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:

  • Who did Fred tell Mary ei left the country?  dispreferred
  • Who did Fred tell ei Mary left the country?  preferred

• Subject-Relative preference:

  • I met the mani that John likes ei.  dispreferred
  • I met the mani that ei likes John.  preferred

• Active Filler Strategy: (“Gap as a first resort”)

  • When a filler has been identified, rank the possibility of assigning it to a gap above all other options.

Further observations ... 

• Filled-Gap effect:

  • My brother wanted to know whoi Ruth will bring (*ei) us home to ei at Christmas

  • My brother wanted to know if Ruth will bring us home to Mom at Christmas

• Found an increased reading time at us, interpreted this as surprise

• Intuitively easy:

  • Whoi (ei) did you want (ei) Mother to bake (ei) a cake for ei?

  • ... despite 3 possible earlier gap locations
Gaps versus Dependencies

• Consider:

  • 
  
  [In which tin]\textsubscript{i} did you put the cake? \textsubscript{i} Gap account
  
  • 
  
  [In which tin]\textsubscript{i} did you put the cake? \textsubscript{i} Dependency account

• If keeping the filler in memory causes difficulty, we can compare:

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

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

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

Other evidence

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

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

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

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

• Pickering and Barry (1996) argued that a dependency-based account was preferable to a 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* sah *Maria e* 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