

Computational Psycholinguistics

Lecture 3: Syntactic Processing

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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



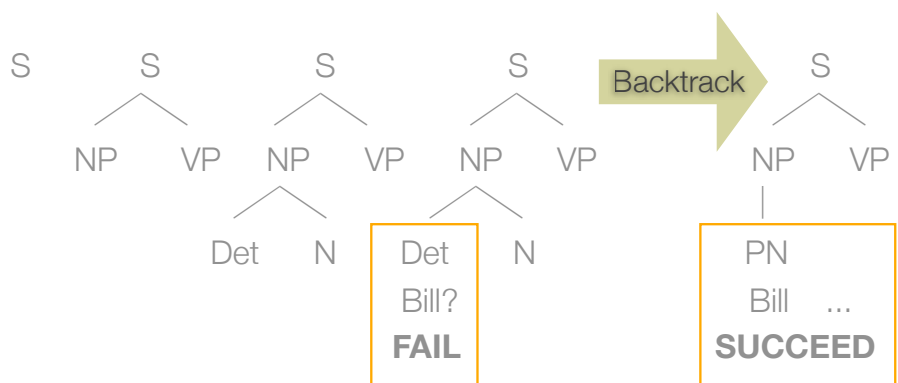
Backtracking Parsers

- 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

Bill reads

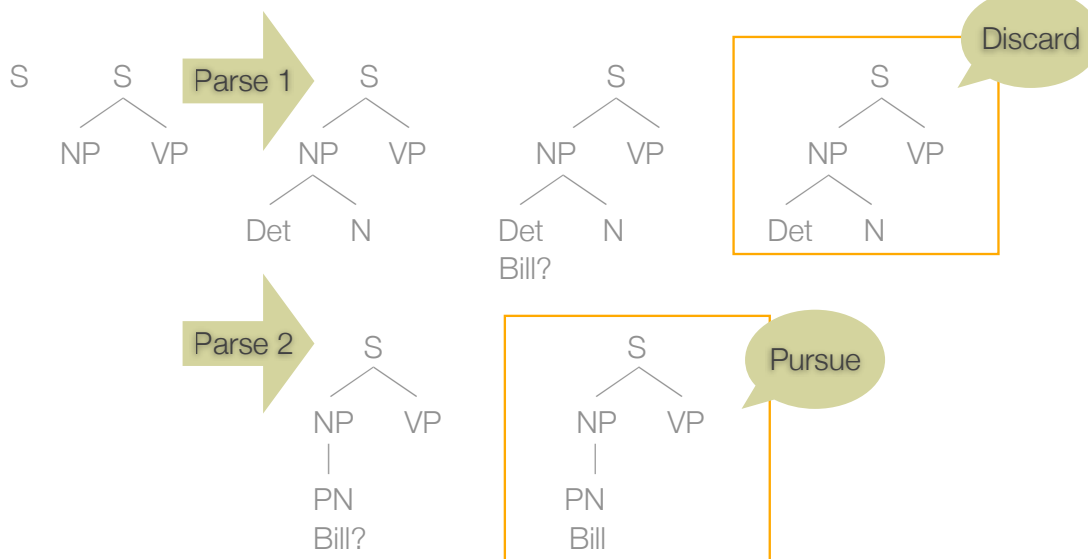


Parallel Parsers

- ❁ 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



Parsing and ambiguity resolution

☘ What predictions do these approaches make for ambiguity resolution?

☘ Consider the following high-low attachment ambiguity:

☘ “Two sisters reunited after eighteen years in a checkout counter

☘ “John said that he will go to Edinburgh last week

☘ Perceived as odd:

☘ people prefer to attach the modifier low but it must be attached high

☘ does either approach to parsing ambiguity explain this?



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



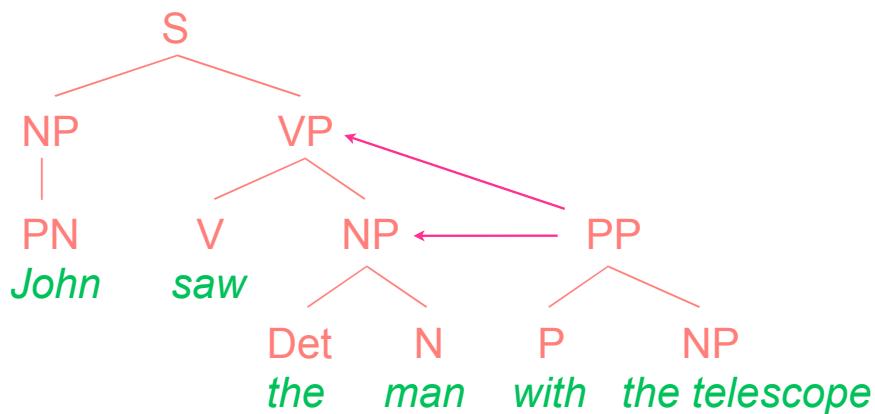
Garden-Path Theory: Frazier

- ❁ 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 structure
- ❁ **Linking Hypothesis:**
 - ❁ Parse complexity and reanalysis cause increased RTs



The Garden Path Theory (Frazier)

- ❁ Prepositional Phrase Attachment:

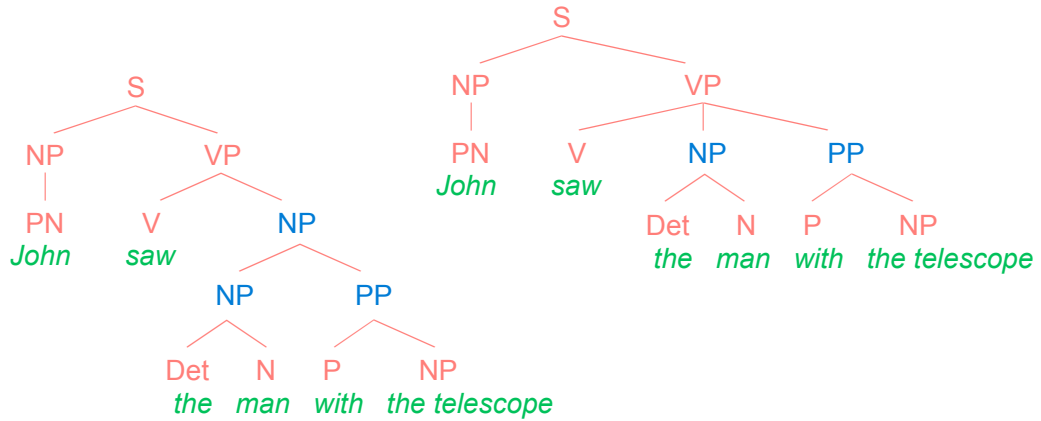


Which attachment do people initially prefer?



First Strategy: Minimal Attachment

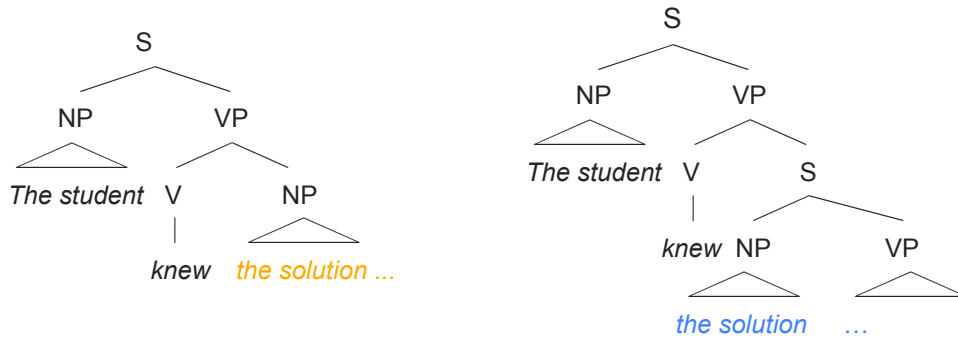
Minimal Attachment: Adopt the analysis which requires postulating the fewest nodes



NP/S Complement Ambiguity

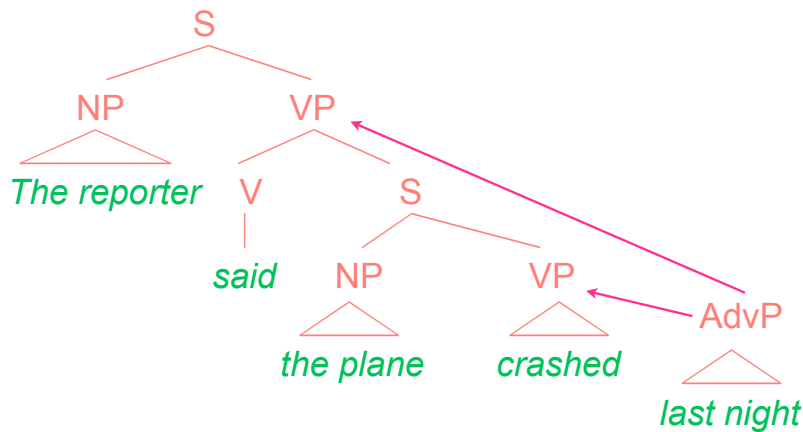
The student knew the solution to the problem.

The student knew the solution was incorrect.



Second Strategy: Late Closure

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



☛ **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



Grammar-Based Strategies

- ✿ Not concerned with representation or ‘form’, but defined in terms of syntactic ‘content’
- ✿ Strategies are modular, but ‘knowledge-based’
- ✿ Motivation: strategies are derived from the purpose of the task, not e.g. computational efficiency
- ✿ Closer competence-performance relationship
- ✿ Defined w.r.t. to deeper syntactic notions: less sensitive to minor structural details (cf. Minimal Attachment)
- ✿ Pritchett (1988), Abney(1989), Crocker(1991;1996), Gibson (1992)



Pritchett (1992)

- Incrementally establish primary syntactic dependencies
- Theta-Criterion:** (GB theory, also in LFG + HPSG)
 - Each argument must receive exactly one theta-role, and each theta role must be assigned to exactly one argument
- Consider:

The boy put the candy on the table in his mouth



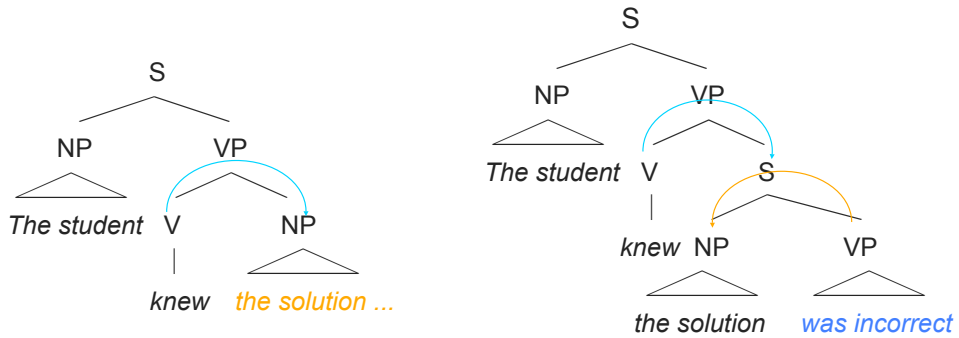
Pritchett (1992)

- Theta-Attachment:**
 - Maximally satisfy the theta-criterion at every point during processing, given the maximal theta-grid of the verb
- Theta Reanalysis Constraint:**
 - Reanalysis of a constituent out of its theta-domain results in a conscious garden-path effect



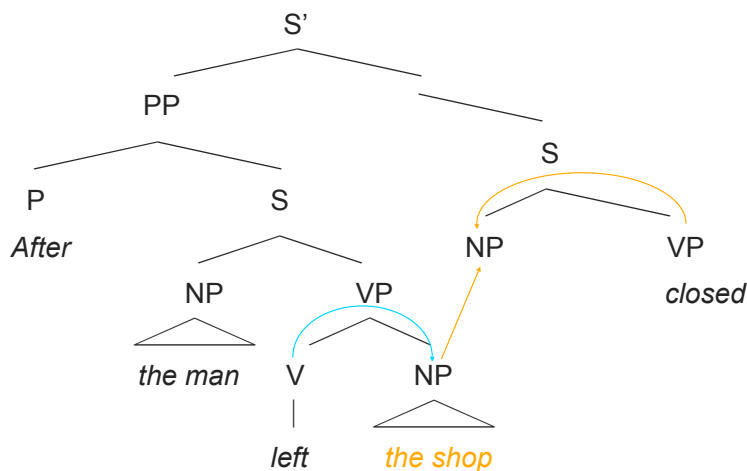
Theta-Reanalysis: Easy

☘ Reanalysis to a position within the original theta-domain is easy.



Theta-Reanalysis: Difficult

☘ Reanalysis to a position outside the original theta-domain is difficult.



Pritchett: Another example

☛ *“Without her contributions the orphanage closed”*

☛ ‘Without’: a Prep with a single thematic role

☛ ‘her’:

☛ an determiner of an unseen NP head, or a Full NP (Pronoun) [Theta-attach]

☛ ‘contributions’:

☛ head of a new NP, with no role, or combine with ‘her’ for a Full NP [Theta-attach]

☛ *“Without her contributions failed to come in”*

☛ ‘contributions’ becomes subject of ‘failed’, violating [Theta-reanalysis Constraint]



☛ NP/VP Attachment Ambiguity:

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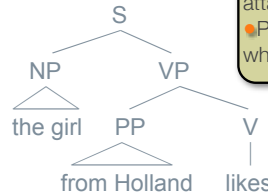
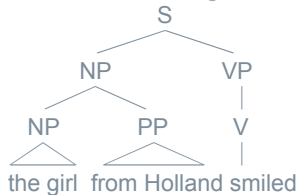
Grammar-Based (cont'd)

- Theta-Attachment: reliance on theta-grids means it's head driven

- O.k. for English, but not incremental for head-final languages
- Same problem for Abney (1989), and other head-driven models

- Argument-Attachment: Attach constituent into potentially role-receiving positions (Crocker, 1992)

"... dat het meisje van Holland glimlachte/houdt"
 ... that the girl from Holland smiled/likes



- That study used phrase-by-phrase self-pace reading.
- Eye-tracking studies suggest the modifier attachment is actually preferred.
- Problematic for A-Attachment, unclear what Theta-Attachment would predict, why?



Pritchett's Theory (1992)

- What **architecture** is assumed?

- Modular lexico-syntactic processor with syntactic and thematic role features

- What **mechanisms** is used to construct interpretations?

- Incremental, serial parsing, with reanalysis

- What **information** is used to determine preferred structure?

- Grammar principles and thematic role information

- Linking Hypothesis:**

- TRC violation causes garden-path, reanalysis without TRC is relatively easy

