

Computational Psycholinguistics, Day 1

Introduction and a classic computational model of sentence production

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Computational Psycholinguistics

Psycholinguistics deals with the problem of how humans

- ▶ acquire
- ▶ represent
- ▶ comprehend
- ▶ produce

language.

In this class, we will study these problems from a computational perspective.

Class goals

- ▶ Overview the literature and major areas in which computational psycholinguistic research is carried out
- ▶ Gain experience in reading papers in this field
- ▶ Gain experience in working out the details of a model from the papers
- ▶ Critical analysis of models

What is computational modeling? Why do we do it?

- ▶ Any phenomenon involving human behavior is so complex that we cannot hope to formulate a comprehensive theory
- ▶ Instead, we devise a *model* that simplifies the phenomenon to capture some key aspect of it

What might we use a model for?

Models can serve any of the following (related) functions:

- ▶ *Prediction*: estimating the behavior/properties of a new state/datum on the basis of an existing dataset
- ▶ *Hypothesis testing*: as a framework for determining whether a given factor has an appreciable influence on some other variable
- ▶ *Data simulation*: creating artificial data more cheaply and quickly than through empirical data collection
- ▶ *Summarization*: If phenomenon X is complex but relevant to phenomenon Y, it can be most effective to use a simple model of X when constructing a model of Y
- ▶ *Insight*: Most generally, a good model can be explored in ways that give insight into the phenomenon under consideration

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Course Contents

- ▶ Most of the work we will look at involves *probabilistic* modeling of psycholinguistic phenomena
- ▶ Probabilistic effects are pervasive in acquisition, representation, comprehension, and production
- ▶ ...but we'll start off with a paper from another tradition: *memory* in sentence comprehension

Feedback from you

Please take a moment to fill out an index card with the following info:

Name (optional)

School & Program/Department

Year/stage in program

Computational Linguistics background

Psycholinguistics background

Probability/Statistics background

Other courses you're taking at LSA Summer Institute

(other side) What do you hope to learn in this class?

A bit of history

The formal revolution in linguistic analysis:

- ▶ Symbolic mathematical models for the description of natural language sentences Chomsky (1956, 1957)

Its psychological ramifications:

- ▶ Miller (1956): the human working-memory capacity has severe limits on how many items can be stored simultaneously
- ▶ Miller and Chomsky (1963): Although human linguistic *competence* requires transformational grammars, human linguistic *performance* might require only simpler (even finite-state) grammars

Yngve 1960

A model and an Hypothesis for Language Structure

Perhaps the very first paper in computational psycholinguistics

Defining the computational problem

There is an infinite number of sentences in any natural language. How is any given sentence produced?

Basic modeling assumptions

- ▶ The *grammar* by which a sentence is produced consists of a finite, unordered set of context-free production rules

$$S \rightarrow NP VP$$
$$NP \rightarrow Det N$$

...

- ▶ An utterance is constructed incrementally—top-down and “left to right”

The model in more detail

Yngve's model has the following components:

- ▶ A *computing register* that can store a single symbol
- ▶ A *temporary memory* that can store any number of symbols in a stack (first-in, last-out)
- ▶ An *output*

The model in more detail (2)

The model starts with the root symbol S in the computing register.

One execution cycle consists of the following steps:

1. Copy the symbol in the register to the output.
2. If the symbol X in the register is a word,
 - 2.1 delete it;
 - 2.2 if the temporary memory is not empty, move its top symbol to the register;
 - 2.3 otherwise end.
3. Otherwise: with the register's symbol on the left-hand side,
 - 3.1 choose a production rule $X \rightarrow Y\alpha$;
 - 3.2 replace the symbol in the register with Y , and put α in the temporary memory.

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S	
NP	VP
Det	N VP
the	N VP
N	VP
dog	VP
VP	
V	NP
chased	NP
NP	
Det	N
the	N
N	
cat	

*S → NP VP

*NP → Det N

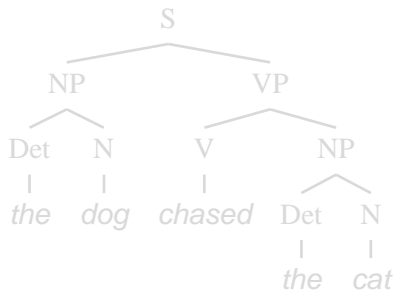
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Register | Temporary Memory

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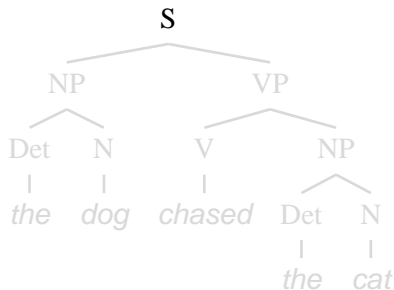
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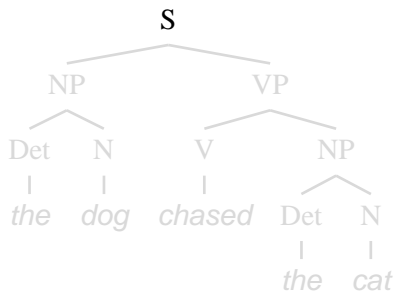
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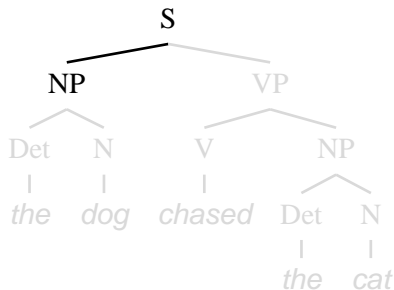
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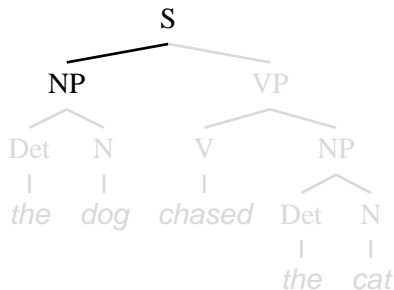
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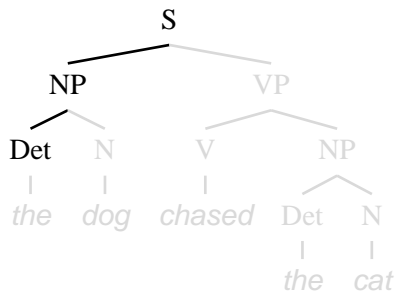
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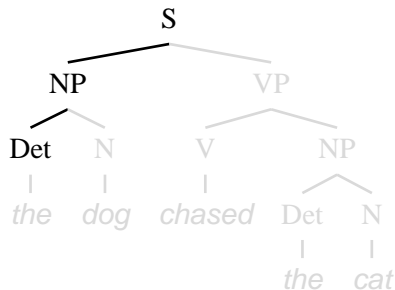
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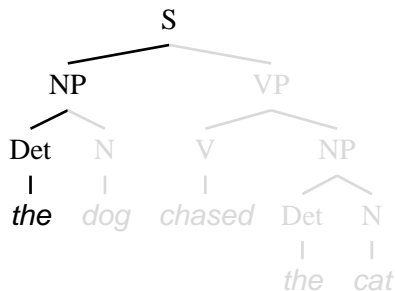
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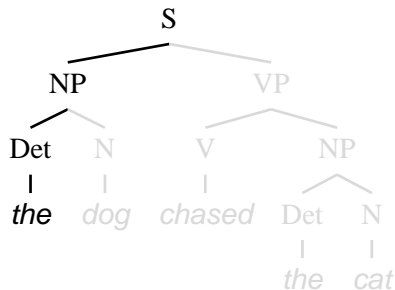
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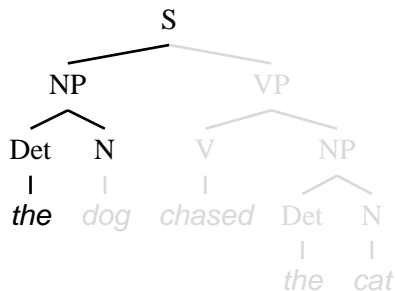
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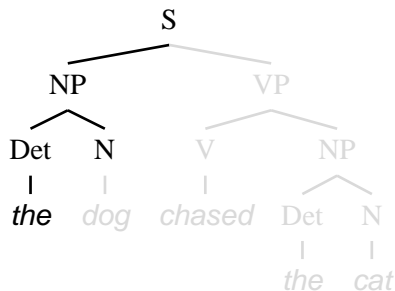
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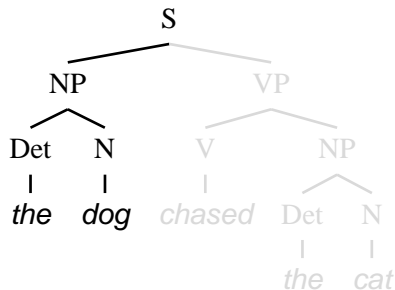
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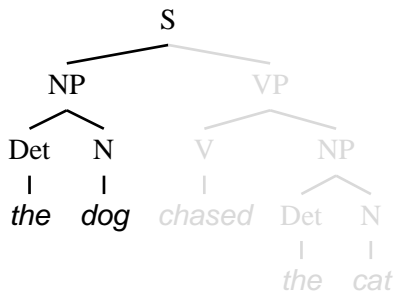
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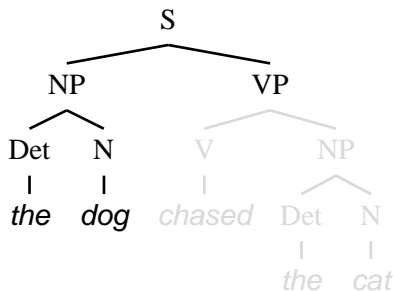
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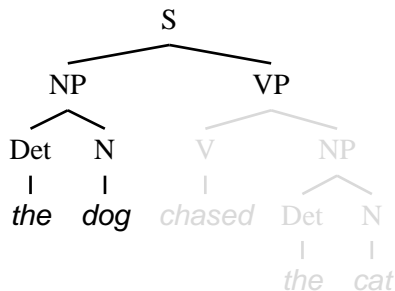
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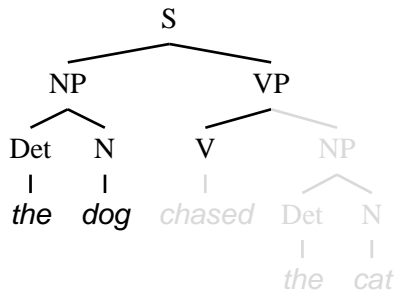
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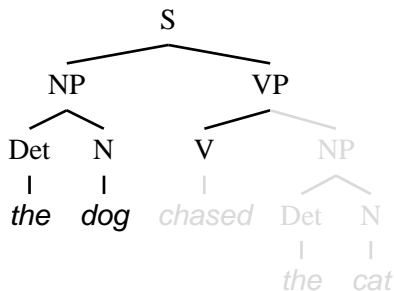
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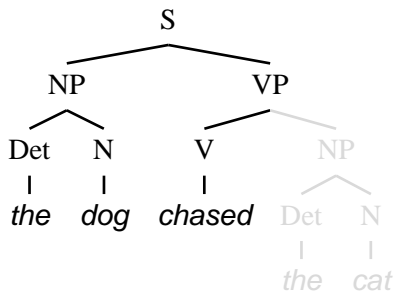
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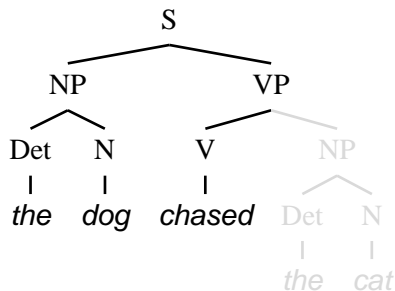
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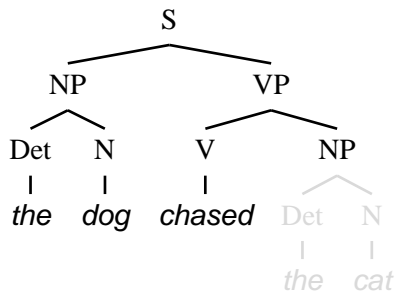
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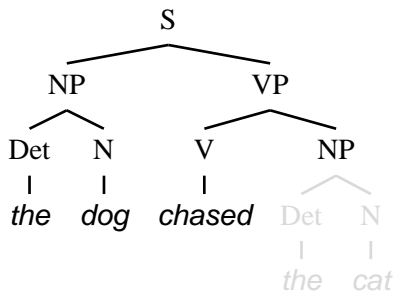
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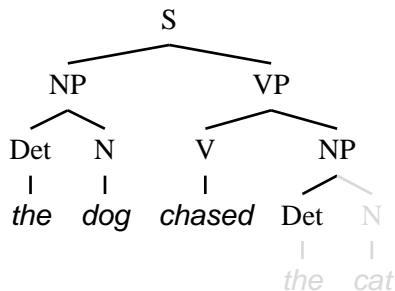
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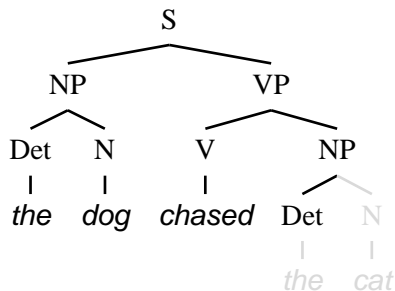
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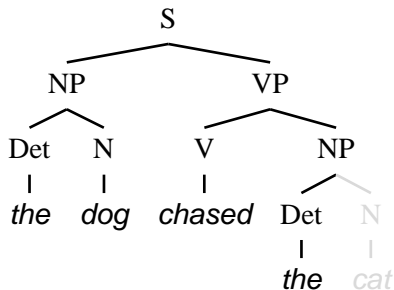
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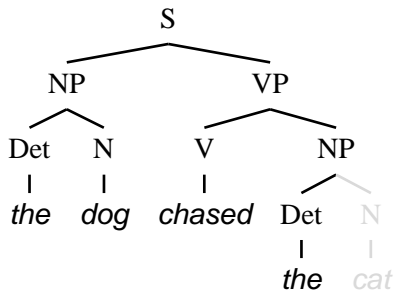
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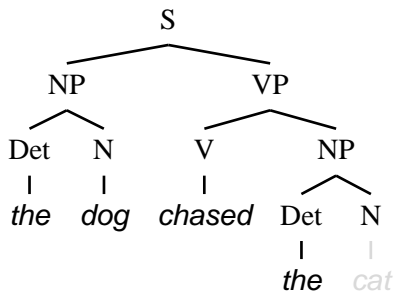
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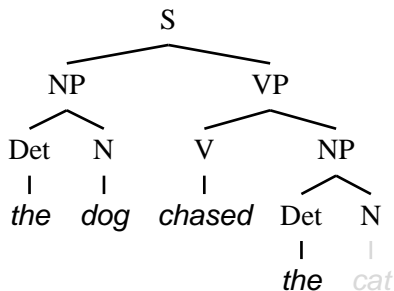
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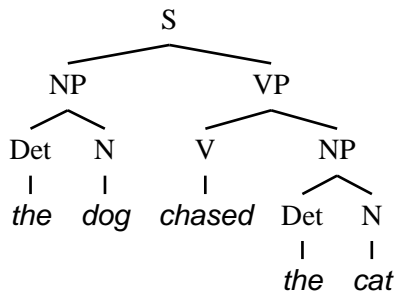
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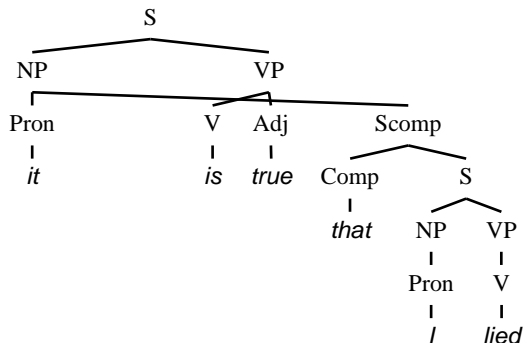
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Discontinuous constituents

One type of structure that the model thus far cannot produce is a *discontinuous constituent*.



Discontinuous constituents (2)

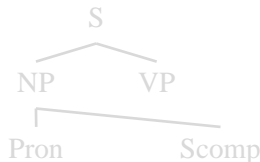
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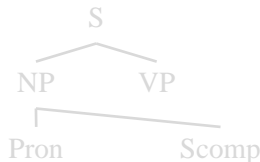
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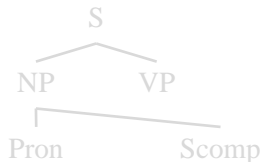
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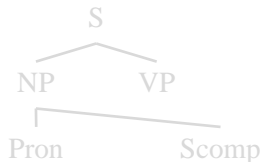
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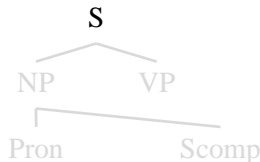
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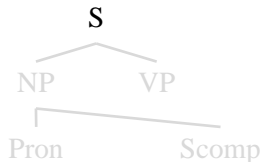
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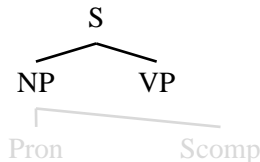
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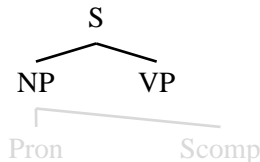
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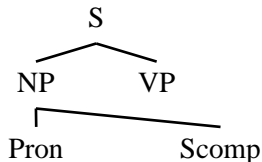
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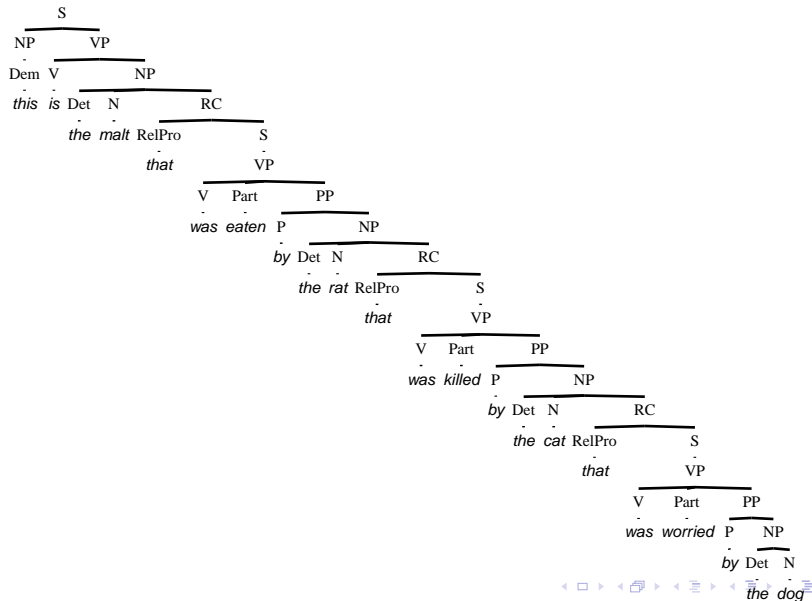
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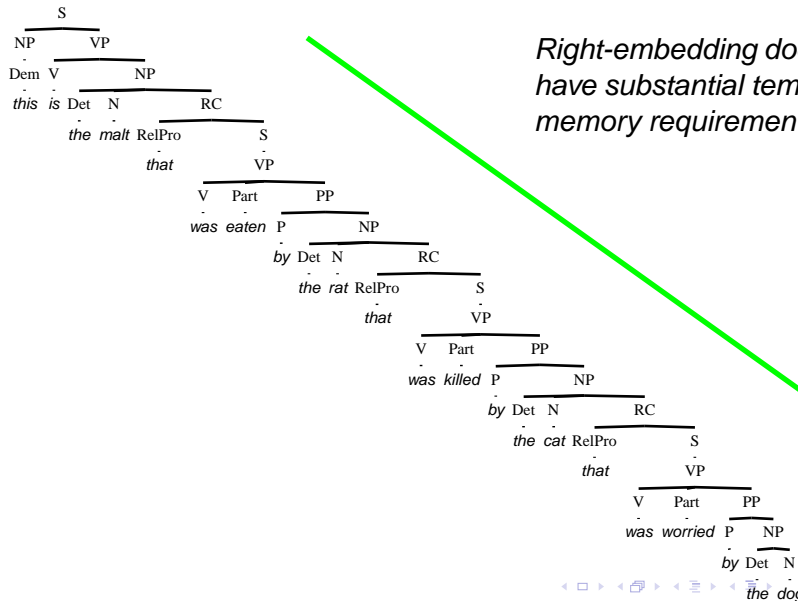
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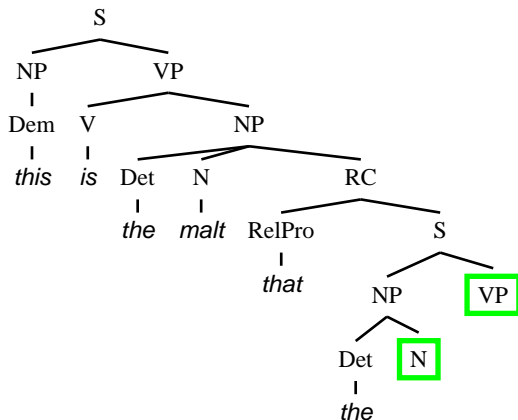
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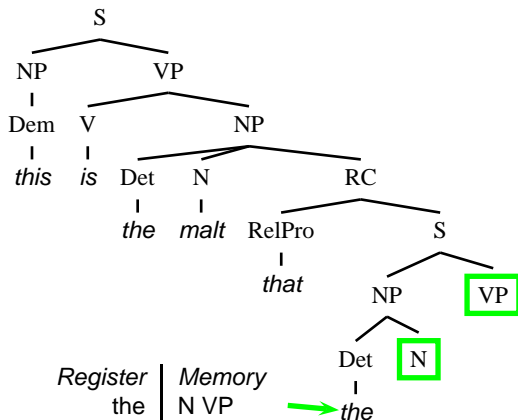
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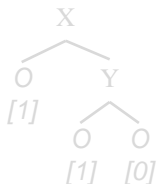
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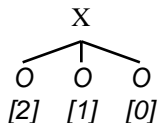


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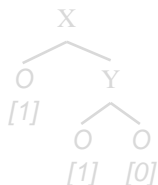


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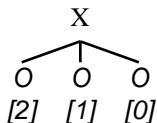


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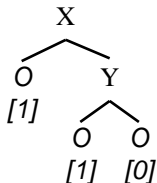


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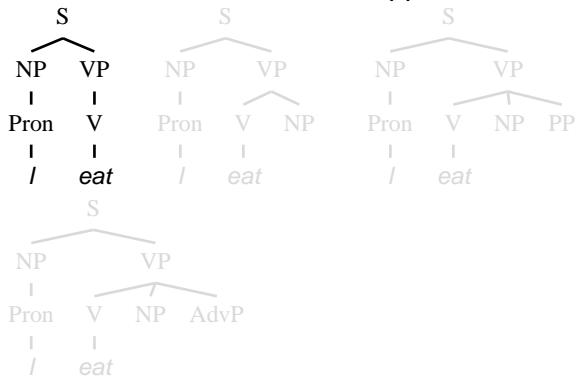


Weaknesses for Yngve's theory

- ▶ As an incremental sentence processor, the model “over-commits” in many types of constructions
- ▶ Left-branching constructions are pervasive in some languages (e.g., Japanese) and not necessarily hard

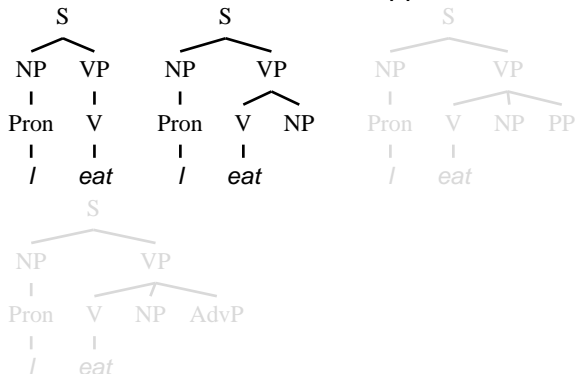
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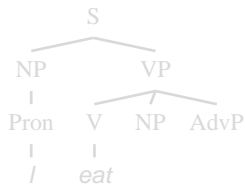
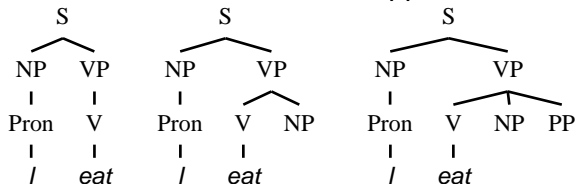
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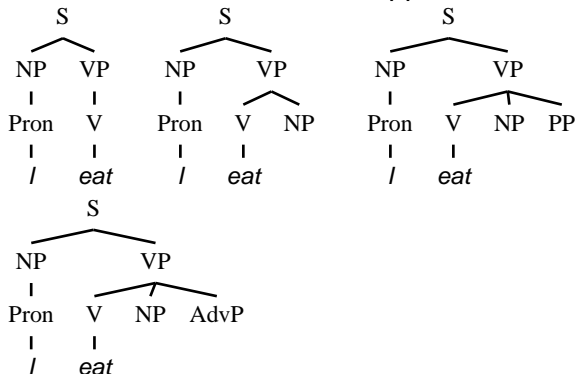
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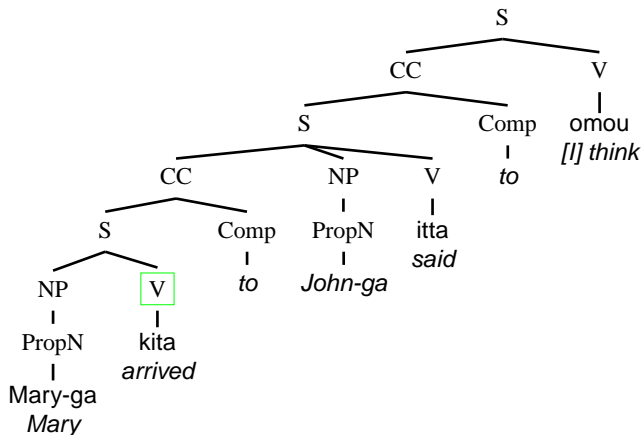
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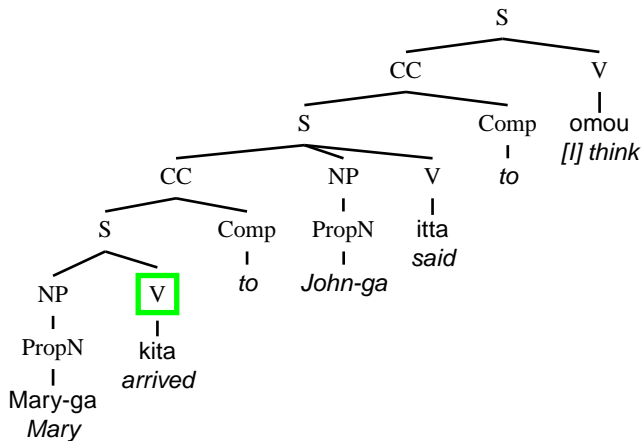
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For Tuesday

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References

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