Why are you telling me this?
Relevance & informativity in language processing

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(1) The Santa Fe Trail goes to Santa Fe.

(2) Today is the last day of your life.

(2) is more informative more than (1)
But which one is more relevant?
Informativity & relevance

- Where does the Santa Fe Trail go?
- How long will I live?

→ An utterance’s status depends on its ability to reduce uncertainty and address a question under discussion (QUQD)
If informativity is about addressing an open QUD, then \textit{informativity} = \textit{relevance}.

But if informative utterances yield belief updates, then \textit{informativity} \neq \textit{relevance}

- Informative utterances update prior probabilities

\begin{itemize}
  \item Today is the last day of your life.
  \item For breakfast, I ate twenty bananas.
  \item For breakfast, I ate one banana.
  \item For breakfast, I ate one yellow banana.
  \item The Santa Fe Trail goes to Santa Fe.
\end{itemize}

- Relevant utterances address probable QUDs
This talk: How do we infer relevance and how do we process (un)informative information?

- **Relevance relations**
  - Where to look? [multiple concurrent relations]
  - What to listen for? [focus intonation]
  - What cues? [adverbials, verbs, segment properties]
  - Where else to look? [relative clauses]
  - Don’t miss available relations or (machine-identifiable) cues

- **Informativity**
  - Redundant facts [“dozen cookies…12”]
  - Redundant visual cues [REG]
  - Not all redundant information is irrelevant
Recipe for whipped cream frosting:

Put cream cheese and whipping cream into a bowl.
(then)
Add sugar and vanilla.
(then)
Beat the mixture until the cream can hold a stiff peak.
(then)
Cover cakes with this frosting that won't melt at room temperature.

Otherwise you'll be left with soggy cupcakes.

Some relations can be left implicit; others can’t.

Inference occurs alongside overt connectives.

(Asher & Lascarides 2003; Hobbs 1979; Kehler 2002; Mann & Thompson 1988; Marcu 2000; Prasad et al 2014; Roberts 1996; Sanders et al. 1992)
Coherence relations in NLP

Question-answering

Query: “why treat strep throat?”

It’s possible to carry streptococci in your throat even if you’re not sick. But if you do get strep throat, doctors recommend immediate attention because otherwise you risk more serious problems, possibly rheumatic fever or worse.

length of your illness. It is extremely important to treat strep throat completely and adequately otherwise, certain complications may occur: Some of the most common complications of strep throat can include:
Query: “why treat strep throat?”

Query: “how to treat strep throat?”

What is the strep throat treatment?

Once you or your child have been diagnosed with strep throat, you will need to be treated in order to successfully fight off the infection and avoid complications. The most common treatment for strep throat is antibiotics. In particular, the three most common antibiotics used to treat strep throat are amoxicillin, penicillin, and cephalaxin. Typically, amoxicillin or penicillin will be prescribed unless there is an allergy to those medications. In that case, cephalaxin is often prescribed instead.

to numb the throat, and/or lozenges to help alleviate the sore throat. Children should only take Tylenol, unless you are directed to give them children's ibuprofen in a certain dosage.
Coherence relations in NLP

- Question-answering

- Query: “why treat strep throat?”
- Query: “how to treat strep throat?”

- Extraction of best answer may depend on linked clauses
- Links may not always be explicit
Coherence relations in NLP

- Question-answering

- Text generation, automatic summarisation: What to make explicit to sound natural?

- Coreference resolution
  Best antecedent may vary across coherence relations.

John handed a book to Bob. He thought Bob might like it. He then thanked John for the book.

(Kehler & Rohde, 2013)
Coherence relations in NLP

- Question-answering

- Text generation, automatic summarisation:
  What to make explicit to sound natural?

- Coreference resolution
  Best antecedent may vary across coherence relations.

- Given this utility,
  - large-scale annotated resources
  - discourse parsing tasks
Assumption: implicit *or* explicit relations

Cover cakes with this frosting
 OTHERWISE you’ll be left with soggy cupcakes.

‣ How widespread is inference alongside explicit connectives?
‣ How much variation across adverbials/passages?

‣ If deterministic →

‣ If not →

(cf. other types of multiplicity in Asher & Lascarides 2003; Mann & Thompson 1988)
Expt1: Conjunction insertion task

Mr. Lurie and Mr. Jarmusch actually catch a shark, a thrashing 10-footer /// _____ otherwise the action is light.

Conjunction:
- because
- or
- but
- so
- and
- none at all
- other word or phrase

Once you have made your selections, press submit to complete the trial. To share additional comments about this trial, please click here.

Materials: Passages from NYTimes, half implicit, half explicit

(Rohde, Dickinson, Schneider, Louis, & Webber, 2017, IWCS; see also Scholman et al. 2016)
accordingly  for instance  in turn  overall
actually  for one thing  indeed  previously
additionally  furthermore  instead  really
after all  hence  later  similarly
afterwards  however  likewise  specifically
alternatively  in addition  meanwhile  still
as a result  in contrast  moreover  then
consequently  in fact  nevertheless  thereafter
earlier  in general  nonetheless  therefore
ever since  in other words  of course  thus
finally  in particular  on the one hand  ultimately
first  in that case  on the other hand  what's more
first of all  in the end  otherwise  yet
for example

→ 50+ adverbials, each in 50+ passages, 28 people/passage
→ 70,000+ judgments
→ Not uniform across adverbials
→ Not uniform within adverbials
<table>
<thead>
<tr>
<th>0</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>in fact</strong></td>
<td><strong>on the other hand</strong></td>
<td><strong>nevertheless</strong></td>
<td><strong>nonetheless</strong></td>
<td><strong>none</strong></td>
</tr>
<tr>
<td><strong>then</strong></td>
<td><strong>actually</strong></td>
<td><strong>instead</strong></td>
<td><strong>however</strong></td>
<td><strong>for example</strong></td>
</tr>
<tr>
<td><strong>indeed</strong></td>
<td><strong>specifically</strong></td>
<td><strong>in general</strong></td>
<td><strong>first of all</strong></td>
<td><strong>after all</strong></td>
</tr>
<tr>
<td><strong>thus</strong></td>
<td><strong>in other words</strong></td>
<td><strong>otherwise</strong></td>
<td><strong>on the one hand</strong></td>
<td><strong>therefore</strong></td>
</tr>
<tr>
<td><strong>because</strong></td>
<td><strong>but</strong></td>
<td><strong>or</strong></td>
<td><strong>so</strong></td>
<td><strong>other</strong></td>
</tr>
</tbody>
</table>

**Natural Text:**
- however
- and
- because
- before
- but
- or
- so
- other
- none
- nevertheless
- nonetheless
- on the other hand
- actually
- instead
- however
- indeed
- specifically
- in general
- first of all
- thus
- in other words
- otherwise
- on the one hand
- therefore
- for instance
- for example
- after all
Multiple concurrent relations

- Inference is widespread alongside explicit connectives and varies across adverbials and passages
  - Pockets of systematicity
  - Not deterministic
- What if humans disagree?
Inter-annotator disagreement

You got to be nice to them // _______ otherwise they're not going to be nice to you.

Author=OR
14 Participants=OR
13 Participants=BECAUSE
1 Participant=NONE

- Not evidence of mistakes or ambiguity
- Improbable combinations, but both valid
- Multiple concurrent discourse relations

(see also de Marneffe, 2016 on other types of annotation disagreement)
Proper placement of the testing device is an important issue ______ otherwise the test results will be inaccurate.

"a reason to place the test properly is to avoid inaccuracy"

A baked potato, plonked on the side with sour cream and chives, is the perfect accompaniment ______ otherwise you could serve a green salad and some good country bread.

"there are two choices for a side: potato or salad"

"a reason to have a potato is to avoid a salad"

Mr. Lurie and Mr. Jarmusch actually catch a shark, a thrashing 10-footer ______ otherwise the action is light.

"shark catching is a special case; generally action is light"

"there are two choices for a film: sharks or light action"
Proper placement of the testing device is an important issue _____ otherwise the test results will be inaccurate.

→ Confirmed: BECAUSE & OR
→ Cue: Segment 2 contains undesirable outcome
A baked potato, plonked on the side with sour cream and chives, is the perfect accompaniment ______ otherwise you could serve a green salad and some good country bread.

- Confirmed: BUT & OR
- Cue: Segments1&2 list equal alternatives
Mr. Lurie and Mr. Jarmusch actually catch a shark, a thrashing 10-footer _____ otherwise the action is light.

→ Confirmed:  BUT only
→ Cue:  Segment2 describes a generalisation
Expt3: Different passage logic *(instead)*

<table>
<thead>
<tr>
<th></th>
<th>and</th>
<th>but</th>
<th>so</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>instead</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Contrast**

I was really hoping for a promotion // _____ instead I got fired.

Verb cue: *hoping/wanting/planning* $\rightarrow$ BUT

**Causal**

I was too pushy when I applied for a promotion // _____ instead I got fired.

Downward entailing operator: *too+[adj] $\rightarrow$ SO*
确认：段落属性预测BUT vs SO

- 使用人类研究来识别可用的解释和相关线索（参见语料库注释中关系信号的使用：Taboada & Das 2013; Zeldes 2018）
This talk: How do we infer relevance and how do we process (un)informative information?

- Relevance relations
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  - What to listen for? [focus intonation]
  - What cues? [adverbials, verbs, segment properties]
  - Where else to look? [relative clauses]

- Informativity
  - Redundant facts [“dozen cookies…12”]
  - Redundant visual cues [REG]
Recovering QUDs

- Intonation can signal the question under discussion
  (Büring, 2004; Most & Saltz, 1979; Roberts, 1996)

  \[ \text{THE PITCHER threw the ball.} \quad \text{The pitcher threw THE BALL.} \]

  - “Who threw the ball?”
  - “What did the pitcher throw?”

- Coherence relations can be understood as QUDs

  \[ \text{Mary congratulated Sue. She won the race.} \]

  Why

- But is there a “Why” intonation?
Charles congratulated Simon. He …

- Implicit causality verbs: *congratulate/scold/admire/*…
  - Create expectation for answer to “Why?”
  - For IC2 verb, causally implicated referent = 2nd NP

- Different QUDs $\rightarrow$ different interpretations of pronoun
  - What did Charles do and why? [*because Simon*…]
  - What all did Charles do? [*and also Charles*…]

$\rightarrow$ Causal relation favors causally implicated Simon

$\rightarrow$ Focus intonation may signal a parallel relation, reducing bias to Simon

(Cummins & Rohde, 2015)
Expt4: What to listen for?

N=75, vary intonation, only NP2-biased verbs

IC Intro
Charles congratulated Simon.

- focus
He had criticized Stephanie.

+focus
He had CRITICIZED STEPHANIE.

Task: Who criticized Stephanie? ________

- Replicate known implicit causality bias: 65% NP2
- Reduce that bias with +focus: 59% NP2
- Intonation guides relation, relation guides coreference
Other cues to upcoming relations

- Adverbials can establish long-distance dependencies
  (Scholman, Rohde, & Demberg, 2017)

  [On the one hand …]  On the other hand …

- Verb class guides expectations in story continuations
  (Kehler, Kertz, Rohde & Elman 2008; Rohde & Horton 2014)

  [implicit causality]  Mary *congratulated* Sue. …  → explanation

  [transfer]  Mary *handed* a book to Sue. …  → narration

- Event structure constrains upcoming relations
  (Kehler, Kertz, Rohde & Elman 2008; Rohde & Horton 2014)

  [imperfective]  Mary *was handing* a book to Sue. …  → elaboration/
                 violated expectation
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- Informativity
  - Redundant facts [“dozen cookies...12”]
  - Redundant visual cues [REG]
What can a relative clause do?

CLAIM: Only some relative clauses serve as discourse segments (Mann & Thompson 1988; Reese et al. 2007; Sanders & van Wijk 1996; Verhagen 2001)

Restrictive RCs — only aid in establishing reference

Mary congratulated the guy who lives next door.

Non-restrictive RCs — can enter into relevance relations

Mary congratulated Bob, who won the lottery. [reason]

What about restrictive RCs with simultaneous relevance?

Mary congratulated the guy who won the lottery. [reason]
### Expt5: Where else to look?

#### Self-paced reading, N=52, vary matrix verb

<table>
<thead>
<tr>
<th>Section</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro</td>
<td>Jenny walked through the hallway to check on the daily goings-on around the office.</td>
</tr>
<tr>
<td>causal RC</td>
<td>She <em>congratulated</em> the guy who made lots of money for the company.</td>
</tr>
<tr>
<td>neutral RC</td>
<td>She <em>joked</em> with the guy who made lots of money for the company.</td>
</tr>
<tr>
<td>concessive RC</td>
<td>She <em>fired</em> the guy who made lots of money for the company.</td>
</tr>
</tbody>
</table>

#### Diagram

- **Restrictive RCs:**
  - **allow inference**
  - **only restrict reference**

- **Relevance:**
  - **RC: plausible inference**
  - **RC: implausible inference**

- **Informativity:**
  - **RC**

(with Jet Hoek; see also Rohde, Levy, & Kehler 2011; Kehler & Rohde 2018)
Expt5: Where to look?

- Infer relevance of RC to matrix clause during real-time processing

→ Where else?

Mary scolded the lazy student.

Mary congratulated the winner.
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→ Don’t miss available relations or (machine-identifiable) cues

- Informativity
  - Redundant facts [“dozen cookies…12”]
  - Redundant visual cues [REG]
Why are you bothering telling me this?
This room is full of …

- chairs
- people
- computational linguists
- air

- “air” is very likely to be true, but it’s uninformative
- nonetheless, probable stuff often appears easy to process
Predictability in psycholinguistic studies

The Dutch trains are …

- Improbable words yield more surprisal than probable ones (Hagoort et al. 2004)
  - sour > white > yellow

- Uninformative material is fine in the lab (cf. Kravtchenko & Demberg 2015)
Uninformativity outside the lab?

This is not how we use language!
(Stalnaker 1973; Grice 1975)
Expt6: Redundancy in reading

Self-paced reading of text messages, N=214, IbexFarm, vary informativity

[informative] promised a dozen cookies ...
... baked 5

[duh] promised a dozen cookies ...
... baked 12

“yellow Dutch train”
 p(situation) is high
 p(utterance | situation) is low

“white Dutch train”
 unlikely, but interesting!
Expt6: Redundancy in reading

your old housemates are throwing a party... you going?

we don’t talk much anymore

well, the party is Friday night and everyone’s invited

I’m just gonna stop by, they promised me a drink

oh the promises they make
once they promised to bake me a dozen cookies and then they baked something like 12, this was last year
### Expt6: Redundancy in reading

<table>
<thead>
<tr>
<th>scenario</th>
<th>inf</th>
<th>duh</th>
</tr>
</thead>
<tbody>
<tr>
<td>bake a dozen cookies</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>invite 5 people</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>toddler’s age</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>25-year-old’s age</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>cost of one sock</td>
<td>$150</td>
<td>$2</td>
</tr>
<tr>
<td>cost of a leather jacket</td>
<td>$2</td>
<td>$150</td>
</tr>
<tr>
<td>cost of a headband</td>
<td>$200</td>
<td>$10</td>
</tr>
<tr>
<td>cost of a Versace scarf</td>
<td>$10</td>
<td>$200</td>
</tr>
</tbody>
</table>
Expt6: Redundancy in reading

→ People expected to be surprised, unlike in prior lab studies
→ Uninformative messages are hard, even if content is predictable
Relevance relations

- Where to look? [multiple concurrent relations]
- What to listen for? [focus intonation]
- What cues? [adverbials, segment properties, verbs]
- Where else to look? [relative clauses]

Informativity

- Redundant facts [“dozen cookies…12”]
- Redundant visual cues [REG]
Find the guy in glasses wearing the red and white striped hat and shirt who is behind the bench and above the cows that are on the train.

(Clarke, Elsner, & Rohde, 2013)
Expt7: Redundancy in REG

Describe a target person, N=155, 28 Waldo images

How many landmarks are mentioned, given visual properties of target and scene?

There is a man wearing a green jacket and red pants.

Find Waldo! Northwest of him is a woman with blonde hair in a pink top and red skirt in front of the man with papers coming out of his briefcase.

Find Waldo! Northwest of him is a man in a gray jacket and brown pants. He is to the right of a woman with a yellow shirt/blue top, and to the right of the girl with the red top.
Expt7: Redundancy in REG

- 85% of responses mentioned at least one landmark
- Targets with smaller area → more landmarks
- Targets with lower visual salience → more landmarks
- Scenes with more visual clutter → larger landmarks

→ Redundant landmarks are made relevant by visual scene and the task of visual search
Overspecification: The yellow pair?

- In production, speakers overspecify color more with clothing than with food.
- Color may be more relevant to clothing (variable color) than food (constrained color).
- In comprehension, is the inclusion of a color adjective informative regarding object *category*?
Expt 8: Redundancy in comprehension

Choose one of two pictures, N=19

- **Color**
  - Click on the yellow...

- **Control**
  - Click on the two...

Balance left/right side of screen

- **Bigram frequency?**
  - “yellow shirts” vs “yellow bananas”
    - “yellow shirts” is more frequent, but so is “two shirts”
    - clothing is more frequent
  
  **Prediction:** clothing bias overall

- **Point-wise mutual information?**
  - yellow~bananas vs yellow~shirts
    - PMI(red, cherries) > PMI(red, scarves)
    - PMI(purple, figs) > PMI(purple, heels)
  
  ...  
  - color~food > color~clothing
  
  **Prediction:** color biases to food

- **Color as relevant to clothes**
  
  **Prediction:** color biases to clothing

(with Paula Rubio-Fernández)
Expt8: Redundancy in comprehension

Color is made relevant by properties of the object category

Comprehenders are informed by “uninformative” color

(with Paula Rubio-Fernández)
Why are you (bothering) telling me this?

- **Relevance relations**
  - Cues to recovering relations
  - Repercussions for other phenomena
  - Don’t miss available relations or (machine-identifiable) cues

- **Informativity**
  - Overly predictable messages
  - Useful redundancy in referring expression generation
  - Not all redundant information is irrelevant

- **Processing:** sweet spot for utterances that convey information that’s
  - Plausible enough to be probable
  - Rare enough to be interesting
  - Relevant in context
Thanks to:

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And thank you!