ACS Syntax and Semantics of Natural Language
Lecture 4: Cross-Serial Dependencies in Dutch

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... omdat ik Cecilia de nijlpaarden zag voeren.

... because I$_1$ Cecilia$_2$ the hippopotamuses$_3$ saw$_1$ feed$_2,3$.

“... because I saw Cecilia feed the hippopotamuses.”

- The Dutch construction is illustrated by the subordinate clauses above and on the next slide
- The co-indexing indicates the dependencies between the verbs and NPs represented in the semantics
- The dependencies cross rather than nest (as they do in the English translation)
... omdat ik Cecilia Henk de nijlpaarden zag helpen voeren.

... because $I_1$ Cecilia$_2$ Henk$_3$ the hippopotamses$_4$ saw$_1$ help$_2$ feed$_3,4$.

“... because I saw Cecilia help Henk feed the hippopotamses.”
dat ik Cecilia de nijlpaarden zag voeren

\[ (S \setminus NP_1) \setminus NP_2 / VP \quad (>B_x) \quad VP \setminus NP_3 \]

\[ ((S \setminus NP_1) \setminus NP_2) \setminus NP_3 \]

\[ (S \setminus NP_1) \setminus NP_2 \]

\[ S \setminus NP_1 \]

\[ S \]
Another Combinatory Rule

- Forward-Crossed Composition:

\[ X/Y \ Y \backslash Z \Rightarrow_{B_x} X \backslash Z \]

- Generalised Forward-Crossed Composition:

\[ X/Y \ (\ldots (Y \backslash Z)\backslash W)\ldots \Rightarrow_{B_x^y} (\ldots (X \backslash Z)\backslash W)\ldots \]

- Generalised case needed for the next derivation

- These rules not part of the English grammar
dat  ik  Cecilia  Henk  de  nijlpaarden  zag  helpen  voeren
NP₁  NP₂  NP₃  NP₄  ((S\NP₁)\NP₂)/VP  (VP\NP₃)/VP  VP\NP₄

Bₓ

B²ₓ

(((S\NP₁)\NP₂)\NP₃)\NP₄

((S\NP₁)\NP₂)\NP₃

(S\NP₁)\NP₂

S\NP₁

S
Mild Context Sensitivity

- It is the generalised composition rules which lead to greater-than-context-free power.
- A CCG with generalised composition and certain rule restrictions has the same generative power as Tree Adjoining Grammar (TAG) (“mildly context-sensitive”)
- Interestingly, Kuhlman et al. show that *relaxing* some of the rule restrictions can provide a CCG with greater-than-context-free power, but with strictly less power than TAG.
• Mark Steedman. The Syntactic Process, Chapter 6, MIT Press, 2000
• Stuart M. Shieber. Evidence against the context-freeness of natural language. Linguistics and Philosophy, 8:333-343, 1985