Computational Psycholinguistics

Lecture 4: Principles of Parsing

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Overview

- Syntactic processing requires a solution to the problem of local and global ambiguity
- Serial/backtracking:
  - Initial disambiguation: rule (or structure?) selection strategy
  - Reanalysis: choice point selection
- Parallel:
  - Initial: ranking strategy
  - Limit: what structures to forget
  - Reanalysis: reranking/adjusting
- Parsing/Ranking strategies:
  - Structural, syntactic
  - Interactive: semantics, discourse, ...
  - Probabilistic

Evidence for Selection Strategies

- Evidence from reading times ...
  - "The cop saw the burglar with the gun"
  - "The athlete realised his aims were too high"
  - "After the man left the shop closed"
  - "After the child sneezed the doctor arrived"
  - "The man delivered the junkmail threw it away"
  - "The doctor told the woman that he was in love with to leave"

Modular Models

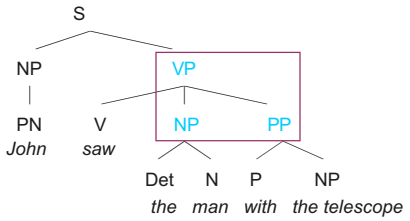
- Modular models:
  - If we assume a "distinct" human syntactic processor, on what basis should ambiguity be resolved?
- Structural:
  - Kimball's 7 principles
  - Frazier's "Garden Path Theory"
- Grammar-Based:
  - Theta-attachment: Pritchett, Abney
  - Argument Attachment: Crocker
  - Dependency: Pickering
- Memory-based:
  - prefer structures with the least memory load (Gibson)
- Experience-Based:
  - Lexical guidance: Ford
  - Tuning: Mitchell
  - Completely probabilistic: Jurafsky; Crocker & Brants

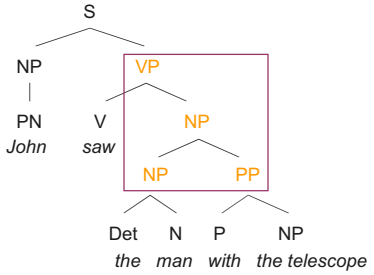
The Garden Path Theory

- Parser operates incrementally:
  - Each word it attached into the *Current Partial Phrase Marker*
- The parser operated serially:
  - A "race" to find an analysis: first wins
  - Reanalyse if the analysis is thematically impossible
- Ambiguity resolution strategies:
  - Minimal Attachment: *Adopt the analysis which requires postulating the fewest nodes*
  - Late Closure: *Attach material into the most recently constructed phrase marker*
  - Active Filler Strategy: *Associate fillers with possible gaps (traces) as early as possible.*

Minimal Attachment: VP Attachment

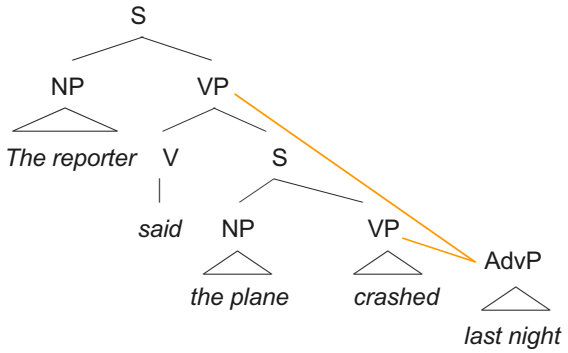
- *John saw the man with the telescope*





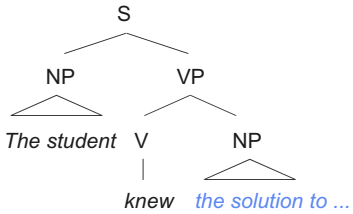
Late Closure

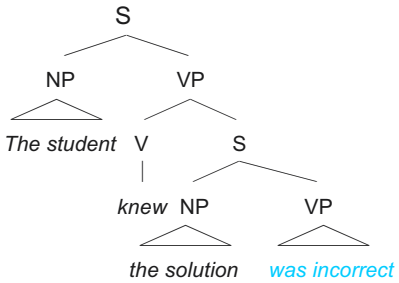
- Prefer 'low attachment'



NP/S Complement Ambiguity

- The student knew the solution to the problem.
- The student knew the solution was incorrect.





Ambiguities revisited: [preferred/dis-preferred]

- 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 goal]] last week"
  - "The athlete realised [[his shoes] were across the room]"
- 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]"
- Red. 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]] [to leave]]"
  - "The doctor [told [the woman] [that he was in love with her]]"

Parsing Empty Categories

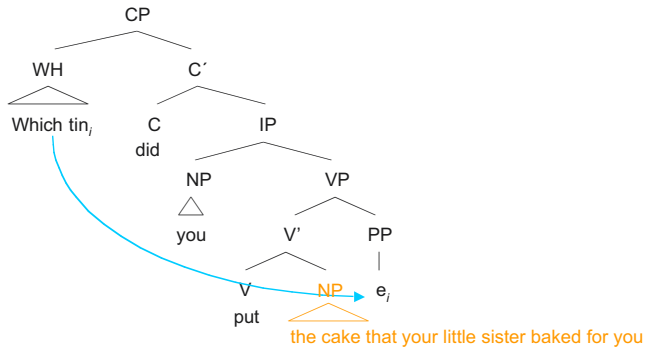
- Active Filler Strategy: ("Gap as a first resort")
  - *When a filler has been identified, rank the possibility of a assigning it to a gap above all other options.*
- Wh-Fillers:
  - Who$_i$ did Fred tell Mary e_i left the country?
  - Who$_i$ did Fred tell e_i Mary left the country?
- Subject-Relative preference:
  - I met the man$_i$ that John likes e_i.
  - I met the man$_i$ that e_i likes John.
- Filled-Gap effect:
  - My brother wanted to know who$_i$ e_i will bring us home at Christmas
  - My brother wanted to know who$_i$ Ruth will bring (*e_i) us home to e_i to Christmas

Evidence Against AFS (& Gaps!)

- Intuitively easy:
  - Who (e_i) did you want (e_i) Mother to bake (e_i)a cake for e_i?
  - ... despite 3 possible earlier gap locations
- Consider:
  - [In which tin]$_i$ did you put the cake e_i ?
  - [In which tin]$_i$ did you put$_i$ the cake ?
- If keeping the filler in memory causes difficulty, we can compare:
  - [In which tin]$_i$ did you put$_i$ the cake that your little sister baked for you e_i ?
  - [Which tin]$_i$ did you put the cake that your little sister baked for you in$_i$ e_i ?

Parsing in the 2nd dimension

- Gaps don't *exist* in the input, so we needn't wait until they are found
- We can associate a filler & gap as soon as the *structure* licenses it:
  - [Which tin]$_i$ did you put$_i$ the cake that your little sister baked for you e_i ?



  - Den Junge$_i$ sah$_j$ Maria e$_j$ e$_i$.

Grammar-Based Strategies

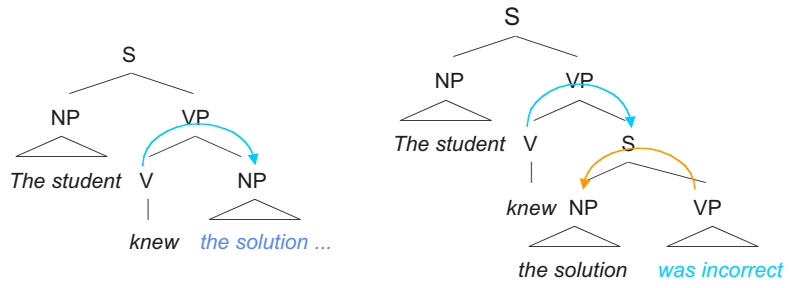
- Not concerned with representation or 'form', but defined in terms of syntactic 'content'
- Strategies are modular, but 'knowledge-based'
- Motivation: strategies are derived from the purpose of the task, not e.g. computational efficiency
- Closer competence-performance relationship
- Defined w.r.t.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

Pritchett (1992)

- Theta-Attachment:
  - The theta-criterion attempts to be maximally satisfied et every point during processing, given the maximal theta-grid
- Theta-Criterion:
  - Each argument must receive exactly one theta-role, and each theta role must be assigned to exactly one argument
- Theta Reanalysis Constraint:
  - Reanalysis of a constituent out of its theta-domain results in a garden-path effect
- Generalised Theta Attachment:
  - Every principle of the Syntax attempts to be maximally satisfied at every point during processing.

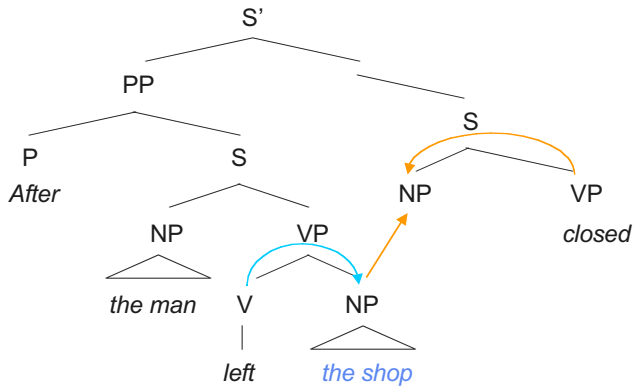
Theta-Reanalysis: Easy

- 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.



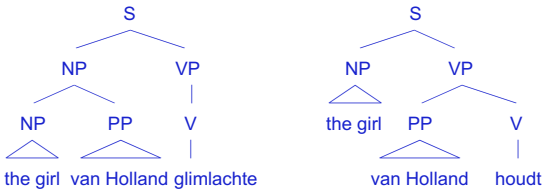
Pritchett: Another example

- "Without her contributions the orphanage closed"
  - 'Without': a Prep with a single thematic role
  - 'her':
    - an NP determiner of a yet unseen NP head, or
    - an Full NP complement (Pronoun), receives the role **[Theta-attach]**
  - 'contributions':
    - head of a new NP, without a theta-role, or
    - build the larger NP with 'her', and receive the role **[Theta-attach]**
- "Without her contributions failed to come in"

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
- Crocker (1992,1996): A-Attachment
  - Prefer attachment into "argument" positions (i.e. potential theta positions)
  - A-position: a position which is visible for theta-role assignment
- Evidence from Frazier (1987): preference for Minimal/A-Attachment
  - "... dat het meisje van Holland glimlachte/houdt"

    … that the girl from Holland smiled/likes



  - Now: preference for 'incremental' attachment has been experimentally confirmed, arguing against MA and AA. Predictions of theta-attachment are unclear.

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Parsing theories & implementation

- Consider the theories we have discussed:
  - Garden path model: Minimal Attachment, Late Closure/Recency
  - Pritchett: Theta-Attachment, Theta-Reanalysis
  - Processing of empty categories (I.e. Active Filler Strategy)
- How could these "theories" be implemented in a computational model
  - Top-down:
    - MA: favour rules with longer RHS
    - LC: follows from standard backtracking/parsing
    - Theta-attachment: sort-of, for head-initial language
    - Empty-categories easily dealt with.
  - Shift-reduce:
    - MA: reduce as many symbols as possible; prefer shift to reduce (non-incremental)
    - LC: depends on the order in which constituents are reduced
    - Theta-attachment: easily implemented
    - Empty categories: a problem for pure bottom-up parsers!
  - Left-corner:
    - MA: favour rules with longer RHS
    - LC: follows from standard backtracking/parsing
    - Theta-attachment: easily implemented, for head initial
    - Empty categories: a problem when trace is the left-corner, otherwise o.k.