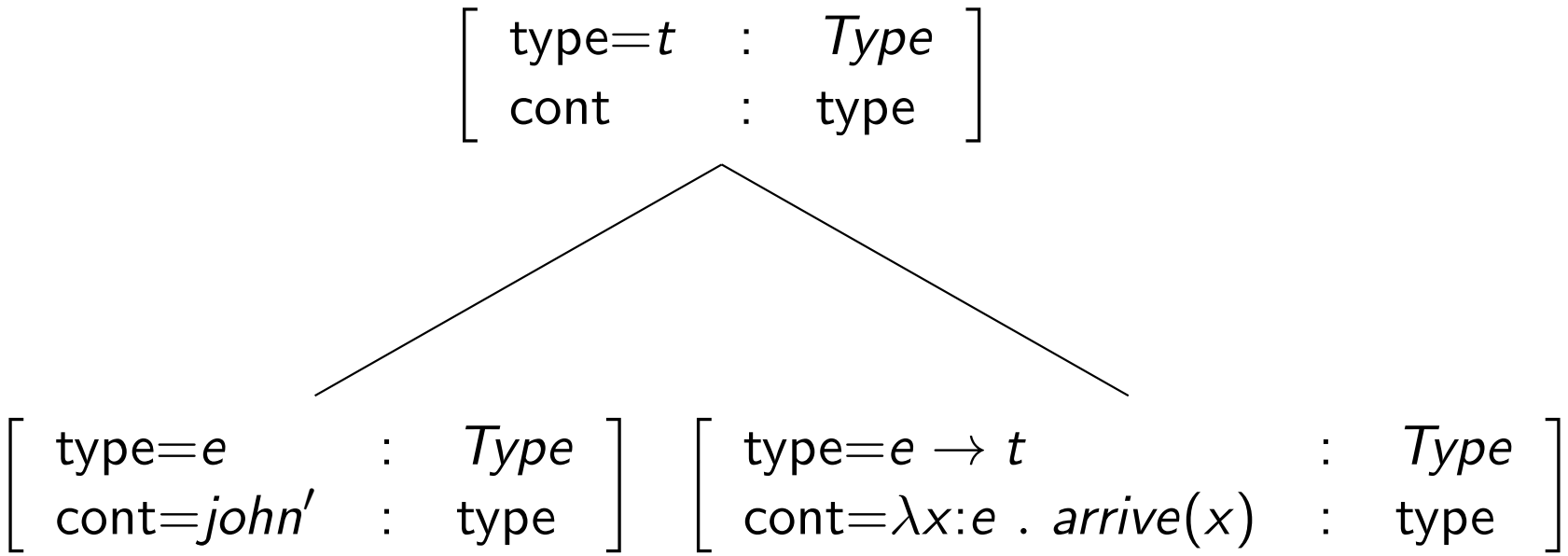

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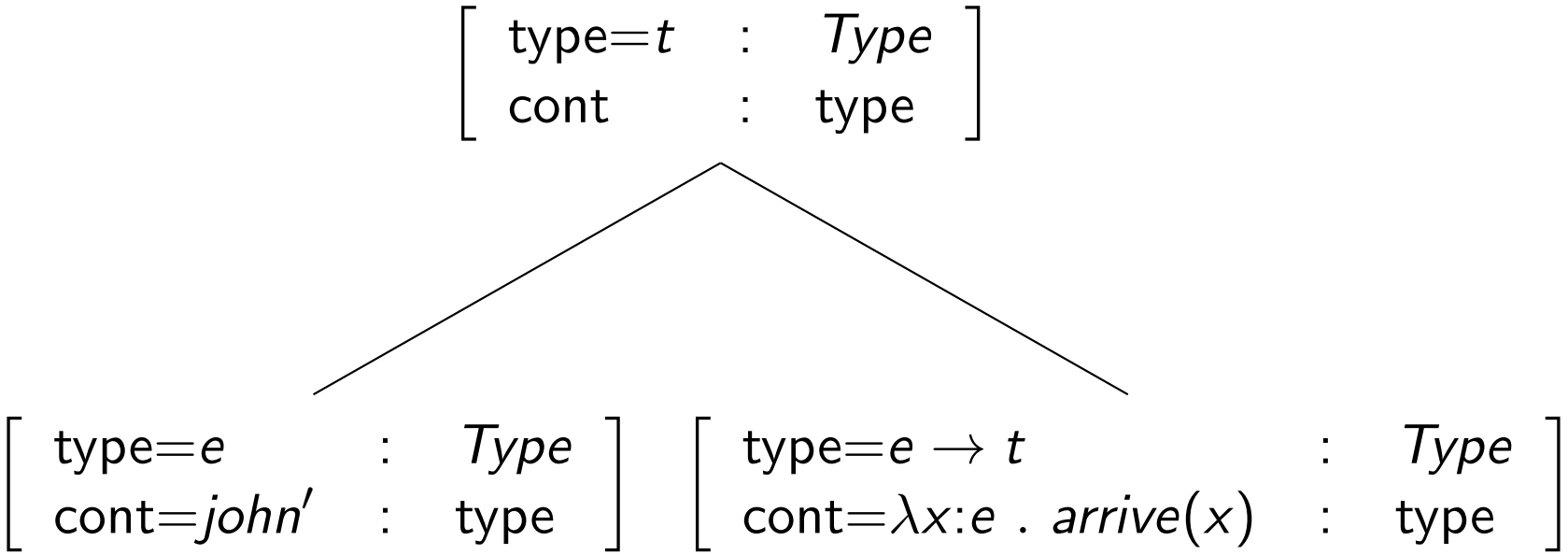

- Note that this represents a tree *type*, not a tree
- cf underspecified trees
- a record type is *fully specified* iff all its fields are manifest
- it is *underspecified* otherwise
- this type is underspecified with respect to the path 'cont'

More underspecification

$$\begin{bmatrix} \text{type}{=}t & : & \mathit{Type} \\ \text{cont} & : & \text{type} \end{bmatrix}$$

$$\begin{bmatrix} \text{type}{=}e & : & \mathit{Type} \\ \text{cont}{=}\mathit{john}' & : & \text{type} \end{bmatrix}$$

cf. D-theory (Marcus *et al.*, 1983), functional uncertainty in LFG

Components in records

- An object, a, is a *component* of a record, r, in symbols, $a \varepsilon r$, just in case there is some path, π, in r such that $r.\pi = a$
- A string $a_0^\frown \ldots ^\frown a_n$ can be viewed as a record
$$\begin{bmatrix} t_0 & = & a_0 \\ \vdots & & \\ t_n & = & a_n \end{bmatrix}$$
- Thus there are paths into strings occuring as a component in a record

Types of objects containing a certain component

If a is an object of some type and T is a type, then $T_{a\varepsilon}$ is a type.
$b : T_{a\varepsilon}$ iff $b : T$ and $a \varepsilon b$.

Type for the tree with unattached node

$$\left[\begin{array}{lcl} \text{type}{=}t & : & \mathit{Type} \\ \text{cont} & : & \text{type} \\ \text{daughters} & : & \mathit{Tree}^{*} \left[\begin{array}{lcl} \text{type}{=}e & : & \mathit{Type} \\ \text{cont}{=}\mathit{john}' & : & \text{type} \end{array}\right]_{\varepsilon} \end{array}\right]$$

Lexical entry for *John*

john:

IF	$?Ty(e)$
THEN	put($Ty(e)$)
	put($Fo(john')$)
ELSE	abort

Lexical entries as update rules

If $T_i = \begin{bmatrix} \text{type=e} & : & \mathit{Type} \\ \text{cont} & : & \text{type} \end{bmatrix}$,

then set T_{i+1} to be $\begin{bmatrix} \text{type=e} & : & \mathit{Type} \\ \text{cont=}\mathit{john}' & : & \text{type} \end{bmatrix}$

Lexical entries as type refinements

$$\begin{bmatrix} \text{type}{=}\text{e} & : & \mathit{Type} \\ \text{cont} & : & \text{type} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{type}{=}\text{e} & : & \mathit{Type} \\ \text{cont}{=}\mathit{john}' & : & \text{type} \end{bmatrix}$$

Type rewrite rule which is a type refinement because $RHS \sqsubseteq LHS$

More general version of type refinement rule

$$\text{If } T \sqsubseteq \begin{bmatrix} \text{type=e} & : & \mathit{Type} \\ \text{cont} & : & \text{type} \end{bmatrix}:$$

$$T \Rightarrow T \wedge_{\cdot} \begin{bmatrix} \text{type=e} & : & \mathit{Type} \\ \text{cont=}\mathit{john}' & : & \text{type} \end{bmatrix}$$

Outline

Alternative using TTR-style content

$$\left[\begin{array}{lcl} \text{type}=\left[\text{x}:\mathit{Ind}\right] & : & \mathit{Type} \\ \text{cont} & : & \text{type} \end{array}\right] \Rightarrow \left[\begin{array}{lcl} \text{type}=\left[\text{x}:\mathit{Ind}\right] & : & \mathit{Type} \\ \text{cont}=\left[\text{x}=\text{john}\right] & : & \text{type} \end{array}\right]$$

Type for *John arrived* with TTR content

$$\begin{bmatrix} \text{type}=\mathit{RecType}:\mathit{Type} \\ \text{cont}=\begin{bmatrix} \text{x}=\text{john}:\mathit{Ind} \\ \text{p:arrive(x)} \end{bmatrix}:\text{type} \end{bmatrix}$$

$$\begin{bmatrix} \text{type}=\left[\text{x}:\mathit{Ind}\right]:\mathit{Type} \\ \text{cont}=\left[\text{x}=\text{john}\right]:\text{type} \end{bmatrix} \qquad \begin{bmatrix} \text{type}=\left(\left[\text{x}:\mathit{Ind}\right]\rightarrow\mathit{RecType}\right):\mathit{Type} \\ \text{cont}=\lambda r:\left[\text{x}:\mathit{Ind}\right] \ . \ \begin{bmatrix} \text{x}=r.\text{x}:\mathit{Ind} \\ \text{p:arrive(x)} \end{bmatrix}:\text{type} \end{bmatrix}$$

Outline

Split utterances

A. You burned . . .
B. . . . myself

Speech events

$$SEvent = \begin{bmatrix} \mathsf{sp} & : & \mathit{Ind} \\ \mathsf{au} & : & \mathit{Ind} \\ \mathsf{e} & : & \mathit{Phon} \\ \mathsf{c}_{\mathsf{sp}} & : & \mathsf{speaker(e,sp)} \\ \mathsf{c}_{\mathsf{au}} & : & \mathsf{audience(e,au)} \end{bmatrix}$$

Indexical pronouns

I, me $\left[\begin{array}{lll} \text{s-event} & : & \mathit{SEvent} \\ \text{type}=\left[\text{x}:\mathit{Ind}\right] & : & \mathit{Type} \\ \text{cont} & : & \text{type} \end{array}\right] \Rightarrow$

$\left[\begin{array}{lll} \text{s-event} & : & \mathit{SEvent} \\ \text{type}=\left[\text{x}:\mathit{Ind}\right] & : & \mathit{Type} \\ \text{cont}=\left[\text{x}=\text{s-event.sp}\right] & : & \text{type} \end{array}\right]$

- different s-event for each incremental item, therefore potentially different speakers for different incremental items
- sign-based approach

Still to be done

- a neat solution for the focus, $\Diamond$ – possibly just an additional field
- linked nodes
- ...
- working out (and implementing) a detailed grammar based on these ideas

Why?

- because we can (or perhaps, ultimately, *cannot*)
- TTR would like to bill itself as a foundation for various linguistic theories
- . . . allowing integration of analyses in different theories or pointing up relations between them
- Perhaps there are elements in TTR which DS would find useful in addition to the use of TTR for semantic representation
- In general, the more theoretical light from different perspectives we can shed on incremental processing of language, the better

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