Constraint-based projection

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Based on joint work with Judith Degen, Stanford University
Goal

motivate a constraint-based projection analysis

Outline

1. Projection
2. The constraint-based approach to projection
3. Exp 1: Lexical meaning matters, but not as expected
4. Exp 2: Listener belief influence projection
5. Conclusions and outlook
Taylor: “Did Kim discover that Sandy’s work is plagiarized?”

Do you (the listener) infer that Taylor is committed to the content of the complement (CC), that Sandy’s work is plagiarized?

- “no”
  - CC does not project
  - increase in strength of inference / projection

- “yes”
  - CC projects

Projection

Projective content is ubiquitous in natural language: appositives, deictic and definite expressions, tense, verbs, adverbs…
(e.g., Levinson 1983, Potts 2005, Tonhauser et al 2013, Tonhauser in print)

Empirical domain in today’s talk:
The content of the complement (CC) of clause-embedding predicates

Taylor: “Did Kim discover that Sandy’s work is plagiarized?”

know, be annoyed, announce, believe, pretend,…

English: about 1,000 (White & Rawlins 2016)
Many information sources influence projection

1. Common ground  
   (e.g., Stalnaker 1972, Karttunen 1974; Gazdar 1979; Heim 1982, 1983)

   Taylor: “Did Kim discover that Sandy’s work is plagiarized?”

   Context 1:  
   Taylor is a professor. Her TA Kim called a student, Sandy, in for a meeting. Taylor asks another TA:

   Context 2:  
   Taylor, Cam and Sandy are collaborating students. Sandy was called in for a meeting by Kim, their TA. Taylor asks Cam:

   Inference to CC is stronger, i.e., CC is more projective, in Context 2 than Context 1.
Many information sources influence projection

2. Predicate (e.g., Kiparsky & Kiparsky 1970; Xue & Onea 2011, Tonhauser, Beaver & Degen 2018)

Taylor: “Does Kim ______ that Sandy’s work is plagiarized?”

Inference to CC is stronger, i.e., CC is more projective, with discover than with think.
Many information sources influence projection

3. Information structure

(e.g., Beaver 2010, Tonhauser 2016, Djärv & Bacovcin 2017)

Taylor: “Did Kim discover that Sandy’s work is plagiarized?”

Prosody 1
(focus: *Kim*)

Prosody 2
(focus: *Sandy*)

Inference to CC is stronger, i.e., CC is more projective, with Prosody 1 than Prosody 2.
Many information sources influence projection

4. Question Under Discussion / At-issueness

Taylor: “Did Kim discover / Does Kim know that Sandy’s work is plagiarized?”

The more the CC is not-at-issue, the more projective it is.

Tonhauser, Beaver & Degen 2018 (Journal of Semantics)
Many information sources influence projection

5. Information about the subject of the attitude or the speaker (e.g., reliability, credibility, political affiliation)

Schlenker 2010; de Marneffe et al 2012; Mahler 2020

Mahler 2020 manipulated the political affiliation of the speaker

Cindy: “Ben doesn’t know that Obama improved the American economy.”

Listeners’ inferences that Cindy is committed to the CC are stronger when Cindy is a Democrat than a Republican.
Interim summary: Listeners rely on multiple sources of information in inferring speaker commitment to the CC, i.e., in inferring projection of the CC.
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Constraint-based approaches to pragmatics
(e.g., Degen & Tanenhaus 2015, 2019)

To identify speaker meaning, listeners integrate probabilistic information from multiple sources.

**top-down information**
- linguistic context
- expectations about speaker

**bottom-up information**
- lexical meaning
- syntax
- prosody

**speaker meaning**
Constraint-based approach to projection

To draw inferences about speaker commitment, listeners integrate probabilistic information from multiple sources.

**Big question:** What are the relevant information sources in the empirical domain and how are they integrated?

![Diagram of information sources](image-url)

- top-down information
  - common ground
  - info about speaker
  - QUD
  - information structure

- bottom-up information
  - predicate
  - prosody

inferences about speaker commitment
Contemporary projection analyses

- **Lexicalist** (e.g., Heim 1983, van der Sandt 1992)
- **Entailment-based** (e.g., Abrusán 2011, 2016; Simons, Beaver, Roberts & Tonhauser 2017)
- **Alternatives-based** (e.g., Chemla 2009; Abusch 2002, 2010; Romoli 2015)
- **Context-dependent triggering** (Schlenker ms/2019)

**Common theme:** Analyses only apply to “presupposed” CCs, i.e., predicates or utterances for which the inference that the speaker is committed to the CC is “sufficiently strong”.

<table>
<thead>
<tr>
<th>Factive</th>
<th>Non-factive</th>
</tr>
</thead>
<tbody>
<tr>
<td>know</td>
<td>inform</td>
</tr>
<tr>
<td>discover</td>
<td>announce</td>
</tr>
<tr>
<td>think</td>
<td>be right</td>
</tr>
</tbody>
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Lexicalist, entailment- and alternatives-based context-dependent triggering
Recasting contemporary projection analyses in the constraint-based framework

Is this empirically adequate?

- Common ground
- Info about speaker
- QUD
- Information structure
- Predicate
- Prosody

Inferences about speaker commitment

Top-down information

Bottom-up information
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Experiment 1: Lexical meaning

(Tonhauser & Degen under review; see LingBuzz)

How does lexical meaning contribute to projection?
Is it empirically adequate for projection analyses to disregard the CCs of particular classes of predicates (e.g., non-factive)?
Experiment 1: Materials

20 clause-embedding predicates

- **Factive:** *know, be annoyed, discover, reveal, see* (5)
- **Non-factive:**
  - **Non-veridical non-factive:** *pretend, think, say, suggest* (4)
  - **Veridical non-factive:** *be right, demonstrate* (2)
  - **Optionally factive:** *prove, confirm, establish, announce, confess, admit, acknowledge, hear, inform* (9)

(Kiparsky & Kiparsky 1970)

Lexicalist, entailment- and alternatives-based analyses predict that the CC of factive predicates is projective but they make no predictions about the CC of most non-factive predicates.

Each predicate was combined with one of 20 complement clauses, for 400 predicate/clause combinations.
Each participant rated the projectivity of the CC for each of the 20 clause-embedding predicates and 6 non-projecting controls.
Sandy: “Is Zack coming to the meeting tomorrow?”

Is Sandy certain that Zack is coming to the meeting tomorrow?
Factive predicates are not categorically different from non-factive predicates.

266 self-declared native speakers of American English
The CC of all predicates is at least mildly projective; there is no non-arbitrary cutoff for “presupposed CCs”

266 self-declared native speakers of American English

(Bayesian ME Beta regression predicting certainty ratings from predicate (treatment coding, MC as reference level); random by-participant and -item intercepts)
Discussion

Predicate meaning influences projection — as long recognized!

It is not empirically adequate to

• privilege particular classes of predicates, like ‘factives’, or CCs, like ‘entailed CCs’ or

• assume a projection threshold to identify “presuppositions”.

Four pieces of converging evidence: (Tonhauser & Degen under review)

1. Experiment with categorical response options (‘yes’, ‘no’)

2. CommitmentBank (de Marneffe et al 2018, SuB)

3. VerbVeridicality (Ross & Pavlick 2019, EMNLP)

4. MegaVeridicality (White & Rawlins 2018, NELS)

datasets that differ in materials and projection diagnostic
Converging evidence: MegaVeridicality dataset

517 predicates

Mean projectivity rating

Somebody didn’t [PRED] that a particular thing happened.

Did that thing happen?

No empirical evidence that some classes of predicates are extremely privileged:

Predicate type
- a non-veridical non-factive
- a non-veridical factive
- a optionally factive
- a factive

Predicate
- think
- suggest
- pretend
- demonstrate
- establish
- prove
- say
- confirm
- discover
- confess
- acknowledge
- admit
- announce
- reveal
- hear
- know
- inform
- be_annoayed
Interim summary

How does lexical meaning contribute to projection?

The lexical meaning of clause-embedding predicates influences the projection of the CC; lexical meaning is a relatively stable predictor across multiple experiments and datasets.

Is it empirically adequate for projection analyses to disregard the CCs of particular classes of predicates (e.g., non-factive)?

No. The CCs of other predicates are projective, too, sometimes even more so!

Thus: An empirically adequate projection must consider the influence on projection by the lexical meaning of all predicates.
Constraint-based approach to projection

To draw inferences about speaker commitment, listeners integrate probabilistic information from multiple sources.

**Big question:** What are the relevant information sources in the empirical domain and how are they integrated?

To draw inferences about speaker commitment, listeners integrate probabilistic information from multiple sources. The relevant information sources include:

- **top-down information**
  - common ground
  - info about speaker
  - QUD
  - information structure

- **bottom-up information**
  - predicate
  - prosody

These sources are integrated to form inferences about speaker commitment.
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Experiment 2: Listener belief

(Degen & Tonhauser in prep)

How does listener belief influence projection?
Listener beliefs influence interpretation

Listeners bring their beliefs about the world, including their beliefs about the speaker’s epistemic state, \( \approx \) world knowledge) to bear on utterance interpretation:

- Pronoun resolution
- Ambiguity resolution
- Scalar implicatures
- Genericity
- Projection

e.g., Winograd 1972; Altmann & Kamide 1999; Chambers et al 2002, 2004; Hagoort et al 2004; Bicknell & Rohde 2009; Degen et al 2015; Kravtchenko & Demberg 2015; Tessler & Goodman 2019; Mahler 2020
Some lexical content is more projective than other

Sally: “Does Kim know that…?”

Tonhauser, Beaver & Degen 2018 (Journal of Semantics) Exp 1a
Hypothesis from Tonhauser, Beaver & Degen 2018: 500

Content is more projective the higher its prior probability, i.e., the stronger listeners’ prior belief in the content.
Experiment 2: Materials

20 clause-embedding predicates (same as Exp 1)

- **Factive**: know, be annoyed, discover, reveal, see (5)
- **Non-factive**:
  - **Non-veridical non-factive**: pretend, think, say, suggest (4)
  - **Veridical non-factive**: be right, demonstrate (2)
  - **Optionally factive**: prove, confirm, establish, announce, confess, admit, acknowledge, hear, inform (9)

(Kiparsky & Kiparsky 1970)

Each predicate was combined with one of 20 complement clauses, for 400 predicate/clause combinations, as in Exp 1.

Additional manipulation: Prior probability of the CC
Experiment 2: Materials and procedure

400 polar questions

    Sally: “Did Kim discover that Julian dances salsa?”

Manipulation of prior probability of the CC
1. **Higher prior probability fact**: Julian is Cuban
2. **Lower prior probability fact**: Julian is German

800 combinations of a polar question and a fact

286 participants (AMT)
Block 1: Prior probability of the CC, given the fact
Block 2: Projection of the CC, given the fact and the predicate
(block order randomized)
Block 1: Prior probability of the CC, given the fact

Fact: Julian is German.

How likely is it that Julian dances salsa?

impossible

definitely

Every participant rated the prior probability of 20 CCs: 10 with higher and 10 with lower probability facts
Prior probability of the 20 CCs is influenced by their facts

- Julian is Cuban
- Julian is German
- Julian dances salsa
- Mary is pregnant
- Mary is taking a prenatal yoga class
- Mary is a middle school student

286 self-reported speakers of American English
Each participant rated the projectivity of 20 CCs given a fact and a unique predicate and 6 main clause controls.
Higher-probability CCs are more projective than lower-probability CCs

LMEM predicting certainty rating from prior probability rating; random effects for participant, predicate, CC; by-participant slope for prior probability ($\beta = .27$, SE = .02, t = 12.8, p < .0001)
Listener prior belief predicts projection

discover

286 participants’ projection and prior ratings

\[ r = .27 \]
Experiment 2: Summary of findings

1. The CC of all 20 predicates, including non-factive ones, is at least mildly projective (as in Exp 1).

2. The higher a listeners’ prior belief, the stronger their inference that the speaker is committed to the CC, i.e., the more projective is the CC (see Tonhauser, Beaver & Degen’s 2018 hypothesis).
Constraint-based approach to projection

To draw inferences about speaker commitment, listeners integrate probabilistic information from multiple sources.

**Big question:** What are the relevant information sources in the empirical domain and how are they integrated?

Inferences about speaker commitment

- **Top-down information**
  - Listener prior belief
  - QUD
  - Information structure

- **Bottom-up information**
  - Common ground
  - Info about speaker
  - Predicate
  - Prosody
Discussion

Do contemporary projection analyses lead us to expect this influence of listeners’ prior beliefs on projection?

- **Lexicalist** (e.g., Heim 1983, van der Sandt 1992)
- **Entailment-based** (e.g., Abrusán 2011, 2016; Simons, Beaver, Roberts & Tonhauser 2017)
- **Alternatives-based** (e.g., Chemla 2009; Abusch 2002, 2010; Romoli 2015)
- **Context-dependent triggering** (Schlenker ms/2019)
Simplified characterization:
The CC is presupposed (i.e., a commitment of the speaker) if

1. the CC is contextually entailed

   Context: Julian is German.
   Sentence: Kim discovered that Julian dances salsa.
   Does it definitely follow that Julian dances salsa?

2.
Context-dependent triggering (Schlenker ms/2019)

Fact: Julian is German.
Taylor: “Did Kim discover that Julian dances salsa?”

Simplified characterization:
The CC is presupposed (i.e., a commitment of the speaker) if
1. the CC is contextually entailed
2. the probability that a generic agent believes the CC given that they believe the content of the utterance in that context is at least as high as threshold $a$.

![Graph showing the relationship between prior probability rating and certainty rating]

286 participants’ ratings
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- **Alternatives-based** (e.g., Chemla 2009; Abusch 2002, 2010; Romoli 2015)

- **Context-dependent triggering** (Schlenker ms/2019)

  - Yes, insofar as listeners’ prior beliefs influence their posterior beliefs.

  - But how strong does the inference about speaker commitment need to be to count as a presupposition?
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- **Top-down information**
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  - Information structure

- **Bottom-up information**
  - Common ground
  - Info about speaker
  - QUD
  - Exp 1
  - Predicate

- **Inferences about speaker commitment**
  - Exp 2
  - Principal incorporation of information sources
  - Research on languages other than English
  - Prosody

(Djärv & Bacovcin 2017, Mahler et al 2019)
SUPPLEMENTARY SLIDES
Many information sources influence projection

4. Question Under Discussion / At-issueness (e.g., Simons et al 2010, 2017; Cummins & Rohde 2015)

discover

210 participants’ projection and at-issueness ratings

\[ r = .43 \]

Tonhauser, Beaver & Degen 2018 (Journal of Semantics)
Comparing projectivity ratings

Spearman’s rank correlation
n = 20
rs = .983
Converging evidence: CommitmentBank

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Mean certainty rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>occur</td>
<td>1</td>
</tr>
<tr>
<td>suppose</td>
<td>2</td>
</tr>
<tr>
<td>pretend</td>
<td>3</td>
</tr>
<tr>
<td>think</td>
<td>4</td>
</tr>
<tr>
<td>believe</td>
<td>5</td>
</tr>
<tr>
<td>demand</td>
<td>6</td>
</tr>
<tr>
<td>insist</td>
<td>7</td>
</tr>
<tr>
<td>mean</td>
<td>8</td>
</tr>
<tr>
<td>imagine</td>
<td>9</td>
</tr>
<tr>
<td>assure</td>
<td>10</td>
</tr>
<tr>
<td>figure</td>
<td>11</td>
</tr>
<tr>
<td>see</td>
<td>12</td>
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<tr>
<td>suggest</td>
<td>13</td>
</tr>
<tr>
<td>hypothesize</td>
<td>14</td>
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<tr>
<td>say</td>
<td>15</td>
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<tr>
<td>prove</td>
<td>16</td>
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<td>signal</td>
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<td>take</td>
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<td>find</td>
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<tr>
<td>admit</td>
<td>23</td>
</tr>
<tr>
<td>know</td>
<td>24</td>
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<td>foresee</td>
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<td>suspect</td>
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<td>bet</td>
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<td>announce</td>
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<td>realize</td>
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<td>accept</td>
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<td>understand</td>
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<td>notice</td>
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<tr>
<td>learn</td>
<td>37</td>
</tr>
<tr>
<td>forget</td>
<td>38</td>
</tr>
</tbody>
</table>

Predicate type:
- non-veridical
- optionally factive
- factive
Converging evidence: VerbVeridicality