5. Resolution of ambiguity

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Ambiguity resolution

• Problem of chart parsing: **Structural ambiguity**:

  *Time flies like an arrow.*

  … *paint the office in the building near the research center by the gym* …

• Parser finds all possible parses.
Ambiguity resolution

- Chart parsing is founded on idea of exploring large space of ambiguities.
  - Slow? Not that slow, given a typical median sentence length of < 40.
  - There are simply too many parses on average – it’s proven too hard to write grammars for all and only the right readings.
  - Too much work for semantics.
  - Have to narrow down this potential.
- Possible solution: stop at first parse.
  - Problems?
Ambiguities and parsing

• Questions:
  • Are structural ambiguities really a problem?
  • If so, what kinds of ambiguities?
• Some real text:

  In a general way such speculation is epistemologically relevant, as suggesting how organisms maturing and evolving in the physical environment we know might conceivably end up discoursing of abstract objects as we do. — Quine

The sentence is unambiguous and we have found the parse. What is the problem?
In the usual way such people think, blithely ignorant as bleating sheep, politicians fulminating and bloviating on their oversized TVs, Americans ignore evidence credibly presented pointing out the results of their choices.

Adapted from Steve Abney’s example
In a general way such speculation is epistemologically relevant, as suggesting how organisms maturing and evolving in the physical environment we know might conceivably end up …

Adapted from Steve Abney’s example
Ordinary sentences can have hundreds of different parses due to combinatorial explosion (Church and Patil).

That combinatorial explosion arises to a great extent from the fact that syntactic categories do not – arguably cannot – incorporate all of the real-world knowledge that we bring to bear on this problem.
Combinatorial explosions of parses

• More than 300 parses for 2% of sentences in corpus.

• *E.g.*, 692 parses for:

  *For each plant give the ratio of 1973 to 1972 figures for each type of production cost and overhead cost.*
The 168-year-old Sunday tabloid will cease to exist after this week, Murdoch said today in an announcement to staff e-mailed to news organizations. … Such has been the outcry over the phone hacking of everyday people during times of emotional turmoil that David Cameron’s government on Thursday postponed a decision on News Corp’s bid to purchase full control of BSkyB until September.
At once too many and too few readings

Listen….
At once too many and too few readings

Listen….

OK, robustness is important, but enough is enough.
Global and local ambiguity

- **Global ambiguity:** A sentence has multiple interpretations.

  *I saw the man with the telescope.*
  *Time flies.*

  - See which interpretation(s) people prefer.

- **Local ambiguity:** Resolved by later input.

  *The horse raced…*
  *Mary expected the woman…*
Syntactic sources of ambiguity

- Derived from PoS ambiguity:
  Time flies.

- Attachment of one phrase to another:
  examined the fingerprint with the microscope
  the horse in the barn that the vet examined
  learned that Nadia arrived on Sunday
  He brought the car back \{undamaged\|undismayed\}.

- Gap ambiguities:
  the boys that the police debated about fighting
Syntactic sources of ambiguity

• Internal structure of a phrase:
  winter boot sale
  airport long term car park courtesy vehicle pickup point

• Alternative semantic role of subconstituent:
  The tourists objected to the guide that they couldn’t hear.
  I want the music box on the table.
What do people do?

- Look at human behaviour:
  - Expected / preferred interpretations.
  - Clues for successfully pruning parses.
- Some human strategies: …
What do people do?

- **Minimal attachment:**
  Prefer the simplest structure.

Karen knew the schedule …

1 \[ S [NP [PN Karen]] [VP [V knew [NP the schedule …

2 \[ S [NP [PN Karen]] [VP [V knew [S [NP the schedule …

Karen knew the schedule \{by heart / was wrong\}.  

What do people do? 3

- **Recency** (local/right association): Associate new input with most recent part of the parse tree.

Karen met the mother of a singer who …

1. \([\text{NP the mother [PP [P of] [NP a singer [S who … \]

2. \([\text{NP the mother [PP [P of] [NP a singer]] [S who … \]

- Notice that this might contradict minimal attachment.  When?
Lexical preferences:
Words (especially verbs) may have defaults for their containing or nearby structures.

The tourists \{objected / signalled\} to the guide that they \{couldn’t hear / didn’t like\}.

1. Prefer: AGENT object to PATIENT
   (but AGENT object to PATIENT MESSAGE is also possible).

2. Prefer: AGENT signal to PATIENT MESSAGE
   (but AGENT signal to PATIENT is also possible).

• Might contradict minimal attachment or recency.
PP attachment ambiguity

- Prepositional phrase attachment.
  - An example problem that is a focus of much work in disambiguation.
    - A common ambiguity.
    - A specific example of a very general type (modification ambiguity).
    - Representative of properties of many types of ambiguities.
Why is PP attachment hard?

• Sometimes seems to require complex knowledge of the world:

  Optical anisotropy of the copolyester melts can be determined by examination of the materials with the use of an optical microscope.

  This is the first examination of the material with the impurity CVL in the region of deeply core shells.

  The kinetic advantage arising upon using the NaH/Al mixture to prepare the doped hydride was well reproduced in our examination of the materials with variable dopant amounts and preparation conditions.

When is PP attachment easy (-ier)?

- Many unambiguous cases:
  - *The man with the telescope saw me.*
  - *The signals were analyzed with the oscilloscope.*
- Sometimes syntax really should be able to say ‘no.’
When is PP attachment easy (-ier)?

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• More often, syntax can say ‘probably not’:
  • The preposition of rarely attaches to a transitive verb.
  • Strong constraints on attaching PPs to pronouns and proper names.

He examined it with a microscope.
She examined John with a stethoscope.

But: I saw {John / him} with a hat.
  *{John / He} with a hat saw me.

Functioning as an AdjP, not restrictive
Lexical preferences again

• **Lexical preferences:** Words (especially verbs) may have defaults for their containing or nearby structures — *i.e.*, preferred disambiguation.

• Examples for PP attachment:
  – Preposition $p$ prefers to be attached to a verb.
  – Verb $v$ prefers PPs with preps $p_1$ or $p_2$ or nouns $n_1$ or $n_2$, but dislikes PPs with prep $p_3$ or noun $n_3$.
  – When it’s the head of an NP in a PP, noun $n_1$ prefers the PP to be attached to noun $n_2$ or $n_3$, or verb $v_1$ or $v_2$, if one of these is available.
Limitations of lexical preferences

- Preferences are only preferences:
  - Might not be satisfiable.
  - Might conflict.
  - Might be overridden by coherence, plausibility.

- A given attachment problem might have no applicable preferences.
How to use lexical preferences?

• If a word \( w \) had some preferences …
  • How would we know what they are?
  • How would we apply them in a parser?
Corpus-based attachment disambiguation

- Gather statistics for lexical usages from a *corpus*.
  - That means the corpus gives the preferred structure
  - That means that the corpus may have to be manually annotated by people (expensive)
- Use statistics to numerically estimate the parameters of a model.
- Apply model to new cases.
Corpora

- **Corpus** (pl. corpora): A large collection of text (or similar material).
  - General or specialized content; e.g., news, blog, technical, ESL, errors, …
  - May be (manually or automatically) **annotated**; e.g., with parse, meaning, correction, …
Some important corpora

- Brown Corpus (1M words); British National Corpus (100M words).
  - Tagged with part of speech of each word.
- English Gigaword Corpus (~6B words).
- Penn Treebank (1.6M sentences of *WSJ*).
  - Each with complete human-created parse tree.
- Canadian *Hansard* aligned French–English corpus.
Corpus statistics

• Can count linguistic phenomena in corpus.
  • *E.g.*, count how many times a *with*-PP is noun-attached or verb-attached in Penn Treebank.

• Problems:
  • Sparse data — even with large corpora.
  • Required information may not be explicit in corpus.
Conventional view: Use these counts to estimate numerical parameters of prior, otherwise discrete-looking grammars.

Avant-garde view: treat corpora themselves as a means of specifying the grammars.
  - the phrase-structure rules are *grounded* in actual data.
  - the phrase-structure rules are specified in *context*.
Use corpus statistics to **train** an algorithm — *i.e.*, set parameters of an underlying model.

- Typically output is **classification** of input.
- E.g., classify (*examine, the materials, with the microscope*) as a V-attachment or NP-attachment situation.
- Given input = (V, NP, PP), should PP attach to V or NP?
• Types of training:
  • **Supervised**: Learn from data with known answers: From set of pairs \{input, output\}, learn to classify new inputs.
  • **Unsupervised**: Given only inputs and maybe possible outcomes.
  • In between: *Bootstrapping, minimally supervised.*
A three-way partition of corpus data

- Training data.
- Development (validation, verification) data.
  - To test successive versions of algorithm under development, to guide adjustments to approach.
- Test data.
  - For testing of final version of algorithm.
    (No more tweaking allowed!)