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)

Which attachment do people initially prefer?
First Strategy: Minimal Attachment

NP/S Complement Ambiguity
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

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 (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*

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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]

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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

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
Long Distance Dependencies

- **Wh-Fillers:**
  - \( \text{Who}_i \) did Fred tell Mary \( e_i \) left the country? \textit{dispreferred}
  - \( \text{Who}_i \) did Fred tell \( e_i \) Mary left the country? \textit{preferred}

- **Subject-Relative preference:**
  - I met the man \( e_i \) that John likes \( e_i \). \textit{dispreferred}
  - I met the man \( e_i \) that \( e_i \) likes John. \textit{preferred}

- **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.

Further observations ...

- **Filled-Gap effect:**
  - My brother wanted to know who \( e_i \) Ruth will bring \( (*e_i) \textit{us} \) home to \( e_i \) at Christmas
  - My brother wanted to know if Ruth will bring \textit{us} home to Mom at Christmas

- Found an increased reading time at \textit{us}, interpreted this as surprise

- **Intuitively easy:**
  - \( \text{Who}_i (e_i) \) did you want \( (e_i) \) Mother to bake \( (e_i) \) a cake for \( e_i \)?
  - ... despite 3 possible earlier gap locations
Gaps versus Dependencies

• Consider:
  
  • [In which tin\textsubscript{i} did you put the cake e\textsubscript{i} ? ] \textit{Gap account}
  
  • [In which tin\textsubscript{i} did you put\textsubscript{i} the cake ? ] \textit{Dependency account}
  
  • If keeping the filler in memory causes difficulty, we can compare:

    [In which tin\textsubscript{i} did you put\textsubscript{i} the cake that your little sister baked for you e\textsubscript{i} ? ] \textit{Easy}
    
    [Which tin\textsubscript{i} did you put\textsubscript{i} the cake that your little sister baked for you in\textsubscript{i} e\textsubscript{i} ? ] \textit{Hard}

  • Intuitive support for the dependency account, and against gaps.

Other evidence

• Implausibility detected immediately at the verb, as shown by increased reading times.

  • \textit{That’s the [pistol/garage]\textsubscript{i} with which the heartless killer shot\textsubscript{i} the hapless man e\textsubscript{i} yesterday afternoon.}

• Garnsey et al (1998) found an N400 at the verb, for the implausible condition

  • \textit{The businessman knew which [customer/article]\textsubscript{i} the secretary called e\textsubscript{i} at home}

• Pickering and Barry (1996) argued that a \textit{dependency-based account} was preferable to a \textit{trace-based account}. 
Parsing in 2 dimensions

• 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:

Consider: *Den Hund* i *sah* i *Maria* e i e i.

Summary

• Frazier: early parsing decisions driven by purely syntactic heuristics
  • MA and LC were argued to be by-products of a race mechanism

• Eager dependency-formation plays a strong role in driving parsing decisions:
  • Pritchett’s theta-attachment
  • Local coherence trumps global syntactic parsing constraints
  • Active-Filler Hypothesis
  • Pickering & Barry’s Dependency Association account