Automaton Theories of Human Sentence Comprehension

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Chapter 4. Garden-Pathing

Garden-pathing

- **오도문/오인문**

(1) The horse raced past the barn fell.

(Bever, 1970)

(2) 영희가 아이를 교차로에서 본 소녀에게 맡겼다.

(권유안, 김영진, 남기춘, 2003)

- Comprehension involves recovering a “percept” from the stream of words.

- But this percept is only a *hypothesis* about the word stream, one that is tokened inside the mind of the comprehender, and may turn out to be **illusory**.

- Garden-pathing is just the selection of the wrong structural alternative.

The Garden Path Theory

- The most fundamental of the garden path thory is that comprehension is single-path.

- The parser follows just one “line of reasoning”.

- The correctway to extend a given line of reasoning may be locally indeterminate.

- There may be multiple “attachment sites” available for the current word or phrase, which is to be indeterminacy in a central part of Garden Path Theory.

- One of the famous psycholinguistic model on Garden-pathing is the two-stage model (Frazier and Fodor, 1978)

The Garden Path Theory

- **The Two-Stage model (Frazier and Fodor, 1978)**

- Syntactic processing is performed through two stages

Stage 1. Preliminary Phrase Package (PPP)
- To assign lexical and phrasal nodes to groups of words within the lexical string that is received.
- 'shortsighted' device.
- Insenstive to well-formedness of incoming string.

Stage 2. Sentence Structure Supervisor (SSS)
- To combine stuructued phrases into a complete phrase marker for the sentence by adding higher nonterminal nodes.

The Garden Path Theory

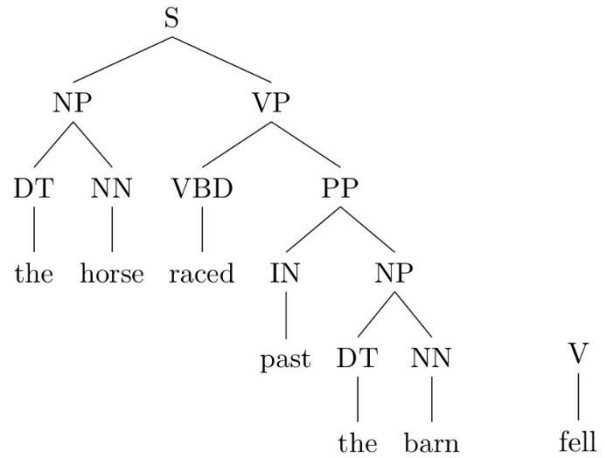
- **The Two-Stage model (Frazier and Fodor, 1978)**

1. Minimal Attachment
- Do not postulate any potentially unnecessary nodes.

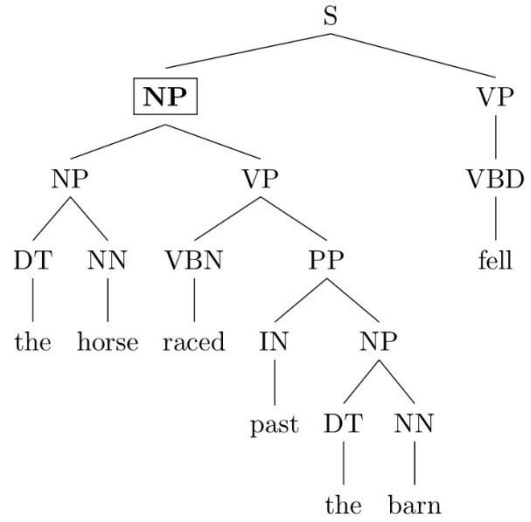
2. Late Closure
- If grammatically permissible, attach new items into the clause or phrase postulated most recently.

(3) John said Mary went to the cinema yesterday.

(4) While Mary was mending a sock fell on the floor.
(4-1) While Mary was mending, a sock fell on the floor.



(a) garden path analysis fails to attach "fell"



(b) globally-correct analysis uses extra node

FIGURE 12 Minimal Attachment in the main-verb/reduced relative ambiguity.

Search Space

- It presents the universe of states that accessible via any sequence of actions, or more properly “operators”.

- It’s important to distinguish this search space from the order in which it is actually searched by some given procedure.

- Whereas the serach tree is implicitly defined by the initial state and the set of operators, there can be many ways of exploring this tree, differing in the number of states the visit and their relative ordering.

- “The parser could compute a single analysis and maintain it until it is contradicted.” (Frazier and Clifton, 1996)

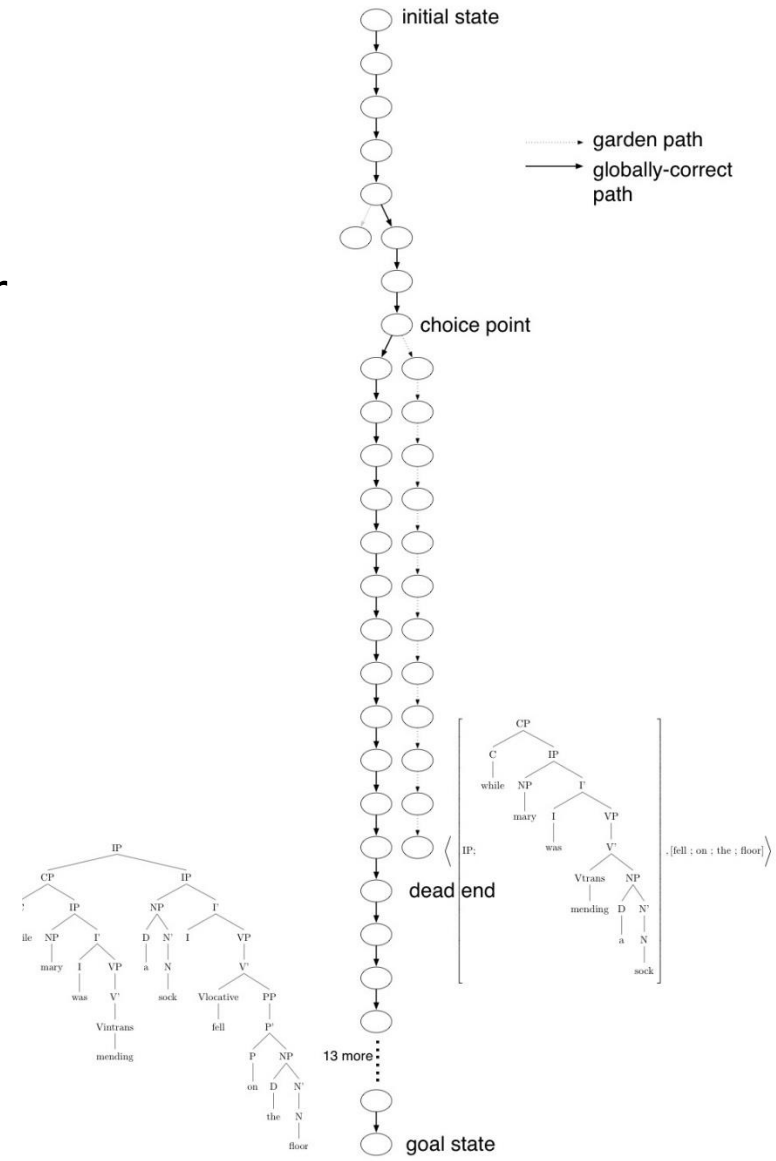


FIGURE 13 The tantalizing picture: garden-pathing as search. Circles are states, arcs as structure-building actions.

The Pereira-Shieber Formalization

- Fernando Pereira and Stuart Shieber (1983) formalized the Garden Path Theory within the framework of shift-reduce parsing.

- This means that all structure-building is bottom-up.

- A recurring question facing an incremental parser of this sort is, should I close this constituent or not?

- To close means applying a *reduce* action, whereas *shift* means going on to the next word without closing off the current constituent.

1. Minimal Attachment
Solve all reduce-reduce conflicts in favor of the reduce move that pops the most symbols from the stack.

2. Late Closure
Solve all shift-reduce conflicts in faor of shifting

(Pereira, 1985)

Minimal Attachment for Automata

- Fig. 14.

- Fig. 15.
  - A shift-reduce parser can either reduce by the ternary rule VP → V NP PP, or reduce bythe binary rule NP → NP PP.
  - Both of these match the stack. But reducing by the longer, ternary rule consumes more symbols from the stac and leads the parser toward minimal analysis in 14(a).

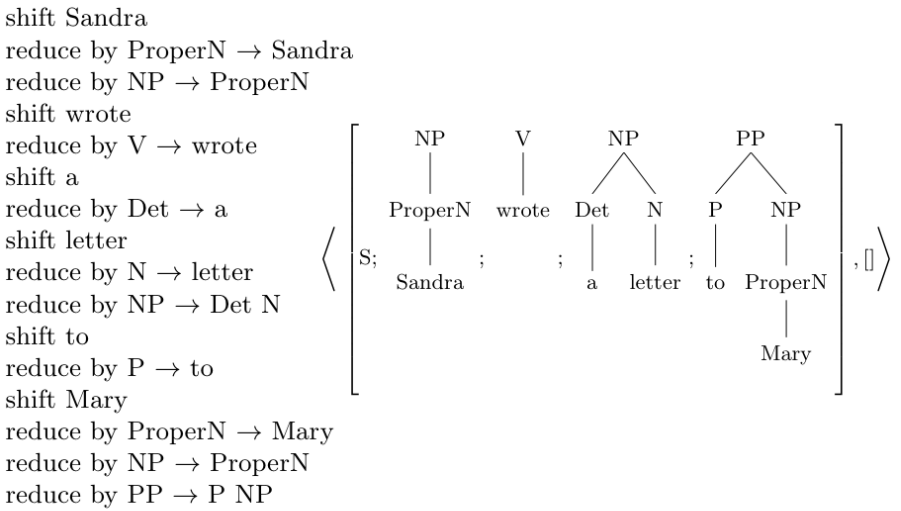
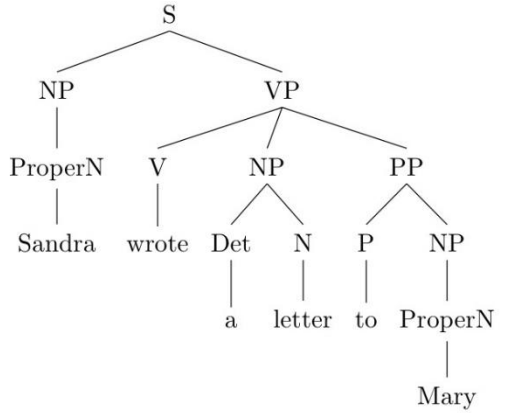
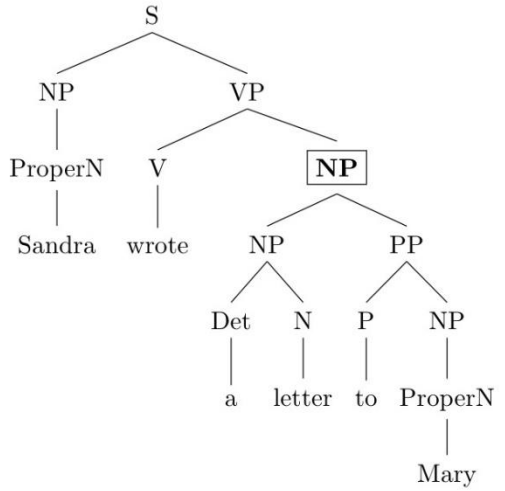


FIGURE 15 Reduce-reduce conflict



(a) Minimal; preferred

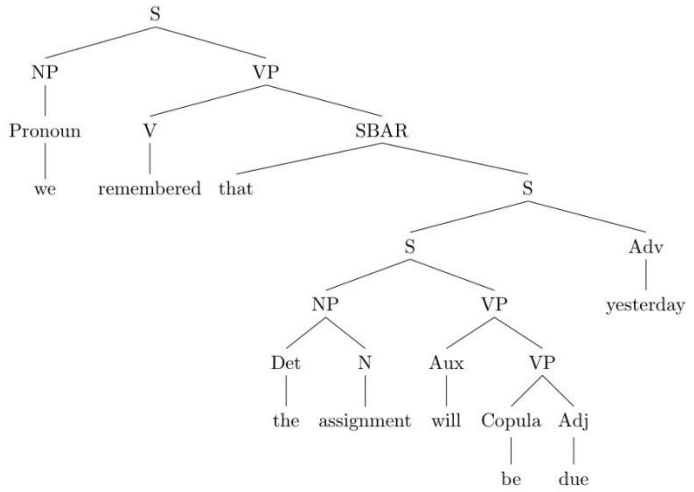


(b) Non-minimal; dispreferred

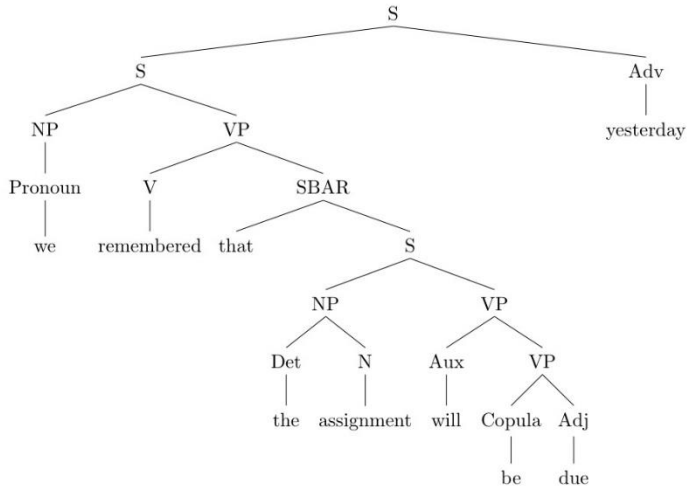
FIGURE 14 Example (e) from page 12 of Construal shows how Mnimal Attachment works

Late Closure for Automata

- Fig. 16.
- Is it time to close off the parent, SBAR, or not?
- Reducing by the rule SBAR that S bring about early closure.
- It effectively chooses a right boundary for the embedded sentence.
- But shifting the next word, "yesterday", leaves the SBAR open.
- Pereira and Shieber's automaton version of Late Closure prioritizes the latter, effectively choosing the low attachment.



(a) Low attachment; preferred



(b) High attachment; dispreferred

FIGURE 16 Example (k) from page 12 of Construal shows how Late Closure works

Late Closure for Automata

shift we
reduce by Pronoun → we
reduce by NP → Pronoun
shift remembered
reduce by V → remembered
shift that
shift the
reduce by Det → the
shift assignment
reduce by N → assignment
reduce by NP → Det N
shift will
reduce by Aux → will
shift be
reduce by Copula → be
shift due
reduce by Adj → due
reduce by VP → Copula Adj
reduce by VP → Aux VP VP
reduce by S → NP VP

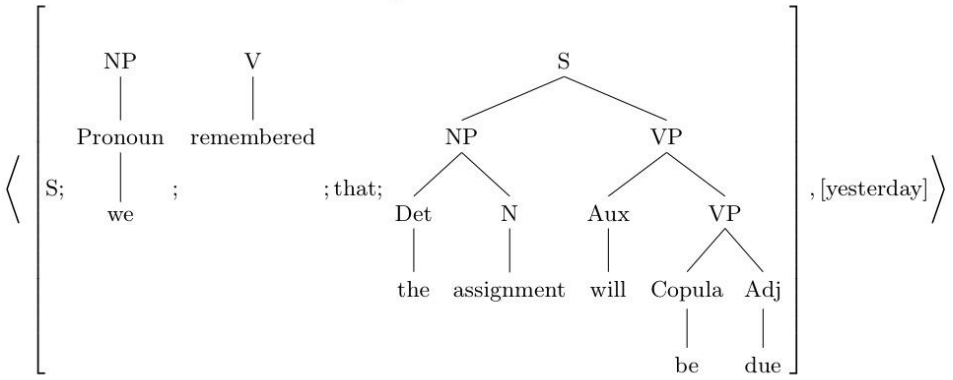


FIGURE 17 Shift-reduce conflict

Same Heuristics, Different Grammar

- Fig. 18.

- Alguien disparó contra la criada de la actriz / que estaba en el balcón
  someone shot the servant(f) of the actress / who was on the balcony

- Cuetos and Mitchell (1988) reported that Spanish participants preferred to attach [que estaba en el balcón] to the first noun, “la criada”, rather than the second noun “actriz”.

- This finding undermined the idea of Late Closure as a language-independent, universal asepect of the human sentence processing mechanism and pointed to an “unappealing” alternative.

Same Heuristics, Different Grammar

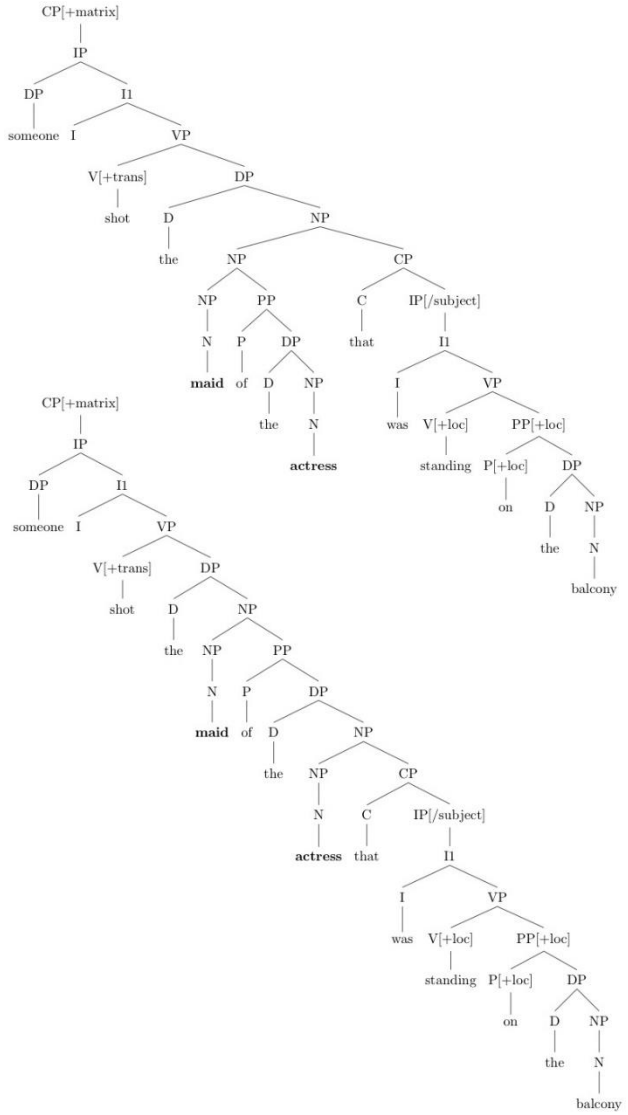


FIGURE 18 English-speakers prefer low attachment in a two-noun case

Same Heuristics, Different Grammar

- Recently, Grillo and Costa (2014) has highlighted a grammatical point which paves the way for a resolution, using another construction Pesudo-relatives. (Tab. 11)

- The important point is when a language offers the Pseudo-Relative costruction, comprehenders seem to perceive it preferentially.

- Their work indicates that the relevant grammatical fact is not adjective-noun order but rather the grammaticality of an entire construction, which fits comfortably into the automata-theoretic framework.

- But realistically, we should expect attachment preferences to result from multiple conflicting factors, as constraint-based lexicalists have long argued (cf. St. John and MeCleland, 1988)

- To achieve a fully mechanistic account, we should employ basic mechanisms that can deal with this sort of conflict.

감사합니다!