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The Constituency of Hyperlinks in a Hypertext Corpus

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Boston University, June 19, 2011

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The generative notion of constituency

- Certain substrings of sentences form natural units of linguistic import. Such units are called ***constituents***.

- Constituents are motivated and verified empirically by converging evidence of different kinds.

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Constituency tests

(1)   John ate an old hamburger.

Q: Is "an old hamburger" a constituent?

a) Clefting:
It's *an old hamburger* that John ate _____.   *ok!*

b) Fronting:
An old hamburger, John ate _____, but a fresh orange, he didn't
_____.   *ok!*

c) Substitution:
Mary ate an old hamburger and John ate *one* too.   *ok!*
("one" = "an old hamburger")

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(1)   John ate an old hamburger.

Q: Is "ate an old" a constituent?

a)   Clefting:
     It's ***ate an old*** that John _____ hamburger.   *no!*

b)   Fronting:
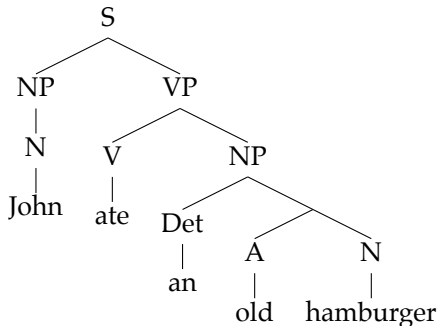   ***Ate an old***, John _____ hamburger...   *no!*

c)   Substitution:
     Mary ate an old hamburger and John ***did*** sandwich too.   *no!*
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Constituency structure

Constituents are organized hierarchically, reflecting a phrase structure grammar:

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Other converging evidence

- Other forms of converging evidence for constituency:
  - Pscholinguistic evidence (Fodor et al., 1974, a.o.)
  - Compositional semantics which tracks syntactic constituency (though perhaps not always perfectly), following Frege, Davidson, Montague

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The limits of constituency tests

- Unfortunately, in some cases constituency tests may not apply or may yield conflicting results.
- Important proposals exist where constituency is at issue:
  - Binary branching (Kayne, 1984, a.o.)
    Branching in phrase structure grammars are always binary, not *n*-ary.
  - The DP hypothesis (Abney, 1987)
    D(eterminers) are the head of what have traditionally been labeled "Noun Phrases," with the D taking the Noun Phrase proper as its complement.
- As such, novel methodologies for constituency verification are welcome.

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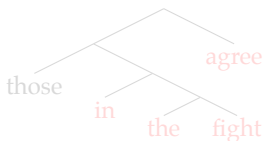- As such, novel methodologies for constituency verification are welcome.

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Observation and goals
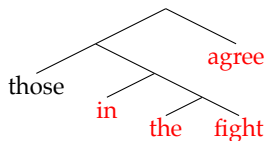Methodology

Hypertext and constituency

Observation:

- Not just *any* substring of sentences can be turned into **hyperlinks**.
  Potential candidates seem to be rule-governed in some way.

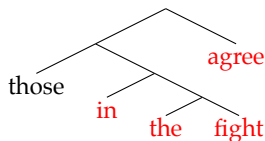`http://metafilter.com/85556:`

- The text "in the fight agree" is not a syntactic constituent.
- Upon closer inspection, it turns out this is actually two links:

  (4) ... and those <u>in the fight</u> <u>agree</u>.

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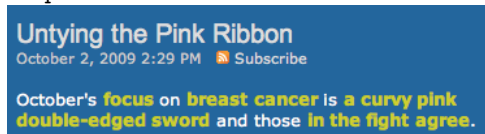
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Goals

1. Test to what extent hyperlinks reflect the constituent structure of their host sentences.

☞ Strong correlation!

2. Present a novel class of linguistic data, non-constituent links, for further study.

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A common insight: Spitovsky et al. (2010)

- A connection between HTML markup and dependencies
- Unsupervised grammar induction of a dependency-based parser (Klein and Manning, 2004) on a hypertext corpus, with constraints limiting dependencies from within each markup region
- 5% improvement over previous state-of-the-art
- But only minimal discussion of what kinds of linguistic objects hyperlinks are

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Corpus:

- MetaFilter (`http://metafilter.com`), a large, link-rich website. Currently about 100,000 "entries."
- 5.7m words, 375k human-annotated links.

Evaluation:

- Statistical parsing in lieu of manual coding, as a first approximation
- Parse the entry texts using the Stanford Parser (Klein and Manning, 2003) trained primarily on the Wall Street Journal section of the Penn Treebank (PTB; Marcus 1993).
- Find the subset of the parse tree that corresponds to the link.
- Check if this is a constituent.

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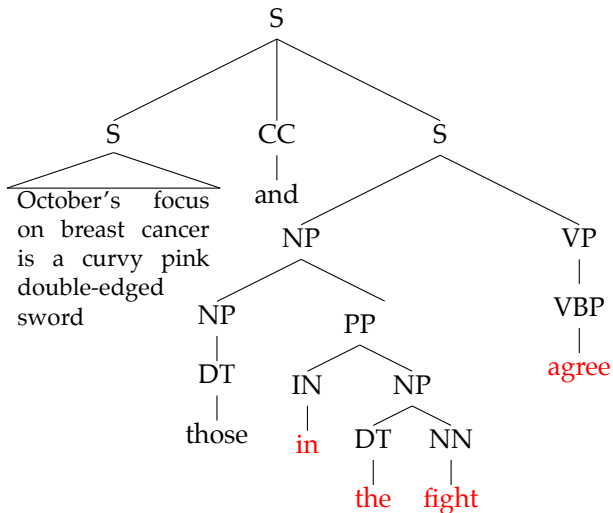
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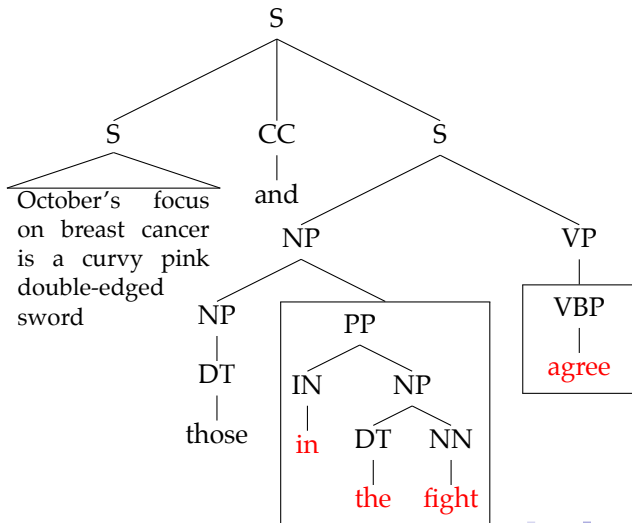Results and discussion
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Entry 85556:

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Results

A work-in-progress metric:

76.2% of all hyperlinks in the corpus are constituents.

- This value is after one type semi-supervised correction of noun phrase structure.

- "Out of the box": 72%

- Choosing random subsentences (null hypothesis) we would expect ≈27.6% constituency.

- Preliminary sampling and manual coding indicates an overwhelming number of false negatives.

Average number of words per sentence: 15.658 (≈ 16)

P(link being constituent in 15-word sentence)=

$\frac{\text{constituents in 15-word sentence}}{\text{number of subsentences}} = \frac{15 \cdot 16 \div 1}{\binom{15}{2}} = \frac{29}{105} = 27.6\%$

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Average number of words per sentence: 15.658 ($\approx$ 16)
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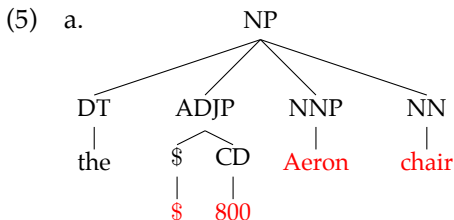Average number of words per sentence: 15.658 (≈ 16)
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Sources of error: *n*-ary branching

- The Stanford Parser trained on the PTB produces *n*-ary branching structures (5a).
- A common configuration tagged by this methodology as a "non-constituent" are noun phrases missing their Determiners.

(5) a.

- In a modern syntax following Abney's (1987) DP hypothesis, "$800 Aeron chair" would actually be a constituent (5b).
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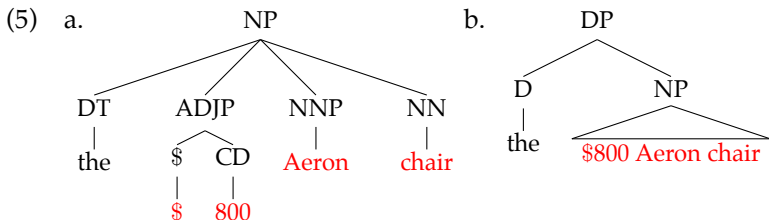# Sources of error: *n*-ary branching

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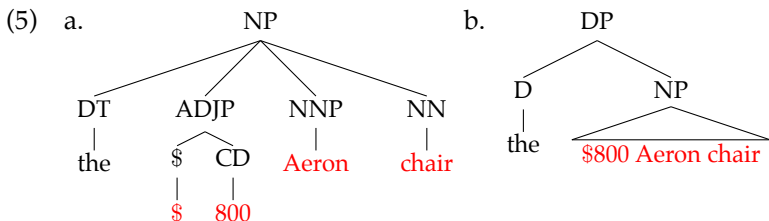
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Types of links by POS

Lowest node dominating all of the link:

POS	N	%
NP	150458	39.9986
S	46434	12.3443
NNP	30651	8.1484
VP	25487	6.7756
NN	25173	6.6921
NNS	12739	3.3866
JJ	11228	2.9849
RB	7703	2.0478
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PRN	6527	1.7352
FRAG	5409	1.4380
PP	4312	1.1463
...		<1

- Over 58% nominal
- Spitovsky et al. (2010) found 74.5% to be nominal using the same metric, but with a different corpus.
- 12.3% sentential, 6.8% verb phrase-level

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A typology of "non-constituents"

- Links deemed to be "non-constituents" by this methodology are then categorized in terms of what material is missing which, if included, would result in a constituent.

(6) A Virginia jury has [found Ahmed Omar Abu Ali [guilty of terrorism related crimes]].   46912
⇒ Missing: PP after the link

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Missing nodes from links classified as "non-constituents":

category	position	N	%
PP	after	9166	12.17%
DT	before	8850	11.75%
NP	after	6173	8.19%
PRN	after	4834	6.42%
SBAR	after	4571	6.07%
JJ	before	4118	5.47%
NNP	after	3602	4.78%
NN	before	3286	4.36%
CC	after	2999	3.98%
NNP	before	2963	3.93%
VP	after	2859	3.79%
...			

- But it cannot just be that certain linguistic units in certain positions (PPs on the right) tend to be left off...

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Grammatical sensitivity

- Consider the frame "V NP PP."
- If V transitive, PP adjunct. If V ditransitive, PP argument.
- Identical structure via the Stanford/PTB parser:

VP

V   NP   PP

- The *n*-ary branching structure may again lead to false negatives.

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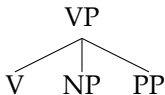Non-constituent links
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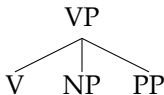
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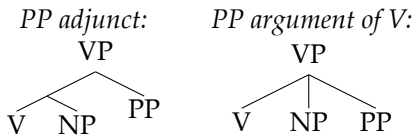
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$$
\begin{array}{c}
\text{VP} \\
\diagup\ |\ \diagdown \\
\text{V}\quad \text{NP}\quad \text{PP}
\end{array}
$$

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"V NP PP"

- A more modern syntactic theory would structurally distinguish the two PPs:[1]

PP adjunct: *PP argument of V:*

```
        VP                      VP
       /  \                   / | \
      /    \                 /  |  \
     /\    PP               /   |   \
    V  NP                  V   NP   PP
```
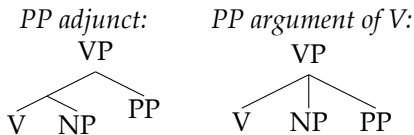
Predictions:

1. Linking "V NP PP" should entail that the PP is an adjunct.

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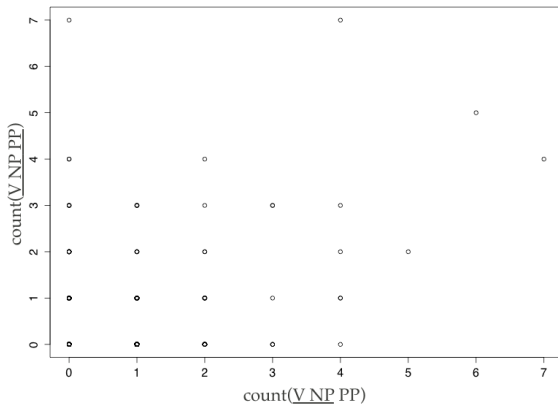*PP adjunct:*   *PP argument of V:*

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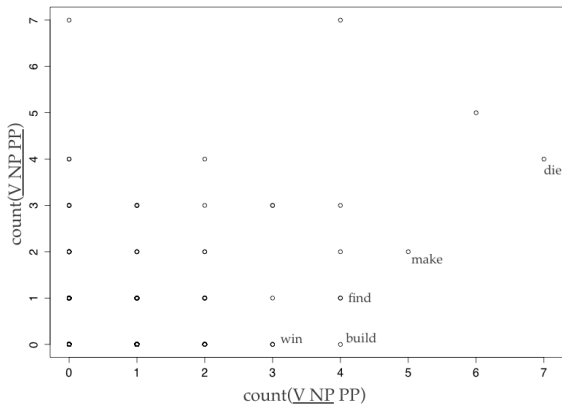
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"V NP PP"

Verbs in "V NP PP" frame by link configurations

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Non-constituent links

- Legitimate non-constituent links exist:

(7) ...the NY Times reports that the F.D.A. is cracking down. 21196

(8) If you're going to kill off an entire section of a newspaper and
     fire all of the staffers who work there, it's probably a good
     idea to get the Twitter password first.   87944

- Intuitively:

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Non-constituent links

- These non-constituent links are not random; they are also rule-governed in some way.
  - Perhaps it's a semantic condition of referentiality?
  - The same string potentially being a constituent in a similar sentence?
- The legitimate non-constituent links seem to be an interesting class of linguistic objects which warrant further study.

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1. Hyperlinks have a strong tendency to reflect the constituent structure of their host sentences, showing sensitivity to structural distinctions.

2. The seeds of a novel methodology of studying hyperlink markup in a hypertext corpus to investigate syntactic constituency.

3. True non-constituent links exist, but seem to form an interesting class of linguistic objects which warrants further study.

   - A novel type of linguistic data: a natural class of non-constituents

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Next steps

- A more precise evaluation of the hyperlink-constituency hypothesis, using sampling and manual coding.
- Improvement of project corpus and tools, to be made publicly-accessible.
- Potentially, expansion of corpus and tools to another language.

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Acknowledgements

Many thanks to my UROP researchers and contributors:

- Patrick Hulin, Patrick Hurst, and Antony Nguyen (MIT)
- Vedrana Janković (Faculty of Electrical Engineering and Computing, Croatia)

and to David Barner, David Pesetsky, and Stuart Shieber for comments and discussion. All errors are my own.

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