

## On Recognizing Discourse Relations

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### Topical structure

There are many bases for discourse structure:

**Topics** can produce a relatively flat structure of discourse in terms of the questions addressed in successive parts.



Kites

- (1) The kite was created in China, about 2,800 years ago. Later it spread into other Asian countries, like India, Japan and Korea. However, the kite only appeared in Europe by about the year 1600. ⇒ **where kites developed**
- The first kites had sails made of paper or light fabrics such as silk. The poles were made from bamboo, or other strong but flexible woods, and the kite line was made from string or twine. ⇒ **what the first kites were made from**
- [<http://simple.wikipedia.org/wiki/Kite>]

Notice that topics correlate with **lexical distribution**.

Topical structure can become conventionalized – cf. Wikipedia:

	Wisconsin	Louisiana	Vermont
1	Etymology	Etymology	Geography
2	History	Geography	History
3	Geography	History	Demographics
4	Demographics	Demographics	Economy
5	Law and government	Economy	Transportation
6	Economy	Law and government	Media
7	Municipalities	Education	Utilities
8	Education	Sports	Law and government
9	Culture	Culture	Public Health
10	...	...	...

Since topics correlate with lexical usage, latent topic models can be used for recognizing and exploiting conventionalised topic structure across texts so organized [CBBK09].

## Genre-specific conventional structures – News Reports

Discourse may be structured by genre-specific conventions about the **function** of successive parts.

Ex 1. The *inverted pyramid* structure of **news reports**:

- ▶ **Headline**
- ▶ **Lead paragraph, specifying**
  - ▶ who is involved
  - ▶ what took place
  - ▶ when it took place
  - ▶ where it took place
  - ▶ why it happened
  - ▶ how it happened
- ▶ **Body providing more details about the lead**
- ▶ **Tail containing less important information**

## Genre-specific conventional structures – Errata

Ex 2. The structure of **errata** used in periodicals to correct an error in a previous issue:

- ▶ Correct statement
  - ▶ Description of error
  - ▶ (Optionally) reason for the error
- (2) [wsj\_1751] EMPIRE PENCIL, later called Empire-Berol, developed the plastic pencil in 1973. Yesterday's Centennial Journal misstated the company's name.
  - (3) [wsj\_0211] ITEL CORP. reported third-quarter earnings, which were mistakenly shown in the Quarterly Earnings Surprises table in yesterday's edition to be lower than the average of analysts' estimates. On a pretax basis, Itel's third-quarter earnings of 30 cents a share were actually 7.14% higher than the average of estimates.

## Genre-specific conventional structures – Structured abstracts

Ex 3. The structure of **biomedical abstracts**, which when explicitly labelled are called *structured abstracts*:

- ▶ **Aim** (*Introduction, Background, Objective, Hypothesis, etc.*)
- ▶ **Methods** (*Study Design, Methodology, etc.*)
- ▶ **Results** (*Outcomes*)
- ▶ (optionally) **Discussion**



## Discourse relations

Focus here is on simpler structure associated with **discourse relations** — essentially **predications** whose arguments are text spans interpretable as *abstract objects* (ie, events, propositions, situations, etc.) – also called *Informational Relations* or *Conjunctive Relations*.)

Evidence for a discourse relation can come from an explicit connective:

- (7) **The kite was created in China, about 2,800 years ago.**  
*Later (Explicit=succession)* **it spread into other Asian countries, like India, Japan and Korea.**  
*However* , the kite only appeared in Europe  
 by about the year 1600.  
[\[http://simple.wikipedia.org/wiki/Kite\]](http://simple.wikipedia.org/wiki/Kite)

## Discourse relations

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Evidence for a discourse relation can come from an explicit connective:

- (8) **The kite was created in China, about 2,800 years ago.** *Later (Explicit=succession)* **it spread into other Asian countries, like India, Japan and Korea.**  
*However (Explicit=contrast)*, **the kite only appeared in Europe by about the year 1600.**  
[\[http://simple.wikipedia.org/wiki/Kite\]](http://simple.wikipedia.org/wiki/Kite)

## Discourse relations

Evidence for a discourse (or informational) relation can also be implicit in adjacency.

- (9) **Clouds are heavy.** *The water in a cloud can have a mass of several million tons.*  
[\[http://simple.wikipedia.org/wiki/Kite\]](http://simple.wikipedia.org/wiki/Kite)

## Discourse relations

Evidence for a discourse (or informational) relation can also be implicit in adjacency.

- (10) **Clouds are heavy.** *(Implicit=specification) The water in a cloud can have a mass of several million tons.*  
[\[http://simple.wikipedia.org/wiki/Kite\]](http://simple.wikipedia.org/wiki/Kite)

The term **rhetorical structure** is often used to cover structure arising from both informational and intentional relations.

## Not all discourse structures have the same properties

Discourse structures vary in their properties:

- ▶ The structure may be linear (flat) or a more complex graph.
- ▶ If non-linear, the structure may or may not be a tree.
- ▶ The structure may fully, or only partially cover the discourse.
- ▶ All parts of the structure may have equal weight or some parts may be more highly weighted than others.

We take the structure associated with discourse relations to be

- ▶ **Relatively flat** (ie, every discourse relation does not have to be either a root node or the arg to another discourse relation)
- ▶ Possibly only a **partial** cover
- ▶ Of **equal** weights.

## Possibly a partial cover

Discourse relations may only **partially** cover a text.

1. There may be gaps **within** a sentence – eg,

(11) "I'm sympathetic with workers who feel under the gun,"

says Richard Barton of the Direct Marketing Association

of America

which is lobbying strenuously against the Edwards beeper bill. "But the only way you can find out how your people are doing is by listening." [wsj\_1058]

Neither the attribution phrase nor the non-restrictive RelClause is covered by this or any other discourse relation.

## Possibly a partial cover

2. There may be gaps **between** sentences — eg,

(12) At Greenville High School, meanwhile, some students – especially on the cheerleading squad – were crushed. (*EntRel*)

"It's hard to explain to a 17-year-old why someone they like had to go," says Mrs. Ward. Soon, T-shirts appeared in the corridors that carried the school's familiar red-and-white GHS logo on the front.

On the back, the shirts read, "We have all the answers." [wsj\_0044]

## Possibly a partial cover

2. There may be gaps **between** sentences — eg,

(13) At Greenville High School, meanwhile, some students – especially on the cheerleading squad – were crushed. (*EntRel*) "It's hard to explain to a 17-year-old why someone they like had to go," says Mrs. Ward. Soon, T-shirts appeared in the corridors that carried the school's familiar red-and-white GHS logo on the front.

(*Implicit=Expansion.Conjunction*) On the back, the shirts read, "We have all the answers." [wsj\_1044]

No discourse relation was annotated as covering "Soon, T-shirts appeared in the corridors".

## Equal or unequal weighting

Rhetorical Structure Theory [MT88] takes certain discourse relations to be **asymmetric**, with one argument (the *nucleus*) more essential to the purpose of the communication than its other argument (the *satellite*).

Stede [Ste08] has argued that asymmetry in discourse has several sources that should not be conflated.

In particular, asymmetry is not associated with informational (discourse) relations.

## Discourse Chunking

I will refer to annotating or recognizing discourse relations as **discourse chunking**, by analogy with **NP chunking**.

Discourse chunking involves (in some order)

- ▶ Identifying the evidence for the discourse relation – ie, evidence for the “discourse predicate”;
- ▶ Identifying the arguments related by that predicate;
- ▶ Identifying the sense of the relation.

## Discourse Chunking

For a **lexicalised approach**, there are four issues in discourse chunking the texts of a given language:

- ➊ Given that language, what affixes, words, terms and/or constructions signal its discourse relations?
- ➋ Given a particular token in context, does it signal a discourse relation (or serve some other function)?
- ➌ Given a token that signals a discourse relation, what are its arguments?
- ➍ Given a discourse relation, what sense is predicated as holding between its arguments?

All illustrations will come from the PDTB corpus [PDL<sup>+</sup>08].

## Discourse Chunking: Problem 1

- ➊ Given that language, what affixes, words, terms and/or constructions signal its discourse relations?

Some entire Part-of-Speech classes can signal discourse relations:

- ▶ Coordinating conjunctions (on clauses or sentences)  
(14) Finches eat seeds, and robins eat worms.  
(15) Finches eat seeds. But today, I saw them eating grapes.
- ▶ Subordinating conjunctions  
(16) While finches eat seeds, robins eat worms.  
(17) Robins eat worms, just as finches eat seeds.

**N.B.** Members of the PoS class can serve other roles as well. the PoS-tag may not distinguish among them (e.g. and/CC).

## Discourse Chunking: Problem 1

With other Parts-of-Speech, only a subset may signal discourse relations:

- ▶ eg, not all adverbials, just *discourse adverbials*
- (18) Robins eat both worms and seeds. Consequently they are omnivores. (*discourse*)
- (19) Robins eat both worms and seeds. Fortunately they prefer worms. (*sentential*)

As noted earlier, *adjacency* can signal a discourse relation.

- (20) **Clouds are heavy.** (*Implicit=specification*) **The water in a cloud can have a mass of several million tons.**  
[<http://simple.wikipedia.org/wiki/Kite>]

## Discourse Chunking: Problem 1

Other constructions have been found to signal discourse relations [PDL<sup>+</sup>08]. For example,

- ▶ *this/that <be> why/when/how <S>*
- ▶ *this/that <be> before/after/while/because/if/etc. <S>*
- ▶ *the reason/result <be> <S>*
- ▶ *what's more <S>*

Since **bootstrapping** and **back translation** have been used effectively to discover new instances of named entities and paraphrases, they may also prove useful for identifying additional signals of discourse relations.

## Discourse Chunking: Problem 1

Syntactically constrained **back translation** [CB08] on EuroParl translation pairs has produced paraphrases that were either not annotated as discourse connectives in the PDTB or don't appear there – eg,

Not annotated	Absent
<i>above all</i>	<i>as a consequence</i>
<i>after all</i>	<i>as an example</i>
<i>despite that</i>	<i>by the same token</i>
...	...

[PJW10b] have proposed using back translation to augment the set of discourse connectives in English. The same can currently be done for any EuroParl language [CB08].

## Discourse Chunking: Problem 2

- ③ Given a particular token in context, does it signal a discourse relation or serve some other function?

One must decide whether an individual explicit token signals a discourse relation because such tokens are often *syntactically ambiguous* [PN09]:

- (21) Asbestos is harmful **once** it enters the lungs. (*subordinating conjunction*)
- (22) Asbestos was **once** used in cigarette filters. (*adverb*)

Sometimes PoS-tags can distinguish discourse from non-discourse usage, if different PoS-tags are used – eg, **once/IN** and **once/RB**. Even without full PoS-tagging, usage can be distinguished through surface cues with at least 94% accuracy [PN09].

## Discourse Chunking: Problem 2

Deciding whether **adjacency** signals a discourse relation in a given instance is a problem, because adjacency too is ambiguous.

- (23) BELL INDUSTRIES Inc. increased its quarterly to 10 cents from seven cents a share. **The new rate will be payable Feb. 15.** (*implicit=Comparison.Contrast*) **A record date hasn't been set.** Bell, based in Los Angeles, makes and distributes electronic, computer and building products.

## Discourse Chunking: Problem 2

Deciding whether **adjacency** signals a discourse relation in a given instance is a problem, because adjacency too is ambiguous.

- (24) BELL INDUSTRIES Inc. increased its quarterly to 10 cents from seven cents a share. The new rate will be payable Feb. 15. **A record date hasn't been set.** (*NoRel*) Bell, based in Los Angeles, makes and distributes electronic, computer and building products.

## Discourse Chunking: Problem 3

- Given a token that signals a discourse relation, what are its arguments?

No discourse relation has yet been identified with >2 arguments.

So, in the PDTB,

- ▶ **Arg2** – arg from text syntactically bound to the connective (or second text span, if relation cued by adjacency)
- ▶ **Arg1** – the other argument

**N.B.** In the Hindi Discourse Relation Bank [OPK<sup>+</sup>09], Arg1/Arg2 labels are associated with particular **senses**, rather than with clause-level syntax – e.g. for a CAUSAL relation

- ▶ **Arg2** – cause
- ▶ **Arg1** – effect

## Discourse Chunking: Problem 3

The main challenge to identifying **Arg2** (syntactically bound arg) comes from whether or not *attribution* is part of the arg.

- (25) **We pretty much have a policy of not commenting on rumors,** and **I think that falls in that category.** [wsj\_2314]

Identifying **Arg1** is harder because it needn't be adjacent to **Arg2**:

- Discourse adverbials are *anaphoric*. Like pronouns, they may refer to an entity introduced earlier in a non-adjacent span.
- On a level site you can provide a cross pitch to the entire slab by **raising one side of the form** (step 5, p. 153), but for a 20-foot-wide drive this results in an awkward 5-inch (20 x 1/4 inch) slant across the drive's width. **Instead, make the drive higher at the center.**

## Discourse Chunking: Problem 3

2. By a *minimality principle*, one may take arguments to contain only the minimal amount of information needed to complete the interpretation of the discourse relation.

- (27) **Big buyers like Procter & Gamble say there are other spots on the globe and in India, where the seed could be grown.**  
 "It's not a crop that can't be doubled or tripled," says Mr. Krishnamurthy. **But no one has made a serious effort to transplant the crop.** [wsj.0515]

The quote and its attribution are not needed to complete the interpretation of the relation signaled by But, thereby distancing **Arg1** from **Arg2**.

## From Discourse Connectives to their Arguments

There have been at least three approaches to date to **automatic** discourse chunking, through identifying the arguments to a discourse relation signalled by an explicit discourse connective:

- ▶ Wellner & Pustejovsky [WP07]
- ▶ Elwell & Baldrige [EB08]
- ▶ Prasad, Joshi & Webber [PJW10a]

## Discourse Chunking [Wellner &amp; Pustejovsky, 2007]

W&P assume a "head-based" (dependency) representation of discourse. Thus the problem is only to locate **heads** of each arg, not how much of the projection it subsumes.

Where there is no natural head (eg, because of clausal or sentential coordination), W&P choose the head of the first coordinate.

Candidate args are identified using a discriminative log-linear ranking model on features involving:

- ▶ syntactic constituency paths
- ▶ dependency paths
- ▶ type of connective (coordinating, subordinating, adverbial)
- ▶ verbs of attribution and clausal complements

A log-linear re-ranking model is then used to select the best pair (**Arg1-Arg2**), to capture any dependency between them.

## Discourse Chunking [Wellner &amp; Pustejovsky, 2007]

**Results** (Training on Sec 00–22 of PDTB 1.0 and testing on Sec 23–24)

Conn Type	Freq	Independent Accuracy	Rerank Accuracy	Error Reduction
Coord	662	75.5	78.3	11.4%
Subord	547	87.2	86.8	-3.0%
Adverb	386	42.2	49.0	11.8%
Total	1595	71.7	74.2	8.8%

**Conclusion:** W&P's models show different levels of performance on different types of connectives, suggesting that **connective specific** models (either by connective or by type of connective) might perform better still.

## Discourse Chunking: [Elwell &amp; Baldridge, 2008]

E&B show this to be the case, using added features that encode

- ▶ the specific connective (eg, *but*, *then*, *while*, etc.)
- ▶ the type of connective (coordinating conjunction, subordinating conjunction, discourse adverbial)
- ▶ local context features, such as the words to the left and right of the candidate and to the left and right of the connective.

**Results** on Sec 23–24 of PDTB 1.0, after training on Sec 2–21:

- ▶ Coordinating conjunctions: No performance difference
- ▶ Subordinating conjunctions: Slightly worse performance
- ▶ Discourse adverbials: **Big improvement** (67.5% vs. 49.0%)

## Discourse Chunking: [Prasad, Joshi &amp; Webber, 2010]

PJW improve on E&B's results by using connective **location** as a feature and taking **sentences** as candidate args.

Arg2 is then simply the sentence containing the connective.

Identifying Arg1 depends on the type of connective:

- ▶ Subordinating and S-medial coordinating conjunctions: Arg1 must be in the same S. ⇒ **Problem solved**
- ▶ S-initial coordinating conjunctions (*But*, *And*): Arg1 must be in some previous S.
- ▶ Discourse adverbials: Arg1 can be in the same or some previous S, but can predict which one with 93% accuracy.

## Discourse Chunking: [Prasad, Joshi &amp; Webber, 2010]

The latter classes of connectives (S-initial coord conjunctions and discourse adverbials) can be further distinguished by their **location** in the text:

- ▶ Paragraph-initial S: Arg1 must be in some previous paragraph
- ▶ Paragraph-non-initial S: Arg1 can be in same paragraph or previous one.

Finding Arg1 of connectives in the first set may be very difficult.

Less difficult is finding Arg1 for connectives in the second set, since its distribution is highly skewed. In the PDTB,

- ▶ Same paragraph:  $4301/4373 = 98\%$
- ▶ Previous paragraph:  $72/4373 = 2\%$

## Discourse Chunking: [Prasad, Joshi &amp; Webber, 2010]

For connectives in the second set, PJW take an approach to locating Arg1 based on:

- ▶ filtering out candidates that don't belong within same scope of direct speech or parentheses as the conn — eg, either both outside that scope:

(28) **Big buyers like Procter & Gamble say there are other spots on the globe, and in India, where the seed could be grown.** "It's not a crop that can't be doubled or tripled," says Mr. Krishnamurthy. **But no one has made a serious effort to transplant the crop.** [wsj\_0515]

► Or both inside that scope:

- (29) When Anne Volokh and her family immigrated to the U.S. 14 years ago, they started life in Los Angeles with only \$400. They'd actually left the Soviet Union with \$480, but during a stop in Italy Ms. Volokh dropped \$80 on a black velvet suit. ... Three months after she arrived in L.A. she spent \$120 she didn't have for a hat. ("A turban," she specifies, "though it wasn't the time for that 14 years ago. But I loved turbans.") [wsh.1367]

Overall accuracy on 743 connectives in paragraph non-initial Ss improved to 86.3%, from 83% baseline.

**Conclusion:** If one can distinguish easy cases from hard ones, one can use different solutions.

## Problem 4

For the sense of **explicitly signalled** discourse relations, several relatively common explicit signals are unambiguous:

- *before* (326): TEMPORAL.ASYNC.PRECEDENCE
- *in addition* (165), *moreover* (101): EXPAN.CONJUNCTION
- *for example* (196), *for instance* (98): EXPAN.INSTANTIATION
- *so* (263): CONTINGENCY.CAUSE.RESULT

And the most common connectives are nearly unambiguous:

- *and* (3000): EXPANSION (96.8%)
- *but* (3308): COMPARISON (97.2%)
- *because* (858): CONTINGENCY (100%)
- *if* (1223): CONTINGENCY (96%)

But only at the top level, which may not be very useful in practical terms.

## Problem 4

- Given a discourse relation, what sense is predicated as holding between its arguments?

First needed is a **sense inventory**. Used in the PDTB 2.0 is:

TEMPORAL	COMPARISON	CONTINGENCY	EXPANSION
Asynchronous	Contrast	Cause	Conjunction
Precedence	juxtaposition	reason	Instantiation
Succession	opposition	result	Restatement
Synchronous	Concession	Condition	(3 subtypes)
	expectation	(6 subtypes)	Alternative
	contra-exp	Prag Cause	(3 subtypes)
	Prag Contrast	Prag Condition	Exception
	Prag Concession		List

This will be modified and augmented in the next version of the PDTB.

## Recognizing sense of explicitly signalled relations

1. More often than not, COMPARISON (69%) and TEMPORAL (79.6%) relations are signalled explicitly in the PDTB [PRM+08].
2. The explicit signals for COMPARISON and CONTINGENCY are mostly unambiguous.
3. Taking only the explicit signal (ie, the discourse connective) as a feature, a 2-way decision tree classifier shows high accuracy on identifying the top-level sense of an explicitly signalled relations:

TEMPORAL	COMPARISON	CONTINGENCY	EXPANSION
95.4% (80%)	97.23% (69.72%)	94% (79.73%)	97.61% (65.16%)

Majority class given in parentheses [PRM+08].

4. A 4-way decision tree classifier shows high precision and recall on this same task [PRM<sup>+</sup>08].

	TEMPORAL	COMPARISON	CONTINGENCY	EXPANSION
Precision	0.841	0.935	0.947	0.973
Recall	0.903	0.971	0.844	0.957

## Recognizing sense of implicit relations

Considerable work on the more difficult problem of automatically labelling sense in the **absence** of discourse connectives [SM03, ME02, BGM07, SL08, PLN09].

Efforts to date have focused on word-pairs as features – one word from *Arg1*, the other from *Arg2* – usually based on **synthetic** data constructed from the clause/sentence span to the left and right of a (relatively) unambiguous connective such as *but* (CONTRAST) and *because* CAUSAL.

Cf. corpus of CONTRAST and CAUSAL relations from the English Gigaword Corpus, along with NORELATIONS based on pairs >3 sentences apart [BGM07].

## Recognizing sense of implicit relations

Efforts to automatically recognize the sense of otherwise unmarked relations vary by whether

- ▶ words or word stems are used
- ▶ "stop words" included or not
- ▶ all PoS classes included or only some (eg, nouns and verbs)
- ▶ frequency cut-off used on what words or stems are included
- ▶ pairs come from synthetic or actual data
- ▶ whether abstract lexical features used or not (eg, polarity)

Pitler et al [PLN09] have experimented with the usefulness of a variety of features, from both synthetic and actual data.

## Recognizing sense of implicit relations

The results of [PLN09] on a test set of manually annotated **implicit relations** from the PDTB show that

- ▶ Training on word pairs from implicit PDTB relations led to significantly better performance than training on word pairs from **either** the Gigaword Corpus relations [BGM07] or manually annotated explicit PDTB relations.
- ▶ **Polarity** wasn't a good basis for distinguishing COMPARISON relations from CONTINGENCY, EXPANSION and TEMPORAL, as about 30% of the sets had opposite polarity pairs.
- ▶ As previously discovered [WPH<sup>+</sup>07], the first and last words of *Arg1* and *Arg2* – together with the first three words of each *arg* – were the most useful features in distinguishing among these senses.

## Recognizing sense of implicit relations

But confounding sense labelling (both annotation and recognition) are difficulties in saying what the sense of a relation is. Recall **Errata**: 23 2-sentence instances in PDTB.

(30) [wsj.1751] EMPIRE PENCIL, later called Empire-Berol, developed the plastic pencil in 1973. Yesterday's Centennial Journal misstated the company's name.

- ▶ 1 annotated as COMPARISON
- ▶ 6 annotated as COMPARISON.CONTRAST
- ▶ 2 annotated as COMPARISON.CONTRAST.JUXTAPOSITION
- ▶ 1 annotated as COMPARISON.CONTRAST.OPPOSITION
- ▶ 1 annotated as COMPARISON.CONCESSION.EXPECTATION
- ▶ 10 annotated as ENTREL
- ▶ 2 annotated as TEMPORAL.ASYNCHRONOUS.SUCCESION

## Conclusions

For discourse chunking (discourse structure based on discourse relations), discourse-level pred-arg structure seems to raise different issues than does clause-level pred-arg structure.

- ① Verbs vary in their arity: Discourse relations all seem to have two arguments
- ② The set of verbs is clear (though generative): The set of explicit signals of discourse relations is not.
- ③ Args to verbs are maximal projection of syntactic nodes (or in dependency grammar, a head and its dependents), while the *minimality principle* can lead to smaller projections as args.
- ④ At high level, explicit signals of discourse relations seem unambiguous, while at lower-levels, annotators seem less confident as to what sense involves.



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