

**CSC 2519F : Natural Language Semantics,
Lecture Notes 6**

$$\begin{array}{c}
 \frac{}{np : x} \text{ } \frac{}{np \setminus s / np : see} \text{ } \frac{}{np : x} \text{ } \frac{}{np : x} \\
 \hline
 \frac{}{np : x} \text{ } \frac{}{np \setminus s : see(x)} \text{ } \frac{}{np : x} \\
 \hline
 \frac{}{s : see(x)(x)} \text{ } \frac{}{np \setminus s : \lambda x . see(x)(x)} \\
 \hline
 \frac{}{np \setminus s / np : \lambda x . \lambda x . see(x)(x)} \text{ } [x - new, \Delta - non-empty]
 \end{array}$$

$$\frac{}{A : x} \text{ } \frac{}{A / A : \lambda x . x} \text{ } (CT \text{ Assumption})$$

/e, \e, /i, \i + new additions to Lambek Calculus, \cdot i and \cdot e

$$\frac{}{A : \alpha} \text{ } \frac{}{B : \beta} \text{ } \frac{}{A \cdot B : \langle \alpha, \beta \rangle} \text{ } \frac{}{A \cdot B : \alpha} \text{ } \frac{}{A : \pi_1(\alpha)} \text{ } \frac{}{B : \pi_2(\alpha)} \text{ }$$

LC_{prod} – CF, NP-complete

LC_{nonprod} – CF, ?

Combinatory Categorical Grammars (CCG's)

re-writing : S → NP VP OR S ← NP VP

CCG : X / Y ← w (Unary Phrase Structure Rule)

Functional Application

$X / Y \quad Y \Rightarrow X \quad (>)$

(Steedman notation) $Y \quad X \backslash Y \Rightarrow X \quad (<)$

(how we write it) $(Y \backslash X)$

Coordination

$\alpha \text{ CONJ } \alpha \Rightarrow \alpha \quad (<\Phi>)$

Functional Composition

$X / Y \quad Y / Z \Rightarrow X / Z \quad (>B)$

(Steedman) $Y \backslash Z \quad X \backslash Y \Rightarrow X \backslash Z$

(ours) $(Z \backslash Y \quad Y \backslash X \Rightarrow Z \backslash X) \quad (<B)$

(*) = only CCG can do, not Lambek

(Steedman) $X / Y \quad Y \backslash Z \Rightarrow X \backslash Z \quad (*)$

(ours) $(X / Y \quad Z \backslash Y \Rightarrow Z \backslash X) \quad (>B_x)$

[B = composition

x = extended]

(Steedman) $Y / Z \quad X \backslash Y \Rightarrow X / Z \quad (*)$

(ours) $(Y / Z \quad Y \backslash X \Rightarrow X \backslash Z) \quad (<B_x)$

Functional Substitution

$(X / Y) / Z \quad Y / Z \Rightarrow X / Z \quad (>S) \quad (*)$

(Steedman) $Y \setminus Z \quad (X \setminus Y) \setminus Z \Rightarrow X \setminus Z \quad (*)$

(ours) $(Z \setminus Y \quad Z \setminus (Y \setminus X) \Rightarrow Z \setminus X) \quad (<S)$

(Steedman) $(X / Y) \setminus Z \quad Y \setminus Z \Rightarrow X \setminus Z \quad (*)$

(ours) $(Z \setminus (X / Y) \quad Z \setminus Y \Rightarrow Z \setminus X) \quad (>S_x)$

(Steedman) $Y / Z \quad (X \setminus Y) / Z \Rightarrow X / Z \quad (*)$

(ours) $(Y / Z \quad (Y \setminus X) / Z \Rightarrow X / Z) \quad (<S_x)$

Type-raising (LCG can do this, but CCG can't)

(Steedman) $X \Rightarrow T / (T \setminus X)$, some T

(ours) $(X \Rightarrow T / (X \setminus T)) \quad (>T)$

(Steedman) $X \Rightarrow T \setminus (T / X)$

(ours) $(X \Rightarrow (T / X) \setminus T) \quad (<T)$

$T \setminus X, T / X \rightarrow$ “parametrically licensed”

$x \leftarrow w$

Type-raise:

$y \leftarrow v$

$NP \setminus (NP \setminus S)$

\leftarrow not in English, but OK in German

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