A Computational Model of Attachment Preferences

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LING 72500 - Sentence Processing
CUNY Graduate Center

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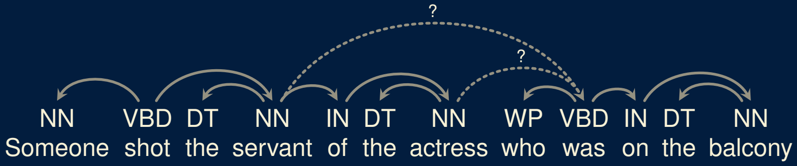
?
?
NN VBD DT NN IN DT NN WP VBD IN DT NN
Someone shot the servant of the actress who was on the balcony

Introduction to Dependency Grammar

Basic Principles

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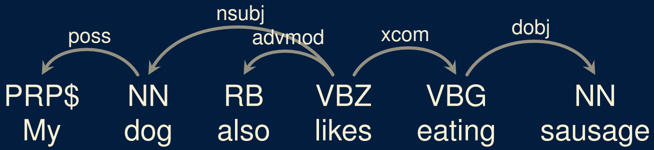

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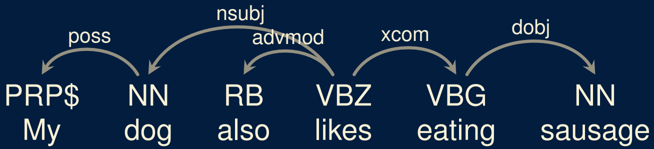

Key notions (Tesnière 1959) and (Nivre 2006)

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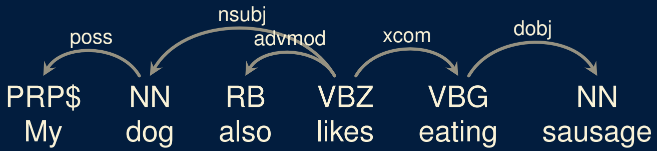

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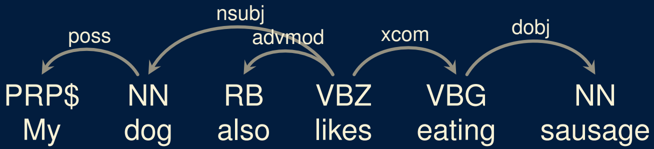

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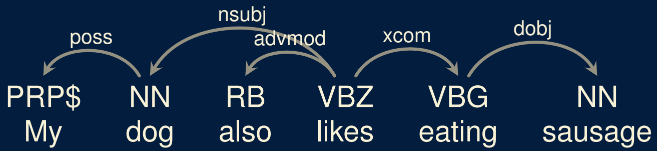

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- Constituent elements of a sentence are words [as opposed to phrases].
- The structure of the sentence is formed by the connections the mind perceives between the word and its neighbors.
- The structural connections establish dependency relations between the words.

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Comparison to Phrase Structure Graphs

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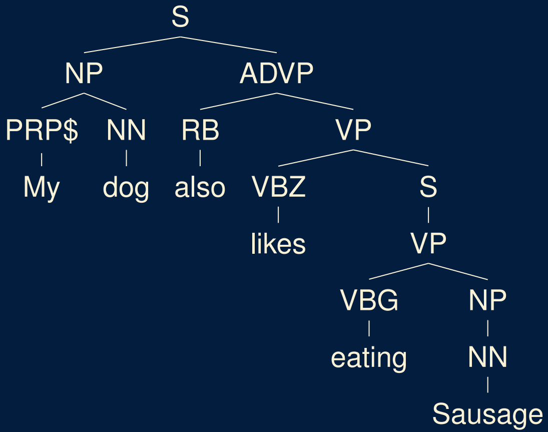

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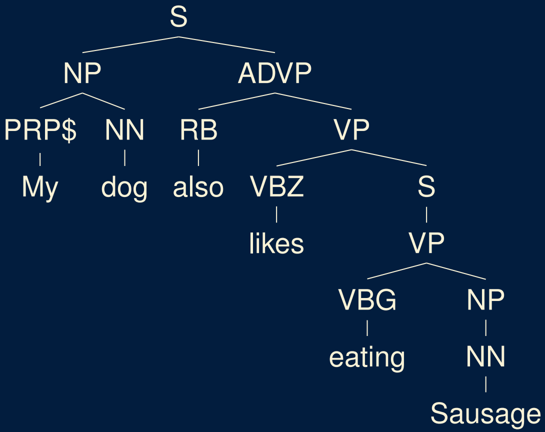

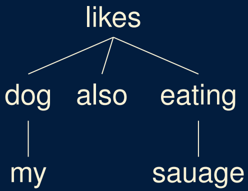

Introduction to Dependency Parsers

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$$\textit{word}_7\ \textit{word}_8\ \textit{word}_9\ \ldots$$

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$$\begin{array}{|c|} word_6 \\ word_5 \\ word_4 \\ \hline \end{array}$$

- and a set of edges, which represents the dependency tree

$$\begin{gathered} \langle word_1, word_2 \rangle \\ \langle word_2, word_3 \rangle \\ \vdots \end{gathered}$$

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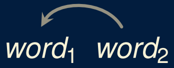

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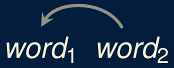

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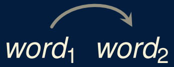
- RIGHT-ARC: Make the next word in the queue the dependent of the word at the top of the stack.



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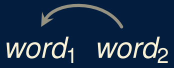

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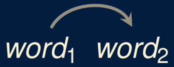

- Reduce: Remove the word at the top of the stack.

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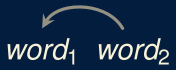

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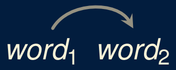

word$_1$ *word*$_2$

- REDUCE: Remove the word at the top of the stack.
- SHIFT: Move the next word from the queue onto the stack.

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How does the Parser know which action to take?

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[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

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`DLT`	: 1
`intervenors`	: NN
`baseline act.`	: 0.0681
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Next Transition should be Right-Arc.

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- Similarity is defined as: $S_{ji} = S_{max} - \ln(\text{fan}_j)$. ($S_{max} = 1.5$)
- fan_j identifies the number of words already seen that have the same grammatical category as the cue j.

Past Experiments

Summary

The model, as developed by Boston et al has been shown to:

- Predict reading difficulty as measured in eye-tracking (M. Boston et al. 2008).
- Predict strong and week island constraint violations (M. F. Boston 2011)
- Predict garden path phenomena (M. F. Boston and Hale 2007)

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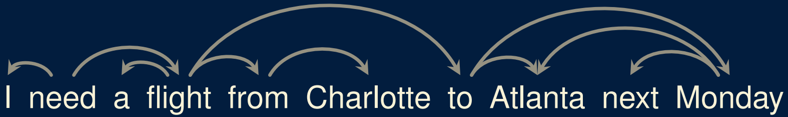
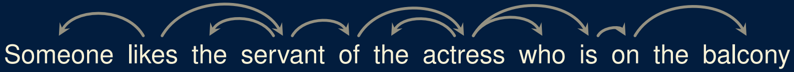


I need a flight from Charlotte to Atlanta next Monday



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	English	Italian
Percent Attachment to first noun	?	?
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- Explore impact of other features (e.g. phrase length).

Select References I

Boston, Marisa Ferrara (2011). *A processing model of the strong and weak island distinction*. Presentation at the CUNY Sentence Processing Conference.

– (2012). “A Computational Model Of Cognitive Constraints In Syntactic Locality”. PhD thesis. Cornell University.

Boston, Marisa Ferrara and John T Hale (2007). “Garden-pathing in a statistical dependency parser”. In: *Proceedings of the Midwest Computational Linguistics Colloquium. West Lafayette, IN: Midwest Computational Linguistics Colloquium*.

Boston, Marisa et al. (2008). “Parsing costs as predictors of reading difficulty: An evaluation using the Potsdam Sentence Corpus”. In: *Mind Research Repository* 1.

Select References II

Lewis, Richard L and Shravan Vasishth (2005). "An activation-based model of sentence processing as skilled memory retrieval". In: *Cognitive science* 29.3, pp. 375–419.

Nivre, Joakim (2006). "Dependency parsing". In: *Inductive Dependency Parsing*, pp. 45–86.

– (2008). "Sorting out dependency parsing". In: *Advances in Natural Language Processing*. Springer, pp. 16–27.

Tesnière, L. (1959). *Éléments de syntaxe structurale*. Éditions Klinksieck.