Chapter 4 🧩 Sentence Processing II

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Chapter 4: Sentence Processing II

📖 Required Reading

- **Traxler (2nd ed.), Chapter 4** — *Sentence Processing*.
  Link to Chapter 4

1. Argument Structure Hypothesis

1.1 Core Problem: The "Storage Dilemma" of Constraint-Based Models

> **Key Issue:**
> Constraint-based models link syntactic structure to the verb.
> But verbs appear in *many* configurations → storing every possibility is impossible.

Examples of structural variability

- *was reading* → intransitive: **Dr. Phil was reading**
- transitive: **Dr. Phil was reading a book**
- ditransitive: **Dr. Phil was reading a book to a child**
- with PPs: **Dr. Phil was reading a book to a child at the park**

Storing all possible frames would be cognitively infeasible—similar to the classic **"leg-shaving problem"** (where do you stop?).

Solution: The Argument Structure Hypothesis (ASH)

- Only **arguments** (obligatory, verb-required participants) are stored with the verb.
- **Adjuncts** (optional modifiers) are *not* stored; they are computed dynamically during parsing.

Key sources: Boland & Blodgett (2006), Boland & Boehm-Jernigan (1998), Tutunjian & Boland (2008), Matchin & Hickok (2020).

1.2 Precise Definitions: Arguments vs. Adjuncts

Arguments = required, lexically governed
Adjuncts = optional, descriptive additions

Criterion	Arguments	Adjuncts
Obligatoriness	Required; cannot be omitted	Optional; removable
Semantic Necessity	Fill a core meaning gap	Add peripheral info
Lexical Link	Stored with the verb	Not tied to verb meaning

Examples

Arguments

- *devoured* → must have an object
  - ✔ Dr. Phil **devoured the sandwich**
  - ✘ Dr. Phil **devoured**
- *put* → requires object + goal
  - ✔ Dr. Phil **put the book on the shelf**
  - ✘ Dr. Phil **put the book**

Adjuncts

- *quickly* in **Dr. Phil devoured the sandwich quickly**
- *at the park* in **Dr. Phil put the book on the shelf at the park**

Adjunct removal leaves the core event intact.

1.3 Verb Argument Frames: Stored Structures in the Lexicon

ASH proposes that each verb stores **only its argument frame** (0–4 arguments).

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1. Zero-Argument Verbs (Weather Verbs)

- Describe natural events with no real participants.
- Dummy *it* is not an argument.
- **Examples:** *It rained*, *It snowed*

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2. One-Argument Verbs (Intransitive)

- Require only a subject.
- **Examples:** *Dr. Phil sneezed*, *The baby cried*

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3. Two-Argument Verbs (Transitive)

- Require a subject + object.
- **Examples:** *Dr. Phil devoured the sandwich*, *The cat chased the mouse*

- Object omission makes the sentence ungrammatical.

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4. Three-Argument Verbs (Ditransitive)

- Subject + direct object + goal/recipient.
- **Example:** *Dr. Phil gave Rush Limbaugh a book*
- Alternate PP form still contains 3 arguments:
  - *Dr. Phil gave a book* ***to Rush Limbaugh***

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5. Four-Argument Verbs (Rare)

- Involve agent, opponent, stake, and event.
- **Example:**
  - *Dr. Phil bet Rush Limbaugh a sandwich that Big Brown would win.*
- No verbs exceed this number → **cognitive limit**.

1.4 Experimental Evidence for ASH

> **Three major empirical findings support the distinction between arguments and adjuncts.**

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1. Faster Processing of Arguments vs. Adjuncts

Argument relations are pre-stored → processed faster.
Adjunct relations are built on the fly → slower.

Clifton et al. (1991)

- (51) **...interested the man in the wallet** → *in the wallet* = argument
- (52) **...interested the man in his fifties** → *in his fifties* = adjunct

Result:

- Argument PP processed **100–150 ms faster** than adjunct PP.

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2. Argument Interpretation Bias

When a phrase could be an argument *or* adjunct,

> the parser initially treats it as an **argument**.

Examples

- *sent a letter to Harry* → **argument**
- *stapled a letter to Harry* → ambiguous

- parser first treats *to Harry* as the goal argument
- revision needed when semantics conflict
- longer fixations at *to Harry*

(Source: Schutze & Gibson, 1999)

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3. Inference of "Missing" Arguments

If a verb requires an argument but it's omitted, comprehenders **infer** it.
Adjuncts are *never* inferred.

Mauner et al. (1995)

- *The ship was sunk* → infer an agent ("by someone")
- *The ship sank* → no agent inferred

Continuation task:

- *…to collect the insurance money*
- Faster reading for *was sunk* → inferred agent links to purpose, easing integration.

Follow-ups: Koenig et al. (2003).

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2. Limitations, Criticisms, and Some Alternative Parsing Theories

2.1 Key Limitations of Constraint-Based Models

> Constraint-based models successfully explain cue interaction,
> but the text highlights **two fundamental problems** that limit their universality.

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1. Simplicity Overrides Frequency

Constraint-based models predict that the parser should choose the **most frequent** structure.
But the parser sometimes chooses the **simplest** structure—even when it is rarely correct.

Example (Pickering et al., 2000)

> **(53) The athlete realized her shoes somehow got left on the bus**

- *Realized* takes a sentence complement **90%** of the time
  → expected structure: *realized [that] her shoes…*
- But the parser initially takes **her shoes** as a direct object (only 10% frequency)
  → because this structure is **simpler** (minimal attachment)
- Slowdown at **somehow** shows reanalysis

Conclusion:

> Simplicity (from two-stage heuristics) can overpower frequency (a constraint-based cue).
> This contradicts pure constraint-based predictions.

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2. No "Reverse" Garden Paths

Constraint-based models predict:

> When context strongly favors a **complex** structure,
> the simpler structure should become **harder**, creating a "reverse garden path."

But such reverse garden paths do **not** occur.

Example (Binder et al., 2001)

> **(54) The criminal exiled his undependable partner and changed his identity**

Context manipulation:

- **One-criminal context** → supports simple structure
- **Two-criminals context** → should support complex structure (*criminal [who was] exiled…*)

Result:

- Reading times identical in both contexts
- No interference from the complex structure
- Contradiction for constraint-based models (Binder et al., 2001; Sedivy, 2002)

2.2 Alternative Parsing Theories

> The text introduces three theories that "blend" elements from two-stage and constraint-based models
> to account for the limitations above.

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1. Construal Theory (Frazier & Clifton, 1996)

Core Premise:
Parsing depends on whether the relation is:

- **Primary (arguments):**
  - processed like Garden Path model
  - syntax-first, one structure at a time
  - uses late closure + minimal attachment
- **Non-primary (adjuncts):**

- processed like constraint–based model
- multiple structures activated in parallel
- context + semantics guide selection

Key Example: Relative Clause Attachment (Traxler et al., 1998)

> **(55)** The daughter of the colonel who had a black dress left the party
> **(56)** The daughter of the colonel who had a black mustache left the party

- *who had…* is an **adjunct** (non–primary relation)
- semantics selects correct match immediately
- **Prediction:** equal reading times
- **Result:** confirmed via eye–tracking

Supports Construal's parallel processing for adjuncts.

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2. Good–Enough Parsing

(Ferreira, 2003; Ferreira & Patson, 2007)

Core Premise:

> Comprehenders often build **shallow, incomplete structures**.
> They stop once the interpretation is "good enough" for the task.

Evidence 1: Semantic Override of Syntax

(Christianson et al., 2006)

> **(57) The mouse was eaten by the cheese**

- Grammatical meaning: **cheese ate mouse**
- People interpret it as **mouse ate cheese**
- Semantic plausibility overrides syntax
- The parser does not "fix" the syntactic mismatch because the gist is "good enough."

Evidence 2: Persistent Misinterpretations

(Ferreira et al., 2002)

> **(60) While the hunter was stalking the deer drank from the puddle**

Garden path: *the deer* = subject of *drank*
But participants answer:

> **"Was the hunter stalking the deer?" → 70%: YES**

- They retain the **initial misparse** (deer = object of stalking)
- Why? The scenario ("hunter and deer in stalking situation") is good enough.

When Good-Enough Parsing Occurs

- Low-stakes tasks
- Abstract or unusual sentences
- Complex syntax (passives, garden paths)
- When semantics easily supply a plausible structure

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3. Race-Based Models

(Van Gompel et al., 2005; Van Gompel & Pickering, 2006)

Core Premise:

> Multiple structures are triggered.
> They **race** to reach an activation threshold.
> The first structure to finish becomes the interpretation.

If the wrong one wins → garden path + reanalysis.

How it differs from constraint-based models:

- No weighted ranking
- All structures start equal
- Cues (context, semantics) only influence **race speed**

Example: Garden Path Sentence (7)

> *While Susan was dressing the baby played…*

Competing structures:

1. *the baby* = object of *dressing*
    - simple → fast activation
2. *the baby* = subject of *played*
    - complex → slower activation

Outcome:

- Structure 1 wins → garden path
- Reanalysis occurs at *played*

Matches reading-time evidence.

Evidence: Structural Priming

(Van Gompel et al., 2006)

- Participants read a prime sentence with Structure A
- Then an ambiguous target sentence
- Target more likely to adopt Structure A
- → The prime **accelerates** that structure in the race

  Supports the race-based competition model.

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3. Parsing Long-distance Dependencies

3.1 Local vs. Long-distance Dependencies: A Critical Distinction

Most sentences involve **local dependencies**:

> syntactically related words (subject—verb, verb—object) appear adjacent, with no intervening material.

Local Example

- *The girl chased the boy*
  - *girl* + *chased* = adjacent
  - *chased* + *boy* = adjacent

However, many structures create **long-distance (unbounded) dependencies** where related words are separated by intervening phrases.

Common sources of long-distance dependencies:

- clefts
- wh-questions
- relative clauses

Long-distance Example

- *It was the boy whom the girl chased*
  - *the boy* (object) is separated from *chased* by the clause *whom the girl*

3.2 Two Competing Theories of Long-distance Parsing

The text highlights two major approaches to how comprehenders connect **fillers** (moved elements) to their **partners** (the words they depend on).

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1. Gaps-and-Traces Theory

(Chomsky, 1965; 1981)

Core Premise

> Movement leaves behind a **gap**.
> The parser identifies the filler, searches for a gap, and links the two via a **trace**.

Canonical vs. Moved Forms

- **Canonical (no movement):**
  The girl chased the boy
  - object (*the boy*) appears after the verb
- **Moved (cleft):**
  It was the boy whom the girl chased [gap]
  - *the boy* appears fronted
  - a **gap** is left after *chased*

Parsing Steps for *It was the boy whom the girl chased*

1. **Filler detection**
   - Recognize *the boy* as fronted constituent
2. **Gap search**
   - Look for the canonical object position
3. **Gap finding**
   - *chased* requires a direct object → identifies the gap
4. **Filler–gap linking**
   - Link *the boy* to the gap → interpret as object of *chased*

Experimental Evidence: Cross-modal Priming

(Nicol & Swinney, 1989; Nicol & Pickering, 1993)

Task:
Participants hear:

> *That's the boy that the people at the party liked [gap].*

At two points (before *liked*, after *liked*) they name visual words (*boy*, *child*).

Result:

- Naming **faster at the gap** (100 ms) than before *liked*
- Indicates **reactivation** of the filler at the gap
- Supports trace-mediated linking

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2. Gap–Free Theory

(Pickering & Barry, 1991; 1993)

Core Premise

> There are **no gaps**.
> Comprehenders link fillers directly to the verb that requires them.
> Long–distance dependencies are processed like local ones.

Parsing Steps for *It was the boy whom the girl chased*

1. **Filler detection**
   - Identify *the boy* as potential object
2. **Verb encounter**
   - Retrieve argument frame for *chased*
3. **Direct linking**
   - Link *the boy* to *chased* immediately
   - No gap needed

Experimental Evidence: Verb–Based Activation

(Pickering & Traxler, 2001; Traxler & Pickering, 1996)

Sentence Pair

- (68) *That's the pistol with which the killer shot the helpless man [gap] yesterday.*
  - sensible: *pistol* fits as instrument of *shot*
- (69) *That's the pistol in which the killer shot the helpless man [gap] yesterday.*
  - nonsensical: *pistol* cannot be a location argument

Result:

- Slowdown occurs at the **verb** (*shot*), not at the gap
- Suggests filler links to the verb directly
- Supports gap–free model

3.3 The Active Filler Strategy

(Fodor, 1979; 1989)

Long–distance sentences often contain **multiple possible gaps**.
The parser uses an **active filler strategy**:

> **Attach the filler to the first possible gap**,
> even if later information shows it is wrong.

Example (Stowe, 1986)

(67) *That's the boy that the girl liked [doubtful gap] to ignore [real gap]*

- **Doubtful gap:** after *liked*
- **Real gap:** after *ignore*

Parsing outcome:

1. Attach *the boy* to *liked* (first possible gap)
2. Encounter *to ignore* → realize *liked* needs infinitival complement
3. Revise filler attachment to *ignore*

Evidence: Reading Time Slowdown

(Stowe, 1986; Pickering & Traxler, 2003)

- Reading slows by **≈250 ms** at *to ignore*
- Reflects revision from initial (incorrect) attachment
- Confirms **active filler strategy**

In-Class Activities (Tied to Chapter4.pdf)

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1. Argument Frame Mapping

Give verbs (*give*, *eat*, *rain*, *bet*) and ask students to:

- draw argument frames
- generate grammatical vs. ungrammatical sentences
- explain why omitting an argument sounds odd

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2. Good-Enough Parsing Quiz

Read aloud sentences like:

- *The cheese ate the mouse*
- *While the hunter was stalking the deer drank…*

Students:

- write first interpretation
- compare with correct syntax
- discuss why semantics override syntax

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3. Filler-Gap Detection

Examples:

- *Who did the teacher say the student helped?*
- *It was the book that the librarian gave to the child.*

Students:

- label the filler
- circle the gap (or verb, for gap–free theory)
- discuss which theory matches their experience

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4. Active Filler Strategy Demo

Ambiguous start:

> *The actor that the director wanted to praise…*

Students predict attachment location (*after wanted*).
Reveal continuation (*…was late*).
Discuss how the initial garden path fits the active filler strategy.