A Formal Interpretation of Frame Composition

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CTF 09, Düsseldorf

outline

outline

frames

Barsalou (1992) *Frames, Concepts, and Conceptual Fields*

- Frames provide the fundamental representation of knowledge in human cognition.
- At their core, frames contain **attribute-value sets**.

feature structures

typed feature structure

$$
\begin{bmatrix}
\textit{phrase} & \\
\textsc{head}: & \begin{bmatrix}
\textit{noun} & \\
\textsc{agr}: & \begin{bmatrix}
\textit{agr} & \\
\textsc{pers}: & 3 \\
\textsc{num}: & \textit{pl}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

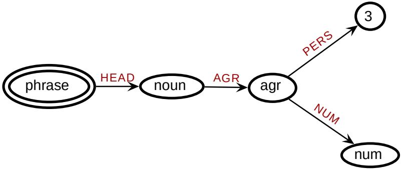
untyped feature structure

$$
\begin{bmatrix}
\textsc{cat}: & \textit{phrase} \\
\textsc{head}: & \begin{bmatrix}
\textsc{cat}: & \textit{noun} \\
\textsc{agr}: & \begin{bmatrix}
\textsc{pers}: & 3 \\
\textsc{num}: & \textit{pl}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

feature structures

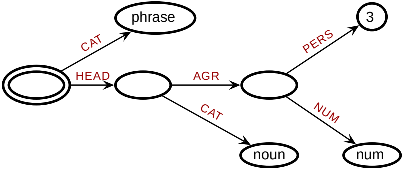
typed feature structure

$$\begin{bmatrix} \text{phrase} & \\ \text{HEAD:} & \begin{bmatrix} \text{noun} & \\ \text{AGR:} & \begin{bmatrix} \text{agr} & \\ \text{PERS:} & 3 \\ \text{NUM:} & \text{pl} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

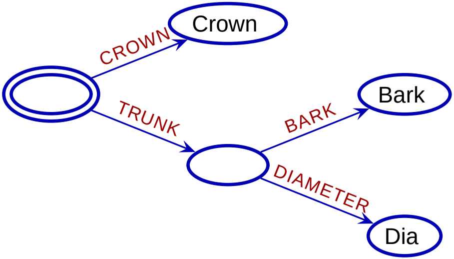


untyped feature structure

$$\begin{bmatrix} \text{CAT:} & \text{phrase} \\ \text{HEAD:} & \begin{bmatrix} \text{CAT:} & \text{noun} \\ \text{AGR:} & \begin{bmatrix} \text{PERS:} & 3 \\ \text{NUM:} & \text{pl} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$



frames as generalized feature structures

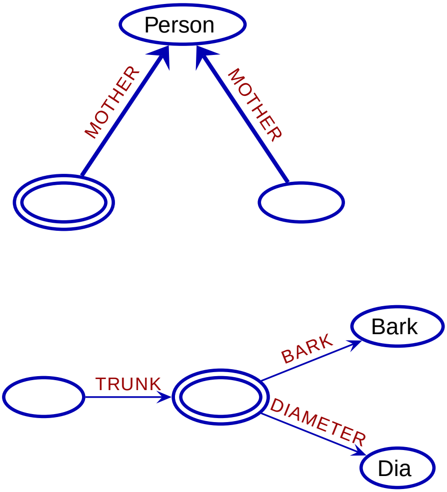


feature structures (Carpenter 1992)

feature structures
are connected directed graphs with

- one central node
- nodes labeled with types
- arcs labeled with attributes
- no node with two outgoing arcs with the same label
- and such that each node can be reached from the central node via directed arcs.

frames as generalized feature structures

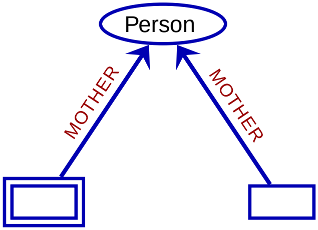


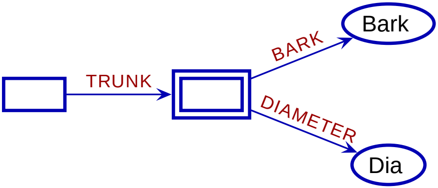
Frames (Petersen 2007)

Frames
are connected directed graphs with

- one central node
- nodes labeled with types
- arcs labeled with attributes
- no node with two outgoing arcs with the same label

frames as generalized feature structures





Frames (Petersen 2007)

Frames
are connected directed graphs with

- one central node
- nodes labeled with types
- arcs labeled with attributes
- no node with two outgoing arcs with the same label

Open argument nodes are marked as rectangular nodes.

outline

concept classification

person, pope, house, verb, sun, Mary, wood, brother, mother, meaning, distance, spouse, argument, entrance

concept classification: relationality

non-relational	person, pope, house, verb, sun, Mary, wood
relational	brother, mother, meaning, distance, spouse, argument, entrance

Löbner

concept classification: uniqueness of reference

	non-unique reference	unique reference
non-relational	person, house, verb, wood	Mary, pope, sun
relational	brother, argument, entrance	mother, meaning, distance, spouse

Löbner

concept classification

	non-unique reference	unique reference
non-relational	**sortal concept** $\lambda x.\, P(x)$	**individual concept** $\lambda x.\ x = \iota u.\ P(u)$
relational	**proper relational concept** $\lambda y \lambda x.\, R(x,y)$	**functional concept** $\lambda y \lambda x.\ x = f(y)$

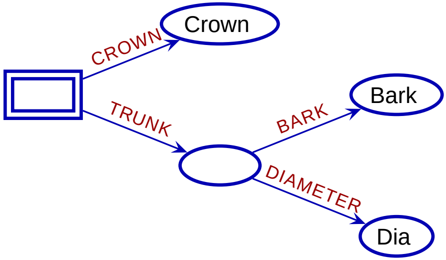
Löbner

concept classification

	non-unique reference	unique reference
non-relational	**sortal concept** $\lambda x.\, P(x)$	**individual concept** $\lambda x.\ x = \iota u.\ P(u)$ $\iota u.\, P(u)$
relational	**proper relational concept** $\lambda y \lambda x.\, R(x, y)$	**functional concept** $\lambda y \lambda x.\ x = f(y)$ $\lambda y.\, f(y)$

Löbner

frames and functional concepts



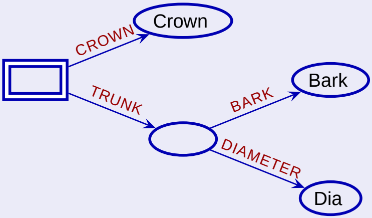
- attributes describe functional relations, i.e., they represent functions
- attributes correspond to functional concepts

⇒ frames decompose concepts into functional concepts

⇒ functional concepts embody the concept type on which categorization is based

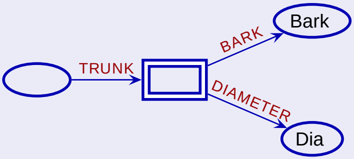
sortal concepts

tree-Frame



$$\lambda x.\ \mathrm{Crown}(\textsc{crown}(x)) \wedge$$
$$\mathrm{Bark}(\textsc{bark}(\textsc{trunk}(x))) \wedge$$
$$\mathrm{Dia}(\textsc{diameter}(\textsc{trunk}(x)))$$

trunk-Frame



$$\lambda x.\ \textsc{trunk}(\varepsilon u.\ x = \textsc{trunk}(u)) \wedge$$
$$\mathrm{Bark}(\textsc{bark}(x)) \wedge \mathrm{Dia}(\textsc{diameter}(x))$$

individual concepts

Mary-frame

predicate constant ‘Mary’:

$\lambda x.\, x = \iota y.\, (y = \text{Mary})$

pope-frame

predicate constant ‘pope’:

$\lambda x.\, x = \text{HEAD}(\iota y.\, \text{RCC}(y))$

individual concepts

Mary-frame

predicate constant ‘Mary’:

$\lambda x.\, x = \iota y.\, (y = \text{Mary})$

individual constant ‘Mary’:

$\iota x.\, x = \text{Mary}$

pope-frame

predicate constant ‘pope’:

$\lambda x.\, x = \ \text{HEAD}(\iota y.\, \text{RCC}(y))$

individual constant ‘pope’:

$\iota x.\, x = \text{HEAD}(\iota y.\, \text{RCC}(y))$

non-relational concepts

sortal concepts

default frame:

$\lambda x.\, P(x)$

- one open argument

individual concepts

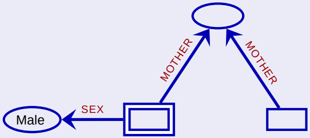
default frame:

$\lambda x.\, x = \iota u.\, P(u)$

- one open argument
- there is a direct path from a definite node to the central node

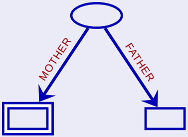
proper relational concepts

brother-frame



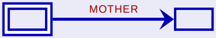
$\lambda y \lambda x.\ \text{MOTHER}(x) = \text{MOTHER}(y) \wedge \text{Male}(\text{SEX}(x))$

co-parent-frame



$\lambda y \lambda x.\ x = \text{MOTHER}(\varepsilon u.\ y = \text{FATHER}(u))$

child-frame



$\lambda y \lambda x.\ y = \text{MOTHER}(x)$

functional concepts

head-frame

predicate constant ‘head’:

$\lambda y \lambda x.\, x = \mathrm{HEAD}(y)$

haircolor-frame

predicate constant ‘haircolor’:

$\lambda y \lambda x.\, x = \mathrm{COLOR}(\mathrm{HAIR}(y))$

functional concepts

head-frame

predicate constant ‘head’:

$\lambda y \lambda x.\, x = \textsf{HEAD}(y)$

function constant ‘head’:

$\lambda y.\, \textsf{HEAD}(y)$

haircolor-frame

predicate constant ‘haircolor’:

$\lambda y \lambda x.\, x = \textsf{COLOR}(\textsf{HAIR}(y))$

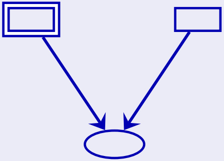
function constant ‘haircolor’:

$\lambda y.\, \textsf{COLOR}(\textsf{HAIR}(y))$

relational concepts

proper relational concepts

default frame:



$\lambda y \lambda x.\, R(x, y)$

- two open arguments
- no direct path from the other open argument to the central node

functional concepts

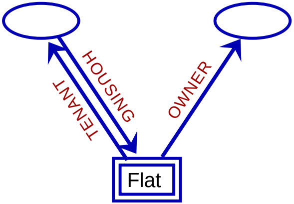
default frame:

$\lambda y \lambda x.\, y = f(x)$

- two open arguments
- there is a direct path from the other open argument to the central node

type shifts: non-relational → relational

sortal	**individual**
proper relational	**functional**

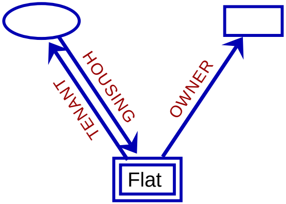


sortal concept *flat:*
"Many flats are offered in the newspaper."

type shifts: non-relational $\longrightarrow$ relational

sortal	**individual**
proper relational	**functional**

$\downarrow$

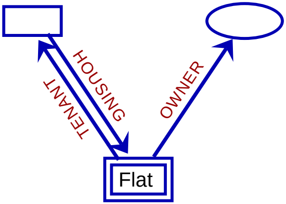


proper relational concept *flat:*
"This flat is a flat of John, he owns more than five."

type shifts: non-relational → relational

sortal	**individual**
proper relational	**functional**

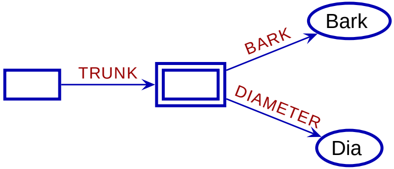
↓



functional concept *flat:*
“The flat of Mary is huge and the rent is reasonable.”

type shifts: relational → non-relational

sortal	**individual**
proper relational	**functional**

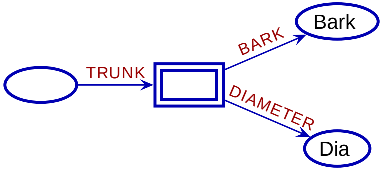


functional concept *trunk:*
“She sat with her back against the trunk of an oak.”

type shifts: relational → non-relational

sortal	**individual**
proper relational	**functional**

↑



sortal concept *trunk:*
"They rested and sat on a trunk."

summary: concept classes and frames

sortal concepts

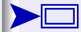
default frame:

$\lambda x.\, P(x)$ $\langle e,t\rangle$

Examples: stone, teenager, tree

individual concepts

default frame:

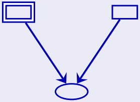


$\lambda x.\, x = \iota u.\, P(u)$ $\langle e,t\rangle$

Examples: pope, Mary

proper relational concepts

default frame:

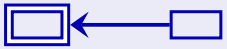


$\lambda y \lambda x.\, R(x,y)$ $\langle e,\langle e,t\rangle\rangle$

Examples: sister, son, finger

functional concepts

default frame:



$\lambda y \lambda x.\, x = f(y)$ $\langle e,\langle e,t\rangle\rangle$

Examples: mother, trunk, color

outline

1. Frames
2. Classification of concepts (Löbner)
3. **Frame Composition**
4. Composition and Language

hypothesis: composition works uniformly with respect to concept types

RC	$\overset{OF}{\sqcup}$	SC	$\mapsto$	SC	finger OF woman
RC	$\overset{OF}{\sqcup}$	IC	$\mapsto$	SC	finger OF Mary
RC	$\overset{OF}{\sqcup}$	RC	$\mapsto$	RC	finger OF friend
RC	$\overset{OF}{\sqcup}$	FC	$\mapsto$	RC	finger OF spouse
FC	$\overset{OF}{\sqcup}$	SC	$\mapsto$	SC	head OF woman
FC	$\overset{OF}{\sqcup}$	IC	$\mapsto$	IC	head OF Mary
FC	$\overset{OF}{\sqcup}$	RC	$\mapsto$	RC	head OF friend
FC	$\overset{OF}{\sqcup}$	FC	$\mapsto$	FC	head OF spouse

proper relational concepts:

type of composed concept = relational type of possessor concept

functional concepts:

type of composed concept = referential + relational type of possessor concept

Löbner

concept composition

$$\mathrm{RC}(\varepsilon(\mathrm{SC})) \mapsto \mathrm{SC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$$

$$\mathrm{RC}(\varepsilon(\mathrm{IC})) \mapsto \mathrm{SC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$$

$$\mathrm{RC} \circ (\varepsilon \circ \mathrm{RC}) \mapsto \mathrm{RC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,\langle e,t\rangle\rangle \mapsto \langle e,\langle e,t\rangle\rangle$$

$$\mathrm{RC} \circ (\varepsilon \circ \mathrm{FC}) \mapsto \mathrm{RC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,\langle e,t\rangle\rangle \mapsto \langle e,\langle e,t\rangle\rangle$$

$$\mathrm{FC}(\varepsilon(\mathrm{SC})) \mapsto \mathrm{SC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$$

$$\mathrm{FC}(\varepsilon(\mathrm{IC})) \mapsto \mathrm{IC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$$

$$\mathrm{FC} \circ (\varepsilon \circ \mathrm{RC}) \mapsto \mathrm{RC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,\langle e,t\rangle\rangle \mapsto \langle e,\langle e,t\rangle\rangle$$

$$\mathrm{FC} \circ (\varepsilon \circ \mathrm{FC}) \mapsto \mathrm{FC} \qquad \langle e,\langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,\langle e,t\rangle\rangle \mapsto \langle e,\langle e,t\rangle\rangle$$

$\varepsilon: \; \lambda Q.\varepsilon u.Q(u)$

concept composition

$\mathrm{RC}(\varepsilon(\mathrm{SC})) \mapsto \mathrm{SC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$
$\mathrm{RC}(\iota(\mathrm{IC})) \mapsto \mathrm{SC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$
$\mathrm{RC} \circ (\varepsilon \circ \mathrm{RC}) \mapsto \mathrm{RC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e, \langle e,t\rangle\rangle \mapsto \langle e, \langle e,t\rangle\rangle$
$\mathrm{RC} \circ (\iota \circ \mathrm{FC}) \mapsto \mathrm{RC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e, \langle e,t\rangle\rangle \mapsto \langle e, \langle e,t\rangle\rangle$
$\mathrm{FC}(\varepsilon(\mathrm{SC})) \mapsto \mathrm{SC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e,t\rangle \mapsto \langle e,t\rangle$
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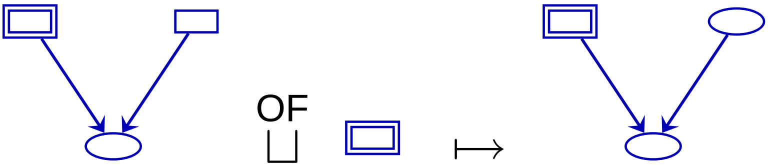
$\mathrm{FC} \circ (\varepsilon \circ \mathrm{RC}) \mapsto \mathrm{RC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e, \langle e,t\rangle\rangle \mapsto \langle e, \langle e,t\rangle\rangle$
$\mathrm{FC} \circ (\iota \circ \mathrm{FC}) \mapsto \mathrm{FC}$	$\langle e, \langle e,t\rangle\rangle \overset{\mathrm{OF}}{\sqcup} \langle e, \langle e,t\rangle\rangle \mapsto \langle e, \langle e,t\rangle\rangle$

$\varepsilon: \ \lambda Q.\varepsilon u.Q(u)$

RC $\overset{\text{OF}}{\sqcup}$ SC $\mapsto$ SC : finger OF woman



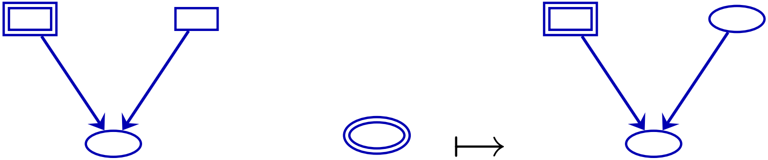
$\langle e, \langle e, t\rangle\rangle \qquad \langle e, t\rangle \qquad \langle e, t\rangle$

$\lambda y \lambda x.\ R(x, y) \overset{\text{OF}}{\sqcup} \lambda r.\ P(r) \mapsto \lambda x.\ R(x, \varepsilon u.\ P(u))$

RC(ε(SC)) $\mapsto$ SC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

RC $\overset{\textbf{OF}}{\sqcup}$ SC $\mapsto$ SC : finger OF woman



$\langle e, \langle e, t\rangle\rangle$ $\qquad$ e $\qquad$ $\langle e, t\rangle$

$\lambda y \lambda x.\, R(x, y) \overset{\text{OF}}{\sqcup} \lambda r.\, P(r) \mapsto \lambda x.\, R(x, \varepsilon u.\, P(u))$

RC(ε(SC)) $\mapsto$ SC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

1. ε(SC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, P(r)) \rightarrow_\beta \varepsilon u.\, \lambda r.\, P(r)(u) \rightarrow_\beta \varepsilon u.\, P(u)$
2. RC(ε(SC)): $\lambda y \lambda x.\, R(x, y)(\varepsilon u.\, P(u)) \rightarrow_\beta \lambda x.\, R(x, \varepsilon u.\, P(u))$

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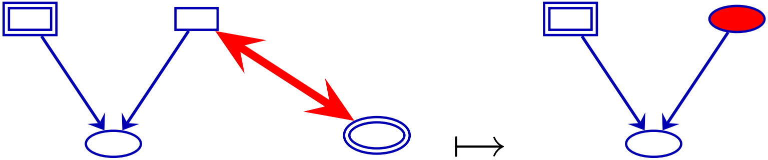

$\langle e, \langle e, t\rangle\rangle$ e $\langle e, t\rangle$

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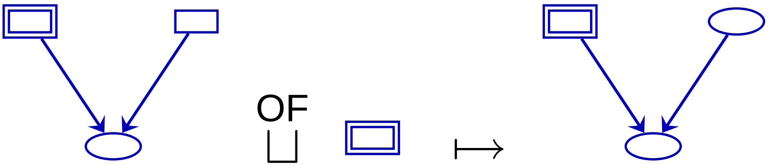
RC $\overset{\text{OF}}{\sqcup}$ SC $\mapsto$ SC : finger OF woman



$\langle e, \langle e, t \rangle \rangle$ $\quad$ $\langle e, t \rangle$ $\quad$ $\langle e, t \rangle$

$\lambda y \lambda x.\, R(x,y) \overset{\text{OF}}{\sqcup} \lambda r.\, P(r) \mapsto \lambda x.\, R(x, \varepsilon u.\, P(u))$

RC(ε(SC)) $\mapsto$ SC

$\langle e, \langle e, t \rangle \rangle (\langle \langle e, t \rangle, e \rangle (\langle e, t \rangle)) \mapsto \langle e, \langle e, t \rangle \rangle (e) \mapsto \langle e, t \rangle$

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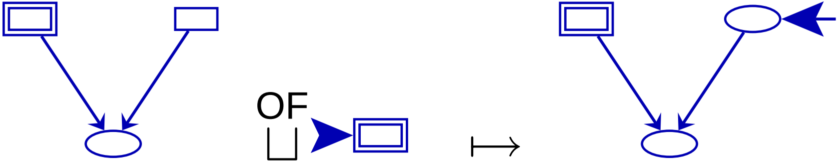
2. RC(ε(SC)): $\lambda y \lambda x.\, R(x,y)(\varepsilon u.\, P(u)) \rightarrow_\beta \lambda x.\, R(x, \varepsilon u.\, P(u))$

RC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ SC: finger OF Mary



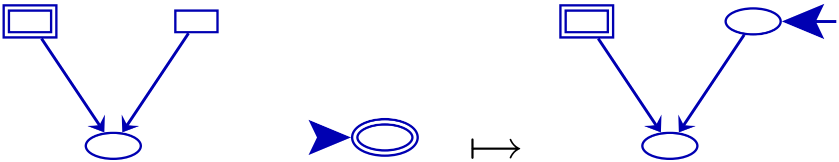
$\langle e, \langle e, t \rangle \rangle$ $\qquad$ $\langle e, t \rangle$ $\qquad$ $\langle e, t \rangle$

$\lambda y \lambda x.\, R(x, y) \overset{\text{OF}}{\sqcup} \lambda r.\, r = \iota v.\, P(v) \mapsto \lambda x.\, R(x, \iota u.\, P(u))$

RC(ε(IC)) $\mapsto$ SC

$\langle e, \langle e, t \rangle \rangle (\langle \langle e, t \rangle, e \rangle (\langle e, t \rangle)) \mapsto \langle e, \langle e, t \rangle \rangle (e) \mapsto \langle e, t \rangle$

RC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ SC: finger OF Mary



$\langle e, \langle e, t\rangle\rangle$ e $\langle e, t\rangle$

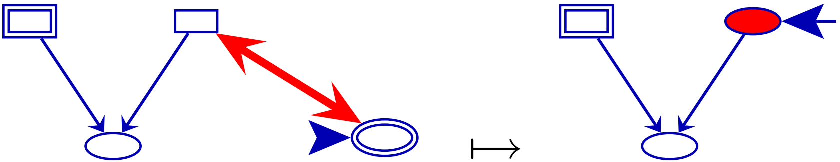
$\lambda y \lambda x.\, R(x,y) \overset{\text{OF}}{\sqcup} \lambda r.\, r = \iota v.\, P(v) \mapsto \lambda x.\, R(x, \iota u.\, P(u))$

RC(ε(IC)) $\mapsto$ SC

$\langle e, \langle e,t\rangle\rangle(\langle\langle e,t\rangle, e\rangle(\langle e,t\rangle)) \mapsto \langle e, \langle e,t\rangle\rangle(e) \mapsto \langle e,t\rangle$

1. ε (IC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, r = \iota v.\, P(v)) \rightarrow_\beta \varepsilon u.\, u = \iota v.\, P(v) \rightarrow \iota u.\, P(u)$
2. RC(ε (IC)): $\lambda y \lambda x.\, R(x,y)(\iota u.\, P(u)) \rightarrow_\beta \lambda x.\, R(x, \iota u.\, P(u))$

RC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ SC: finger OF Mary



$\langle e, \langle e, t\rangle\rangle$ e $\langle e, t\rangle$

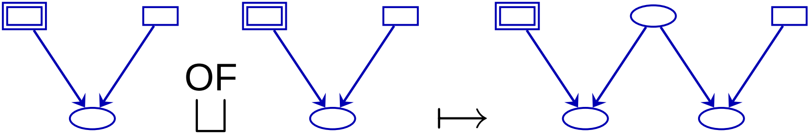
$\lambda y \lambda x.\, R(x,y) \overset{\text{OF}}{\sqcup} \lambda r.\, r = \iota v.\, P(v) \mapsto \lambda x.\, R(x, \iota u.\, P(u))$

RC(ε(IC)) $\mapsto$ SC

$\langle e, \langle e,t\rangle\rangle(\langle\langle e,t\rangle, e\rangle(\langle e,t\rangle)) \mapsto \langle e, \langle e,t\rangle\rangle(e) \mapsto \langle e,t\rangle$

1. ε (IC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, r = \iota v.\, P(v)) \rightarrow_\beta \varepsilon u.\, u = \iota v.\, P(v) \rightarrow \iota u.\, P(u)$
2. RC(ε (IC)): $\lambda y \lambda x.\, R(x,y)(\iota u.\, P(u)) \rightarrow_\beta \lambda x.\, R(x, \iota u.\, P(u))$

$\text{RC} \overset{\text{OF}}{\sqcup} \text{RC} \mapsto$ RC: finger OF friend



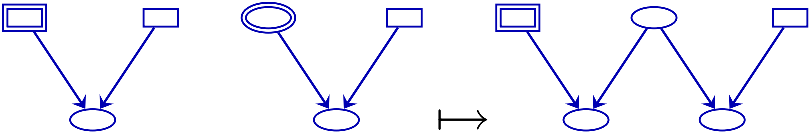
$\langle e, \langle e, t \rangle \rangle$ OF ⊔ $\langle e, \langle e, t \rangle \rangle$ $\mapsto$ $\langle e, \langle e, t \rangle \rangle$

$\lambda y \lambda x.\, R(x, y) \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u, y'))$

RC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t \rangle \rangle \circ (\langle \langle e, t \rangle, e \rangle \circ \langle e, \langle e, t \rangle \rangle) \mapsto \langle e, \langle e, t \rangle \rangle \circ \langle e, e \rangle \mapsto \langle e, \langle e, t \rangle \rangle$

$\mathrm{RC} \overset{\mathrm{OF}}{\sqcup} \mathrm{RC} \mapsto \mathrm{RC}$: finger OF friend



$\langle e, \langle e, t\rangle\rangle$ $\quad$ $\langle e, e\rangle$ $\quad$ $\langle e, \langle e, t\rangle\rangle$

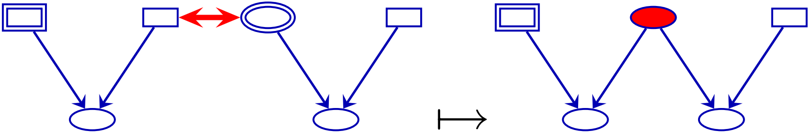
$\lambda y \lambda x.\, R(x,y) \overset{\mathrm{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x',y') \mapsto \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u,y'))$

RC $\circ(\varepsilon\circ$ RC$)$

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e,t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x',y'))) \rightarrow_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x',y')(u)) \rightarrow_\beta \lambda y'.\, \varepsilon u.\, S(u,y')$
2. RC $\circ(\varepsilon\circ$ RC$)$: $\lambda y'(\lambda y \lambda x.\, R(x,y)(\varepsilon u.\, S(u,y'))) \rightarrow_\beta \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u,y'))$

$\mathrm{RC} \overset{\mathrm{OF}}{\sqcup} \mathrm{RC} \mapsto \mathrm{RC}$: finger OF friend



$\langle e, \langle e, t \rangle\rangle$ $\qquad$ $\langle e, e \rangle$ $\qquad$ $\langle e, \langle e, t \rangle\rangle$

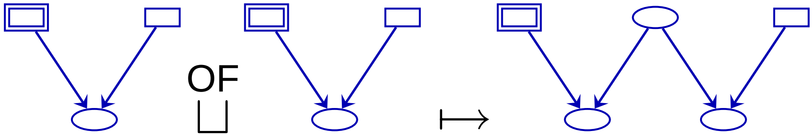
$\lambda y \lambda x.\, R(x, y) \overset{\mathrm{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u, y'))$

RC $\circ(\varepsilon \circ$ RC)

$\langle e, \langle e, t \rangle\rangle \circ (\langle\langle e, t \rangle, e\rangle \circ \langle e, \langle e, t \rangle\rangle) \mapsto \langle e, \langle e, t \rangle\rangle \circ \langle e, e \rangle \mapsto \langle e, \langle e, t \rangle\rangle$

1. $\varepsilon \circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x', y'))) \rightarrow_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x', y')(u)) \rightarrow_\beta \lambda y'.\, \varepsilon u.\, S(u, y')$
2. RC $\circ(\varepsilon \circ$ RC): $\lambda y'(\lambda y \lambda x.\, R(x, y)(\varepsilon u.\, S(u, y'))) \rightarrow_\beta \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u, y'))$

$\mathrm{RC} \overset{\mathrm{OF}}{\sqcup} \mathrm{RC} \mapsto$ RC: finger OF friend



$\langle e, \langle e, t\rangle\rangle$ $\qquad$ $\langle e, \langle e, t\rangle\rangle$ $\qquad$ $\langle e, \langle e, t\rangle\rangle$

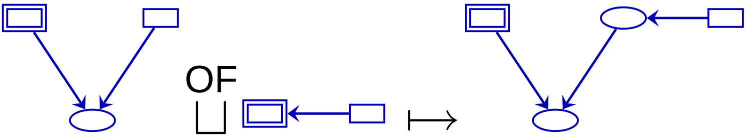
$\lambda y \lambda x.\, R(x, y) \overset{\mathrm{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u, y'))$

RC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x', y'))) \rightarrow_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x', y')(u)) \rightarrow_\beta \lambda y'.\, \varepsilon u.\, S(u, y')$
2. RC $\circ(\varepsilon\circ$ RC): $\lambda y'(\lambda y \lambda x.\, R(x, y)(\varepsilon u.\, S(u, y'))) \rightarrow_\beta \lambda y' \lambda x.\, R(x, \varepsilon u.\, S(u, y'))$

RC $\overset{\text{OF}}{\sqcup}$ FC $\mapsto$ RC: finger OF spouse



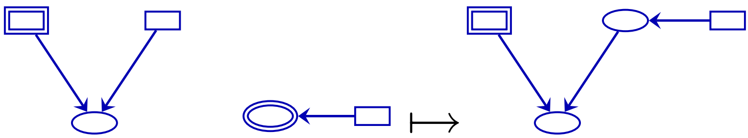
$\langle e, \langle e, t\rangle\rangle$ $\langle e, \langle e, t\rangle\rangle$ $\langle e, \langle e, t\rangle\rangle$

$\lambda y \lambda x.\ R(x, y) \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\ x' = g(y') \mapsto \lambda y' \lambda x.\ R(x, f(y'))$

RC $\circ(\varepsilon \circ$ FC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

RC $\overset{\text{OF}}{\sqcup}$ FC $\mapsto$ RC: finger OF spouse



$\langle e, \langle e, t\rangle\rangle$ $\langle e, e\rangle$ $\langle e, \langle e, t\rangle\rangle$

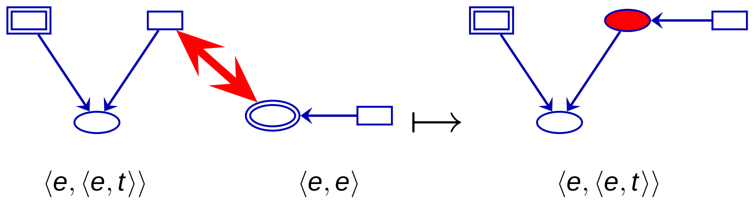
$\lambda y \lambda x.\, R(x, y) \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, x' = g(y') \mapsto \lambda y' \lambda x.\, R(x, f(y'))$

RC $\circ(\varepsilon\circ$ FC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ FC: $(\lambda Q.\, \varepsilon u.\, Q(u)) \circ (\lambda y' \lambda x'.\, x' = g(y')) \;\rightarrow$ $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda y'.\, y' = g(x'))) \;\rightarrow_\beta\; \lambda y'(\varepsilon u.\, \lambda x'.\, x' = g(y')(u)) \;\rightarrow_\beta$ $\lambda y'.\, \varepsilon u.\, u = g(y') \;\rightarrow\; \lambda y'.\, \iota u.\, u = g(y') \;\rightarrow\; \lambda y'.\, g(y')$
2. RC $\circ(\varepsilon\circ$ FC): $(\lambda y \lambda x.\, R(x, y)) \circ (\lambda y'.\, g(y')) \;\rightarrow\; \lambda y'((\lambda y \lambda x.\, R(x, y))(f(y'))) \;\rightarrow_\beta$ $\lambda y' \lambda x.\, R(x, f(y'))$

RC $\overset{\text{OF}}{\sqcup}$ FC $\mapsto$ RC: finger OF spouse



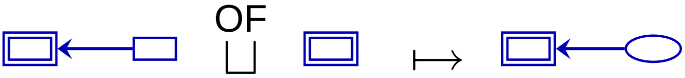
$\lambda y \lambda x.\ R(x,y) \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\ x' = g(y') \mapsto \lambda y' \lambda x.\ R(x, f(y'))$

RC $\circ(\varepsilon\circ$ FC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ FC: $(\lambda Q.\ \varepsilon u.\ Q(u)) \circ (\lambda y' \lambda x'.\ x' = g(y')) \rightarrow$
   $\lambda y'(\lambda Q.\ \varepsilon u.\ Q(u)(\lambda y'.\ y' = g(x'))) \rightarrow_\beta \lambda y'(\varepsilon u.\ \lambda x'.\ x' = g(y')(u)) \rightarrow_\beta$
   $\lambda y'.\ \varepsilon u.\ u = g(y') \rightarrow \lambda y'.\ \iota u.\ u = g(y') \rightarrow \lambda y'.\ g(y')$
2. RC $\circ(\varepsilon\circ$ FC): $(\lambda y \lambda x.\ R(x,y)) \circ (\lambda y'.\ g(y')) \rightarrow \lambda y'((\lambda y \lambda x.\ R(x,y))(f(y'))) \rightarrow_\beta$
   $\lambda y' \lambda x.\ R(x, f(y'))$

FC $\overset{\text{OF}}{\sqcup}$ SC $\mapsto$ SC: head OF woman



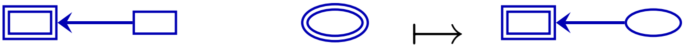
$\langle e, \langle e, t\rangle\rangle$ $\qquad$ $\langle e, t\rangle$ $\qquad$ $\langle e, t\rangle$

$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda r.\, P(r) \mapsto \lambda x.\, x = f(\varepsilon u.\, P(u))$

FC(ε(SC)) $\mapsto$ SC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

FC $\overset{\text{OF}}{\sqcup}$ SC $\mapsto$ SC: head OF woman



$\langle e, \langle e, t\rangle\rangle$ e $\langle e, t\rangle$

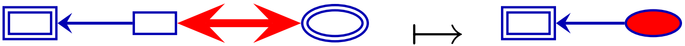
$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda r.\, P(r) \mapsto \lambda x.\, x = f(\varepsilon u.\, P(u))$

FC(ε(SC)) $\mapsto$ SC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

1. ε(SC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, P(r)) \to_\beta \varepsilon u.\, \lambda r.\, P(r)(u) \to_\beta \varepsilon u.\, P(u)$
2. $\lambda y \lambda x.\, x = f(y)(\varepsilon u.\, P(u)) \to_\beta \lambda x.\, x = f(\varepsilon u.\, P(u))$

FC $\overset{\text{OF}}{\sqcup}$ SC $\mapsto$ SC: head OF woman



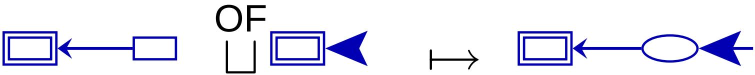
$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda r.\, P(r) \mapsto \lambda x.\, x = f(\varepsilon u.\, P(u))$

FC(ε(SC)) $\mapsto$ SC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

1. ε(SC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, P(r)) \rightarrow_\beta \varepsilon u.\, \lambda r.\, P(r)(u) \rightarrow_\beta \varepsilon u.\, P(u)$
2. $\lambda y \lambda x.\, x = f(y)(\varepsilon u.\, P(u)) \rightarrow_\beta \lambda x.\, x = f(\varepsilon u.\, P(u))$

FC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ IC: head OF Mary



$\langle e, \langle e, t\rangle\rangle$ $\langle e, t\rangle$ $\langle e, t\rangle$

$\lambda y \lambda x.\ x = f(y) \overset{\text{OF}}{\sqcup} \lambda r.\ r = \iota v.\ P(v) \mapsto \lambda x.\ x = f(\iota u.\ P(u))$

FC(ε(IC)) $\mapsto$ IC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

FC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ IC: head OF Mary

$\langle e, \langle e, t\rangle\rangle$ e $\langle e, t\rangle$

$\lambda y \lambda x.\, x = f(y) \overset{\text{OF}}{\sqcup} \lambda r.\, r = \iota v.\, P(v) \mapsto \lambda x.\, x = f(\iota u.\, P(u))$

FC(ε(IC)) $\mapsto$ IC

$\langle e, \langle e, t\rangle\rangle(\langle\langle e, t\rangle, e\rangle(\langle e, t\rangle)) \mapsto \langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

1. ε (IC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, r = \iota v.\, P(v)) \rightarrow_\beta \varepsilon u.\, u = \iota v.\, P(v) \rightarrow \iota u.\, P(u)$
2. FC(ε(IC)): $\lambda y \lambda x.\, x = f(y)(\iota u.\, P(u)) \rightarrow_\beta \lambda x.\, x = f(\iota u.\, P(u))$

FC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ IC: head OF Mary

$\langle e, \langle e, t \rangle \rangle$ e $\langle e, t \rangle$

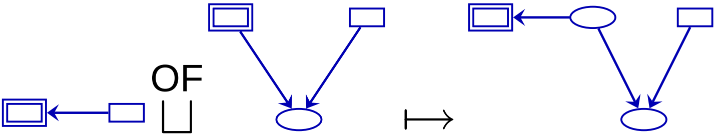
$\lambda y \lambda x.\, x = f(y) \overset{\text{OF}}{\sqcup} \lambda r.\, r = \iota v.\, P(v) \mapsto \lambda x.\, x = f(\iota u.\, P(u))$

FC(ε(IC)) $\mapsto$ IC

$\langle e, \langle e, t \rangle \rangle (\langle \langle e, t \rangle, e \rangle (\langle e, t \rangle)) \mapsto \langle e, \langle e, t \rangle \rangle (e) \mapsto \langle e, t \rangle$

1. ε (IC): $\lambda Q.\, \varepsilon u.\, Q(u)(\lambda r.\, r = \iota v.\, P(v)) \rightarrow_\beta \varepsilon u.\, u = \iota v.\, P(v) \rightarrow \iota u.\, P(u)$
2. FC(ε(IC)): $\lambda y \lambda x.\, x = f(y)(\iota u.\, P(u)) \rightarrow_\beta \lambda x.\, x = f(\iota u.\, P(u))$

FC $\overset{\text{OF}}{\sqcup}$ RC $\mapsto$ RC: head OF friend



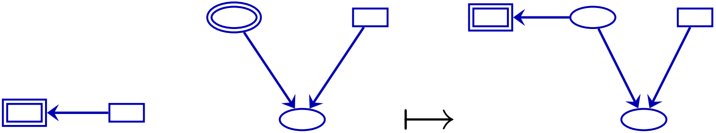
$\langle e, \langle e, t\rangle\rangle$ $\quad$ $\langle e, \langle e, t\rangle\rangle$ $\quad$ $\langle e, \langle e, t\rangle\rangle$

$\lambda y'\lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y'\lambda x'.\, S(x', y') \mapsto \lambda y'\lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

FC $\overset{\text{OF}}{\sqcup}$ RC $\mapsto$ RC: head OF friend



$\langle e, \langle e, t\rangle\rangle$ $\langle e, e\rangle$ $\langle e, \langle e, t\rangle\rangle$

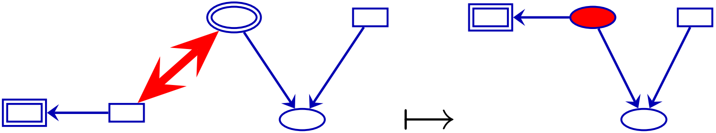
$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x', y'))) \to_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x', y')(u)) \to_\beta \lambda y'.\, \varepsilon u.\, S(u, y')$
2. FC $\circ(\varepsilon\circ$ RC): $(\lambda y \lambda x.\, x = f(y)) \circ (\lambda y'.\varepsilon u.\, S(u, y')) \to \lambda y'(\lambda y \lambda x.\, x = f(y)(\varepsilon u.\, S(u, y'))) \to_\beta \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

$FC \overset{\text{OF}}{\sqcup} RC \mapsto$ RC: head OF friend



$\langle e, \langle e, t \rangle\rangle$ $\langle e, e \rangle$ $\langle e, \langle e, t \rangle\rangle$

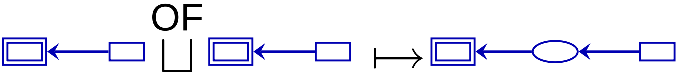
$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t \rangle\rangle \circ (\langle\langle e, t \rangle, e \rangle \circ \langle e, \langle e, t \rangle\rangle) \mapsto \langle e, \langle e, t \rangle\rangle \circ \langle e, e \rangle \mapsto \langle e, \langle e, t \rangle\rangle$

1. $\varepsilon\circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x', y'))) \rightarrow_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x', y')(u)) \rightarrow_\beta \lambda y'.\, \varepsilon u.\, S(u, y')$
2. FC $\circ(\varepsilon\circ$ RC): $(\lambda y \lambda x.\, x = f(y)) \circ (\lambda y'.\varepsilon u.\, S(u, y')) \rightarrow \lambda y'(\lambda y \lambda x.\, x = f(y)(\varepsilon u.\, S(u, y'))) \rightarrow_\beta \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\overset{\text{OF}}{\sqcup}$ FC $\mapsto$ FC: head OF spouse



$\langle e, \langle e, t\rangle\rangle$ $\langle e, \langle e, t\rangle\rangle$ $\langle e, \langle e, t\rangle\rangle$

$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, x' = g(y') \mapsto \lambda y' \lambda x.\, x = f(g(y'))$

FC $\circ(\varepsilon\circ$ FC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

FC $\overset{\text{OF}}{\sqcup}$ FC $\mapsto$ FC: head OF spouse

$\langle e, \langle e, t\rangle\rangle$ $\qquad$ $\langle e, e\rangle$ $\qquad$ $\langle e, \langle e, t\rangle\rangle$

$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, x' = g(y') \mapsto \lambda y' \lambda x.\, x = f(g(y'))$

FC $\circ(\varepsilon\circ$ FC$)$

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ FC: $\lambda y'.\, g(y')$
2. FC $(\circ\varepsilon\circ$ FC$)$: $(\lambda y \lambda x.\, x = f(y)) \circ (\lambda y'.\, g(y')) \rightarrow \lambda y'(\lambda y \lambda x.\, x = f(y)(g(y')) \rightarrow_\beta \lambda y' \lambda x.\, x = f(g(y'))$

$\text{FC} \overset{\text{OF}}{\sqcup} \text{FC} \mapsto$ FC: head OF spouse

$\langle e, \langle e, t \rangle\rangle$ $\langle e, e\rangle$ $\langle e, \langle e, t \rangle\rangle$

$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, x' = g(y') \mapsto \lambda y' \lambda x.\, x = f(g(y'))$

FC $\circ$($\varepsilon\circ$ FC)

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

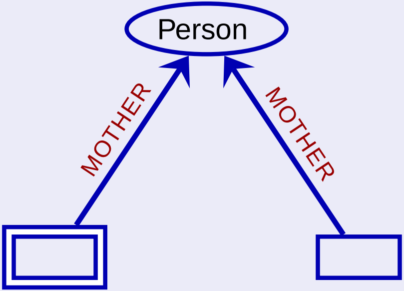
1. $\varepsilon\circ$ FC: $\lambda y'.\, g(y')$
2. FC ($\circ\varepsilon\circ$ FC): $(\lambda y \lambda x.\, x = f(y)) \circ (\lambda y'.\, g(y')) \rightarrow \lambda y'(\lambda y \lambda x.\, x = f(y)(g(y')) \rightarrow_\beta \lambda y' \lambda x.\, x = f(g(y'))$

outline

three kinds of relational constructions

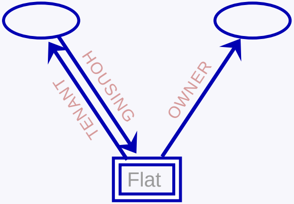
1. the possessum frame is relational and demands an argument

sibling:



2. the possessum frame is sortal, but can be shifted to a relational one

flat



three kinds of relational constructions

1. the possessum frame is relational and demands an argument

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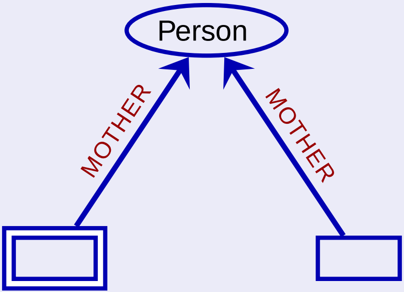

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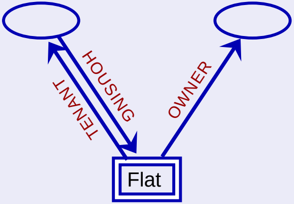
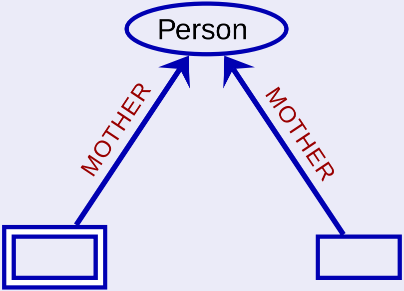


three kinds of relational constructions

1. the possessum frame is relational and demands an argument

sibling:



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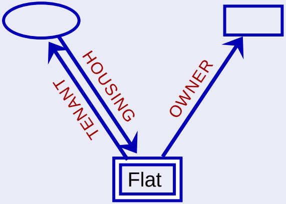
flat

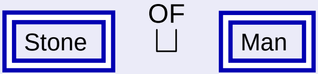


Note that the relation is already encoded in the lexical frame

three kinds of relational constructions

3. the possessum frame is sortal and cannot be shifted to an appropriate relational one

stone OF man



$\lambda x.\,\mathit{Stone}(x) \overset{\text{OF}}{\sqcup} \lambda x.\,\mathit{Man}(x)$

Stone does not encode an appropriate relation. Hence, the ownership relation in *'stone OF man'* must be established by *man*.

$\lambda x.\,\mathit{Man}(\mathit{owner}(x))$ ['OF man']

Which results in:

$\lambda x.\,\mathit{Stone}(x) \wedge \mathit{Man}(\mathit{owner}(x))$

['stone OF man']

genitive constructions

Genitive constructions are sensitive to concept classes:

(1)
- **a.** John's team.
- **b.** a team of John's
- **c.** That team is John's.

(2)
- **a.** John's brother
- **b.** a brother of John's
- **c.** (♯) That brother is John's.

Partee & Borschev (2003)

shifted vs. unshifted

genitive constructions

Genitive constructions are sensitive to concept classes:

(1) a. John's team.
    b. a team of John's
    c. That team is John's.

(2) a. John's brother
    b. a brother of John's
    c. (♯) That brother is John's.

Partee & Borschev (2003)

shifted vs. unshifted

genitive constructions

Genitive constructions express a variety of relations:

(1)
a. *the girl's sister (V&J)   [kinship]*
b. *the girl's nose (V&J)   [part-whole]*
c. *the girl's car (V&J)   [ownership]*

One expression can be interpreted in more than one way:

(2)
a. *the girl's poem (V&J)   [authorship, ownership, . . .]*
b. *the girl's teacher (V&J)*
c. *the description of the policeman's (H&Z)   [agent, theme]*

V&J: Vikner & Jensen (2002), H&Z: Hartmann & Zimmermann (2003)

conclusion

- Frames decompose concepts into functional concepts.
- The concept classes of possessum and possessor determine the concept class of the composed concept.
- This can be modeled both in predicate logic and in frames – where the composition in terms of frames may be more easily grasped as it is based on visual operations.
- Frames and their composition offer a promising approach to understand the complex semantics of possessive constructions as they explicitly express the inner structure of a concept and the relations therein.

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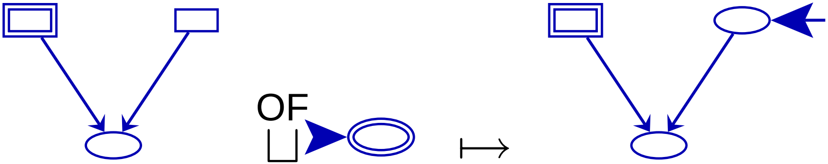
RC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ SC: finger OF Mary



$\langle e, \langle e, t \rangle \rangle$ $\qquad$ $\langle e, t \rangle$ $\qquad$ $\langle e, t \rangle$

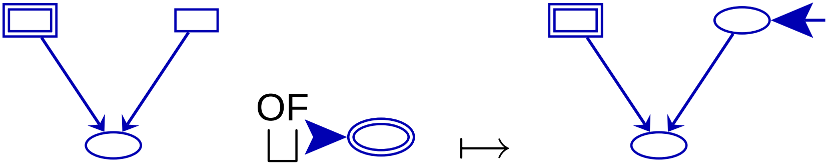
$\lambda y \lambda x.\, R(x, y) \overset{\text{OF}}{\sqcup} \iota u.\, P(u) \mapsto \lambda x.\, R(x, \iota u.\, P(u))$

RC(ι IC) $\mapsto$ SC

$\langle e, \langle e, t \rangle \rangle (e) \mapsto \langle e, t \rangle$

1. ι IC: $\iota u.\, P(u)$
2. $\lambda y \lambda x.\, R(x, y)(\iota u.\, P(u)) \;\rightarrow_\beta\; \lambda x.\, R(x, \iota u.\, P(u))$

RC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ SC: finger OF Mary



$\langle e, \langle e, t \rangle \rangle$ $\quad$ $\langle e, t \rangle$ $\quad$ $\mapsto$ $\quad$ $\langle e, t \rangle$

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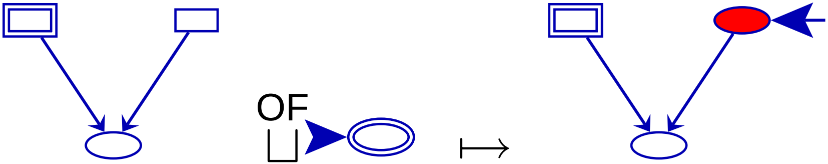

$\langle e, \langle e, t \rangle \rangle$ $\langle e, t \rangle$ $\langle e, t \rangle$

$\lambda y \lambda x.\, R(x,y) \overset{\text{OF}}{\sqcup} \iota u.\, P(u) \mapsto \lambda x.\, R(x, \iota u.\, P(u))$

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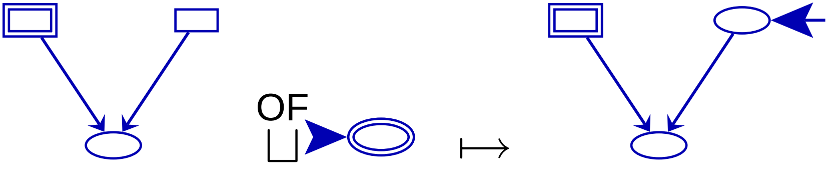
RC $\overset{\text{OF}}{\sqcup}$ IC $\mapsto$ SC: finger OF Mary



$\langle e, \langle e, t\rangle\rangle$ $\langle e, t\rangle$ $\langle e, t\rangle$

$\lambda y \lambda x.\, R(x, y) \overset{\text{OF}}{\sqcup} \iota u.\, P(u) \mapsto \lambda x.\, R(x, \iota u.\, P(u))$

RC(ι IC) $\mapsto$ SC

$\langle e, \langle e, t\rangle\rangle(e) \mapsto \langle e, t\rangle$

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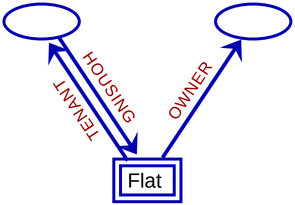
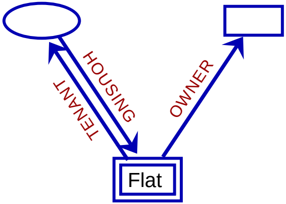
genitive constructions are sensitive to concept classes



sortal concept *flat:*
“Many flats are offered in the newspaper.”

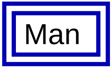
genitive constructions are sensitive to concept classes



proper relational concept *flat:*
"This flat is a flat of John, he owns more than five."

possessive construction - sortal

stone



$\lambda x.\, \mathit{Stone}(x)$

man

$\lambda x.\, \mathit{Man}(x)$

of man

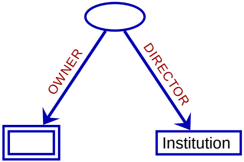
$\lambda x.\, \mathit{Man}(\mathit{owner}(x))$

stone of man

possessive construction - functional

car

$\lambda x.\, Car(x)$

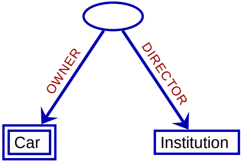


of director

$\lambda y \lambda x.\, owner(x) = director(y) \wedge Institution(y)$

director

$\lambda y \lambda x.\, Institution(y) \wedge x = director(y)$



car of director

$\lambda y \lambda x.\, Car(x) \wedge owner(x) = director(y) \wedge Institution(y)$

age of a student, price of a snowboard
problematisch
description of the policeman’s (

(4) a. John's team.
b. a team of John's
c. That team is John's.

(5) a. John's brother
b. a brother of John's
c. (♯) That brother is John's.

(6) a. John's favorite movie
b. a favorite movie of John's
c. (♯) That favorite movie is John's.

Partee, Borschev 2003, p. 69

(22) a. ♯ That father is John's.
b. ♯ That favorite movie is John's.
c. That teacher is John's.
d. His [pointing] father is also John's.
e. Dad's favorite movie is also mine.
f. ?That father is John's father

Partee, Borschev 2003, p. 81

(28)
a. Diese Bücher sind meine.
b. Diese Bücher sind mein.

Partee, Borschev 2003, p. 85

(40)
a. Many teachers voted for John.
b. Many mothers voted for John.
c. Many parents voted for John.
d. ♯ Many brothers voted for John.
e. ♯ Many uncles voted for John.

Partee, Borschev 2003, p. 91

(1)
a. The girl’s sister
b. The girl’s name
c. The girl’s car

Vikner, Jensen 2002, p. 192

(2)
a. The girl’s teacher
b. The girl’s poem

Vikner, Jensen 2002, p. 192

(7)
- **a.** The car's teacher
- **b.** The company's nose
- **c.** The nose's poem
- **d.** The car's cake

Vikner, Jensen 2002, p. 196

(28)
- **a.** ?A brother was standing in the yard
- **b.** ?An edge was lying in the yard

(29)
- **a.** A car was parked in the yard
- **b.** A wheel was lying in the yard

Vikner, Jensen 2002, p. 209

(39)
- **a.** I saw John's car yesterday.
- **b.** ♯ I saw John's bus yesterday.

(40)
- **a.** John accidentally snapped his pencil.
- **b.** ♯ John accidentally snapped his stick.

Vikner, Jensen 2002, p. 214

(27) **a.** last fall’s Presidential elections
b. this week’s meeting
c. tomorrow’s contest
d. a week’s idleness

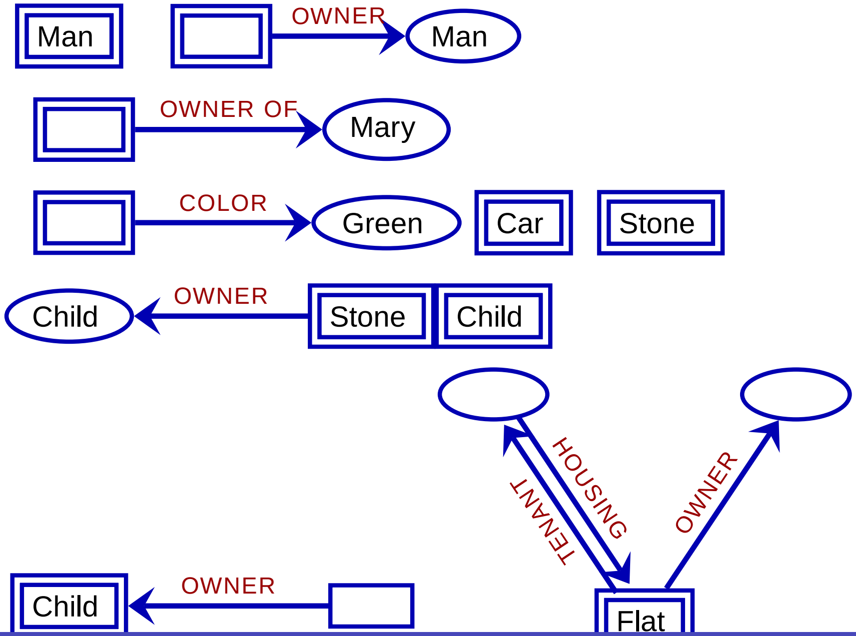
(28) **a.** yesterday’s New York Times
b. the season’s cotton and tobacco crops

Jensen, Vikner 2002, p. 17

unification of nodes

$\lambda x_n \dots x_1 \mathbf{body}_1 \sqcup_{i,j} \lambda y_m \dots y_1 \mathbf{body}_2$ **(**$i \leq n, j \leq m$**)**
$\mapsto \lambda y_m \dots y_{j+1} y_{j-1} \dots y_1 \lambda x_n \dots x_{i+1} x_{i-1} \dots x_1 .\ \exists u\ (\mathbf{body}_1 \wedge \mathbf{body}_2)[u/x_i, u/y_j]$

1. description of the unified node:
   $\varepsilon u.\ (\text{body}_1 \wedge \text{body}_2)[u/x_i, u/y_j]$ =: B
2. composed frame: $(\text{body}_1 \wedge \text{body}_2)[B/x_i, B/y_j]$
3. equivalent to: $\exists u\ (\text{body}_1 \wedge \text{body}_2)[u/x_i, u/y_j]$
4. λ-abstraction:
   $\lambda y_m \dots y_{j+1} y_{j-1} \dots y_1 \lambda x_n \dots x_{i+1} x_{i-1} \dots x_1 .\ \exists u\ (\text{body}_1 \wedge \text{body}_2)[u/x_i, u/y_j]$


Man
OWNER
Man
OWNER OF
Mary
COLOR
Green
Car
Stone
Child
OWNER
Stone
Child
HOUSING
TENANT
OWNER
Child
OWNER
Flat