

B2: On the information conveyed by discourse connectives

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Discourse Relation Processing

Project B2 explores whether information-theoretic notions apply to language production and comprehension at the level of discourse relation processing.

New Perspective:

An incremental model of discourse relation processing

Research Hypotheses:

- 1 Discourse relation surprisal can account for processing difficulty in human text comprehension.
- 2 The occurrence of optional discourse markers can be explained by the uniform information density hypothesis.

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Discourse Relations

Discourse connective:

a cohesive device that contributes to making a text coherent.

Example

- a. Peter stayed indoors, **although** it was sunny outside.
- b. It was sunny outside, **but** Peter stayed indoors.
- c. It was sunny outside. Peter stayed indoors.

Discourse Connectors

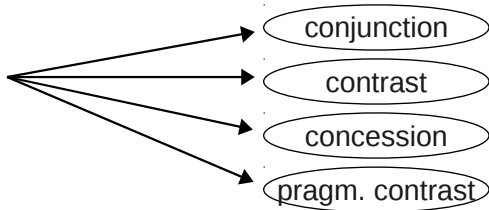
Relevant background on discourse connectors:

Discourse Connectors

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► **ambiguity**

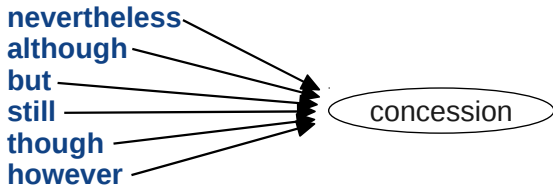
but



Discourse Connectors

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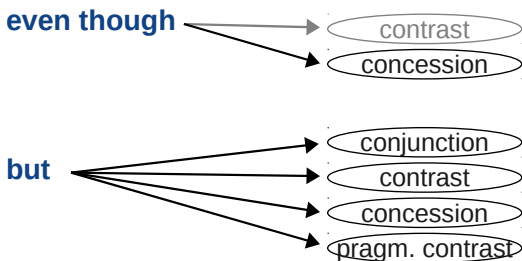
- ▶ **ambiguity**
- ▶ **variation**



Discourse Connectors

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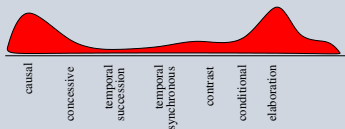
- ▶ **ambiguity**
- ▶ **variation**
- ▶ **specificity**



Surprisal and Processing Difficulty

When do we predict processing difficulty?

probability distribution for identity of upcoming discourse relation



connector →

probability distribution for identity of upcoming discourse relation

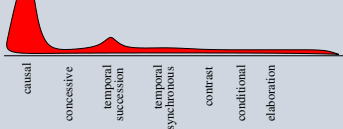


Figure: large change in probability distribution of discourse relations before vs. after processing a connector.

Surprisal and Processing Difficulty

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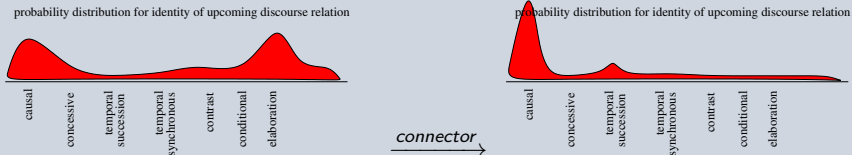


Figure: large change in probability distribution of discourse relations before vs. after processing a connector.

In order to quantify this we need to know:

- ▶ **What is the information conveyed by a discourse connective?**
- ▶ **How can we quantify this in a computational model?**

Surprisal and Processing Difficulty

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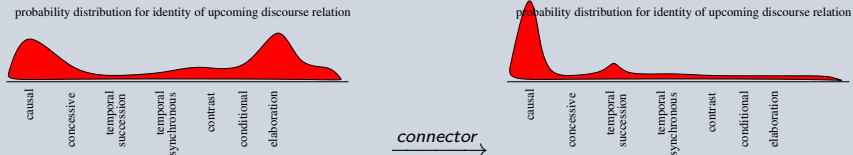


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Case study: two highly overlapping connectors *but* and *although*

What do we know about discourse connectors and processing discourse relations?

- ▶ markers of contrastive and concessive discourse relations are more difficult to process than additive or causal connectors
(Murray 1995; Drenhaus et al., 2014; Xiang and Kuperberg, 2014)
- ▶ connectives shape expectations online and therefore facilitate processing downstream
(e.g., Köhne and Demberg, 2013)
- ▶ lack of research on processing of highly overlapping connectives

But vs. although

What do we know regarding *but* vs. *although*?

| <i>but</i> | <i>although</i> |
|--|---|
| coordinating | subordinating |
| P but Q : Q denies an accessible assumption of P. | Q although P : Suspend an inference from P that would result in an unresolvable contradiction. |
| contrast | concession |

(e.g., Iten, 2000)

Examples

- ▶ It's raining **but** Peter is going out.
- ▶ Peter is going out **although** it's raining.
- ▶ **Although** it's raining, Peter is going out.

But vs. although

Despite these differences described in the theoretical literature, *but* and *although* often appear interchangeably:

- ▶ *but* is claimed to be the more general connective (Fraser, 1999)
- ▶ in translation, *although* is often rendered as the more general *but* (Swedish-English) (Altenberg, 2000)
- ▶ meaning of *although* order-independent; affects processing ease? (Iten 2000)

Examples

- ▶ It's raining **but** Peter is going out.
- ▶ Peter is going out **although** it's raining.
- ▶ **Although** it's raining, Peter is going out.

What is the meaning of a discourse connective?

Hypothesis 1:

A highly ambiguous discourse connector like *but* only carries a core meaning, the rest is inferred by the content of the arguments.

(Fraser, 1999)

Hypothesis 2:

But and *although* come with different sets of processing instructions.

(Iten, 2000)

Hypothesis 3:

A discourse connectors meaning is defined by its distribution in text.

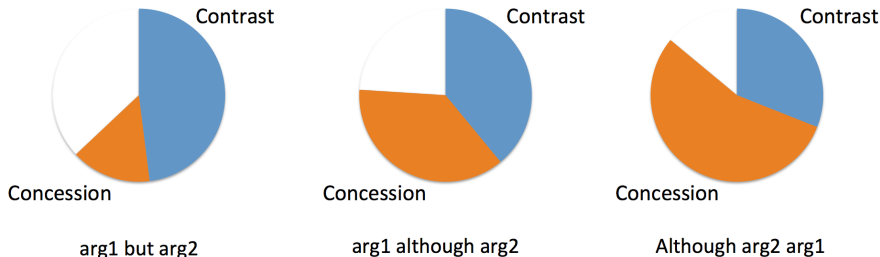
(Asr and Demberg, 2012b)

Large resources like the Penn Discourse Treebank (PDTB) enable us to look at the distribution of *but* and *although*.

Corpus Statistics

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Statistics extracted from corpus data (PDTB)



Experiment Design

Experimental design:

- ▶ two clauses, such that **both a contrast and a concession interpretation** are possible.
- ▶ disambiguate contrast vs. concession reading on third sentence
- ▶ manipulate connective: **but** vs. **although** vs. **sentence-initial although**
- ▶ fully counter-balanced design

Comparing the interpretation of **but** vs. **although**

- (1) After a busy day at the university and attending a lot of courses, Jane came home, made some tea, and started looking for something to eat.

- (2a) She took some pizza from the fridge that was left from the day before, **but** she desired to have something sweet with her drink.
- (2b) She took some pizza from the fridge that was left from the day before, **although** she desired to have something sweet with her drink.
- (2c) **Although** she desired to have something sweet with her drink, she took some pizza from the fridge that was left from the day before.

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Comparing the interpretation of **but** vs. **although**

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- (2c) **Although** she desired to have something sweet with her drink, she took some pizza from the fridge that was left from the day before.
- (3a) She had a piece of **cake** and went to bed early.
→ *consistent with a contrast reading of 2*
- (3b) She had a piece of **pizza** and went to bed early.
→ *consistent with a concession reading of 2*

Mechanical Turk experiment

Two offline coherence judgment tasks via Amazon Mechanical Turk:

1) Norming first two sentences, excluding disambiguation

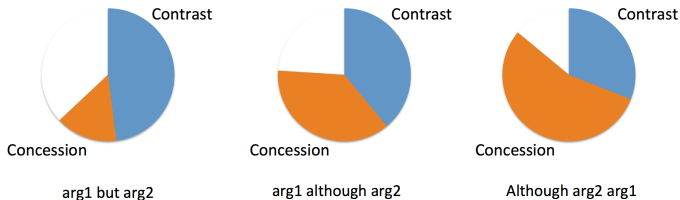
- ▶ 48 native English speakers (US American), 24 items
 - ▶ Likert scale scoring between 1 and 7
- first two sentences are matched for coherence

2) Full stories

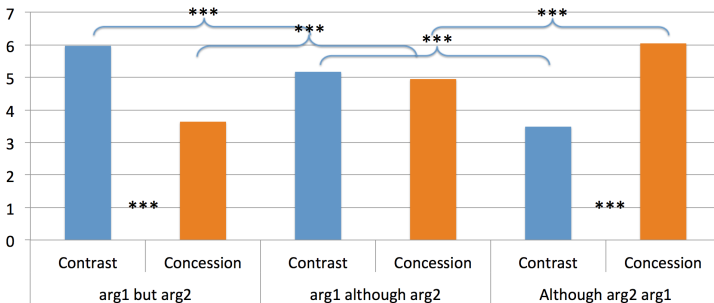
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Results Acceptability Study

Statistics extracted from corpus data (PDTB)



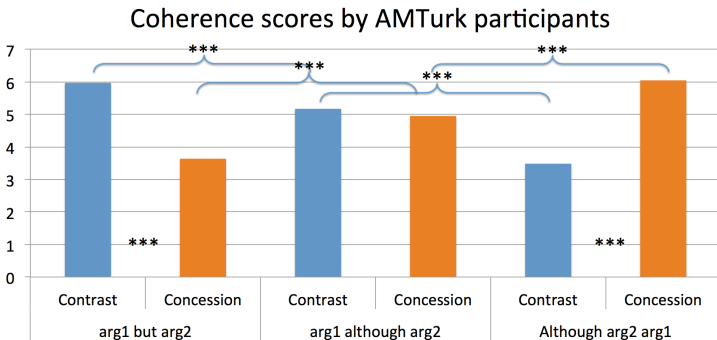
Coherence scores by AMTurk participants



Results Acceptability Study

Conclusions:

- ▶ not consistent with Fraser's account of "core" meaning
- ▶ not fully consistent with Iten's account of differing processing instructions
- ▶ fully consistent with a distributional account for discourse connectors.



Eyetracking study

Are these results replicable in online processing?

Do readers slow down during first-pass reading of the critical region in the third sentence?

Stimuli (repeated)

- (1) After a busy day at the university and attending a lot of courses, Jane came home, made some tea, and started looking for something to eat.
- (2a/b) She took some pizza from the fridge that was left from the day before, **but** / **although** she desired to have something sweet with her drink.
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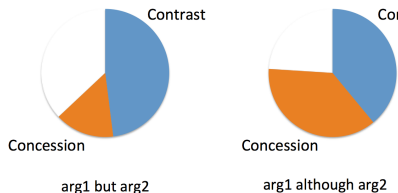
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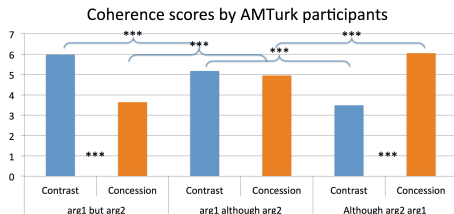
- ▶ 32 native English speakers in Edinburgh, 24 items
- ▶ Stimuli same as above excluding the Although-initial conditions

Results Online Study

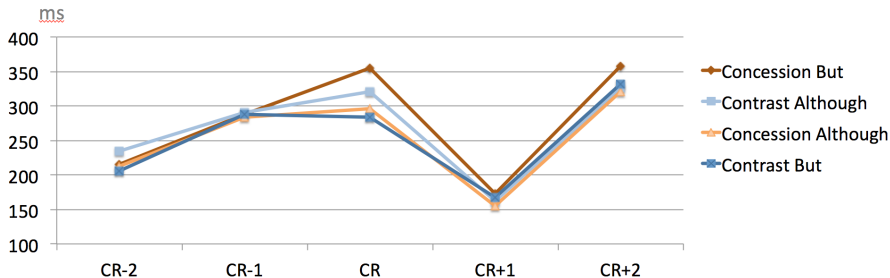
Corpus Statistics



MTurk Coherence Judgments



Go-past times on critical region of third sentence.



Conclusions

- ▶ Discourse connectors which can mark the same relations but are differently distributed lead to different interpretations.
- ▶ Syntactic arrangement (P although Q vs. Although Q, P) affect inferred meaning.
- ▶ This information can be collected from discourse-annotated natural text corpora.
- ▶ Important result for B2's goal of modelling discourse relation surprisal.
- ▶ Results can also inform other NLP tasks such as textual entailment.

Thank you for your attention!



Fatemeh Torabi Asr