A Brief Introduction to Lexical Functional Grammar

Ash Asudeh*

LING233B

Monday, January 14, 2002

* Based on material by
Mary Dalrymple and Ron Kaplan

Architectural Issues

Representation:

Formal encoding of linguistic dependencies

Modularity:

Factoring independent generalizations

Mathematical tractability:

Provable mathematical properties

Implementability:

Transparent, efficient computation

LFG: Formal Concepts

- **Structure**
- **Structural Description**
- **Structural Correspondence (Projection)**

Architectural themes:

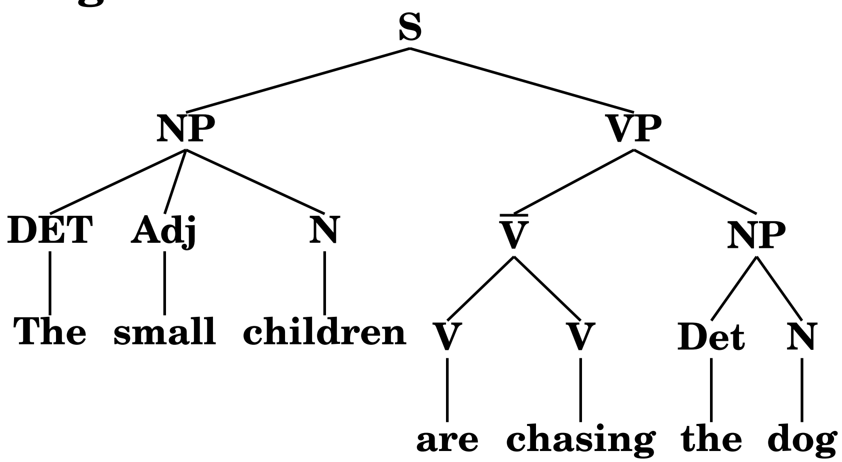
Importance of partial specification

Factor generalizations on related but dissimilar representations

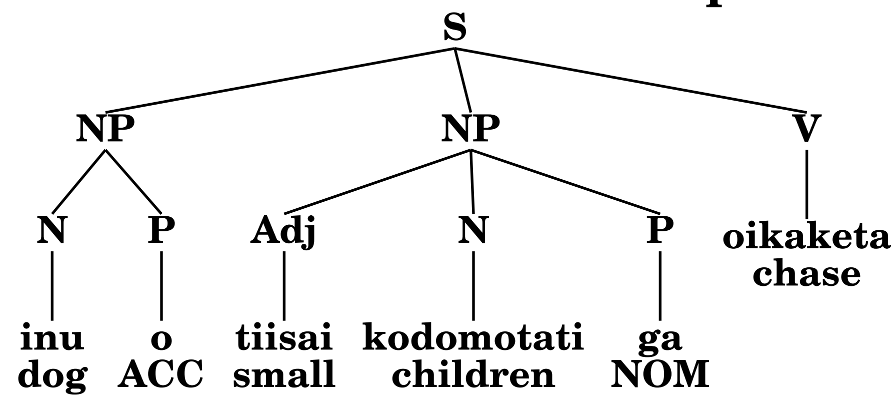
Variation in External Structure

"The small children are chasing the dog."

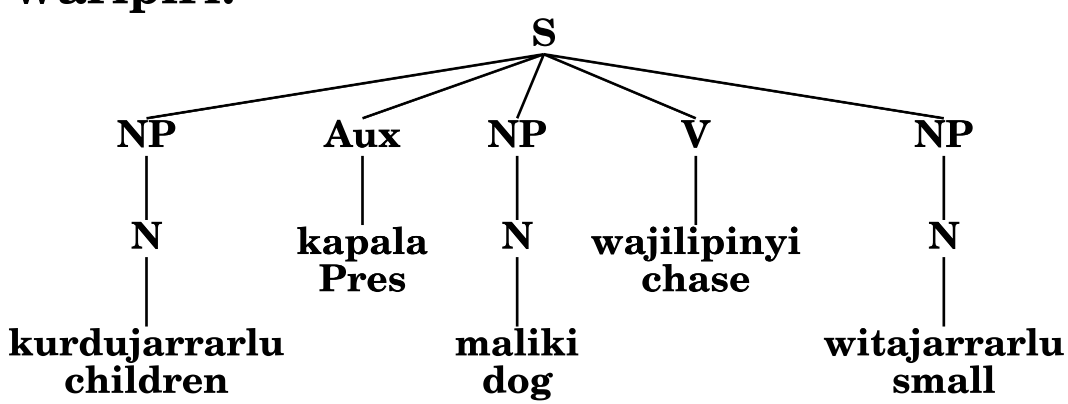
English:



Japanese:



Warlpiri:



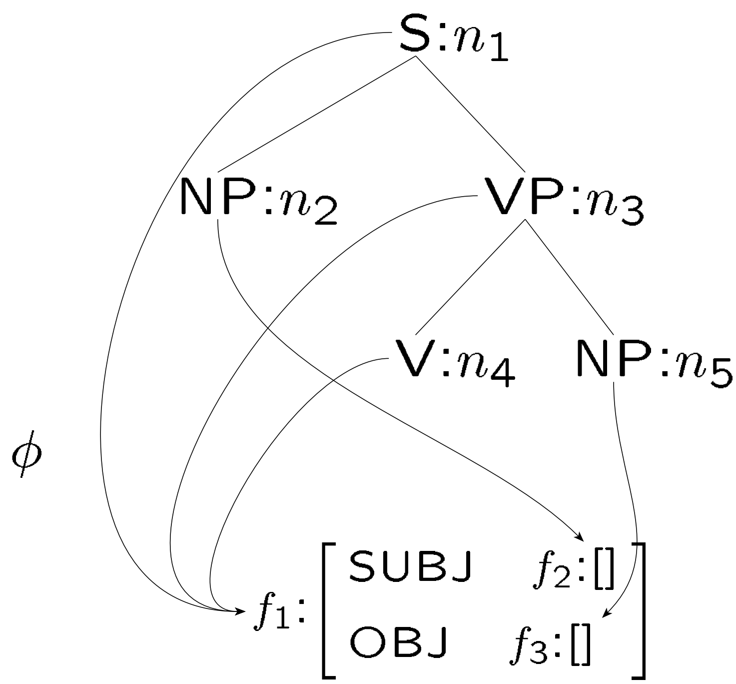
Internal structural invariance:

F-structure for
English, Japanese, and Warlpiri
'The small children are chasing the dog':

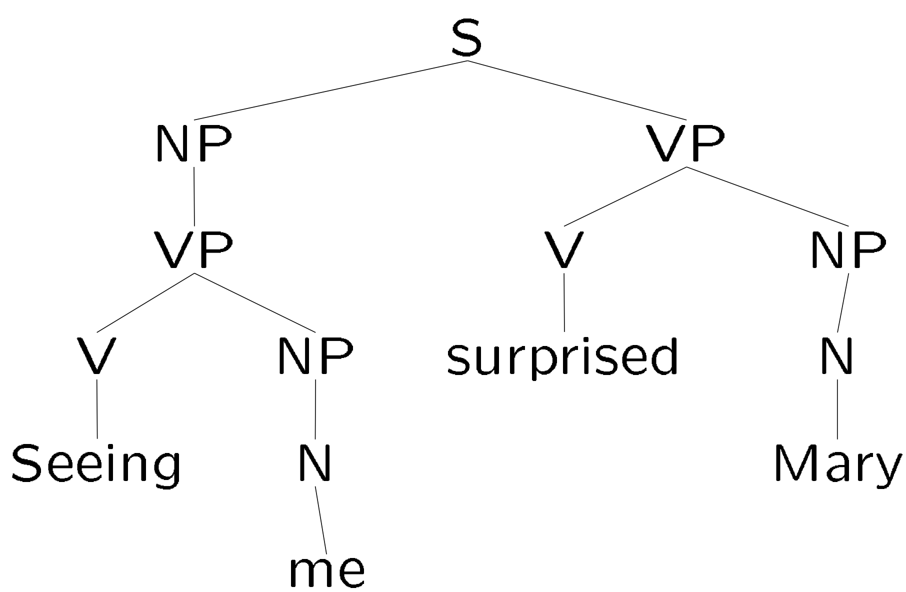
$$\begin{bmatrix} \text{PRED} & \text{`chase'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`children'} \\ \text{SPEC} & \text{`the'} \\ \text{MODS} & \left\{ \begin{bmatrix} \text{PRED} & \text{`small'} \end{bmatrix} \right\} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`dog'} \\ \text{SPEC} & \text{`the'} \end{bmatrix} \end{bmatrix}$$

C-structure/f-structure mapping: Many-to-one

ϕ: N $\rightarrow$ F



C-structure/f-structure mapping: Not ‘onto’



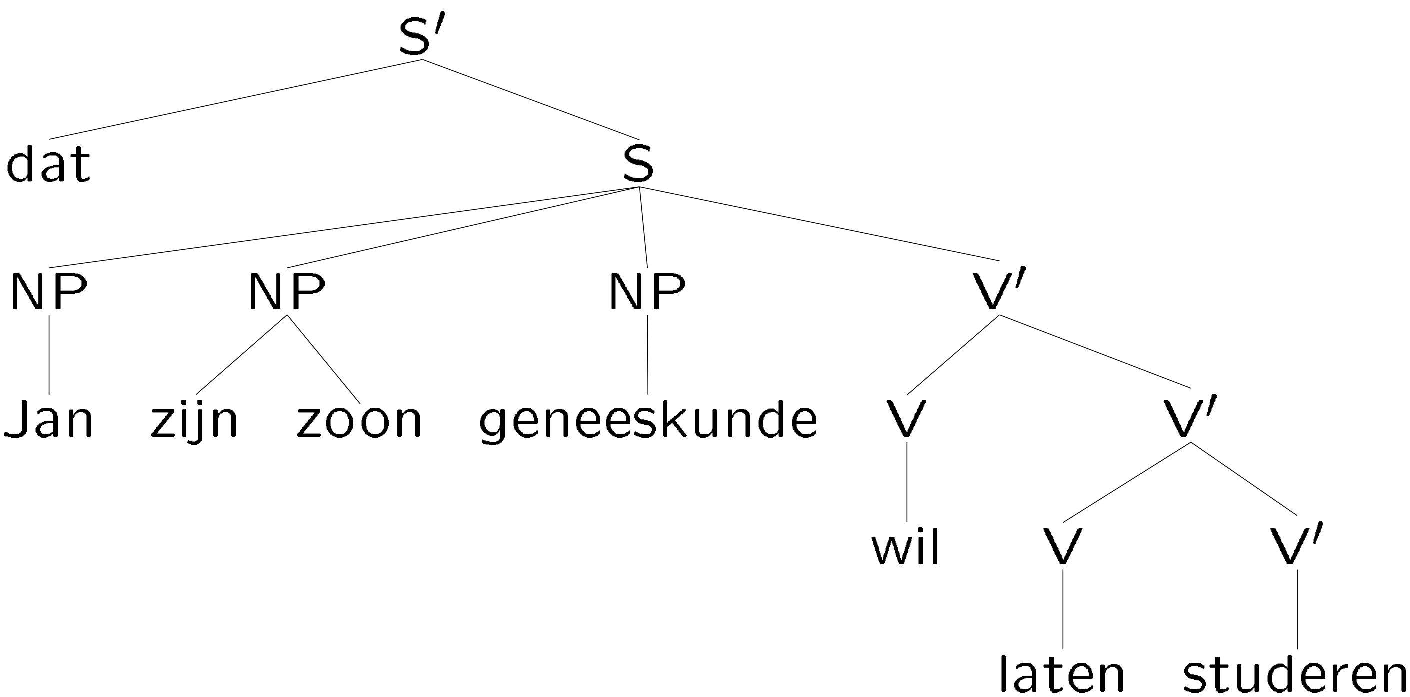
$$\left[\begin{array}{ll} \text{PRED} & \text{`surprise}\langle\,(\uparrow\ \text{SUBJ}),\ (\uparrow\ \text{OBJ})\,\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`see}\langle\,(\uparrow\ \text{SUBJ}),\ (\uparrow\ \text{OBJ})\,\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`pro'}\end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`me'}\end{array}\right] \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`Mary'}\end{array}\right] \end{array}\right]$$

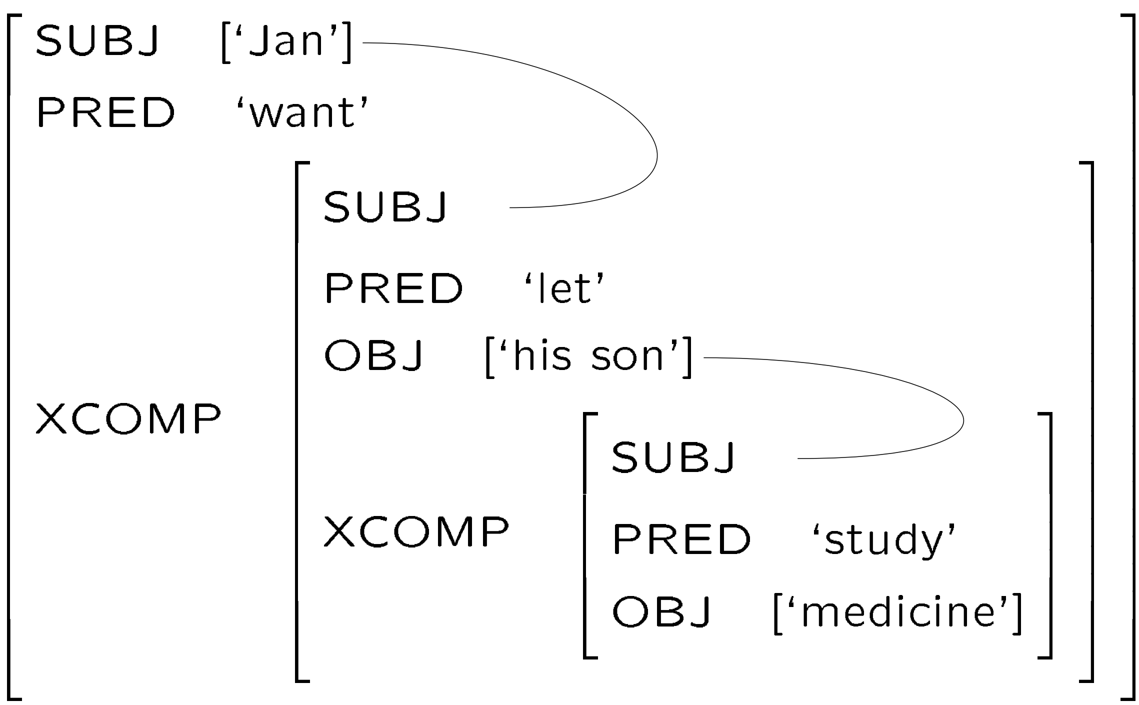
Non-native relationships induced by correspondence: Functional precedence

$f_1 <_f f_2$ iff

for all $n_1 \in \phi^{-1}(f_1)$ and for all $n_2 \in \phi^{-1}(f_2)$,

$n_1 <_c n_2$


S′
dat
S
NP
NP
NP
V′
Jan
zijn
zoon
geneeskunde
V
V′
wil
V
V′
laten
studeren


SUBJ [‘Jan’]
PRED ‘want’
XCOMP
SUBJ
PRED ‘let’
OBJ [‘his son’]
XCOMP
SUBJ
PRED ‘study’
OBJ [‘medicine’]

F-Structural Relations: Functional Uncertainty

Jane, John telephoned yesterday.

$$\begin{bmatrix} \text{TOPIC} & \begin{bmatrix} \text{PRED} & \text{`Jane'} \end{bmatrix} \\ \text{PRED} & \text{`telephone'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`John'} \end{bmatrix} \\ \text{OBJ} & \end{bmatrix}$$

Jane, Bill claimed that John telephoned yesterday.

$$\begin{bmatrix} \text{TOPIC} & \begin{bmatrix} \text{PRED} & \text{`Jane'} \end{bmatrix} \\ \text{PRED} & \text{`claim'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`Bill'} \end{bmatrix} \\ \text{COMP} & \begin{bmatrix} \text{PRED} & \text{`telephone'} \\ \text{SUBJ} & \text{`John'} \\ \text{OBJ} & \end{bmatrix} \end{bmatrix}$$

Jane, Bill claimed that Sue said that John telephoned yesterday.

$$(\uparrow\ \text{TOPIC}) = (\uparrow\ \text{COMP* OBJ})$$

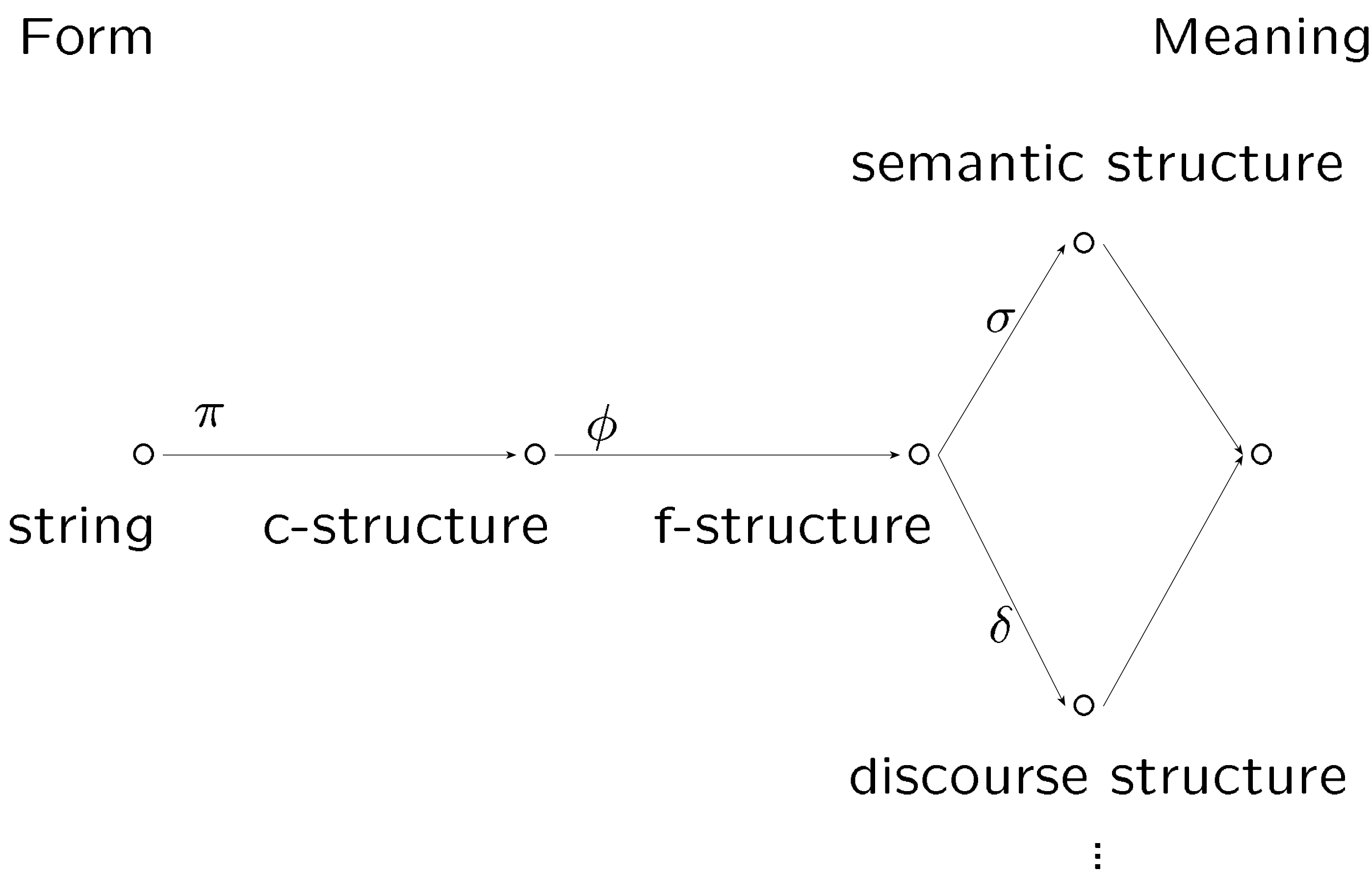
$$(f1\ \text{SUBJ}) = (f1\ \text{GF* OBJ})$$

$$\text{GF* is COMP COMP COMP}$$

$$f6 = f5$$

$$1{:}\begin{bmatrix} \text{SUBJ} & f6 \\ \text{COMP} & 2{:}\begin{bmatrix} \text{SUBJ} & f7 \\ \text{COMP} & 3{:}\begin{bmatrix} \text{SUBJ} & f8 \\ \text{COMP} & 4{:}\begin{bmatrix} \text{SUBJ} & f9 \\ \text{OBJ} & f5 \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Beyond Syntax: Other Structures



Quick introduction to LFG

Annotated phrase structure rules:

$$\text{IP} \longrightarrow \underset{(\uparrow\ \text{SUBJ}) = \downarrow}{\text{NP}} \quad \underset{\uparrow = \downarrow}{\text{I}'}$$

$$\text{I}' \longrightarrow \left(\underset{\uparrow = \downarrow}{\text{I}}\right) \quad \underset{\uparrow = \downarrow}{\text{VP}}$$

$$\text{VP} \longrightarrow \left(\underset{\uparrow = \downarrow}{\text{V}}\right) \quad \left(\underset{(\uparrow\ \text{OBJ}) = \downarrow}{\text{NP}}\right)$$

$$\text{NP} \longrightarrow \underset{\uparrow = \downarrow}{\text{N}}$$

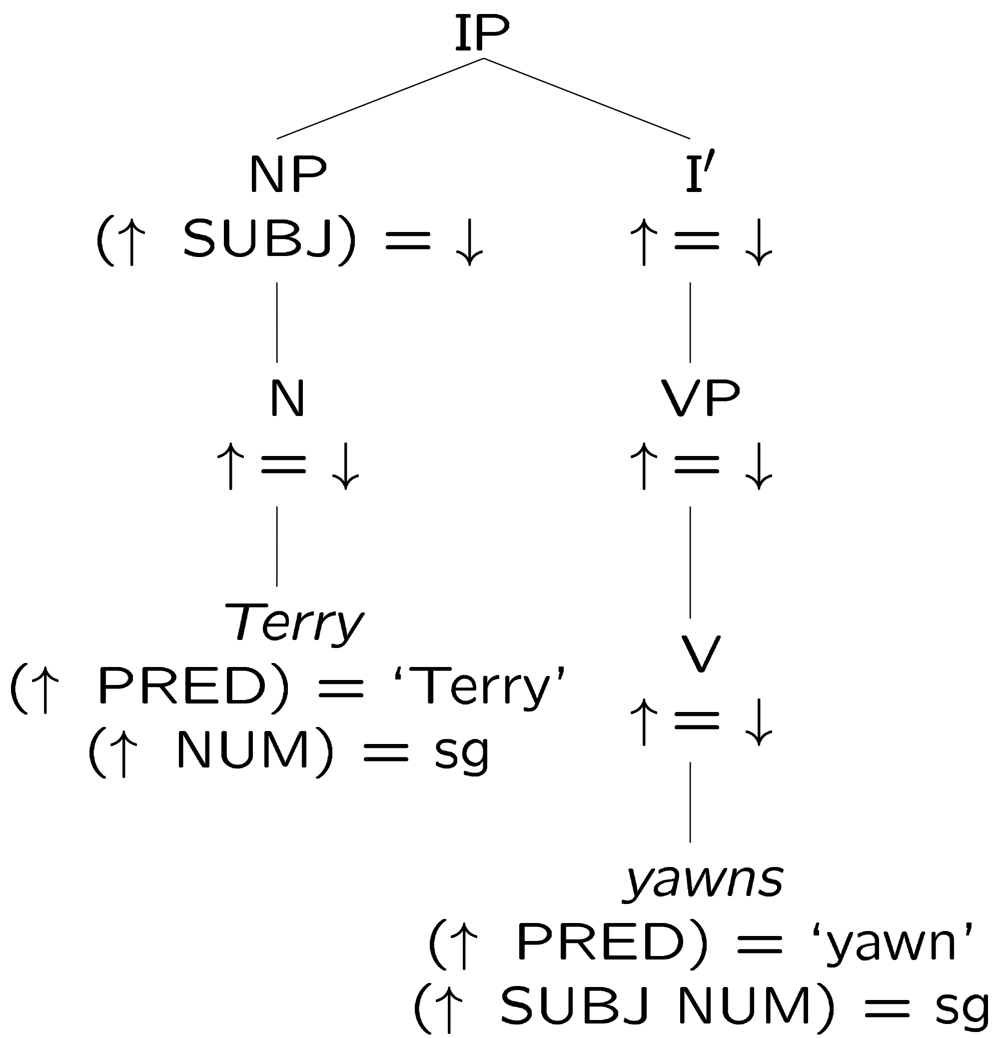
$\uparrow$ is the f-structure of the mother node.

$\downarrow$ is the f-structure of the node the annotation appears on.

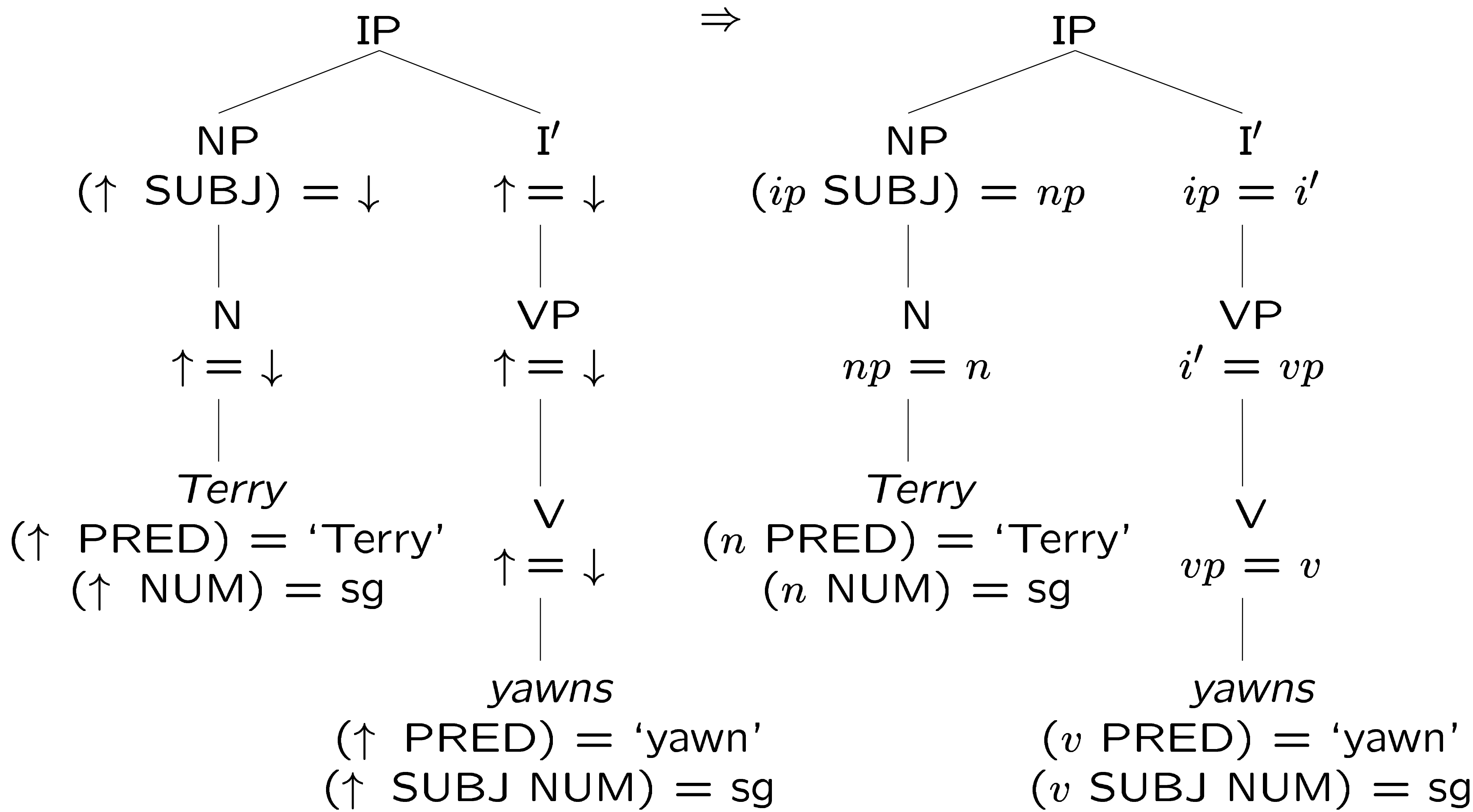
Lexical entries:

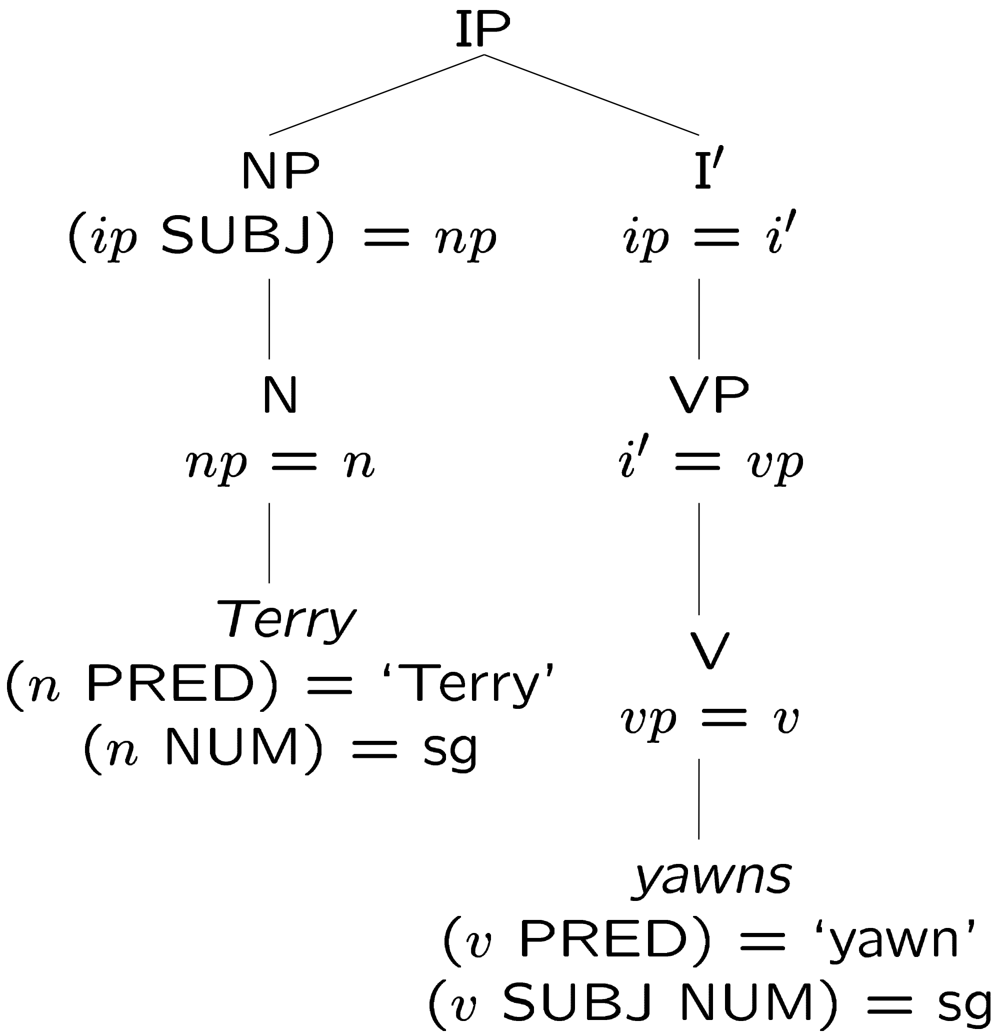
Terry	N	$(\uparrow$ PRED$)$ = 'Terry'
		$(\uparrow$ NUM$)$ = sg
yawns	V	$(\uparrow$ PRED$)$ = 'yawn'
		$(\uparrow$ SUBJ NUM$)$ = sg

Terry yawns.


IP
NP
(↑ SUBJ) = ↓
I′
↑ = ↓
N
↑ = ↓
VP
↑ = ↓
Terry
(↑ PRED) = 'Terry'
(↑ NUM) = sg
V
↑ = ↓
yawns
(↑ PRED) = 'yawn'
(↑ SUBJ NUM) = sg

Terry yawns.


IP
NP
(↑ SUBJ) = ↓
I′
↑ = ↓
N
↑ = ↓
VP
↑ = ↓
Terry
(↑ PRED) = 'Terry'
(↑ NUM) = sg
V
↑ = ↓
yawns
(↑ PRED) = 'yawn'
(↑ SUBJ NUM) = sg
⇒
IP
NP
(ip SUBJ) = np
I′
ip = i′
N
np = n
VP
i′ = vp
Terry
(n PRED) = 'Terry'
(n NUM) = sg
V
vp = v
yawns
(v PRED) = 'yawn'
(v SUBJ NUM) = sg



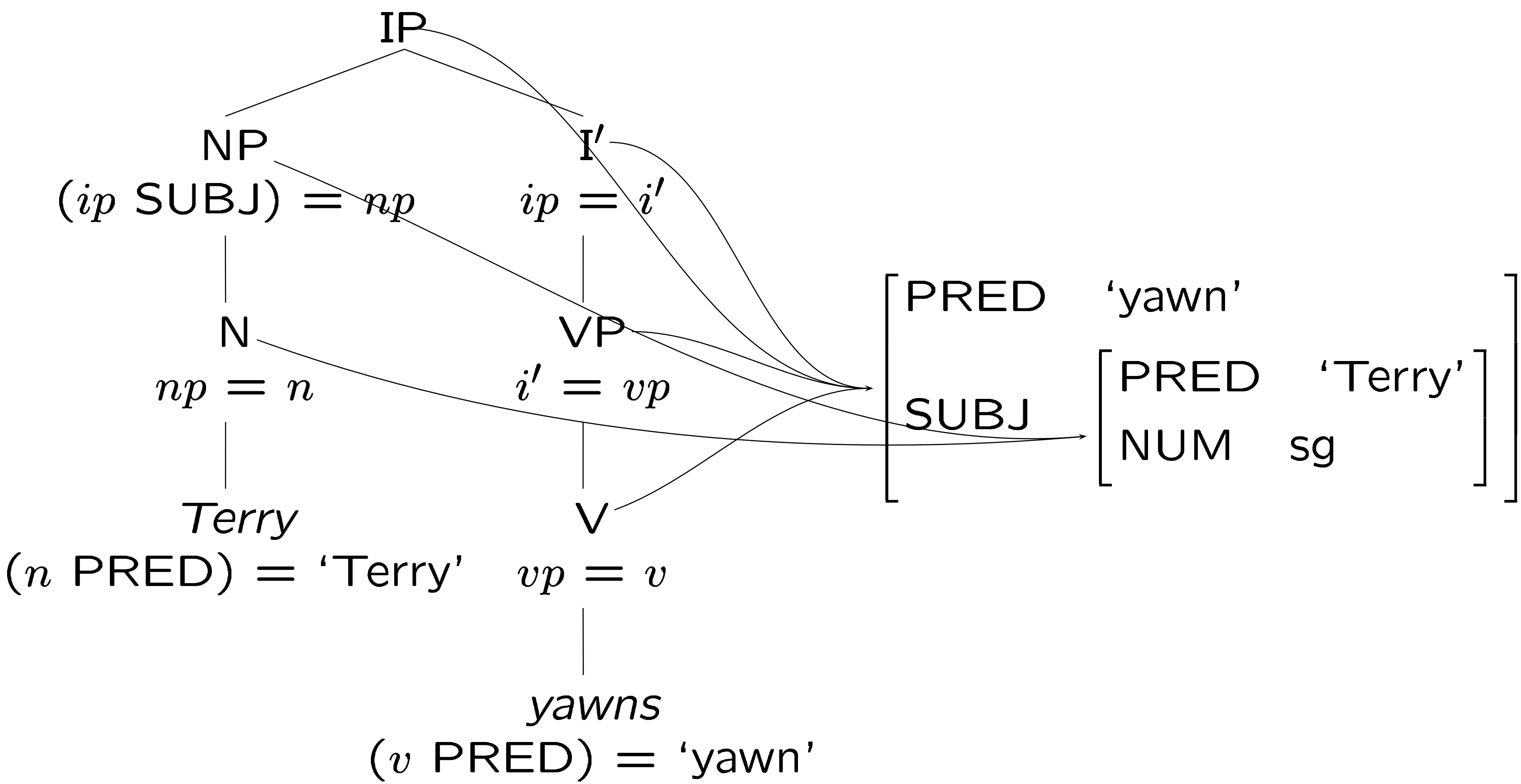
F-description:

$(ip \text{ SUBJ}) = np$
$np = n$
$(n \text{ PRED}) = \text{'Terry'}$
$(n \text{ NUM}) = \text{sg}$
$ip = i'$
$i' = vp$
$vp = v$
$(v \text{ PRED}) = \text{'yawn'}$
$(v \text{ SUBJ NUM}) = \text{sg}$

$$
\begin{aligned}
&(ip\ \text{SUBJ}) = np \\
&np = n \\
&(n\ \text{PRED}) = \text{`Terry'} \\
&(n\ \text{NUM}) = \text{sg} \\
&ip = i' \\
&i' = vp \\
&vp = v \\
&(v\ \text{PRED}) = \text{`yawn'} \\
&(v\ \text{SUBJ NUM}) = \text{sg}
\end{aligned}
$$

Minimal solution to f-description:

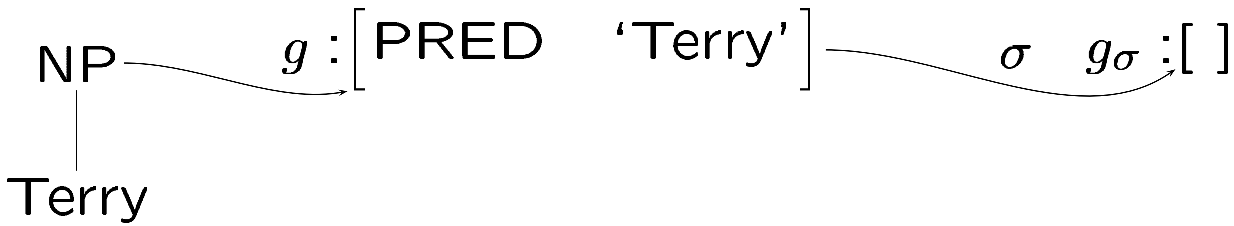
$$
ip, i', vp, v : \begin{bmatrix} \text{PRED} & \text{`yawn'} \\ \text{SUBJ} & np, n : \begin{bmatrix} \text{PRED} & \text{`Terry'} \\ \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}
$$


IP
NP
(ip SUBJ) = np
I′
ip = i′
N
np = n
VP
i′ = vp
Terry
(n PRED) = ‘Terry’
V
vp = v
yawns
(v PRED) = ‘yawn’
PRED ‘yawn’
SUBJ
PRED ‘Terry’
NUM sg

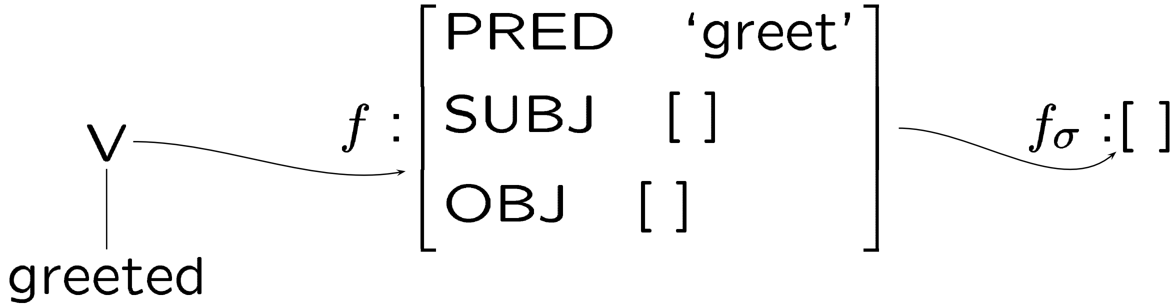
F-structures and semantic projections: Dalrymple et al. (1999)

$$(g \text{ PRED}) = \text{`Terry'}$$

$$\textit{Terry} : g_\sigma$$



“Glue language” deductions:



$$\lambda X.\lambda Y.\mathit{greet}(X,Y) : (f\ \mathrm{SUBJ})_\sigma \multimap ((f\ \mathrm{OBJ})_\sigma \multimap f_\sigma)$$

- if we have a resource for f’s subject (f SUBJ)

- then ($\multimap$) if we have a resource for f’s object (f OBJ)

- then we have a resource for f.

Augmenting the lexicon with semantic information:

Sam	N	$(\uparrow \text{ PRED}) = \text{'Sam'}$ $\mathit{Sam} : \uparrow_\sigma$
Terry	N	$(\uparrow \text{ PRED}) = \text{'Terry'}$ $\mathit{Terry} : \uparrow_\sigma$
greeted	V	$(\uparrow \text{ PRED}) = \text{'greet'}$ $\lambda X.\lambda Y.\mathit{greet}(X, Y) : (\uparrow \text{ SUBJ})_\sigma \multimap ((\uparrow \text{ OBJ})_\sigma \multimap \uparrow_\sigma)$

Sam greeted Terry.

$$f : \begin{bmatrix} \text{PRED} & \text{`greet'} \\ \text{SUBJ} & g : \begin{bmatrix} \text{PRED} & \text{`Sam'} \end{bmatrix} \\ \text{OBJ} & h : \begin{bmatrix} \text{PRED} & \text{`Terry'} \end{bmatrix} \end{bmatrix}$$

sam : $\quad$ *Sam* : g_σ
terry : $\quad$ *Terry* : h_σ
greeted : $\quad \lambda X.\lambda Y.greet(X, Y) : g_\sigma \multimap (h_\sigma \multimap f_\sigma)$

$$f : \begin{bmatrix} \text{PRED} & \text{'greet'} \\ \text{SUBJ} & g : \begin{bmatrix} \text{PRED} & \text{'Sam'} \end{bmatrix} \\ \text{OBJ} & h : \begin{bmatrix} \text{PRED} & \text{'Terry'} \end{bmatrix} \end{bmatrix}$$

sam : *Sam* : g_σ
terry : *Terry* : h_σ
greeted : $\lambda X.\lambda Y.\textit{greet}(X, Y) : g_\sigma \multimap (h_\sigma \multimap f_\sigma)$

sam-greeted : $\lambda Y.\textit{greet}(\textit{Sam}, Y) : h_\sigma \multimap f_\sigma$

$$\begin{array}{ll} & \textbf{sam} \otimes \textbf{terry} \otimes \textbf{greeted} \quad (Premises.) \\ \vdash & \textbf{sam-greeted} \otimes \textbf{terry} \\ \vdash & \textit{greet}(\textit{Sam}, \textit{Terry}) : f_\sigma \end{array}$$

$$f : \begin{bmatrix} \text{PRED} & \text{'greet'} \\ \text{SUBJ} & g : \begin{bmatrix} \text{PRED} & \text{'Sam'} \end{bmatrix} \\ \text{OBJ} & h : \begin{bmatrix} \text{PRED} & \text{'Terry'} \end{bmatrix} \end{bmatrix}$$

sam : $\mathit{Sam} : g_\sigma$
terry : $\mathit{Terry} : h_\sigma$
greeted : $\lambda X.\lambda Y.\mathit{greet}(X, Y) : g_\sigma \multimap (h_\sigma \multimap f_\sigma)$

greeted-terry : $\lambda X.\mathit{greet}(X, \mathit{Terry}) : g_\sigma \multimap f_\sigma$

sam $\otimes$ **terry** $\otimes$ **greeted** $(\mathit{Premises.})$
$\vdash$ **sam** $\otimes$ **greeted-terry**
$\vdash$ $\mathit{greet}(\mathit{Sam}, \mathit{Terry}) : f_\sigma$

Choice of glue language:

Klein and Sag (1985, page 172):

Translation rules in Montague semantics have the property that the translation of each component of a complex expression occurs exactly once in the translation of the whole. ... That is to say, we do not want the set S [of semantic representations of a phrase] to contain *all* meaningful expressions of IL which can be built up from the elements of S, but only those which use each element exactly once.

Linear logic

multiplicative conjunction: $\otimes$

linear implication: $\multimap$

INCORRECT:	A	$\vdash$	$(A \otimes A)$
INCORRECT:	$(A \otimes B)$	$\vdash$	A
CORRECT:	$(A \otimes (A \multimap B))$	$\vdash$	B
INCORRECT:	$(A \otimes (A \multimap B))$	$\vdash$	$(A \otimes B)$
INCORRECT:	$(A \otimes (A \multimap B))$	$\vdash$	$(A \multimap B) \otimes B$

Completeness and coherence:

*Terry yawns the sink. [**incoherent**]
*Terry devoured. [**incomplete**]

Resources in syntax and semantics: F-descriptions

$$(ip \text{ SUBJ}) = np$$
$$np = n$$
$$(n \text{ PRED}) = \text{‘Terry’}$$
$$(n \text{ NUM}) = \text{sg}$$
$$(n \text{ NUM}) = \text{sg}$$
$$(n \text{ NUM}) = \text{sg}$$
$$ip = i'$$
$$i' = vp$$
$$vp = v$$
$$(v \text{ PRED}) = \text{‘yawn’}$$
$$(v \text{ SUBJ NUM}) = \text{sg}$$

Minimal solution to f-description:

$$ip, i', vp, v : \begin{bmatrix} \text{PRED} & \text{‘yawn’} \\ \text{SUBJ} & np, n : \begin{bmatrix} \text{PRED} & \text{‘Terry’} \\ \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}$$

Resources in syntax and semantics:
Glue language premises

$$f : \begin{bmatrix} \text{PRED} & \text{`yawn'} \\ \text{SUBJ} & g : \begin{bmatrix} \text{PRED} & \text{`Terry'} \\ \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}$$

$$\begin{array}{ll} \textbf{terry}: & \textit{Terry} : g_\sigma \\ \textbf{terry}: & \textit{Terry} : g_\sigma \\ \textbf{terry}: & \textit{Terry} : g_\sigma \\ \textbf{yawns}: & \lambda X.\textit{yawn}(X) : g_\sigma \multimap f_\sigma \end{array}$$

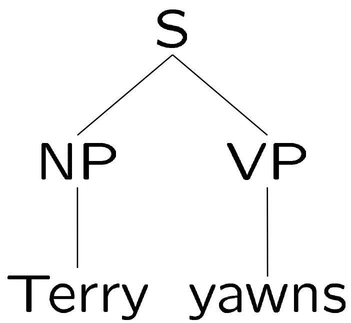
$$\begin{array}{lll} & \textbf{terry} \otimes \textbf{terry} \otimes \textbf{terry} \otimes \textbf{yawns} & \\ \vdash & \textit{yawn}(\textit{Terry}) : f_\sigma \otimes \textbf{terry} \otimes \textbf{terry} & \text{Incoherent!} \end{array}$$

Resource accounting in syntax: R-LFG (Johnson 1999)

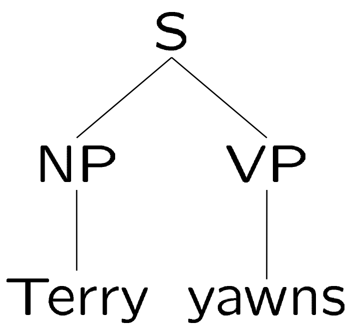
Terry	NP	*Terry* : NOM $\multimap e$
yawns	VP	$\lambda x.$*yawn*(x) : SUBJ $e \multimap t$

$$\begin{array}{lll} \text{S} & \longrightarrow & \begin{array}{cc} \text{NP} & \text{VP} \\ \text{SUBJ(NOM}, \downarrow) & \downarrow \end{array} \end{array}$$

C-structure and f-term for *Terry yawns*:



$$\left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{l} \textit{Terry} : \text{NOM} \multimap e \\ \text{NOM} \end{array}\right] \\ \lambda x.\textit{yawn}(x) : \text{SUBJ}\ e \multimap t & \end{array}\right]$$



$$\begin{bmatrix} \text{SUBJ} & \begin{bmatrix} \textit{Terry} : \text{NOM} \multimap e \\ \text{NOM} \end{bmatrix} \\ \lambda x.\textit{yawn}(x) : \text{SUBJ}\ e \multimap t & \end{bmatrix}$$

$$\dfrac{\dfrac{\dfrac{\textit{Terry} : \text{SUBJ}(\text{NOM} \multimap e)}{\textit{Terry} : \text{SUBJ NOM} \multimap \text{SUBJ}\ e} \qquad \text{SUBJ NOM}}{\textit{Terry} : \text{SUBJ}\ e} \qquad \lambda x.\textit{yawn}(x) : \text{SUBJ}\ e \multimap t}{\textit{yawn}(\textit{Terry}) : t}$$

Johnson (1999): All NPs must receive exactly one case.