Computational Linguistics

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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 …

Our parsers, so far, find all possible parses.

Ambiguity resolution

Chart parsing is founded on idea of exploring large space of ambiguities.

- It can still be slow.
- It still does not really incorporate semantics.
- We have to streamline things.

Possible solution: stop at first parse.

- Problems?

Ambiguities and parsing

Questions:

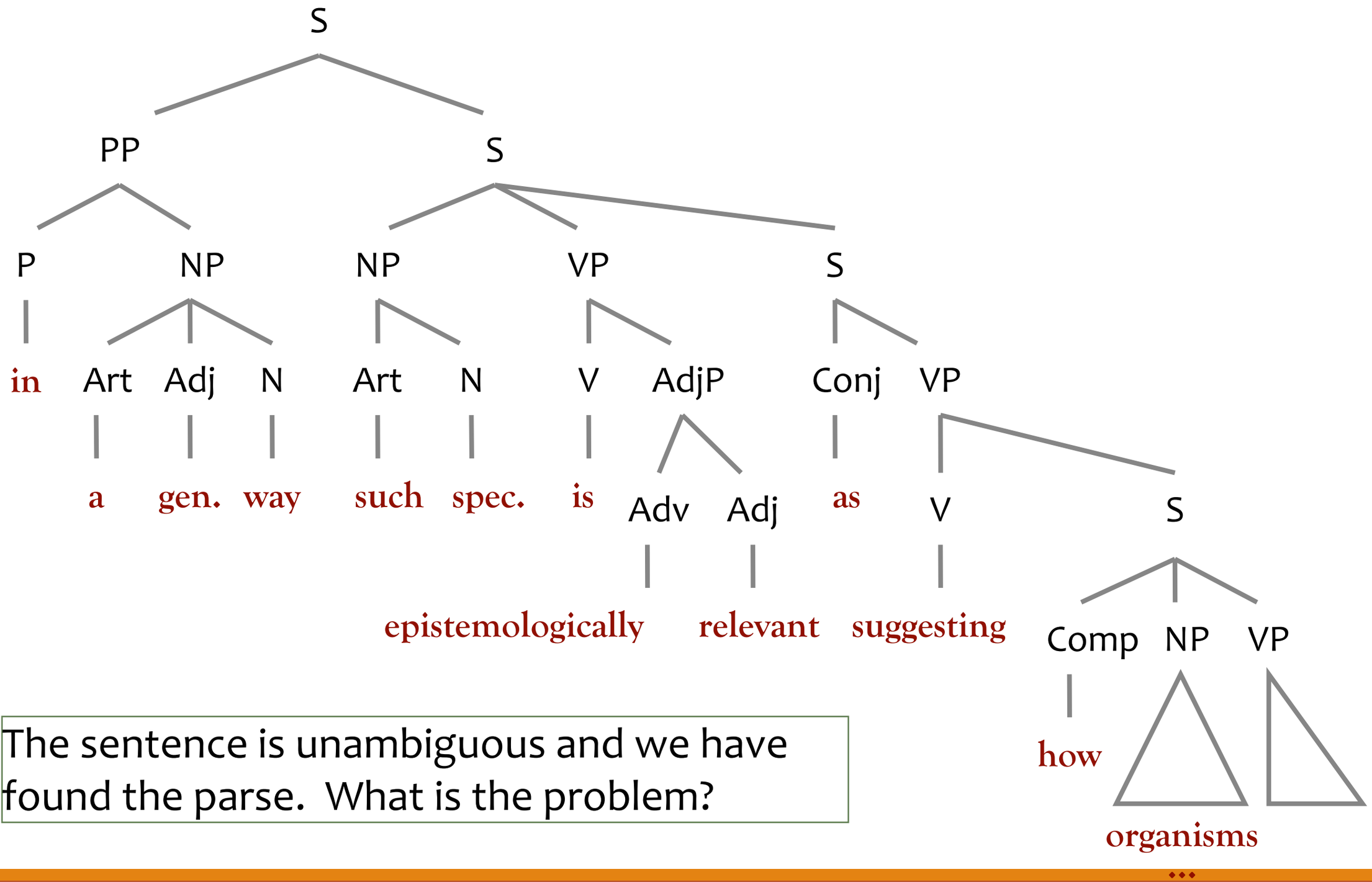
- Are structural ambiguities *really* a problem?
- If so, what *kinds* of ambiguities?

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

W.V. Quine. "Speaking of objects." *Proceedings and Addresses of the American Philosophical Association*, Vol. 31 (1957–1958), pp. 5–22. Quoted in: Steven Abney, "Statistical methods and linguistics." In: Judith Klavans and Philip Resnik (eds.), *The Balancing Act: Combining Symbolic and Statistical Approaches to Language.* The MIT Press, Cambridge, MA. 1996.

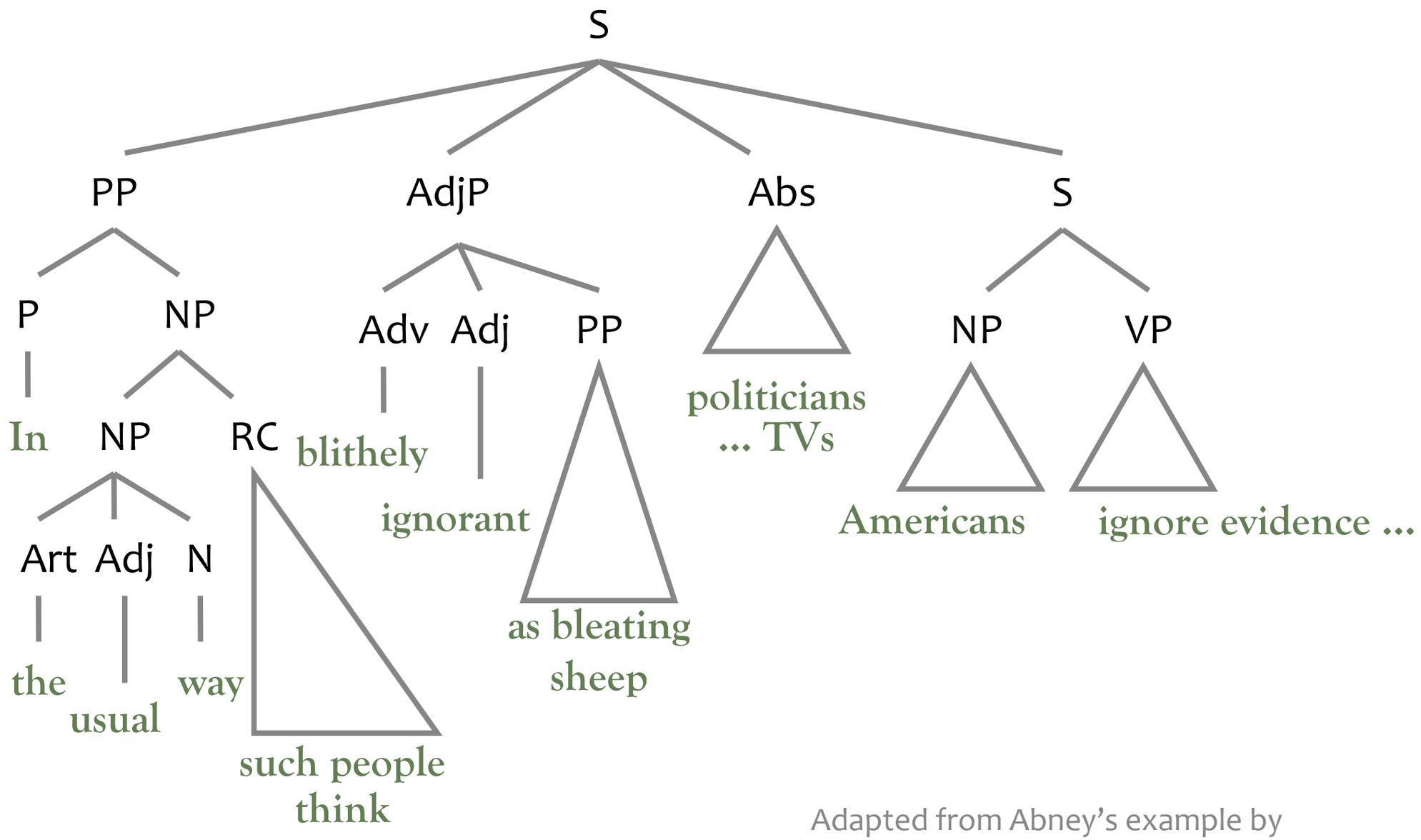
Ambiguities and parsing (example)



The sentence is unambiguous and we have found the parse. What is the problem?

Another example

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 Abney's example by Graeme Hirst and Suzanne Stevenson

Find the structural ambiguities

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.

Bloomberg, 8 July 2011

Combinatorial explosion of parses

Ordinary sentences can have hundreds of different parses due to combinatorial explosion (Church and Patil).

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.*

Global and local ambiguity

Global ambiguity: A sentence has multiple interpretations.

I saw the man with the telescope.
Time flies.

- *Count* which interpretation(s) people prefer.

Local ambiguity: Resolved by later input.

- *The horse raced…*
  Mary expected the woman…

Syntactic sources of ambiguity 1

Derived from PoS ambiguity:

Time flies. Is 'flies' a noun or a verb?

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

Who did he tell you that to?

Syntactic sources of ambiguity 2

Internal structure of a phrase:

winter boot sale

airport long term car park courtesy vehicle pickup point

Alternative analyses of constituent:

The tourists objected to the guide that they couldn't hear.

I want the music box on the table.

What do people do all day? 1

Look at human behaviour:

- Expected / preferred interpretations.
- Clues for successfully pruning parses.

Some human strategies: …

What do people do all day? 2

Minimal attachment:

Prefer the simplest structure.

Karen knew the schedule …

❶ [S [NP [PN *Karen*]] [VP [V *knew* [NP *the schedule* …

❷ [S [NP [PN *Karen*]] [VP [V *knew* [S [NP *the schedule* …

Fits ❶.

Karen knew the schedule {by heart | was wrong}.

Requires ❷; hence need to back up; longer processing time.

W.D.Marslen-Wilson *et al.* Prosodic effects in minimal attachment. *Quarterly Journal of Experimental Psychology*, 45A(1), 73–87, 1992.

What do people do all day? 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. [NP *the mother* [PP [P *of*] [NP *a singer* [S *who …*

2. [NP *the mother* [PP [P *of*] [NP *a singer*]] [S *who …*

Notice that this might contradict minimal attachment. When?

What do people do all day? 4

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 it 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. ???

(1) Brewbaker, James L. and Marshall, William B. Liquid crystalline copolyesters of 4-hydroxybenzoic acid and substituted 4-hydroxybenzoic acids. U.S Patent 5268443.
(2) V. B. Mikhailik. XEOL studies of impurity core-valence luminescence in mixed rubidium caesium chloride crystals. *Journal of Physical Studies*, 9 (2005) 182–184.
(3) P. Wang, X.D. Kanga, H.M. Cheng. Dependence of H-storage performance on preparation conditions in TiF3 doped NaAlH4. *J of Alloys & Compounds*, 2006, 217–22.

When can we make it easier? 1

Many unambiguous cases.

The man with the telescope saw me.

The signals were analyzed with the oscilloscope.

When can we make it easier? 2

Can often rule out structural possibilities:

- The preposition *of* almost never 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.* ← Functioning as an AdjP, not restrictive
**{John | He} with a hat saw me.*

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 be 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.
- A noun n_1 in the head of an NP in a PP 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 preference

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 disambiguities

- Gather statistics for lexical usages from a ***corpus***.
- Use statistics to train algorithm, set parameters.
- Apply algorithm 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.

Wall Street Journal Corpus 1987–92 (80M words).

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

You can count linguistic phenomena in corpora.

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

Use as data for statistically based methods.

Problems:

- Sparse data — even with large corpora.
- Required information is not explicit in corpus.

Statistical algorithms 1

Use corpus statistics to ***train*** an algorithm — *i.e.*, set parameters.

- 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 to NP?

Statistical algorithms 2

Types of training:

- ***Supervised***: Learn from data with known answers: From set of pairs {*input, output*}, learn to classify new inputs.
- ***Unsupervised***: Given inputs and possible classes only.
- 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!)