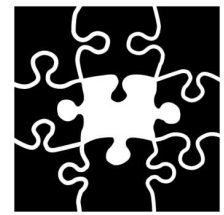
Revisiting competence & performance

Andreas van Cranenburgh



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25 years of DOP, Amsterdam, 2015

Introduction

Chomsky (1965):

Competence system of rules describing idealized knowledge of language

Performance language behavior affected by ambiguity, errors, reaction times, frequency effects

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Performance language behavior affected by ambiguity, errors, reaction times, frequency effects

Scha (1990):

- Difficult to write descriptively adequate grammar by hand.
- Problem of ambiguity;
  need to know relative plausibility of analyses.

Ergo, we need "performance-models of language (...), "which take into account statistical properties of actual language use."

Traditional parsing approach

1. Pick a grammar with the right linguistic & computational properties (competence)
2. Add a probabilistic disambiguation component (performance)
3. Apply pruning if necessary (performance)
4. Evaluate quality of model (performance)

Formal language theory

Definition

A *formal grammar* characterizes a language as a set of sentences and their structures.

Chomsky hierarchy:

Type 0: Unrestricted: Model-Theoretic Syntax, e.g., HPSG

Type 1: Context-Sensitive: Mildly Context-Sensitive, e.g., TAG, CCG, LCFRS

Type 2: Context-Free: PCFG, proj. dependency grammar

Type 3: Regular: finite-state technology

Grammar transformations

Capabilities of grammar formalisms can be extended, e.g.:

- Encode information in labels
- Apply pre- and postprocessing
- Intersect multiple grammars

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Examples:

- TSG or TIG $\Rightarrow$ CFG + backtransform table
- Dependency grammar $\Rightarrow$ PCFG
- Discontinuous constituents $\Rightarrow$ non-projective dependencies
- ...

Psycholinguistic Evidence

Do humans exploit hierarchical structure during processing?

- No Frank & Bod (Psy. Sci. 2011): Insensitivity of the human sentence-processing system to hierarchical structure
- Yes van Schijndel & Schuler (NAACL 2015): Hierarchic syntax improves reading time prediction

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Center-embedding:

- Hard for humans, natural for CFG
- Karlsson (2007): only occurs up to depth 3 in written language, depth 2 in spoken lang.

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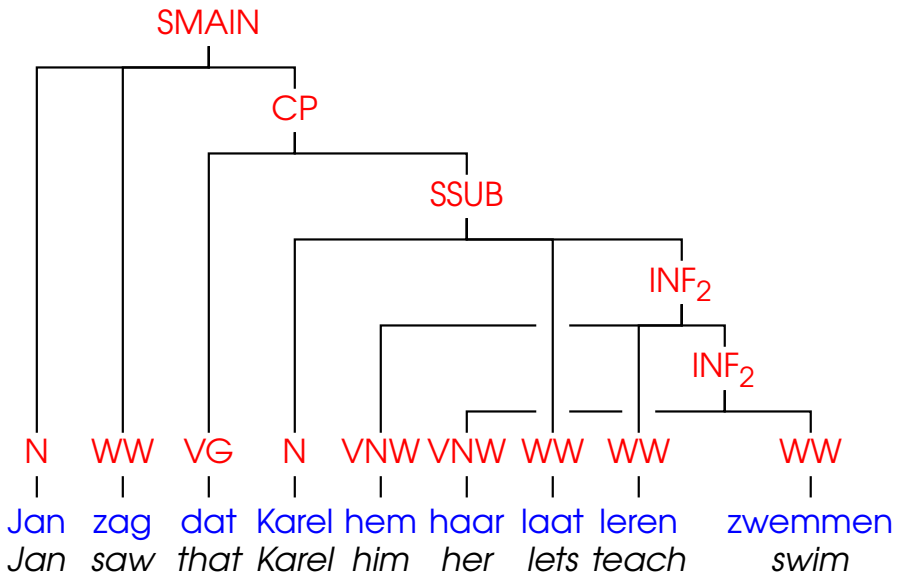
Cross-serial dependencies:

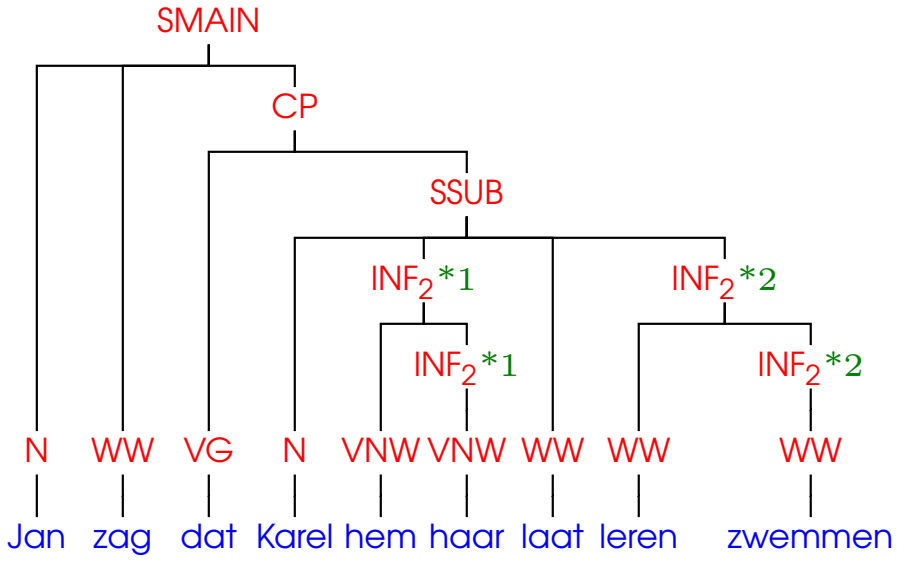
- Cross-serial dependencies not possible with CFG, but easier for humans than center-embedding: Bach et al. (1986) Cross and nested dependencies in German and Dutch: A psycholinguistic study.

Long-Distance Dependencies



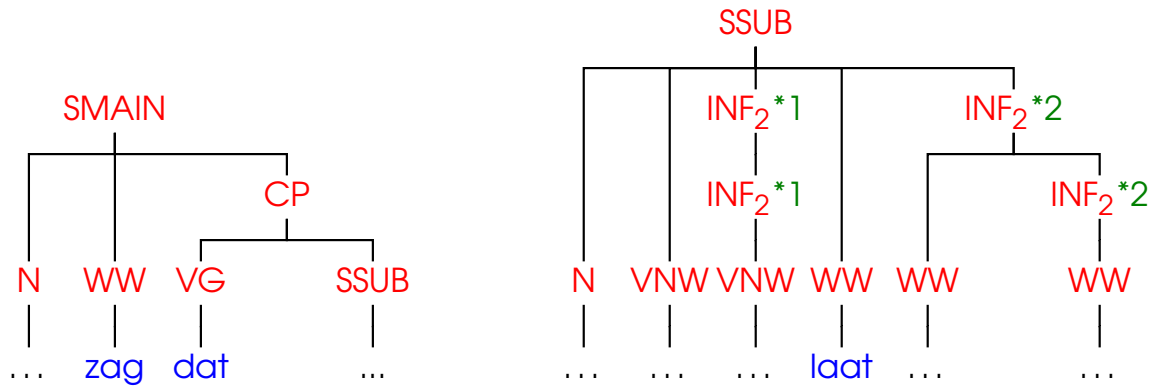
- Cross-serial dependencies are beyond context-free
- Can be captured by mildly context-sensitive grammars

CFG approximation



- Alternatively, long-distance dependencies can be encoded in the labels

DOP fragments



- With DOP tree fragments,
  complex linguistic phenomena can be captured
  statistically instead of formally

Conclusion

- Performance phenomena play an important role in computational models of language
- Instead of searching for the right formal grammar, consider how system as a whole copes with
  - ambiguity
  - cognitive limitations
  - linguistic complexity

References

- Noam Chomsky (1965). Aspects of the Theory of Syntax, MIT press.
- Remko Scha (1990). Language theory and language technology; competence and performance, in Q.A.M. de Kort and G.L.J. Leerdam, editors, *Computertoepassingen in de Neerlandistiek*, pp. 7–22. English translation: `http://iaaa.nl/rs/LeerdamE.html`