Dependent Record Types and Compositional Semantics

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Overview

- Classical DRT
- Extending classical DRT with intensional constructions
- Introducing questions
- Clarification ellipsis (HPSG, situation semantics)

Why use dependent record types

- suitability for semantic notions (e.g. functions, binding)
- feature structure like objects that can combine phonological, syntactic and semantic information
- dependent record types inherently dynamic – DRT-like analysis of anaphora.
- structured objects needed for our analysis of clarification ellipses

Records and record types

If $a_1 : T_1, a_2 : T_2(a_1), \ldots, a_n : T_n(a_1, a_2, \ldots, a_{n-1})$,

the record:

$$\left[\begin{array}{lcl} l_1 & = & a_1 \\ l_2 & = & a_2 \\ \ldots & & \\ l_n & = & a_n \end{array}\right]$$

is of type:

$$\left[\begin{array}{lcl} l_1 & : & T_1 \\ l_2 & : & T_2(l_1) \\ \ldots & & \\ l_n & : & T_n(l_1, l_2, \ldots, l_{n-1}) \end{array}\right]$$

a man owns a donkey

Record type:

$$\begin{bmatrix} x & : & \text{Ind} \\ c_1 & : & \text{man}(x) \\ y & : & \text{Ind} \\ c_2 & : & \text{donkey}(y) \\ c_3 & : & \text{own}(x,y) \end{bmatrix}$$

Record:

$$\begin{bmatrix} x & = & a \\ c_1 & = & p_1 \\ y & = & b \\ c_2 & = & p_2 \\ c_3 & = & p_3 \end{bmatrix}$$

where
a, b are of type Ind, individuals
p_1 is a proof of man(a)
p_2 is a proof of donkey(b)
p_3 is a proof of own(a, b)

a man

$$[\![\ [_{\text{Det}}\ \text{a}]\ ]\!] = \lambda R_1{:}(\left[\text{x:Ind}\right])\text{RecType}\ \lambda R_2{:}(\left[\text{x:Ind}\right])\text{RecType}\ (\begin{bmatrix} \text{par} & : & [\ \text{x} & : & \text{Ind}\ ] \\ \text{restr} & : & R_1\ @\ \text{par} & & \\ \text{scope} & : & R_2\ @\ \text{par} & & \end{bmatrix})$$

$$[\![\ [_{\text{N}}\ \text{man}]\ ]\!] = {}^{\lambda}\begin{bmatrix} \text{x} & : & \text{Ind} \\ \text{c} & : & \text{man(x)} \end{bmatrix}$$

$${}^{\lambda}\begin{bmatrix} \ell_1 & : & T_1 \\ \ell_2 & : & T_2(\ell_1) \\ & \vdots & \\ \ell_n & : & T_n(\ell_1, \ell_2, \ldots, \ell_{n-1}) \end{bmatrix} = \lambda r{:}\left[\ell_1{:}T_1\right](\begin{bmatrix} \ell_2 & : & T_2(r.\ell_1) \\ & \vdots & \\ \ell_n & : & T_n(r.\ell_1, \ell_2, \ldots, \ell_{n-1}) \end{bmatrix})$$

$$[\![\ [_{\text{NP}}\ \text{Det N}]\ ]\!] = [\![\ \text{Det}\ ]\!]\ @\ [\![\ \text{N}\ ]\!]$$

$$\lambda R_1{:}(\big[\text{x:Ind}\big])\text{RecType}\,\lambda R_2{:}(\big[\text{x:Ind}\big])\text{RecType}\,(\begin{bmatrix} \text{par} & : & \big[\ \text{x} & : & \text{Ind}\ \big] \\ \text{restr} & : & R_1\ @\ \text{par} & & \\ \text{scope} & : & R_2\ @\ \text{par} & & \end{bmatrix})$$

$@$

$$\lambda r{:}\big[\text{x:Ind}\big](\big[\text{c:man}(r.\text{x})\big])$$

$=$

$$\lambda R_2{:}(\big[\text{x:Ind}\big])\text{RecType}\begin{bmatrix} \text{par} & : & \big[\ \text{x} & : & \text{Ind}\ \big] \\ \text{restr} & : & \big[\ \text{c} & : & \text{man}(\text{par.x})\ \big] \\ \text{scope} & : & R_2\ @\ \text{par} & & \end{bmatrix}$$

$$[\![\ [_{\mathrm{V}}\ \text{owns}]\ ]\!] = \overset{\text{tvr}}{\begin{bmatrix} \text{x} & : & \text{Ind} \\ \text{y} & : & \text{Ind} \\ \text{c} & : & \text{own(x,y)} \end{bmatrix}}$$

$$\overset{\text{tvr}}{\begin{bmatrix} \text{x} & : & \text{Ind} \\ \text{y} & : & \text{Ind} \\ \text{c} & : & T\text{(x,y)} \end{bmatrix}} = \lambda\mathcal{N}{:}((([\text{x:Ind}])\text{RecType})\text{RecType}\ \lambda r_1{:}[\text{x:Ind}]\ (\mathcal{N}\ @\ \lambda r_2{:}[\text{x:Ind}]([\text{c:}T(r_1.\text{x},\ r_2.\text{x})])))$$

$$\lambda\mathcal{N}{:}((([\text{x:Ind}])\text{RecType})\text{RecType}\ \lambda r_1{:}[\text{x:Ind}]\ (\mathcal{N}\ @\ \lambda r_2{:}[\text{x:Ind}]([\text{c:own}(r_1.\text{x},\ r_2.\text{x})])))$$

own a donkey

$$\lambda\mathcal{N}{:}((\left[\text{x:Ind}\right])\text{RecType})\text{RecType}\ \lambda r_1{:}\left[\text{x:Ind}\right] \\ (\mathcal{N}\ @\ \lambda r_2{:}\left[\text{x:Ind}\right](\left[\text{c:own}(r_1.\text{x},\ r_2.\text{x})\right]))$$

@

$$\lambda R_2{:}(\left[\text{x:Ind}\right])\text{RecType}\begin{bmatrix}\text{par} & : & \begin{bmatrix}\text{x} & : & \text{Ind}\end{bmatrix} \\ \text{restr} & : & \begin{bmatrix}\text{c} & : & \text{donkey(par.x)}\end{bmatrix} \\ \text{scope} & : & R_2\ @\ \text{par}\end{bmatrix}$$

=

$$\lambda r_1{:}\left[\text{x:Ind}\right]\ (\begin{bmatrix}\text{par} & : & \begin{bmatrix}\text{x} & : & \text{Ind}\end{bmatrix} \\ \text{restr} & : & \begin{bmatrix}\text{c} & : & \text{donkey(par.x)}\end{bmatrix} \\ \text{scope} & : & \begin{bmatrix}\text{c} & : & \text{own}(r_1.\text{x},\text{par.x})\end{bmatrix}\end{bmatrix})$$

$[\![\ [_{\text{VP}}\ \text{V NP}]\ ]\!] = [\![\ \text{V}\ ]\!]\ @\ [\![\ \text{NP}\ ]\!]$

a man owns a donkey

$$\lambda R_2{:}(\left[\text{x:Ind}\right])\text{RecType}\left[\begin{array}{lcl}\text{par} & : & \left[\begin{array}{lcl}\text{x} & : & \text{Ind}\end{array}\right] \\ \text{restr} & : & \left[\begin{array}{lcl}\text{c} & : & \text{man(par.x)}\end{array}\right] \\ \text{scope} & : & R_2 \text{ @ par}\end{array}\right]$$

@

$$\lambda r_1{:}\left[\text{x:Ind}\right]\left(\left[\begin{array}{lcl}\text{par} & : & \left[\begin{array}{lcl}\text{x} & : & \text{Ind}\end{array}\right] \\ \text{restr} & : & \left[\begin{array}{lcl}\text{c} & : & \text{donkey(par.x)}\end{array}\right] \\ \text{scope} & : & \left[\begin{array}{lcl}\text{c} & : & \text{own}(r_1\text{.x, par.x})\end{array}\right]\end{array}\right]\right)$$

=

$$\left[\begin{array}{lcl}\text{par} & : & \left[\begin{array}{lcl}\text{x} & : & \text{Ind}\end{array}\right] \\ \text{restr} & : & \left[\begin{array}{lcl}\text{c} & : & \text{man(par.x)}\end{array}\right] \\ \text{scope} & : & \left[\begin{array}{lcl}\text{par} & : & \left[\begin{array}{lcl}\text{x} & : & \text{Ind}\end{array}\right] \\ \text{restr} & : & \left[\begin{array}{lcl}\text{c} & : & \text{donkey(scope.par.x)}\end{array}\right] \\ \text{scope} & : & \left[\begin{array}{lcl}\text{c} & : & \text{own(par.x, scope.par.x)}\end{array}\right]\end{array}\right]\end{array}\right]$$

$[\![\ [_{\text{S}}\ \text{NP VP}]\ ]\!] = [\![\ \text{NP}\ ]\!] \text{ @ } [\![\ \text{VP}\ ]\!]$

Flattening

$$\left[\begin{array}{lcl}\text{par.x} & : & \text{Ind} \\ \text{restr.c} & : & \text{man(par.x)} \\ \text{scope.par.x} & : & \text{Ind} \\ \text{scope.restr.c} & : & \text{donkey(scope.par.x)} \\ \text{scope.scope.c} & : & \text{own(par.x, scope.par.x)}\end{array}\right]$$

Relabelling

$$\begin{bmatrix} x & : & \text{Ind} \\ c_1 & : & \text{man}(x) \\ y & : & \text{Ind} \\ c_2 & : & \text{donkey}(y) \\ c_3 & : & \text{own}(x,\ y) \end{bmatrix}$$

every man owns a donkey

$$\left[\begin{array}{lcl} f & : & (\left[\begin{array}{lcl} x & : & \text{Ind} \\ c_1 & : & \text{man}(x) \end{array}\right]) \left[\begin{array}{lcl} y & : & \text{Ind} \\ c_2 & : & \text{donkey}(y) \\ c_3 & : & \text{own}(x,y) \end{array}\right] \end{array}\right]$$

every man

$$\lambda R_1{:}(\left[\text{x:Ind}\right])\text{RecType}\ \lambda R_2{:}(\left[\text{x:Ind}\right])\text{RecType}\ \left[\begin{array}{lcl}\text{f} & : & (r : \left[\begin{array}{lcl}\text{par} & : & \left[\begin{array}{lcl}\text{x} & : & \text{Ind}\end{array}\right] \\ \text{restr} & : & R_1\ @\ \text{par}\end{array}\right])\ R_2\ @\ r.\text{par}\end{array}\right]$$

@

$$\lambda r{:}\left[\text{x:Ind}\right](\left[\text{c:man}(r.\text{x})\right])$$

=

$$\lambda R_2{:}(\left[\text{x:Ind}\right])\text{RecType}\ \left[\begin{array}{lcl}\text{f} & : & (r : \left[\begin{array}{lcl}\text{par} & : & \left[\begin{array}{lcl}\text{x} & : & \text{Ind}\end{array}\right] \\ \text{restr} & : & \left[\begin{array}{lcl}\text{c} & : & \text{man}(\text{par.x})\end{array}\right]\end{array}\right])\ R_2\ @\ r.\text{par}\end{array}\right]$$

every man who owns a donkey beats it

$$\left[\begin{array}{lcl} & & \left[\begin{array}{lcl} x & : & \mathrm{Ind} \\ c_1 & : & \mathrm{man}(x) \\ y & : & \mathrm{Ind} \\ c_2 & : & \mathrm{donkey}(y) \\ c_3 & : & \mathrm{own}(x,y) \end{array}\right] \\ f & : & (\quad)\left[\begin{array}{lcl} c_4 & : & \mathrm{beat}(x,y) \end{array}\right] \end{array}\right]$$

$$[\![\ [_{\mathrm{NP}}\ \text{he/him/she/her/it}]\ ]\!] = {}^{\mathrm{npr}}\begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c} & : & \mathrm{eq(Ind,\ x,\ ?)} \end{bmatrix}$$

$$\text{If } T = \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c} & : & T_c(\mathrm{x}) \end{bmatrix}$$

$$\text{then } {}^{\mathrm{npr}}T = \lambda R{:}(\boxed{\mathrm{x{:}Ind}})\mathrm{RecType}\begin{bmatrix} \mathrm{par} & : & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \end{bmatrix} \\ \mathrm{restr} & : & {}^{\lambda}T\ @\ \mathrm{par} \\ \mathrm{scope} & : & R\ @\ \mathrm{par} \end{bmatrix}$$

beats it

$$\lambda\mathcal{N}{:}((\boxed{\mathrm{x{:}Ind}})\mathrm{RecType})\mathrm{RecType}\ \lambda r_1{:}\boxed{\mathrm{x{:}Ind}}$$
$$(\mathcal{N}\ @\ \lambda r_2{:}\boxed{\mathrm{x{:}Ind}}(\boxed{\mathrm{c{:}beat}(r_1.\mathrm{x},\ r_2.\mathrm{x})}))$$

@

$$\lambda R{:}(\boxed{\mathrm{x{:}Ind}})\mathrm{RecType}\left(\begin{bmatrix} \mathrm{par} & : & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \end{bmatrix} \\ \mathrm{restr} & : & \begin{bmatrix} \mathrm{c} & : & \mathrm{eq(Ind,\ par.x,\ ?)} \end{bmatrix} \\ \mathrm{scope} & : & R\ @\ \mathrm{par} \end{bmatrix}\right)$$

=

$$\lambda r_1{:}\boxed{\mathrm{x{:}Ind}}\left(\begin{bmatrix} \mathrm{par} & : & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \end{bmatrix} \\ \mathrm{restr} & : & \begin{bmatrix} \mathrm{c} & : & \mathrm{eq(Ind,\ par.x,\ ?)} \end{bmatrix} \\ \mathrm{scope} & : & \begin{bmatrix} \mathrm{c} & : & \mathrm{beat}(r_1.\mathrm{x},\ \mathrm{par.x}) \end{bmatrix} \end{bmatrix}\right)$$

every man who owns a donkey beats it

$$\left[\begin{array}{l} \\ \text{f} : (r : \left[\begin{array}{ll} \text{par} : \left[\text{x} : \text{Ind}\right] \\ \text{restr} : \left[\text{c} : \left[\begin{array}{ll} \text{pred} : \left[\text{c} : \text{man(par.x)}\right] \\ \text{mod} : \left[\begin{array}{ll} \text{par} : \left[\text{x} : \text{Ind}\right] \\ \text{restr} : \left[\text{c} : \text{donkey(restr.c.mod.par.x)}\right] \\ \text{scope} : \left[\text{c} : \text{own(par.x, restr.c.mod.par.x)}\right] \end{array}\right] \end{array}\right]\right] \end{array}\right] \\ \left[\begin{array}{ll} \text{par} : \left[\text{x} : \text{Ind}\right] \\ \text{restr} : \left[\text{c} : \text{eq(Ind, par.x, ?)}\right] \\ \text{scope} : \left[\text{c} : \text{beat}(r\text{.par.x, par.x})\right] \end{array}\right] \end{array}\right]$$

Resolution

We find candidate paths for the resolution of the metavariable '?' by looking for paths of the form ....par.x:Ind. The candidates are

r.par.x
r.restr.c.mod.par.x
par.x
and in addition if there were any r' defined (representing context) then any path r'. ....par.x would be included in the list (provided x:Ind)

The first and third of these are ruled out by grammatical constraints not yet included in the grammar. Therefore we choose the second.

$$\left[\begin{array}{l} \\ \text{f} : (r : \left[\begin{array}{ll} \text{par} : \left[\text{x} : \text{Ind}\right] & \\ \text{restr} : \left[\text{c} : \left[\begin{array}{ll} \text{pred} : \left[\text{c} : \text{man(par.x)}\right] & \\ \text{mod} : \left[\begin{array}{ll} \text{par} : \left[\text{x} : \text{Ind}\right] & \\ \text{restr} : \left[\text{c} : \text{donkey(restr.c.mod.par.x)}\right] & \\ \text{scope} : \left[\text{c} : \text{own(par.x, restr.c.mod.par.x)}\right] & \end{array}\right] & \end{array}\right] & \end{array}\right] & \\ \left[\begin{array}{ll} \text{par} : \left[\text{x} : \text{Ind}\right] & \\ \text{restr} : \left[\text{c} : \text{eq(Ind, par.x, } r\text{.restr.c.mod.par.x)}\right] & \\ \text{scope} : \left[\text{c} : \text{beat(}r\text{.par.x, par.x)}\right] & \end{array}\right] & \end{array}\right]$$

A man owns a donkey. He beats it.

$$\left[\begin{array}{lcl} x & : & \text{Ind} \\ c_1 & : & \text{man}(x) \\ y & : & \text{Ind} \\ c_2 & : & \text{donkey}(y) \\ c_3 & : & \text{own}(x,y) \\ c_4 & : & \text{beat}(x,y) \end{array}\right]$$

$$[\![\ [_{\mathrm{D}}\ \mathrm{S}]\ ]\!] = [\![\ \mathrm{S}\ ]\!]$$

$$[\![\ [_{\mathrm{D}}\ \mathrm{D\ S}]\ ]\!] = \begin{bmatrix} \mathrm{d} & : & [\![\ \mathrm{D}\ ]\!] \\ \mathrm{s} & : & [\![\ \mathrm{S}\ ]\!] \end{bmatrix}$$

A man owns a donkey. He beats it.

$$\begin{bmatrix} & & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c}_1 & : & \mathrm{man(d.x)} \\ \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_2 & : & \mathrm{donkey(d.y)} \\ \mathrm{c}_3 & : & \mathrm{own(d.x,\ d.y)} \end{bmatrix} \\ \mathrm{d} & : & \\ & & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c}_1 & : & \mathrm{eq(Ind,\ s.x,\ ?)} \\ \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_2 & : & \mathrm{eq(Ind,\ s.y,\ ?)} \\ \mathrm{c}_3 & : & \mathrm{beat(s.x,\ s.y)} \end{bmatrix} \\ \mathrm{s} & : & \end{bmatrix}$$

Resolution

$$\begin{bmatrix} & & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c}_1 & : & \mathrm{man(d.x)} \\ \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_2 & : & \mathrm{donkey(d.y)} \\ \mathrm{c}_3 & : & \mathrm{own(d.x,\ d.y)} \end{bmatrix} \\ \mathrm{d} & : & \\ & & \begin{bmatrix} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c}_1 & : & \mathrm{eq(Ind,\ s.x,\ d.x)} \\ \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_2 & : & \mathrm{eq(Ind,\ s.y,\ d.y)} \\ \mathrm{c}_3 & : & \mathrm{beat(s.x,\ s.y)} \end{bmatrix} \\ \mathrm{s} & : & \end{bmatrix}$$

Flattening

$$\begin{bmatrix} \text{d.x} & : & \text{Ind} \\ \text{d.c}_1 & : & \text{man(d.x)} \\ \text{d.y} & : & \text{Ind} \\ \text{d.c}_2 & : & \text{donkey(d.y)} \\ \text{d.c}_3 & : & \text{own(d.x, d.y)} \\ \text{s.x} & : & \text{Ind} \\ \text{s.c}_1 & : & \text{eq(Ind, s.x, d.x)} \\ \text{s.y} & : & \text{Ind} \\ \text{s.c}_2 & : & \text{eq(Ind, s.y, d.y)} \\ \text{s.c}_3 & : & \text{beat(s.x, s.y)} \end{bmatrix}$$

Relabelling

$$\begin{bmatrix} \text{x} & : & \text{Ind} \\ \text{c}_1 & : & \text{man(x)} \\ \text{y} & : & \text{Ind} \\ \text{c}_2 & : & \text{donkey(y)} \\ \text{c}_3 & : & \text{own(x, y)} \\ \text{z} & : & \text{Ind} \\ \text{c}_z & : & \text{eq(Ind, z, x)} \\ \text{w} & : & \text{Ind} \\ \text{c}_w & : & \text{eq(Ind, w, y)} \\ \text{c}_4 & : & \text{beat(z, w)} \end{bmatrix}$$

Equality elimination

$$\begin{bmatrix} x & : & \text{Ind} \\ c_1 & : & \text{man}(x) \\ y & : & \text{Ind} \\ c_2 & : & \text{donkey}(y) \\ c_3 & : & \text{own}(x, y) \\ c_4 & : & \text{beat}(x, y) \end{bmatrix}$$

Intensionality

Bo believes that a unicorn runs

$$\left[\begin{array}{lcl} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c}_1 & : & \mathrm{named(x,\ ``Bo")} \\ \mathrm{c}_2 & : & \mathrm{believe(x,}\left[\begin{array}{lcl} \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_3 & : & \mathrm{unicorn(y)} \\ \mathrm{c}_4 & : & \mathrm{run(y)} \end{array}\right]\mathrm{)} \end{array}\right]$$

Bo's belief is *true* of a record r just in case r is of type

$$\left[\begin{array}{lcl} \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_3 & : & \mathrm{unicorn(y)} \\ \mathrm{c}_4 & : & \mathrm{run(y)} \end{array}\right]$$

(corresponding to a judgement in type theory or an Austinian proposition in situation semantics) and true simpliciter if there is such an r (corresponding to a Russellian proposition in situation semantics).

Bo seeks a unicorn

$$\left[\begin{array}{lcl} \mathrm{x} & : & \mathrm{Ind} \\ \mathrm{c}_1 & : & \mathrm{named(x,\ ``Bo")} \\ & & \\ \mathrm{c}_4 & : & \mathrm{seek(x,}\left[\begin{array}{lcl} \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_2 & : & \mathrm{unicorn(y)} \\ \mathrm{c}_3 & : & \mathrm{find(x,y)} \end{array}\right)\mathrm{)} \end{array}\right]$$

r is a *successful outcome* for Bo's search just in case r is of type

$$\left[\begin{array}{lcl} \mathrm{y} & : & \mathrm{Ind} \\ \mathrm{c}_2 & : & \mathrm{unicorn(y)} \\ \mathrm{c}_3 & : & \mathrm{find(Bo,y)} \end{array}\right]$$

Bo's search would be *successful* just in case there is such an r.

$$[\![\ [\mathrm{V}_S\ \text{believes}]\ ]\!] = \lambda T{:}\mathrm{RecType}\ \lambda r{:}\big[\mathrm{x{:}Ind}\big](\big[\mathrm{c{:}believe}(r.\mathrm{x},T)\big])$$

$$[\![\ [\mathrm{V}\ \text{seeks}]\ ]\!] = \lambda\mathcal{N}{:}((\big[\mathrm{x{:}Ind}\big])\mathrm{RecType})\mathrm{RecType}\ \lambda r_1{:}\big[\mathrm{x{:}Ind}\big]\ (\big[\mathrm{c{:}seek}(r_1.\mathrm{x},\ \mathcal{N}\ @\ \lambda r_2{:}\big[\mathrm{x{:}Ind}\big](\big[\mathrm{c{:find}}(r_1.\mathrm{x},r_2.\mathrm{x})\big]))\big])$$

$$[\![\ [\mathrm{VP}\ \mathrm{V}_S\ \mathrm{S}]\ ]\!] = [\![\ \mathrm{V}_S\ ]\!]\ @\ [\![\ \mathrm{S}\ ]\!]$$

Questions

yes/no

If T is a record type we define $?T$ to be the following function type:

$(r{:}[])\big[\text{q:tuple}(r,T)\big]$

Here tuple is a type constructor such that $\text{tuple}(a_1, \ldots, a_n)$ is a type whose unique inhabitant is $< a_1, \ldots, a_n >$.

If $f : ?T$ then *the answer to* f is "yes" if for some r, $f(r)_0 : f(r)_1$ and "no" if for no r, $f(r)_0 : f(r)_1$.

wh

If $\lambda r : T_1(T_2(r))$ is a family of record types (i.e. a function from records r of type T_1 to the type T_2, dependent on r) then we define $?\lambda r : T_1(T_2(r))$ to be the following function type:

$(r{:}T_1)\big[\text{q:tuple}(r, T_1, T_2)\big]$

If $f : ?\lambda r{:}T_1(T_2(r))$ then *an answer to* f is a set of records R such that for all $r \in R, f(r)_0 : f(r)_1$ and $f(r)_0 : f(r)_2$.

Analysis of clarification ellipsis

Families of dependent record types – functions from records to record types

$\lambda r : T_1(T_2)$ – a function from records of type T_1 to the type T_2 (dependent on r)

"Utterance skeleton", "meaning", "HPSG sign"

Representing utterances

$u_1 :$ $_0$ Did $_1$ Bo $_2$ leave $_3$

$u_{1,0-1}$ is to represent the utterance of *did* in u_1

Abbreviation

$\left[\; f_{u_{i,n-m}} \; : \; T \; \right]$

is to be an abbreviation for

$$\left[\begin{array}{lcl} f_{u_{i,n-m}} & : & T \\ pf\text{-}f_{u_{i,n-m}} & : & f(u_{i,n-m}, f_{u_{i,n-m}}) \end{array} \right]$$

e.g., $\left[\; \text{utt-time}_{u_{1,0-3}} \; : \; \mathit{Time} \; \right]$ (Time the type of time intervals)

abbreviates

$$\left[\begin{array}{lcl} \text{utt-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{pf-utt-time}_{u_{1,0-3}} & : & \text{utt-time}(u_{1,0-3}, \text{utt-time}_{u_{1,0-3}}) \end{array} \right]$$

u_1 : $_0$ Did $_1$ Bo $_2$ leave $_3$

$$\lambda r : \left[\ \ldots \ \right] \left(\left[\begin{array}{lcl} \text{msg}_{u_{1,0-3}} & : & ?\text{leave}(\text{ref}_{u_{1,1-2}}, \text{ev-time}_{u_{1,0-3}}) \\ \text{cont}_{u_{1,0-3}} & : & \text{ask}(\text{sp}_{u_{1,0-3}}, \text{hearer}_{u_{1,0-3}}, \text{msg}_{u_{1,0-3}}) \end{array} \right] \right)$$

More properly:

$$\lambda r : \left[\ \ldots \ \right] \left(\left[\begin{array}{lcl} \text{msg}_{u_{1,0-3}} & : & ?\text{leave}(r.\text{ref}_{u_{1,1-2}}, r.\text{ev-time}_{u_{1,0-3}}) \\ \text{cont}_{u_{1,0-3}} & : & \text{ask}(r.\text{sp}_{u_{1,0-3}}, r.\text{hearer}_{u_{1,0-3}}, \text{msg}_{u_{1,0-3}}) \end{array} \right] \right)$$

but I will suppress all the extra r's as there is no risk of confusion.

filling in the dots ...

$$\lambda r : \left[\begin{array}{lcl} \text{phon}_{u_{1,0-1}} & : & /\text{dId}/ \\ \text{phon}_{u_{1,1-2}} & : & /\text{bu}/ \\ \text{phon}_{u_{1,2-3}} & : & /\text{liv}/ \\ \text{phon}_{u_{1,0-3}} & : & /\text{dIdbulív}/ \\ \text{utt-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{ev-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{tense}_{u_{1,0-3}} & : & \text{ev-time}_{u_{1,0-3}} < \text{utt-time}_{u_{1,0-3}} \\ \text{ref}_{u_{1,1-2}} & : & \mathit{Ind} \\ \text{res}_{u_{1,1-2}} & : & \text{named}(\text{ref}_{u_{1,1-2}}, \text{“Bo”}) \\ \text{sp}_{u_{1,0-3}} & : & \mathit{Ind} \\ \text{hearer}_{u_{1,0-3}} & : & \mathit{Ind} \\ \text{cat}_{u_{1,0-3}} & : & [\text{V}, +\text{fin}] \end{array}\right]$$

$$\left(\left[\begin{array}{lcl} \text{msg}_{u_{1,0-3}} & : & ?\text{leave}(\text{ref}_{u_{1,1-2}}, \text{ev-time}_{u_{1,0-3}}) \\ \text{cont}_{u_{1,0-3}} & : & \text{ask}(\text{sp}_{u_{1,0-3}}, \text{hearer}_{u_{1,0-3}}, \text{msg}_{u_{1,0-3}}) \end{array}\right]\right)$$

An occurrence of *Bo* between positions (vertices, time points) i and j in utterance u may be modelled by a record of type

$$\left[\begin{array}{lcl}
\text{phon}_{u,i-j} & : & \left[\begin{array}{lcl} \text{seg} & : & /\text{bu}/ \\ \text{prosody} & : & \text{Tune} \end{array}\right] \\
\text{utt-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ref}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{res}_{u,i-j} & : & \text{named}(\text{ref}_{u,i-j}.\text{x}, \text{“Bo”}) \\
\text{sp}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{cat}_{u,i-j} & : & \text{NP}
\end{array}\right]$$

An occurrence of *Bo?* between positions (vertices, time points) i and j in utterance u may be modelled by a record of type

$$\left[\begin{array}{lcl}
\text{phon}_{u,i-j} & : & \left[\begin{array}{lcl} \text{seg} & : & /\text{bu}/ \\ \text{prosody} & : & \text{L-H} \end{array}\right] \\
\text{utt-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ref}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{res}_{u,i-j} & : & \text{named}(\text{ref}_{u,i-j}.\text{x}, \text{“Bo”}) \\
\text{sp}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{cat}_{u,i-j} & : & \text{NP}
\end{array}\right]$$

An occurrence of *leave* between positions (vertices, time points) i and j in utterance u may be modelled by a record of type

$$\left[\begin{array}{lcl}
\text{x} & : & \text{Ind} \\
\text{phon}_{u,i-j} & : & \left[\begin{array}{lcl} \text{seg} & : & /\text{liv}/ \\ \text{prosody} & : & \text{Tune} \end{array}\right] \\
\text{utt-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ev-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{sp}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{msg}_{u,i-j} & : & \text{leave(x, ev-time}_{u,i-j}\text{.t)} \\
\text{cat}_{u,i-j} & : & \text{[V,-fin]}
\end{array}\right]$$

An occurrence of *did* between positions (vertices, time points) i and j in utterance u may be modelled by a record of type

$$\left[\begin{array}{lcl}
\text{phon}_{u,i-j} & : & \left[\begin{array}{lcl} \text{seg} & : & /\text{dId}/ \\ \text{prosody} & : & \text{Tune} \end{array}\right] \\
\text{utt-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ev-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{tense}_{u,i-j} & : & \text{ev-time}_{u,i-j}.\text{t} < \text{utt-time}_{u,i-j}.\text{t} \\
\text{sp}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{cat}_{u,i-j} & : & [\text{V,+aux,+fin}]
\end{array}\right]$$

$$Q \rightarrow Aux\ NP\ VP$$

$$\lambda r_1\!:\!\left[\begin{array}{lcl}
\text{phon}_{u,i-j} & : & T_{Phon,i-j} \\
\text{utt-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ev-time}_{u,i-j} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{tense}_{u,i-j} & : & T_{Tense,i-j} \\
\text{sp}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{cat}_{u,i-j} & : & [\text{V,+aux,+fin}]
\end{array}\right]$$

$$\lambda r_2\!:\!\left[\begin{array}{lcl}
\text{phon}_{u,j-k} & : & T_{Phon,j-k} \\
\text{utt-time}_{u,j-k} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ref}_{u,j-k} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{res}_{u,j-k} & : & T_{res,j-k} \\
\text{sp}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,i-j} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{cat}_{u,i-j} & : & \text{NP}
\end{array}\right]$$

$$\lambda r_3\!:\!\left[\begin{array}{lcl}
\text{x} & : & \text{Ind} \\
\text{phon}_{u,k-l} & : & T_{Phon,k-l} \\
\text{utt-time}_{u,k-l} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ev-time}_{u,k-l} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{sp}_{u,k-l} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,k-l} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{msg}_{u,k-l} & : & T_{msg,k-l}(\text{x,ev-time}_{u,k-l}.t) \\
\text{cat}_{u,i-j} & : & [\text{V,-fin}]
\end{array}\right]$$

$$\left(\left[\begin{array}{lcl}
\text{phon}_{u,i-j} & : & T_{Phon,i-j} \\
\text{phon}_{u,j-k} & : & T_{Phon,j-k} \\
\text{phon}_{u,k-l} & : & T_{Phon,k-l} \\
\text{phon}_{u,i-l} & : & T_{Phon,i-j}{}^\frown T_{Phon,j-k}{}^\frown T_{Phon,k-l} \\
\text{utt-time}_{u,i-l} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{ev-time}_{u,i-l} & : & \left[\begin{array}{lcl} \text{t} & : & \text{Time} \end{array}\right] \\
\text{tense}_{u,i-l} & : & T_{Tense,i-j} \\
\text{ref}_{u,j-k} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{res}_{u,j-k} & : & T_{res,j-k} \\
\text{sp}_{u,i-l} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{hearer}_{u,k-l} & : & \left[\begin{array}{lcl} \text{x} & : & \text{Ind} \end{array}\right] \\
\text{cat}_{u,i-l} & : & [\text{V,+fin}] \\
\text{msg}_{u,i-l} & : & ?T_{msg,k-l}(\text{ref}_{u,j-k}.\text{x,ev-time}_{u,i-l}.\text{t}) \\
\text{cont}_{u,i-l} & : & \text{ask}(\text{sp}_{u,i-l},\ \text{hearer}_{u,k-l},\ \text{msg}_{u,i-l})
\end{array}\right]\right)$$

$$\texttt{mngfun}\begin{bmatrix} \ell_1 & : & T_1 \\ & \vdots & \\ \ell_n & : & T_n(\ell_1,\ldots,\ell_{n-1}) \\ \mathrm{msg}_{u,i-j} & : & T_{msg_{u,i-j}}(\ell_1,\ldots,\ell_n) \\ \mathrm{cont}_{u,i-j} & : & T_{cont_{u,i-j}}(\ell_1,\ldots,\ell_n,\mathrm{msg}_{u,i-j}) \end{bmatrix} =$$

$$\lambda r{:}\begin{bmatrix} \ell_1{:}T_1 \\ \quad\vdots \\ \ell_n{:}T_n(\ell_1,\ldots,\ell_{n-1}) \end{bmatrix}\left(\begin{bmatrix} \mathrm{msg}_{u,i-j} & : & T_{msg_{u,i-j}}(r.\ell_1,\ldots,r.\ell_n) \\ \mathrm{cont}_{u,i-j} & : & T_{cont_{u,i-j}}(r.\ell_1,\ldots,r.\ell_n,\mathrm{msg}_{u,i-j}) \end{bmatrix}\right.$$

Suppose your context is defective - you don't have a referent for $_1$ Bo $_2$

$$\lambda r : \left[\begin{array}{lcl} \text{phon}_{u_{1,0-1}} & : & /\text{dId}/ \\ \text{phon}_{u_{1,1-2}} & : & /\text{bu}/ \\ \text{phon}_{u_{1,2-3}} & : & /\text{liv}/ \\ \text{phon}_{u_{1,0-3}} & : & /\text{dIdbulív}/ \\ \text{utt-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{ev-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{tense}_{u_{1,0-3}} & : & \text{ev-time}_{u_{1,0-3}} < \text{utt-time}_{u_{1,0-3}} \\ \text{ref}_{u_{1,1-2}} & : & \mathit{Ind} \\ \text{res}_{u_{1,1-2}} & : & \text{named}(\text{ref}_{u_{1,1-2}}, \text{“Bo”}) \\ \text{sp}_{u_{1,0-3}} & : & \mathit{Ind} \\ \text{hearer}_{u_{1,0-3}} & : & \mathit{Ind} \\ \text{cat}_{u_{1,0-3}} & : & [\text{V}, +\text{fin}] \end{array}\right]$$

$$\left(\left[\begin{array}{lcl} \text{msg}_{u_{1,0-3}} & : & ?\text{leave}(\text{ref}_{u_{1,1-2}}, \text{ev-time}_{u_{1,0-3}}) \\ \text{cont}_{u_{1,0-3}} & : & \text{ask}(\text{sp}_{u_{1,0-3}}, \text{hearer}_{u_{1,0-3}}, \text{msg}_{u_{1,0-3}}) \end{array}\right]\right)$$

Coercion 1 – Lowering

Existential quantification of deficient parameters

She's asking whether somebody named Bo left

$$\lambda r : \left[\begin{array}{lcl} \text{phon}_{u_{1,0-1}} & : & /\text{dId}/ \\ \text{phon}_{u_{1,1-2}} & : & /\text{bu}/ \\ \text{phon}_{u_{1,2-3}} & : & /\text{liv}/ \\ \text{phon}_{u_{1,0-3}} & : & /\text{dIdbulív}/ \\ \text{utt-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{ev-time}_{u_{1,0-3}} & : & \mathit{Time} \\ \text{tense}_{u_{1,0-3}} & : & \text{ev-time}_{u_{1,0-3}} < \text{utt-time}_{u_{1,0-3}} \\ \text{sp}_{u_{1,0-3}} & : & \mathit{Ind} \\ \text{hearer}_{u_{1,0-3}} & : & \mathit{Ind} \\ \text{cat}_{u_{1,0-3}} & : & [\text{V}, +\text{fin}] \end{array}\right]$$

$$\left(\left[\begin{array}{lcl} \text{ref}_{u_{1,1-2}} & : & \mathit{Ind} \\ \text{res}_{u_{1,1-2}} & : & \text{named}(\text{ref}_{u_{1,1-2}}, \text{“Bo”}) \\ \text{msg}_{u_{1,0-3}} & : & ?\text{leave}(\text{ref}_{u_{1,1-2}}, \text{ev-time}_{u_{1,0-3}}) \\ \text{cont}_{u_{1,0-3}} & : & \text{ask}(\text{sp}_{u_{1,0-3}}, \text{hearer}_{u_{1,0-3}}, \text{msg}_{u_{1,0-3}}) \end{array}\right]\right)$$

Coercion 2 - parameter identification

Ask a question for the value of the parameter

$u_2 :_0$ Bo? $_1$

Who is referred to by your utterance of "Bo"?

$$\lambda r : \left[\begin{array}{ll}
\text{phon}_{u_{1,0-1}} & : \ /\text{dId}/ \\
\text{phon}_{u_{1,1-2}} & : \ /\text{bu}/ \\
\text{phon}_{u_{1,2-3}} & : \ /\text{liv}/ \\
\text{phon}_{u_{1,0-3}} & : \ /\text{dIdbulív}/ \\
\text{utt-time}_{u_{1,0-3}} & : \ \textit{Time} \\
\text{ev-time}_{u_{1,0-3}} & : \ \textit{Time} \\
\text{tense}_{u_{1,0-3}} & : \ \text{ev-time}_{u_{1,0-3}} < \text{utt-time}_{u_{1,0-3}} \\
\text{sp}_{u_{1,0-3}} & : \ \textit{Ind} \\
\text{hearer}_{u_{1,0-3}} & : \ \textit{Ind} \\
\text{cat}_{u_{1,0-3}} & : \ [\text{V}, +\text{fin}] \\
\text{phon}_{u_{2,0-1}} & : \ /\text{bu L-H}/ \\
\text{utt-time}_{u_{2,0-1}} & : \ \textit{Time} \\
\text{sp}_{u_{2,0-1}} & : \ \textit{Ind} \\
\text{hearer}_{u_{2,0-1}} & : \ \textit{Ind}
\end{array}\right]$$

$$\left(\left[\begin{array}{lll}
\text{msg}_{u_{2,0-1}} & : \ ? \ \lambda r' : & \left[\begin{array}{ll}
\text{ref}_{u_{1,1-2}} & : \ \textit{Ind} \\
\text{res}_{u_{1,1-2}} & : \ \text{named}(\text{ref}_{u_{1,1-2}}, \text{“Bo”}) \\
 & (\text{ref}(u_{1.1-2}, \text{ref}_{u_{1,1-2}}))
\end{array}\right]
\end{array}\right]\right)$$

N.B. This last case splits up the abbreviatory convention concerning ref and pf-ref. The type of pf-ref has been used as the body of the question instead.

Coercion 3 – parameter focussing

Are you asking whether Bo left? (The relevant issue is *who are you asking whether (they) left?*)

$$
\lambda r : \left[\begin{array}{ll}
\text{phon}_{u_{1,0-1}} & : \text{/dId/} \\
\text{phon}_{u_{1,1-2}} & : \text{/bu/} \\
\text{phon}_{u_{1,2-3}} & : \text{/liv/} \\
\text{phon}_{u_{1,0-3}} & : \text{/dIdbulív/} \\
\text{utt-time}_{u_{1,0-3}} & : \mathit{Time} \\
\text{ev-time}_{u_{1,0-3}} & : \mathit{Time} \\
\text{tense}_{u_{1,0-3}} & : \text{ev-time}_{u_{1,0-3}} < \text{utt-time}_{u_{1,0-3}} \\
\text{ref}_{u_{1,1-2}} & : \mathit{Ind} \\
\text{res}_{u_{1,1-2}} & : \text{named}(\text{ref}_{u_{1,1-2}}, \text{“Bo”}) \\
\text{sp}_{u_{1,0-3}} & : \mathit{Ind} \\
\text{hearer}_{u_{1,0-3}} & : \mathit{Ind} \\
\text{cat}_{u_{1,0-3}} & : [\text{V}, +\text{fin}] \\
\text{phon}_{u_{2,0-1}} & : \text{/bu L-H/} \\
\text{utt-time}_{u_{2,0-1}} & : \mathit{Time} \\
\text{sp}_{u_{2,0-1}} & : \mathit{Ind} \\
\text{hearer}_{u_{2,0-1}} & : \mathit{Ind} \\
\text{max-QUD}_{u_{2,0-1}} & : ?\ \lambda x : \mathit{Ind}\ (\text{ask}(\text{sp}_{u_{1,0-3}}, \text{hearer}_{u_{1,0-3}}, ?\text{leave}(x, \text{ev-time}_{u_{1,0-3}})))
\end{array}\right]
$$

$$
\left(\left[\ \text{cont}_{u_{2,0-1}} \ : \ ?\text{ask}(\text{sp}_{u_{1,0-3}}, \text{hearer}_{u_{1,0-3}}, ?\text{leave}(\text{ref}_{u_{1,1-2}}, \text{ev-time}_{u_{1,0-3}}))\ \right]\right)
$$

Conclusions

- Meaning in dialogue (not just content) is relative to dialogue participants
- Dialogue context (previous utterance) plays a role in determining meaning – structured meanings
- Syntactic and phonological information about utterances play a role in meaning – clarification questions are about utterances