Computational Psycholinguistics

Lecture 3: **Syntactic Accounts**

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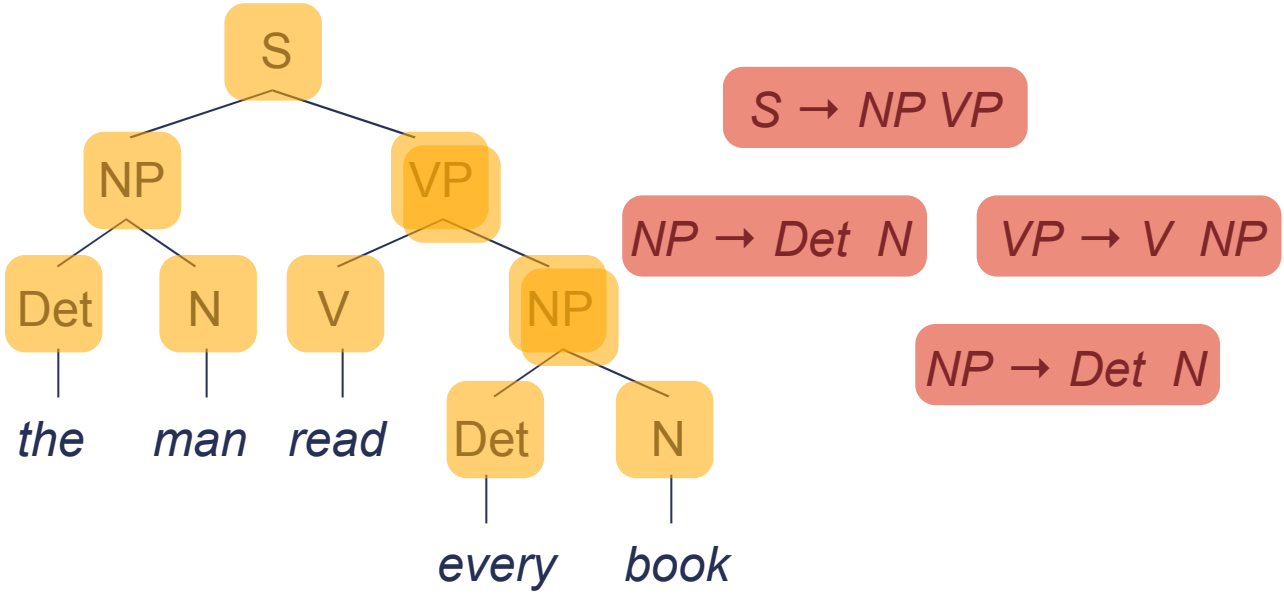
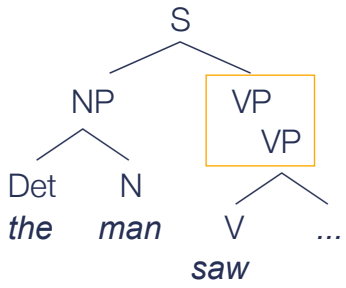
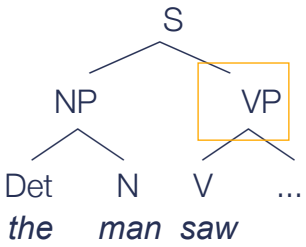
Simple example:Left-Corner



Evaluating the LC Parser

- Variations: **arc-standard** *versus* **arc-eager**





- Affect on ambiguity resolution for arc-eager:
  - Commitment to attachments is early, before daughters are completely built

Quick experiment

- *"The mouse died"*
- *"The mouse that the cat chased died"*
- *"The mouse that the cat that the dog bit died"*
- *"The mouse that the cat that the dog bit chased died"*

Incrementality and Memory

- It wasn't incrementality that led to the LC algorithm, but memory load:
  - *"The mouse died"*
  - *"The mouse the cat chased died"*
  - *"The mouse the cat the dog bit chased died"*

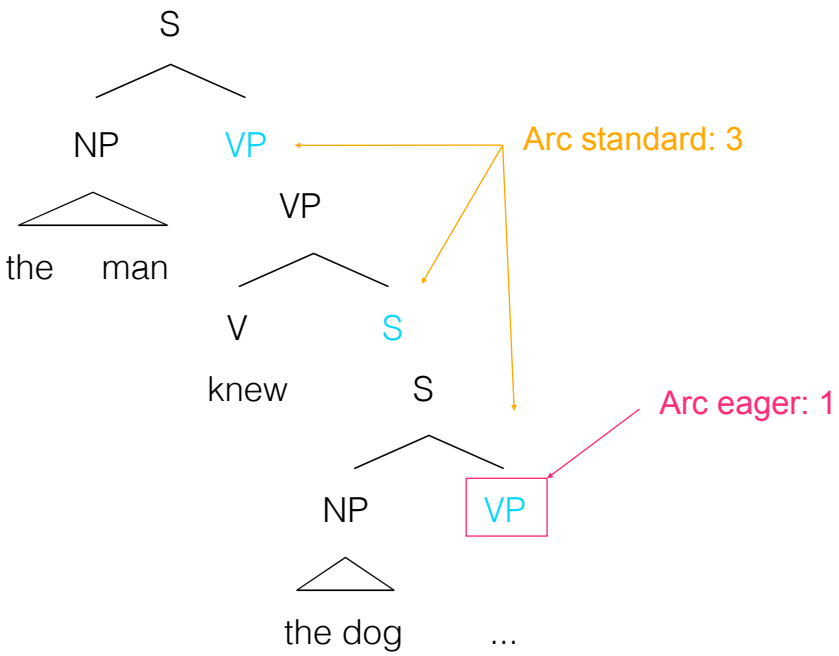
    (Or: "The mouse that the cat that the dog bit chased died")
- Grammatical, not ambiguous, what's the problem?
- Memory load: too high for centre embedding
  - *"[The mouse [the cat [the dog bit] chased] died]"*

Memory Load in Parsing

- Left-embedding is easy:
  - *[[[John's brother]'s car door]'s handle] broke off.*
- Right-embedding too:
  - *John believes [Bill knows [Mary said [she likes cats]]]*
- Centre-embedding is hard:
  - *[The mouse [the cat [the dog bit] chased] died]*
- Memory load for parsers:
  - Top-down: LE: hard CE: hard RE: easy
  - Bottom-up: LE: easy CE: hard RE: hard
  - Left-corner: LE: easy CE: hard RE: easy

Evaluating the LC Parser

- Variations: Arc-standard versus Arc-eager



Summary of Behaviour

Node	Arcs	Left	Centre	Right
Top-down	Either	O(n)	O(n)	O(1)
Shift-reduce	Either	O(1)	O(n)	O(n)
Left-corner	Standard	O(1)	O(n)	O(n)
Left-corner	Eager	O(1)	O(n)	O(1)
People		O(1)	O(n)	O(1)

Comments on Left-Corner

- Mixed data-driven and hypothesis driven approaches
  - Eager corresponds to composition of partial structures
- Arc Standard: less ambiguity
  - attach when constituents are complete: safer
  - delayed attachment means more is kept on the stack
- Arc Eager: less memory
  - early composition reduces stack growth
  - eager attachments are less bottom-up

Ambiguity in Parsing

- Rule selection: ***what if more than one rule can be selected?***
  - Local ambiguity: a parse derivation may fail later
  - Global ambiguity: multiple parses can succeed
- How can we handle local and global ambiguities during parsing:
  - Backtracking
  - Parallelism
  - Determinism
  - Underspecification

Ambiguity in Parsing

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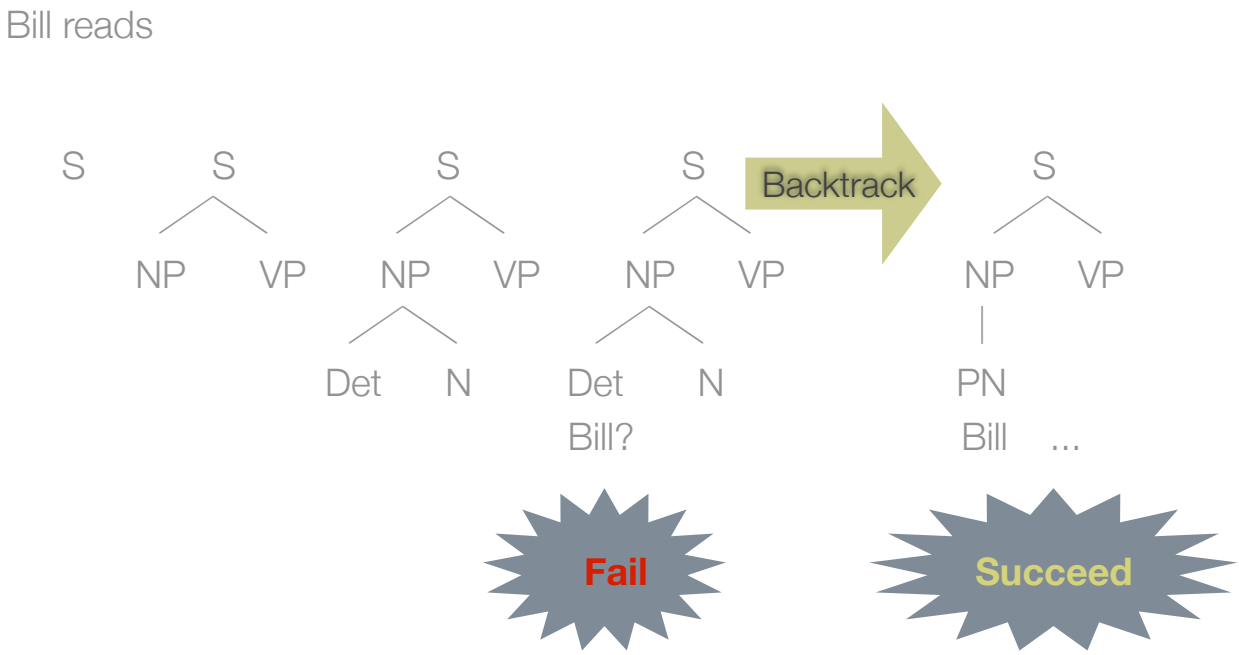
Backtracking Parsers

- Parsing is a sequence of rule selections
- If at one point, more than one rule can be applied, this is called a choice point
    - Make a decision, based on some selection rule
    - If subsequently parsing ‘blocks’, return to a choice point and re-parse from there
- Which choice point to return to?
    - usually the last, why?
    - what other choice point selection rules could be used

Backtracking: an example

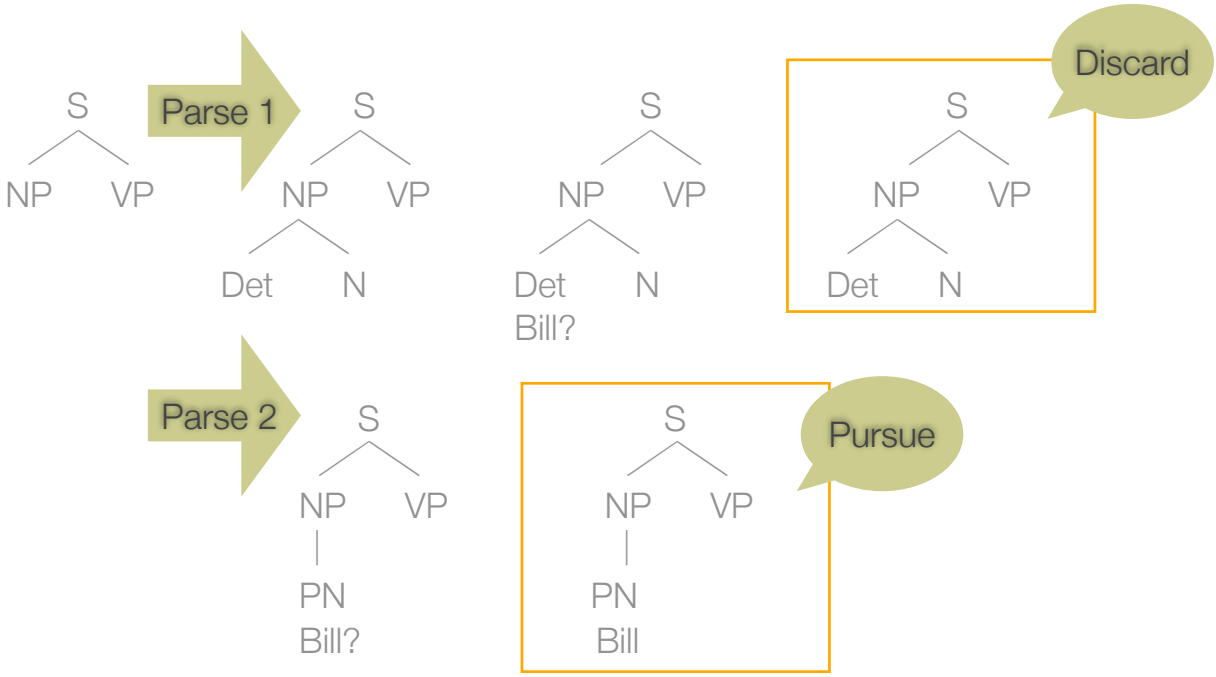


Parallel Parsers

- Build parse trees through successive rule selections
  - If more than one rule may be applied, create a new parse derivation for each possibility
  - Pursue all parses in parallel
  - If any of the parses ‘blocks’, discard it
- Because of multiple local ambiguities, the number of parallel derivation grows exponentially
  - Bounded parallelism: pursue a fixed number
  - How do we choose which ones to keep?

Parallel: an example

Bill reads



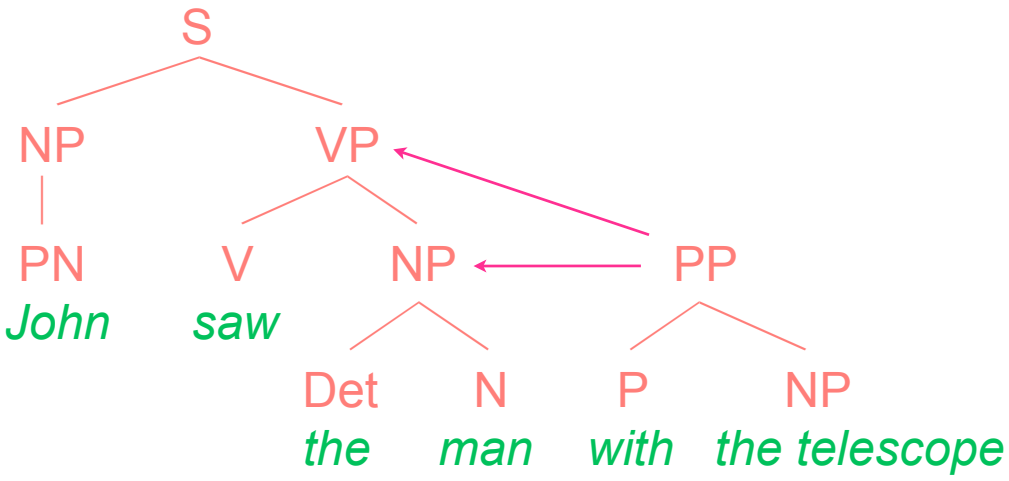
Theories of Sentence Processing

- Explanatory and descriptive goals
- Theories of parsing typically determine …
  - what architecture is assumed: modular? symbolic? ...
  - what mechanism is used to construct interpretations?
  - which information sources are used by the mechanism?
  - which representation is preferred/constructed when ambiguity arises?
- Linking Hypothesis: Relate theory/model to observed measures
  - Preferred sentence structures should have faster reading times in the disambiguating region than dispreferred

Garden-Path Theory: Frazier

- What architecture is assumed?
  - Modular syntactic processor, with restricted lexical (category) and semantic knowledge
- What mechanisms is used to construct interpretations?
  - Incremental, serial parsing, with reanalysis
- What information is used to determine preferred structure?
  - General syntactic principles based on the current phrase stucture
- Linking Hypothesis:
  - Parse complexity and reanalysis cause increased RTs

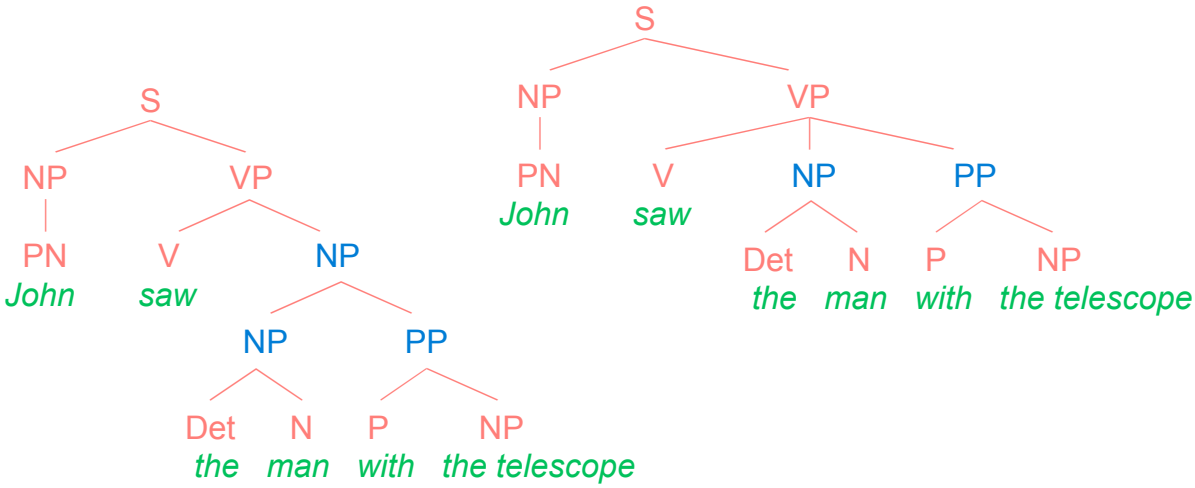
The Garden Path Theory (Frazier)



Which attachment do people initially prefer?

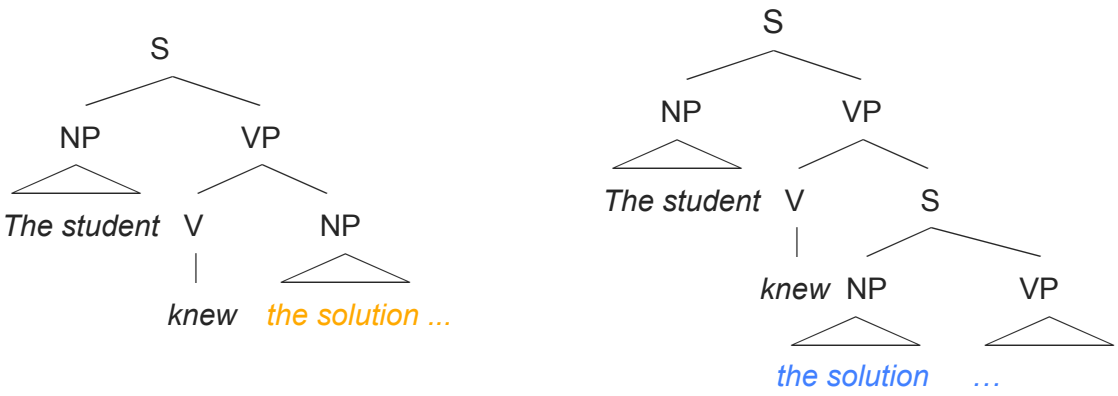
First Strategy: Minimal Attachment

Minimal Attachment: Adopt the analysis which requires postulating the fewest nodes



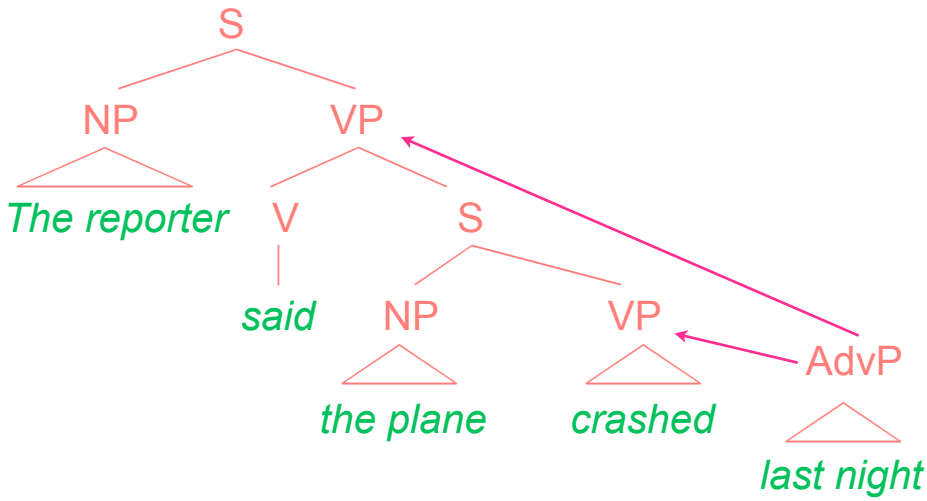
NP/S Complement Ambiguity

Minimal Attachment: Adopt the analysis which requires postulating the fewest nodes



Second Strategy: Late Closure

Late Closure: Attach material into the most recently constructed phrase marker



Well-known local ambiguities

NP/VP Attachment Ambiguity:

"The cop [saw [the burglar] [with the binoculars]]"
"The cop saw [the burglar [with the gun]]"

NP/S Complement Attachment Ambiguity:

"The athlete [realised [his goals]] last week"
"The athlete realised [[his goals] were unattainable]"

Clause-boundary Ambiguity:

"Since Jay always [jogs [a mile]] [the race doesn't seem very long]"
"Since Jay always jogs [[a mile] doesn't seem very long]"

Reduced Relative-Main Clause Ambiguity:

"[The woman [delivered the junkmail on Thursdays]]"
"[[The woman [delivered the junkmail]] threw it away]"

Relative/Complement Clause Ambiguity:

"The doctor [told [the woman] [that he was in love with her]]"
"The doctor [told [the woman [that he was in love with]] [to leave]]"

Summary of Frazier

- Parsing preferences are guided by general principles:
  - Serial structure building
  - Reanalyze based on syntactic conflict
  - Reanalyze based on low plausibility (“thematic fit”)
- Psychological assumptions:
  - Modularity: only syntactic (not lexical, not semantic) information used for initial structure building
  - Resources: emphasizes importance of memory limitations
  - Processing strategies are universal, innate