Distribution, Inference, and Event Structure

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Slides available at aaronstevenwhite.io
Data available at

\{
  \text{megaattitude.io}
  \text{decomp.io}
\}
Collaborators

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Department of Cognitive Science

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Department of Computer Science
Introduction
How are a verb’s **semantic properties** related to its **syntactic distribution**? Gruber 1965; Fillmore 1970; Zwicky 1971; Jackendoff 1972; Grimshaw 1979, 1990; Pesetsky 1982, 1991; Pinker 1989; Levin 1993
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**Semantic Properties**

\[ + \text{TELIC} \]
\[ - \text{DURATIVE} \]
\[ - \text{STATIVE} \]
\[ \ldots \]
Overarching question

How are a verb’s *semantic properties* related to its *syntactic distribution*? Gruber 1965; Fillmore 1970; Zwicky 1971; Jackendoff 1972; Grimshaw 1979, 1990; Pesetsky 1982, 1991; Pinker 1989; Levin 1993

![Diagram showing the relationship between semantic properties and syntactic distribution](image)

Semantic Properties

- TELIC
- DURATIVE
- STATIVE
- ...

Syntactic Distribution

\[
\begin{align*}
&[\_\_\_\_\_\_NP] \\
&[\_\_\_\_\_\_S] \\
&[\_\_\_\_\_\_VP] \\
&\ldots
\end{align*}
\]
What could matter?

Factors claimed to affect the distribution of **nominals**
Sensitive to event structural properties like **stativity**, **telicity**, **durativity**, **causativity**, **transfer**, etc. (see Levin and Rappaport Hovav 2005)
Factors claimed to affect the distribution of nominals
Sensitive to event structural properties like stativity, telicity, durativity, causativity, transfer, etc. (see Levin and Rappaport Hovav 2005)

Factors claimed to affect the distribution of clauses
Hypothesis
The distribution of clauses is determined by the same semantic properties as the distribution of nouns (cf. Koenig and Davis 2001)
Hypothesis

The **distribution of clauses** is determined by the **same semantic properties** as the **distribution of nouns** (cf. Koenig and Davis 2001)

**Not properties dependent on having propositional content**

(White and Rawlins, 2017, 2018)
Overarching Hypothesis

Hypothesis
The distribution of clauses is determined by the same semantic properties as the distribution of nouns (cf. Koenig and Davis 2001)

Not properties dependent on having propositional content
(White and Rawlins, 2017, 2018)

Intuition
Predicates that take clauses characterize neo-Davidsonian eventualities, like any other verb. (Kratzer 2006; Hacquard 2006; Moulton 2009; Anand and Hacquard 2013, 2014; Rawlins 2013; Bogal-Allbritten 2016; White and Rawlins 2016b a.o.)
Question
How direct is the relationship between content-dependent properties and syntactic distribution?
Case study

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How direct is the relationship between content-dependent properties and syntactic distribution?

Focus
Two content-dependent properties – factivity and veridicality – that are argued to determine selection of interrogatives & declaratives.
Case study

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How direct is the relationship between content-dependent properties and syntactic distribution?

Focus
Two content-dependent properties – factivity and veridicality – that are argued to determine selection of interrogatives & declaratives

Claim
There is no direct relationship between factivity and veridicality (qua semantic properties) and syntactic distribution
Question
How direct is the relationship between content-dependent properties and syntactic distribution?

Focus
Two content-dependent properties – factivity and veridicality – that are argued to determine selection of interrogatives & declaratives

Claim
There is no direct relationship between factivity and veridicality (qua semantic properties) and syntactic distribution
The relationship is mediated by event structural properties.
Outline

Introduction
Outline

Introduction
Veridicality and distribution
Outline

Introduction
Veridicality and distribution
Predicting responsivity from veridicality
  Measuring syntactic distribution
  Measuring veridicality inferences
  Predicting responsivity

Predicting distribution from veridicality
Expanded measure of veridicality
Predicting distribution
Case study: decision predicates
Interpretation of embedded questions
Data and proposal
Implementation
Conclusion
Outline

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Veridicality and distribution
Veridicality

A verb $v$ is **veridical** iff $NP \overline{V} S$ entails $S$ Karttunen 1971a; Egré 2008; Karttunen 2012; Spector and Egré 2015 a.o.

Factivity

A verb $v$ is **factive** iff $NP \overline{V} S$ presupposes $S$ Kiparsky and Kiparsky 1970; Karttunen 1971b et seq
Veridicality

A verb v is **veridical** iff NP v S entails S Karttunen 1971a; Egré 2008; Karttunen 2012; Spector and Egré 2015 a.o.

(1) a. Jo **knew** that Bo was alive → Bo was alive
Veridicality

A verb $v$ is **veridical** iff $\text{NP } v \text{ S entails S}$ \cite{Karttunen1971a, Egre2008, Karttunen2012, Spector2015}.

Spector and Egré 2015 a.o.

(1) a. Jo **knew** that Bo was alive $\rightarrow$ Bo was alive
    b. Jo **proved** that Bo was alive $\rightarrow$ Bo was alive

Factivity
Veridicality
A verb $v$ is **veridical** iff $NP\ v\ S$ entails $S$ Karttunen 1971a; Egré 2008; Karttunen 2012; Spector and Egré 2015 a.o.

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Factivity

A verb $v$ is **factive** iff $NP \; v \; S \; presupposes \; S$ Kiparsky and Kiparsky 1970; Karttunen 1971b et seq

(2) a. Jo didn’t **know** that Bo was alive → Bo was alive
Veridicality

A verb $v$ is **veridical** iff $\text{NP } v \text{ S entails S}$

Karttunen 1971a; Egré 2008; Karttunen 2012; Spector and Egré 2015 a.o.

(1) a. Jo **knew** that Bo was alive $\rightarrow$ Bo was alive
    b. Jo **proved** that Bo was alive $\rightarrow$ Bo was alive

Factivity

A verb $v$ is **factive** iff $\text{NP } v \text{ S presupposes S}$

Kiparsky and Kiparsky 1970; Karttunen 1971b et seq

(2) a. Jo didn’t **know** that Bo was alive $\rightarrow$ Bo was alive
    b. Jo didn’t **prove** that Bo was alive $\not\rightarrow$ Bo was alive
Responsivity (Lahiri, 2002)

A verb is **responsive** iff it takes interrogatives and declaratives see also Karttunen 1977b,a; Groenendijk and Stokhof 1984 *et seq*

(3) a. Jo **knew** that Bo was alive.
    b. Jo **knew** *whether* Bo was alive.

Generalization

A verb is **responsive** iff \{**factive** (Hintikka, 1975) / **veridical** (Egré, 2008)\}

see also George 2011; Uegaki 2012, 2015; cf. Beck and Rullmann 1999; Spector and Egré 2015

(4) a. Jo **knew** \{that, *whether\} Bo was alive.
    b. Jo **thought** \{that, *whether\} Bo was alive.
Predicted correlation

Responsivity vs. Factivity/Veridicality
Testing correlation

Measurement of syntactic distribution
MegaAcceptability dataset (White and Rawlins, 2016a)
Testing correlation

Measurement of syntactic distribution
MegaAcceptability dataset (White and Rawlins, 2016a)

Measurement of veridicality
MegaVeridicality dataset (White and Rawlins, 2018)
Predicting responsivity from veridicality
Ordinal (1-7 scale) acceptability ratings
Ordinal (1-7 scale) acceptability ratings for
1000 clause-embedding verbs
Ordinal (1-7 scale) acceptability ratings for 1000 clause-embedding verbs × 50 syntactic frames
Challenge
Automate construction of a very large set of frames in a way that is sufficiently general to many verbs.
Frame construction

Syntactic type

NP

PP

S
Frame construction

Syntactic type

NP

PP

S

Frame construction

Syntactic type

NP

PP

S

Do

No DO

COMP

TENSE

that [+Q]

for ∅

whether ∅

which NP [+FIN] [-FIN]

would ∅

to -ing

-ed
Frame construction

Syntactic type

NP

DO No DO

PP

S

DO No DO
Frame construction

Syntactic type

NP
  ↓
  DO No DO

PP
  ↓
  COMP

S
  ↓
  TENSE
Frame construction

Syntactic type

NP
  DO
  No DO

PP
  COMP
    that
    [+Q]
    for
    ∅

S
  TENSE
Frame construction

Syntactic type

NP
- DO
- No DO

PP

S

COMP

TENSE

[+Q] [∅]

that for whether which NP

[+FIN] [-FIN]

would to -ing
Frame construction

Syntactic type

NP

DO No DO

PP

COMP

that [+Q] for ∅

whether which NP

TENSE

+[FIN] [-FIN]
Frame construction

Syntactic type

NP
- DO
- No DO

PP

S
- COMP
- TENSE

COMP
- that [+Q]
- for
- which NP
- whether

TENSE
- [FIN]
- [-FIN]
- -ed
- would

No DO
- for
- ∅
- [-FIN]
Frame construction

**Syntactic type**

- **NP**
  - DO
  - No DO

- **PP**
  - COMP
    - that [+Q]
    - for
    - [Q]

- **S**
  - TENSE
    - [+FIN]
    - [-FIN]

- **TENSE**
  - [Q]
  - [-Q]
  - [-TENSE]

- **TENSE**
  - [+FIN]
  - [-FIN]

- **TENSE**
  - to
  - [-to]
Challenge
Automate construction of a very large set of frames in a way that is sufficiently general to many verbs

Solution
Construct semantically bleached frames using indefinites

Examples of responsives
a. know + NP V {that, whether} S
   Someone knew {that, whether} something happened.
b. tell + NP V NP {that, whether} S
   Someone told someone {that, whether} something happened.
Challenge
Automate construction of a very large set of frames in a way that is sufficiently general to many verbs

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Construct semantically bleached frames using indefinites

(5) Examples of responsives
   a. *know* + NP V {that, whether} S
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Challenge
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Solution
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(5) Examples of responsives
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Construct semantically bleached frames using indefinites

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Data collection

- 1,000 verbs $\times$ 50 syntactic frames = 50,000 sentences
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- 1,000 lists of 50 items each
Data collection

- 1,000 verbs $\times$ 50 syntactic frames = 50,000 sentences
- 1,000 lists of 50 items each
  - Each verb only once per list
- 727 unique Mechanical Turk participants
- Annotators allowed to do multiple lists, but never the same list twice
- 5 judgments per item
- No annotator sees the same sentence more than once
Data collection

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  - No annotator sees the same sentence more than once
1. Someone needed whether something happened.
   1 2 3 4 5 6 7

2. Someone hated which thing to do.
   1 2 3 4 5 6 7

3. Someone was worried about something.
   1 2 3 4 5 6 7

4. Someone allowed someone do something.
   1 2 3 4 5 6 7

Turktools (Erlewine and Kotek, 2015)
Interannotator agreement
Spearman rank correlation calculated by list on a pilot 30 verbs
Validating the data

Interannotator agreement
Spearman rank correlation calculated by list on a pilot 30 verbs

Pilot verb selection
Same verbs used by White (2015); White et al. (2015), selected based on Hacquard and Wellwood’s (2012) attitude verb classification
Validating the data

Interannotator agreement
Spearman rank correlation calculated by list on a pilot 30 verbs

Pilot verb selection
Same verbs used by White (2015); White et al. (2015), selected based on Hacquard and Wellwood’s (2012) attitude verb classification

1. Linguist-to-linguist
   median: 0.70, 95% CI: [0.62, 0.78]

2. Linguist-to-annotator
   median: 0.55, 95% CI: [0.52, 0.58]

3. Annotator-to-annotator
   median: 0.56, 95% CI: [0.53, 0.59]
Results
What about frequency?

Question
Did you really need to go to all this trouble to collect acceptability judgments? Couldn’t you just get it from frequency distributions?
What about frequency?

Question
Did you really need to go to all this trouble to collect acceptability judgments? Couldn’t you just get it from frequency distributions?

Answer 1
Necessarily yes. Because learners do it.
What about frequency?

Question
Did you really need to go to all this trouble to collect acceptability judgments? Couldn’t you just get it from frequency distributions?

Answer 1
Necessarily yes. Because learners do it.

Answer 2
Practically no. At least not without a model that’s effectively equivalent to whatever the learner uses.
42.8 million verb-subcategorization frame pairs extracted from Parsed ukWaC (PukWaC) (Baroni et al., 2009)
Corpus data

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2 billion word web corpus constructed from crawl of the .uk domain, dependency parsed with MaltParser (Nivre et al., 2007)
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Subcategorization frame extraction

Features extracted see White 2015 for details

1. Form of the matrix subject (i.e. potentially expletive?)
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1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
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1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
Features extracted see White 2015 for details

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2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
4. Whether there are other PP complements
Features extracted see White 2015 for details

1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
4. Whether there are other PP complements
5. Whether there is a clausal complement, and if so...
Subcategorization frame extraction

Features extracted see White 2015 for details

1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
4. Whether there are other PP complements
5. Whether there is a clausal complement, and if so...
   5.1 ...what the complementizer is (if any)
Subcategorization frame extraction

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1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
4. Whether there are other PP complements
5. Whether there is a clausal complement, and if so...
   5.1 ...what the complementizer is (if any)
   5.2 ...what the WH word is (if any)
Features extracted see White 2015 for details

1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
4. Whether there are other PP complements
5. Whether there is a clausal complement, and if so...
   5.1 ...what the complementizer is (if any)
   5.2 ...what the WH word is (if any)
   5.3 ...what the subject is (if any)
1. Form of the matrix subject (i.e. potentially expletive?)
2. Tense/aspect for matrix verb (and all matrix auxiliaries)
3. Whether there is direct or indirect NP objects
4. Whether there are other PP complements
5. Whether there is a clausal complement, and if so...
   5.1 ...what the complementizer is (if any)
   5.2 ...what the WH word is (if any)
   5.3 ...what the subject is (if any)
   5.4 ...tense/aspect for the embedded verb (and all auxiliaries)

Features extracted see White 2015 for details
Acceptability v. PukWaC corpus counts

Predicted acceptability (based on corpus distribution)

Acceptability
Acceptability v. PukWaC corpus counts

Predicted acceptability (based on corpus distribution) vs. Acceptability
Acceptability v. PukWaC corpus counts

\[ r^2 = 0.18 \]
Acceptability v. corpus counts

**Question**
Is this due to noisy parsing and extraction?
Question
Is this due to noisy parsing and extraction?

Question
Probably not; purportedly very clean (but smaller) frequency datasets like VALEX (Korhonen et al., 2006) actually have slightly worse cross-validated $r^2$
Acceptability v. VALEX corpus counts

Predicted acceptability (based on corpus distribution) vs. Acceptability
Acceptability v. VALEX corpus counts

Predicted acceptability (based on corpus distribution) vs. Acceptability
Acceptability v. VALEX corpus counts

Predicted acceptability (based on corpus distribution)

Acceptability

$r^2 = 0.14$
Note #1
Does not imply that frequency and acceptability unrelated
Predicting acceptability

Note #1
Does not imply that frequency and acceptability unrelated

Note #2
Acceptability is derived in part from frequency data
Note #1
Does not imply that frequency and acceptability unrelated

Note #2
Acceptability is derived in part from frequency data

Point
Frequency and acceptability are likely not related at the level of syntactic structure
Predicting acceptability

Note #1
Does not imply that frequency and acceptability unrelated

Note #2
Acceptability is derived in part from frequency data

Point
Frequency and acceptability are likely not related at the level of syntactic structure

Solution
We likely need some sort of abstraction that clears away noise
Acceptability v. corpus-based type signatures

Predicted acceptability (based on corpus distribution) vs. Acceptability
Acceptability v. corpus-based type signatures
Acceptability v. corpus-based type signatures

$\text{Predicted acceptability (based on corpus distribution)}$

Acceptability

$r^2 = 0.27$
Testing correlation

Measurement of syntactic distribution
MegaAcceptability dataset (White and Rawlins, 2016a)

Measurement of veridicality
MegaVeridicality dataset (White and Rawlins, 2018)
...you will be given a statement and a question related to that statement. Your task will be to respond yes, *maybe or maybe not*, or *no* to the question, assuming that the statement is true. (cf. Karttunen et al., 2014)
61. Someone knew that a particular thing happened.

*Did that thing happen?*

- no
- maybe or maybe not
- yes

*How acceptable is the **bolded** sentence?*

- terrible
- 2
- 3
- 4
- 5
- 6
- perfect
68. Someone didn't know that a particular thing happened.

*Did that thing happen?*

- [ ] no
- [ ] maybe or maybe not
- [ ] yes

*How acceptable is the bolded sentence?*

- [ ] terrible
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5
- [ ] 6
- [ ] perfect
517 verbs from the MegaAttitude based on their acceptability in the 
[NP _ that S] and [NP was _ed that S] frames
517 verbs from the MegaAttitude based on their acceptability in the [NP _ that S] and [NP was _ed that S] frames
517 verbs from the MegaAttitude based on their acceptability in the [NP _ that S] and [NP was _ed that S] frames

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517 verbs from the MegaAttitude based on their acceptability in the [NP _ that S] and [NP was _ed that S] frames

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- 142 only in the passive frame
517 verbs from the MegaAttitude based on their acceptability in the [NP _ that S] and [NP was _ed that S] frames

- 348 verbs only in the active frame
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- 27 in both
517 verbs from the MegaAttitude based on their acceptability in the [NP _ that S] and [NP was _ed that S] frames

- 348 verbs only in the active frame
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1,088 items randomly partitioned into 16 lists of 68
Stimuli

Active

(6) a. Someone thought that a particular thing happened.
   b. Someone didn’t think that a particular thing happened.
Active

(6)  a. Someone thought that a particular thing happened.
    b. Someone didn’t think that a particular thing happened.

Passive

(7)  a. Someone was told that a particular thing happened.
    b. Someone wasn’t told that a particular thing happened.
Active

(6) a. Someone thought that a particular thing happened.
   b. Someone didn’t think that a particular thing happened.

Passive

(7) a. Someone was told that a particular thing happened.
   b. Someone wasn’t told that a particular thing happened.

(8) a. Someone was bothered that a particular thing happened.
   b. Someone wasn’t bothered that a particular thing happened.
Participants

160 unique participants through Amazon’s Mechanical Turk
Participants

160 unique participants through Amazon’s Mechanical Turk

• 10 ratings per item...
160 unique participants through Amazon’s Mechanical Turk

- 10 ratings per item...
- ...given by 10 different participants
Raw responses
Raw responses

- know
  - no
  - maybe
  - yes

- prove
  - no
  - maybe
  - yes

- think
  - no
  - maybe
  - yes

\( V(p) \neg V(p) \)
### Raw responses

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<thead>
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<th></th>
<th>know</th>
<th>prove</th>
<th>think</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>maybe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td></td>
<td></td>
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</tbody>
</table>

V(p) ¬V(p)

<table>
<thead>
<tr>
<th></th>
<th>yes</th>
<th>no</th>
<th>maybe</th>
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Raw responses
Raw responses

- know
- prove
- think

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</tr>
<tr>
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</table>

50
Normalization

Transformation (roughly)
Map each verb to single two-dimensional point by assigning -1 to no, 0 to maybe, and 1 to yes, then take the mean.

Normalize
Use ridit scoring to normalize for how often a particular participant gives a particular response. (Similar to z-scoring.)
Transformation (roughly)
Map each verb to single two-dimensional point by assigning -1 to no, 0 to maybe, and 1 to yes, then take the mean.
\[ \neg p \iff \neg \lor (\neg p) \rightarrow p \]
Normalization

Transformation (roughly)
Map each verb to single two-dimensional point by assigning -1 to *no*, 0 to *maybe*, and 1 to *yes*, then take the mean.

Normalize
Use ridit scoring to normalize for how often a particular participant gives a particular response.
Normalized responses

\[ \neg p \leftarrow \neg V(p) \rightarrow p \]

\[ p \leftrightarrow V(p) \rightarrow \neg p \]
Normalized responses

Nonveridicals

\[ \neg p \leftarrow \neg V(p) \rightarrow p \]

Frame

a NP _ that S
a NP was _ed that S
Normalized responses

\[ \neg p \iff \neg V(p) \implies p \]

59
Relating factivity, veridicality, and question-taking

Question
Do factivity-veridicality positively correlate with question-taking?
Correlation: factivity and question-taking

Acceptability of \( CP^{+Q} \)

Factivity
Acceptability of \([\_\_\_\_CP[+Q]]\)
For a particular verb, maximum acceptability over all frames that contain an interrogative complement.
Acceptability of [___CP[+Q]]
For a particular verb, maximum acceptability over all frames that contain an interrogative complement.

Intuition
If a verb is acceptable in some frame that contains an interrogative complement, it is acceptable with interrogatives.
Correlation: factivity and question-taking

Acceptability of \[ CP[+Q]\] vs. Factivity
Correlation: factivity and question-taking
Correlation: factivity and question-taking

Acceptability of [CP[+Q]]

Factivity
Correlation: veridicality and question-taking
Correlation: veridicality and question-taking

Acceptability of \(_{\text{CP}[\text{+Q}]\)
Correlation: veridicality and question-taking
What’s going on?

Question
How could we have gotten the direction of correlation so wrong?

Two hypotheses
1. Previous analyses were biased by verb frequency.
2. Analysis missed subregularities due to verb class.
Question
How could we have gotten the direction of correlation so wrong?

Two hypotheses

1. Previous analyses were biased by verb frequency.
Correlation: factivity with all verbs

Acceptability of 

\[ \text{Factivity} \]

\[ \text{CP}[+Q] \]
Correlation: factivity with high-frequency verbs

- find
- know
- require
- say
- see
- show
- tell
- think
- write

Acceptability of [CP [+Q]]
Correlation: veridicality with all verbs
Correlation: veridicality with high-frequency verbs

Acceptability of [CP[+Q]]

Veridicality

Verbs: find, know, require, say, see, show, show, tell, think, write, require

Graph showing the correlation between veridicality and acceptability of [CP[+Q]].
What’s going on?

Question
How could we have gotten the direction of correlation so wrong?

Two hypotheses

1. Previous analyses were biased by verb frequency.
2. Analysis missed subregularities due to verb class.
What’s going on?

Question
How could we have gotten the direction of correlation so wrong?

Two hypotheses

1. Previous analyses were biased by verb frequency.
2. Analysis missed subregularities due to verb class.
Limitation
Because prior generalizations focus on finite interrogatives & declaratives, prior dataset covered only finite complements.
Moving forward

Limitation
Because prior generalizations focus on finite interrogatives & declaratives, prior dataset covered only finite complements.

But there is substantial variability in the veridicality inferences generated with different complements – even for the same verb.
(9) a. Jo$_i$ forgot that she$_i$ bought tofu.
(9) a. \( J_0 \) forgot that she\( J_1 \) bought tofu. \( \rightarrow \) Jo bought tofu.
Moving forward

(9) a. $J_{o_i}$ forgot that $s_{he_i}$ bought tofu. → Jo bought tofu.
   b. Jo forgot to buy tofu.
Moving forward

(9) a. Jo$_i$ forgot that she$_i$ bought tofu. $\rightarrow$ Jo bought tofu.
    b. Jo forgot to buy tofu. $\rightarrow$ Jo didn’t buy tofu.
(9) a. Jo$_i$ forgot that she$_i$ bought tofu. $\rightarrow$ Jo bought tofu.
   b. Jo forgot to buy tofu. $\rightarrow$ Jo didn’t buy tofu.

(10) a. Jo$_i$ knew that she$_i$ bought tofu.
(9) a. Jo forgot that she bought tofu. → Jo bought tofu.
    b. Jo forgot to buy tofu. → Jo didn’t buy tofu.

(10) a. Jo knew that she bought tofu. → Jo bought tofu.
(9) a. $Jo_i$ forgot that $she_i$ bought tofu. → $Jo$ bought tofu.
b. $Jo$ forgot to buy tofu. → $Jo$ didn’t buy tofu.

(10) a. $Jo_i$ knew that $she_i$ bought tofu. → $Jo$ bought tofu.
b. $Jo$ knew to buy tofu.
Moving forward

(9) a. Jo$_i$ forgot that she$_i$ bought tofu. $\rightarrow$ Jo bought tofu.
    b. Jo forgot to buy tofu. $\rightarrow$ Jo didn’t buy tofu.

(10) a. Jo$_i$ knew that she$_i$ bought tofu. $\rightarrow$ Jo bought tofu.
    b. Jo knew to buy tofu. $\not\rightarrow$ Jo \{bought, didn’t buy\} tofu.
Limitation

Because prior generalizations focus on finite interrogatives & declaratives, prior dataset covered only finite complements.

But there is substantial variability in the veridicality inferences generated with different complements – even for the same verb.
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Because prior generalizations focus on finite interrogatives & declaratives, prior dataset covered only finite complements.

But there is substantial variability in the veridicality inferences generated with different complements – even for the same verb.

Aim
Measure veridicality inferences across a wide variety of syntactic contexts.
Predicting distribution from veridicality
Stimuli

Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:
Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

- \[NP \_ed \text{for NP to VP}\] (184 verbs)
NP _ed for NP to VP

(11) a. Someone wanted for a particular thing to happen.
   b. Someone didn’t want for a particular thing to happen.
Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

• [NP _ed for NP to VP] (184 verbs)
Stimuli

Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

- [NP _ed for NP to VP] (184 verbs)
- [NP _ed NP to VP[+ev]] (197 verbs)
Stimuli

NP _ed for NP to VP

(11) a. Someone wanted for a particular thing to happen.
    b. Someone didn’t want for a particular thing to happen.

NP _ed NP to VP[+ev]

(12) a. Someone told a particular person to do a particular thing.
    b. Someone didn’t tell a particular person to do a particular thing.
Stimuli

Expand MegaVeridicality with 603 verb types from MegaAcceptability based on acceptability in 7 frames involving infinitival complements:

- [NP _ed for NP to VP] (184 verbs)
- [NP _ed NP to VP[+ev]] (197 verbs)
Stimuli

Expand MegaVeridicality with \textbf{603 verb types} from MegaAcceptability based on acceptability in \textbf{7 frames} involving \textit{infinitival complements}:

- [NP \_ed for NP to VP] (184 verbs)
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- [NP \_ed NP to VP[-ev]] (128 verbs)
- [NP was \_ed NP to VP[+ev]] (278 verbs)
- [NP was \_ed NP to VP[-ev]] (256 verbs)
- [NP \_ed to VP[+ev]] (217 verbs)
- [NP \_ed to VP[-ev]] (165 verbs)

2,850 items randomly partitioned into 50 lists of 57
Stimuli

NP _ed for NP to VP

(11) a. Someone wanted for a particular thing to happen.
    b. Someone didn’t want for a particular thing to happen.

NP _ed NP to VP[+ev]

(12) a. Someone told a particular person to do a particular thing.
    b. Someone didn’t tell a particular person to do a particular thing.

NP _ed NP to VP[-ev]

(13) a. Someone believed a particular person to have a particular thing.
    b. Someone didn’t believe a particular person to have a particular thing.
Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

- [NP _ed for NP to VP] (184 verbs)
- [NP _ed NP to VP[+ev]] (197 verbs)
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- \[[\text{NP } \text{ed NP to VP}^{[-ev]}]\] (128 verbs)
- \[[\text{NP was } \text{ed NP to VP}^{[+ev]}]\] (278 verbs)
Stimuli

NP was _ed to VP [+ev]

(14) a. A particular person was ordered to do a particular thing.
   b. A particular person wasn’t ordered to do a particular thing.
Stimuli

Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

- \([\text{NP } \_\text{ed for NP to VP}]\) (184 verbs)
- \([\text{NP } \_\text{ed NP to VP}[+\text{ev}]\) (197 verbs)
- \([\text{NP } \_\text{ed NP to VP}[-\text{ev}]\) (128 verbs)
- \([\text{NP was } \_\text{ed NP to VP}[+\text{ev}]\) (278 verbs)
Stimuli

Expand MegaVeridicality with 603 verb types from MegaAcceptability based on acceptability in 7 frames involving infinitival complements:

- [NP _ed for NP to VP] (184 verbs)
- [NP _ed NP to VP[+ev]] (197 verbs)
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- [NP was _ed NP to VP[+ev]] (278 verbs)
- [NP was _ed NP to VP[-ev]] (256 verbs)
NP was _ed to VP[+ev]

(14) a. A particular person was ordered to do a particular thing.
   b. A particular person wasn’t ordered to do a particular thing.

NP was _ed to VP[-ev]

(15) a. A particular person was overjoyed to have a particular thing.
   b. A particular person wasn’t overjoyed to have a particular thing.
Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

- [NP _ed for NP to VP] (184 verbs)
- [NP _ed NP to VP[+ev]] (197 verbs)
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- [NP was _ed NP to VP[-ev]] (256 verbs)
Stimuli

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- [NP was _ed NP to VP[-ev]] (256 verbs)
- [NP _ed to VP[+ev]] (217 verbs)
Stimuli

NP _ed to VP[+ev]

(16) a. A particular person decided to do a particular thing.
    b. A particular person didn’t decide to do a particular thing.
Stimuli

Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

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- [NP _ed to VP[+ev]] (217 verbs)
Stimuli

Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements:**

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- [NP was _ed NP to VP[-ev]] (256 verbs)
- [NP _ed to VP[+ev]] (217 verbs)
- [NP _ed to VP[-ev]] (165 verbs)
Stimuli

NP _ed to VP[+ev]

(16) a. A particular person decided to do a particular thing.
    b. A particular person didn’t decide to do a particular thing.

NP _ed to VP[-ev]

(17) a. A particular person hoped to have a particular thing.
    b. A particular person didn’t hope to have a particular thing.
Expand MegaVeridicality with **603 verb types** from MegaAcceptability based on acceptability in **7 frames** involving **infinitival complements**:

- [NP _ed for NP to VP] (184 verbs)
- [NP _ed NP to VP[+ev]] (197 verbs)
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- [NP _ed to VP[+ev]] (217 verbs)
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2,850 items randomly partitioned into 50 lists of 57
Note
Mixed-effects ordinal model-based normalization to control for variability in how participants use the response scale. (see Agresti, 2014)
Results

Note

Mixed-effects ordinal model-based normalization to control for variability in how participants use the response scale. (see Agresti, 2014)

Applied to both veridicality and acceptability judgments.
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Mixed-effects ordinal model-based normalization to control for variability in how participants use the response scale. (see Agresti, 2014)

Applied to both veridicality and acceptability judgments.

Intuition
Like z-scoring, but better models response behavior.
Results

\[ \neg p \leftarrow \neg V(p) \rightarrow p \]

<table>
<thead>
<tr>
<th>that $S$</th>
<th>for NP to VP</th>
<th>NP to VP[+ev]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP to VP[−ev]</td>
<td>to VP[+ev]</td>
<td>to VP[−ev]</td>
</tr>
</tbody>
</table>
Example: $x$-axis

A particular person didn’t forget to do a particular thing.
Results

\[ \neg p \leftarrow \neg V(p) \rightarrow p \]

Diagram:

- that S
- for NP to VP
- NP to VP[+ev]
- NP to VP[−ev]
- to VP[+ev]
- to VP[−ev]

\[ \neg p \leftarrow \neg V(p) \rightarrow p \]
Example: $x$-axis

A particular person didn’t forget to do a particular thing.
Example: \textit{x-axis}
A particular person didn’t forget to do a particular thing.

Example: \textit{y-axis}
A particular person forgot to do a particular thing.
Results

\[
p \leftarrow \neg V(p) \rightarrow p
\]
Results

\[
\begin{align*}
\neg p & \iff \neg V(p) \rightarrow p \\
\neg p & \iff V(p) \rightarrow p \\
\neg p & \iff \neg V(p) \rightarrow p \\
\end{align*}
\]
<table>
<thead>
<tr>
<th>that S</th>
<th>for NP to VP</th>
<th>NP to VP[+ev]</th>
</tr>
</thead>
<tbody>
<tr>
<td>know</td>
<td></td>
<td></td>
</tr>
<tr>
<td>remember</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>think</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>believe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pretend</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NP to VP[−ev]</th>
<th>to VP[+ev]</th>
<th>to VP[−ev]</th>
</tr>
</thead>
<tbody>
<tr>
<td>¬p ← ¬V(p) → p</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ ¬p ← ¬V(p) → p \]
Results

\[-p \leftarrow \neg V(p) \rightarrow p\]
Results

\[ \neg p \leftarrow \neg V(p) \rightarrow p \]
What about frequency?

Question
Did you really need to go to all this trouble to collect veridicality judgments? Couldn’t you just get it from annotated corpora?
What about frequency?

Veridicality corpus annotations

1. FactBank (Saurí and Pustejovsky, 2009, 2012)

Current state-of-the-art

Hybrid linear-chain/tree structured neural model. (Rudinger et al., 2018)
What about frequency?

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3. MEANTIME (Minard et al., 2016)
What about frequency?

Veridicality corpus annotations

1. FactBank (Saurí and Pustejovsky, 2009, 2012)
2. UW (Lee et al., 2015)
3. MEANTIME (Minard et al., 2016)
4. UDS (White et al., 2016; Rudinger et al., 2018)
Question
Did you really need to go to all this trouble to collect veridicality judgments? Couldn’t you just get it from annotated corpora?
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Did you really need to go to all this trouble to collect veridicality judgments? Couldn’t you just get it from annotated corpora?

Answer 1
Necessarily yes. Because learners do it.
What about frequency?

Question
Did you really need to go to all this trouble to collect veridicality judgments? Couldn’t you just get it from annotated corpora?

Answer 1
Necessarily yes. Because learners do it.

Answer 2
Practically no. At least not without a model that’s effectively equivalent to whatever the learner uses.
What about frequency?

Veridicality corpus annotations

1. FactBank (Saurí and Pustejovský, 2009, 2012)
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Current state-of-the-art

Hybrid linear-chain/tree structured neural model. (Rudinger et al., 2018)
Predicting veridicality

Predicted factuality

True factuality

Polarity • Positive • Negative
<table>
<thead>
<tr>
<th>Sentence</th>
<th>True</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>someone faked that something happened.</td>
<td>-3.15</td>
<td>0.86</td>
</tr>
<tr>
<td>someone was misinformed that something happened.</td>
<td>-2.62</td>
<td>1.37</td>
</tr>
<tr>
<td>someone neglected to do something.</td>
<td>-3.07</td>
<td>-0.02</td>
</tr>
<tr>
<td>someone pretended to have something.</td>
<td>-2.96</td>
<td>0.05</td>
</tr>
<tr>
<td>someone was misjudged to have something.</td>
<td>-2.46</td>
<td>0.55</td>
</tr>
<tr>
<td>someone forgot to have something.</td>
<td>-3.18</td>
<td>-0.17</td>
</tr>
<tr>
<td>someone neglected to have something.</td>
<td>-2.93</td>
<td>0.07</td>
</tr>
<tr>
<td>someone pretended that something happened.</td>
<td>-2.11</td>
<td>0.87</td>
</tr>
<tr>
<td>someone declined to do something.</td>
<td>-3.18</td>
<td>-0.22</td>
</tr>
<tr>
<td>someone was refused to do something.</td>
<td>-3.16</td>
<td>-0.22</td>
</tr>
<tr>
<td>someone refused to do something.</td>
<td>-3.12</td>
<td>-0.20</td>
</tr>
<tr>
<td>someone pretended to do something.</td>
<td>-3.02</td>
<td>-0.11</td>
</tr>
<tr>
<td>someone disallowed someone to do something.</td>
<td>-2.56</td>
<td>0.34</td>
</tr>
<tr>
<td>someone was declined to have something.</td>
<td>-2.36</td>
<td>0.55</td>
</tr>
<tr>
<td>someone declined to have something.</td>
<td>-3.12</td>
<td>-0.23</td>
</tr>
<tr>
<td>someone did n’t hesitate to have something.</td>
<td>1.84</td>
<td>-0.96</td>
</tr>
<tr>
<td>someone ceased to have something.</td>
<td>-2.22</td>
<td>0.57</td>
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<tr>
<td>someone did n’t hesitate to do something.</td>
<td>1.86</td>
<td>-0.92</td>
</tr>
<tr>
<td>someone lied that something happened.</td>
<td>-1.99</td>
<td>0.78</td>
</tr>
<tr>
<td>someone feigned to have something.</td>
<td>-3.07</td>
<td>-0.31</td>
</tr>
</tbody>
</table>
Goal

Extract patterns of inference – e.g. factive, veridical, or implicative.
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Approach
Use an automated method to discover inference patterns across verbs by decomposing veridical data into underlying factors.
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Use an automated method to discover inference patterns across verbs by decomposing veridical data into underlying factors.

Method
Regularized censored factor analysis with loss weighted by normalized acceptability and scores constrained to (-1, 1).
Goal
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Regularized censored factor analysis with loss weighted by normalized acceptability and scores constrained to (-1, 1).

Selected number of factors (12) using cross-validation procedure.
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Regularized censored factor analysis with loss weighted by normalized acceptability and scores constrained to (-1, 1).

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(Ask about specifics after the talk.)
## Inference patterns

<table>
<thead>
<tr>
<th>Pattern 0</th>
<th>Pattern 1</th>
<th>Pattern 2</th>
<th>Pattern 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP _ed that S</td>
<td>NP was _ed that S</td>
<td>NP _ed for NP to VP</td>
<td>NP _ed NP to VP [+ev]</td>
</tr>
<tr>
<td>NP _ed NP to VP [-ev]</td>
<td>NP _ed to VP [+ev]</td>
<td>NP was _ed to VP [+ev]</td>
<td>NP was _ed to VP [+ev]</td>
</tr>
<tr>
<td>NP _ed for NP to VP</td>
<td>NP _ed to VP [-ev]</td>
<td>NP was _ed to VP [-ev]</td>
<td>NP was _ed to VP [-ev]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pattern 4</th>
<th>Pattern 5</th>
<th>Pattern 6</th>
<th>Pattern 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP _ed that S</td>
<td>NP was _ed that S</td>
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<td>NP was _ed to VP [-ev]</td>
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</table>

<table>
<thead>
<tr>
<th>Pattern 8</th>
<th>Pattern 9</th>
<th>Pattern 10</th>
<th>Pattern 11</th>
</tr>
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</tr>
</tbody>
</table>

### Inference polarity

- **Matrix polarity**
  - negative
  - positive
### Inference patterns

<table>
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**Inference polarity**

**Matrix polarity**

- **negative**
- **positive**
### Inference patterns

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### Inference polarity

Matrix polarity: negative, positive
Inference patterns

Pattern 3

Pattern 5
Inference patterns
Inference patterns: factivity/veridicality
Inference patterns: factivity/veridicality

Pattern 3

Pattern 5

find out
know
prove
realize
verify
Inference patterns: factivity/veridicality
Inference patterns

Pattern 0
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
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Pattern 1
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
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NP was _ed to VP[+ev]
NP _ed to VP[−ev]
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Pattern 2
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
NP was _ed to VP[+ev]
NP _ed to VP[−ev]
NP was _ed to VP[−ev]

Pattern 3
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
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NP _ed to VP[−ev]
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Pattern 4
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
NP was _ed to VP[+ev]
NP _ed to VP[−ev]
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Pattern 5
NP _ed that S
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NP _ed NP to VP[+ev]
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NP _ed to VP[−ev]
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Pattern 6
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
NP was _ed to VP[+ev]
NP _ed to VP[−ev]
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Pattern 7
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
NP was _ed to VP[+ev]
NP _ed to VP[−ev]
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Pattern 8
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NP _ed NP to VP[+ev]
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Pattern 9
NP _ed that S
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NP _ed for NP to VP
NP _ed NP to VP[+ev]
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NP was _ed to VP[+ev]
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Pattern 10
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
NP was _ed to VP[+ev]
NP _ed to VP[−ev]
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Pattern 11
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
NP _ed NP to VP[−ev]
NP was _ed to VP[+ev]
NP _ed to VP[−ev]
NP was _ed to VP[−ev]

Inference polarity

Matrix polarity 🔴negative 🔵positive
Inference patterns
Inference patterns: factivity/veridicality

Pattern 7

Pattern 3
Inference patterns: factivity/veridicality

Pattern 7

Pattern 3
Inference patterns

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NP _ed that S
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Pattern 1
NP _ed that S
NP was _ed that S
NP _ed for NP to VP
NP _ed NP to VP[+ev]
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NP _ed to VP[+ev]
NP _ed to VP[−ev]
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Pattern 2
NP _ed that S
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NP _ed for NP to VP
NP _ed NP to VP[+ev]
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Inference polarity

Matrix polarity

negative
positive
Inference patterns

Inference polarity

Matrix polarity

Pattern 0 Pattern 1 Pattern 2 Pattern 3
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Inference polarity

Matrix polarity
Inference patterns

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Inference polarity

Matrix polarity

128
Inference patterns: implicatives
Inference patterns: implicatives
Inference patterns

Pattern 0

Pattern 1

Pattern 2

Pattern 3

Pattern 4

Pattern 5

Pattern 6

Pattern 7

Pattern 8

Pattern 9

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Pattern 11

Inference polarity

Matrix polarity

negative
positive
Inference patterns

Pattern 0
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Inference polarity
Matrix polarity

negative
positive
Question
Can we predict *syntactic distribution* directly from *veridicality inference patterns*?
Question
Can we predict **syntactic distribution** directly from **veridicality inference patterns**?

Approach
Learn optimal mapping from **veridicality inference patterns** to **syntactic distribution** using cross-validated ridge regression.
Question
Can we predict syntactic distribution directly from veridicality inference patterns?

Approach
Learn optimal mapping from veridicality inference patterns to syntactic distribution using cross-validated ridge regression.

Finding
Across all frames in MegaAcceptability, this mapping explains about 20% of the variance in the acceptability judgments.
Predicting distribution from inference

![Graph showing variance explained vs. syntactic structure.](Image)

- **Variance explained**
  - 0.00
  - 0.25
  - 0.50
  - 0.75
  - 1.00

- **Syntactic structure**
  - about_NP:active
  - about_NP:passive
  - about_whether_S:active
  - about_whether_S:passive
  - for_NP_to_VP:active
  - NP_that_S_future:active
  - NP_that_S_notense:active
  - NP_that_S:active
  - NP_to_NP:active
  - NP_to_VPeventive:active
  - NP_to_VPstative:active
  - NP_VP:active
  - NP_VPing:active
  - NP_whether_S_future:active
  - NP_whether_S:active
  - NP_whichNP_S:active
  - null:active
  - null:passive
  - S:active
  - S:passive
  - Slift:active
  - so:active
  - so:passive
  - that_S_future:active
  - that_S_future:passive
  - that_S_notense:active
  - that_S_notense:passive
  - that_S:active
  - that_S:passive
  - to_NP_that_S_future:active
  - to_NP_that_S_notense:active
  - to_NP_that_S:active
  - to_NP_whether_S_future:active
  - to_NP_whether_S:active
  - to_VPeventive:active
  - to_VPeventive:passive
  - to_VPstative:active
  - to_VPstative:passive
  - whether_S_future:active
  - whether_S_future:passive
  - whether_S:active
  - whether_S:passive
  - whether_to_VP:active
  - whether_to_VP:passive
  - whichNP_S:active
  - whichNP_S:passive
  - whichNP_to_VP:active
  - whichNP_to_VP:passive
Predicting distribution from inference

Variance explained

Syntactic structure
Predicting distribution from inference

Variance explained

Syntactic structure
Points

1. Some amount of information about syntactic distribution carried in veridicality inferences.
Predicting distribution from inference

Points

1. Some amount of information about syntactic distribution carried in veridicality inferences.
   
   1.1 **Caveat:** It’s hard to tell how much explanation is driven by syntactic information encoded in the patterns.
Inference patterns

Matrix polarity: negative, positive
Points

1. Some amount of information about syntactic distribution carried in veridicality inferences.

   1.1 **Caveat:** It’s hard to tell how much explanation is driven by syntactic information encoded in the patterns.
Points

1. Some amount of information about syntactic distribution carried in veridicality inferences.
   1.1 **Caveat:** It’s hard to tell how much explanation is driven by syntactic information encoded in the patterns.

2. Not nearly enough information to base a generalization on.
Question
What drives the relationship between veridicality and distribution?
Question
What drives the relationship between veridicality and distribution?

Possibility
The relationship is **indirect**, mediated by underlying features that explain both **distribution** and **veridicality**.
Exploratory analysis

Question
What drives the relationship between veridicality and distribution?

Possibility
The relationship is \textit{indirect}, mediated by underlying features that explain both \textit{distribution} and \textit{veridicality}.

Motivation
Relationship may be mediated by non-contentful properties of contentful events Kratzer 2006; Hacquard 2006; Moulton 2009; Anand and Hacquard 2013, 2014; Rawlins 2013; Bogal-Allbritten 2016; White and Rawlins 2016b a.o.
Exploratory analysis

Question
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Approach
Use Uniform Manifold Approximation and Projection (UMAP) to visualize the topological structure of the distribution and veridicality data. McInnes and Healy 2018
Exploratory analysis
Exploratory analysis

- shock
- thrill
- upset
- vex
- fear
- terrify
- unnerved
- worry
- panic
- unsettle
- fear
- startle
- shock
- disgust
- loosen
- panic
- perplex
- scare
- frighten
- chill
Exploratory analysis
Exploratory analysis
Exploratory analysis
Exploratory analysis
Exploratory analysis
Exploratory analysis
Finding
Fine-grained clusters like verb classes among ‘action’ verbs
Finding
Fine-grained clusters like verb classes among ‘action’ verbs

Question
What could explain distributional properties like responsivity?
Finding
Fine-grained clusters like verb classes among ‘action’ verbs

Question
What could explain distributional properties like responsivity?

Possibility 1
Verb class-specific rules (possibly sensitive to content-dependent properties, like veridicality and factivity).
Finding
Fine-grained clusters like verb classes among ‘action’ verbs

Question
What could explain distributional properties like responsivity?

Possibility 1
Verb class-specific rules (possibly sensitive to content-dependent properties, like veridicality and factivity).

Possibility 2
More abstract semantic properties relevant to thematic roles – e.g. affectedness, existence, creation/destruction, ...
Case study: decision predicates
Why decision predicates?

Observation
Decision predicates are one of multiple classes of responsive verbs that are not veridical (Beck and Rullmann, 1999; Lahiri, 2002; Egré, 2008)
Observation
Decision predicates are one of multiple classes of responsive verbs that are not veridical (Beck and Rullmann, 1999; Lahiri, 2002; Egré, 2008)

(18) a. Jo told Mo that Bo was alive.  ↛ Bo was alive.
    b. Jo told Mo whether Bo was alive.
Why decision predicates?

Observation
Decision predicates are one of multiple classes of responsive verbs that are not veridical (Beck and Rullmann, 1999; Lahiri, 2002; Egré, 2008)

(18) a. Jo told Mo that Bo was alive. $\not\rightarrow$ Bo was alive.
b. Jo told Mo whether Bo was alive.

(19) a. Jo and Mo agreed that Bo was alive. $\not\rightarrow$ Bo was alive.
b. Jo and Mo agreed on whether Bo was alive.
Observation
Decision predicates are one of multiple classes of responsive verbs that are not veridical (Beck and Rullmann, 1999; Lahiri, 2002; Egré, 2008)

(18) a. Jo told Mo that Bo was alive. \( \not \rightarrow \) Bo was alive.
    b. Jo told Mo whether Bo was alive.

(19) a. Jo and Mo agreed that Bo was alive. \( \not \rightarrow \) Bo was alive.
    b. Jo and Mo agreed on whether Bo was alive.

(20) a. Jo_i decided PRO_i to leave. \( \not \rightarrow \) Jo will leave.
    b. Jo_i decided whether PRO_i to leave.
Why decision predicates?

Decide is part of a nontrivial class of Change-of-mental-state (CoMS) responsives not captured by standard theories of responsivity

(21) decide, judge, estimate, determine, assess, conclude, resolve, choose, assess, evaluate, appraise, rate, select, infer, diagnose, opt, elect
**Why decision predicates?**

**Decide** is part of a nontrivial class of Change-of-mental-state (CoMS) responsives not captured by standard theories of responsivity.

\[(21)\] decide, judge, estimate, determine, assess, conclude, resolve, choose, assess, evaluate, appraise, rate, select, infer, diagnose, opt, elect

**Minimal pair**

Change-of-mental-state (CoMS) **decide** v. stative **intend**

\[(22)\] a. Jo decided (whether) to go out.
   b. Jo intended (*whether) to go out.
Why decision predicates?

Overarching claim

Responsivity is licensed by CoMS
Why decision predicates?

Overarching claim
Responsivity is licensed by CoMS

• decide is Q-agnostic because it is CoMS
Overarching claim

Responsivity is licensed by CoMS

- **decide** is *Q-agnostic* because it is CoMS
- **intend** is *Q-rejecting* because it is not (and because no other lexical property of **intend** licenses *Q-agnosticism*)
Overarching claim
Responsivity is licensed by CoMS

- **decide** is *Q-agnostic* because it is CoMS
- **intend** is *Q-rejecting* because it is not (and because no other lexial property of **intend** licenses *Q-agnosticism*)

Argument outline

1. Interpretation of decision predicates with embedded questions is not captured by standing theories.
Why decision predicates?

Overarching claim

Responsivity is licensed by CoMS

- decide is Q-agnostic because it is CoMS
- intend is Q-rejecting because it is not (and because no other lexical property of intend licenses Q-agnosticism)

Argument outline

1. Interpretation of decision predicates with embedded questions is not captured by standing theories.
2. Capturing the interpretations of decision predicates must make explicit reference to the structure of selection events.
Two notions of veridicality

P-veridicality
A verb \( V \) is (P-)veridical iff
\[
\forall x, p : \lbrack V \rbrack^w(x, p) \rightarrow p(w@)
\]

(23) Jo knew that Bo was alive \( \rightarrow \) Bo was alive

Q-veridicality
A verb \( V \) is Q-veridical iff
\[
\forall x, Q : \lbrack V \rbrack^w(x, Q) \rightarrow \lbrack V \rbrack^w(x, \text{ans}(Q))
\]
Two notions of veridicality

P-veridicality
A verb $V$ is \((P-)\)veridical iff $\forall x, p : \semantics{V}(x, p) \rightarrow p(w_\emptyset)$

(23) Jo knew that Bo was alive $\rightarrow$ Bo was alive

Q-veridicality
A verb $V$ is \(Q\)-veridical iff $\forall x, Q : \semantics{V}(x, Q) \rightarrow \semantics{V}(x, \text{ANS}_{w_\emptyset}(Q))$
Two notions of veridicality

**P-veridicality**
A verb $V$ is (P-)veridical iff $\forall x, p : [V]^{w@}(x, p) \rightarrow p(w@)$

(23) Jo **knew** that Bo was alive $\rightarrow$ Bo was alive

**Q-veridicality**
A verb $V$ is Q-veridical iff $\forall x, Q : [V]^{w@}(x, Q) \rightarrow [V]^{w@}(x, ANS_{w@}(Q))$

(24) Jo **knew** whether Bo was alive
      $\rightarrow$ Jo **knew** the true answer to “was Bo alive?”

A verb $V$ is Q-**non**veridical if it is not Q-veridical.
Spector and Egré’s (2015) observation
High correlation between Q-veridicality and P-veridicality

Spector and Egré’s (2015) proposal
Q-veridicality is derived from P-veridicality
Spector and Egré’s (2015) formalization

When a Q-agnostic predicate takes a question Q, it relates an attitude holder to some possible (complete) answer to Q

(cf. Hamblin, 1973; Groenendijk and Stokhof, 1984; Beck and Rullmann, 1999; Lahiri, 2002)
Spector and Egré’s (2015) formalization

When a Q-agnostic predicate takes a question Q, it relates an attitude holder to some possible (complete) answer to Q

(cf. Hamblin, 1973; Groenendijk and Stokhof, 1984; Beck and Rullmann, 1999; Lahiri, 2002)

\[ \forall x : [V]^W@ (x, Q) \rightarrow \exists p \in Q : [V]^W@ (x, p) \]
Spector and Egré’s (2015) formalization

When a \textit{Q-agnostic} predicate takes a question \(Q\), it relates an attitude holder to some possible (complete) answer to \(Q\)

(cf. Hamblin, 1973; Groenendijk and Stokhof, 1984; Beck and Rullmann, 1999; Lahiri, 2002)

\[
\forall x : [V]^{w@}(x, Q) \rightarrow \exists p \in Q : [V]^{w@}(x, p)
\]

But if a verb \(V\) is \textit{P-veridical}, then...
Spector and Egré’s (2015) formalization

When a Q-agnostic predicate takes a question \( Q \), it relates an attitude holder to some possible (complete) answer to \( Q \)

\((\text{cf. Hamblin}, 1973; \text{Groenendijk and Stokhof}, 1984; \text{Beck and Rullmann}, 1999; \text{Lahiri}, 2002)\)

\[
\forall x : [V]^{w \odot}(x, Q) \rightarrow \exists p \in Q : [V]^{w \odot}(x, p)
\]

But if a verb \( V \) is P-veridical, then...

\[
\left[ \forall x, p' : [V]^{w \odot}(x, p') \rightarrow p'(w \odot) \wedge \exists p \in Q : [V]^{w \odot}(x, p) \right] \implies \exists p'' \in Q : p''(w \odot) \wedge [V]^{w \odot}(x, p'')
\]
System

Adopt Spector and Egré’s proposal that embedded interrogatives denote possible complete answers (exhaustified Hamblin Qs)
Moving forward

System
Adopt Spector and Egré’s proposal that embedded interrogatives denote possible complete answers (exhaustified Hamblin Qs)

Goal
Some explanation of Q-agnostic predicates that are neither P-veridical nor Q-veridical – e.g. CoMS predicates
Hamblin (1973) questions
Sets of possible answers (cf. Beck and Rullmann, 1999; Spector and Egré, 2015)
Hamblin (1973) questions

Sets of possible answers (cf. Beck and Rullmann, 1999; Spector and Egré, 2015)

(25) a. \([\text{whether Jo left}] = \lambda p. p \in \{\text{[Jo left]}, \neg \text{[Jo left]}\}\]

b. \([\text{who left}] = \lambda p. \exists x : p = \lambda w. \text{[left]}^w(x)\]
Hamblin (1973) questions
Sets of possible answers (cf. Beck and Rullmann, 1999; Spector and Egré, 2015)

\[ \begin{align*}
(25) \quad & \text{a. } [\text{whether Jo left}] = \lambda p. p \in \{[[\text{Jo left}]], \neg[[\text{Jo left}]]\} \\
& \quad \text{b. } [\text{who left}] = \lambda p. \exists x : p = \lambda w.[\text{left}]^w(x) 
\end{align*} \]

Karttunen (1977b) questions
Sets of true answers (cf. Groenendijk and Stokhof, 1984; Heim, 1994)

\[ \begin{align*}
(26) \quad & \text{a. } [\text{whether Jo left}] = \lambda p. p(w@) \land p \in \{[[\text{Jo left}]], \neg[[\text{Jo left}]]\} \\
& \quad \text{b. } [\text{who left}] = \lambda p. p(w@) \land \exists x : p = \lambda w.[\text{left}]^w(x) 
\end{align*} \]
The proposal

Plan
Show that...

1. ...Spector and Egré’s proposal makes no wrong predictions about CoMS verbs, but it undergenerates entailments
2. ...to strengthen their predictions without overgenerating, reference to CoMS is necessary
Two contexts

Selecting  Alternating
### Two contexts

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<th>Selecting</th>
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Two contexts

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Selecting contexts

DECIDER selects an intention from set of possible intentions

Before 3pm, Jo was considering whether to leave.

It's false that Jo intended to leave before 3pm.

It's false that Jo intended not to leave before.

At 3pm, Jo decided to leave at 5pm.
Selecting contexts

DECIDER selects an intention from set of possible intentions

(27) a. Before 3pm, Jo was considering whether to leave.
   b. → It’s false that Jo intended to leave before 3pm.
   c. → It’s false that Jo intended not to leave before.

(28) At 3pm, Jo decided to leave at 5pm.
Alternating contexts
DECIDER changes intention from mutually exclusive intention

(29) At 3pm, Jo decided to leave at 5pm.

(30) At 4pm, Jo changed her mind and decided not to leave.
Two contexts

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<tr>
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<td>decide whether to</td>
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Selecting v. switching contexts

Possibility
Given only the (prototypical) selecting contexts...

(31) At 3pm, Jo decided to leave at 5pm.
   a. \( \rightarrow \) Jo intended to leave after 3pm.
   b. \( \rightarrow \) It’s F that Jo intended to leave before 4pm
   c. \( \rightarrow \) It’s F that Jo intended not to leave before 4pm
Conclusion
The availability of alternating contexts suggests...

(32) At 4pm, Jo decided not to leave at 5pm.
   a. → Jo intended not to leave after 4pm.
   b. → It’s F that Jo intended to leave before 4pm
   c. ✔ it’s F that Jo intended not to leave before 4pm
A CoMS denotation
Suggests a very straightforward CoMS denotation for decide to (simplified to capture just entailments of interest)

\[(33) \quad \llbracket \text{decide } S \rrbracket^t = \lambda x. \neg \text{INTEND}(x, \llbracket S \rrbracket, < t) \land \text{INTEND}(x, \llbracket S \rrbracket, \geq t)\]
Question
What predictions does Spector and Egré’s (2015) proposal make?

(34) Jo decided whether to leave.

Answer 1
Predicts everything correctly for post-states

(35) Either Jo intended to leave or she intended not to leave.
Question
What predictions does Spector and Egré’s (2015) proposal make?

(36) At 4pm, Jo decided whether to leave at 5pm.

Answer 2
For pre-states, where it makes predictions, they are correct
Question
What predictions does Spector and Egré’s (2015) proposal make?

(36) At 4pm, Jo decided whether to leave at 5pm.

Answer 2
For pre-states, where it makes predictions, they are correct

(37) Before 4pm, either it’s false that Jo decided to leave at 5pm or it’s false that she decided not to leave at 5pm.
Question
What predictions does Spector and Egré’s (2015) proposal make?

(36) At 4pm, Jo decided whether to leave at 5pm.

Answer 2
For pre-states, where it makes predictions, they are correct

(37) Before 4pm, either it’s false that Jo decided to leave at 5pm or it’s false that she decided not to leave at 5pm.

(38) \( \exists p \in Q : \neg \text{INTEND}(x, p, < t) \land \text{INTEND}(x, p, \geq t) \)
Question
What predictions does Spector and Egré’s (2015) proposal make?

(36) At 4pm, Jo decided whether to leave at 5pm.

Answer 2
For pre-states, where it makes predictions, they are correct

(37) Before 4pm, either it’s false that Jo decided to leave at 5pm or it’s false that she decided not to leave at 5pm.

(38) \exists p \in Q : \neg \text{INTEND}(x, p, < t) \land \text{INTEND}(x, p, \geq t)

But this prediction is too weak
Observation
While *decide to* is licensed in selecting and alternating contexts, *decide whether to* is only licensed in selective contexts

(39) a. Before 3, Jo intended neither to leave nor not to.
    b. At 3, Jo decided whether to leave.

(40) a. Before 4, Jo intended either to leave or not to.
    b. #At 4pm, Jo decided whether to leave at 5pm

Intuition
(40-b) $\rightarrow$ Jo have no intention with respect to leaving before 4pm
Two contexts

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## Two contexts

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Consequence
We need (42), rather than (41) for CoMS embedded questions.

(41) \( \exists p \in Q : \neg \text{INTEND}(x, p, < t) \land \text{INTEND}(x, p, \geq t) \)

(42) \( \forall p \in Q : \neg \text{INTEND}(x, p, < t) \land \exists p \in Q : \text{INTEND}(x, p, \geq t) \)

Observation
The pre-state conjunct is equivalent to the negation of the post-state conjunct (modulo tense)

(43) \( \forall p \in Q : \neg \text{INTEND}(x, p) \iff \neg \exists p \in Q : \text{INTEND}(x, p) \)
Idea

Apply Spector and Egré’s (2015) proposal to each conjunct

\[(44)\] \[Q = [\text{whether } S] = \{[S], \neg[S]\} = \{p, \neg p\}\]

\[(45)\] \[[\text{decide whether } S]^t = \lambda x. \neg\text{INTEND}(x, Q, < t) \land \text{INTEND}(x, Q, \geq t)\]

\[(46)\] \[[\text{decide whether } S]^t = \lambda x. \neg\exists p \in Q : \text{INTEND}(x, p, < t) \land \exists p \in Q : \text{INTEND}(x, p, \geq t)\]
Problem
Mysterious why we shouldn’t be able to do this for \textit{intend}

(47) a. Jo hasn’t \textbf{decided} whether to go out.
b.*Jo didn’t \textbf{intend} whether to go out.

\[
\begin{align*}
\text{[intend whether } S\text{]} &= \lambda x.\text{INTEND}(x, [\text{whether } S]) \\
&= \lambda x.\exists p \in [\text{whether } S] : \text{INTEND}(x, p)
\end{align*}
\]
Observation
Problem doesn’t arise for CoMS veridicals
Observation
Problem doesn’t arise for CoMS veridicals

(48) a. Jo doesn’t **figure out** (whether) Bo left.
   b. Jo doesn’t **know** (whether) Bo left.
Observation
Problem doesn’t arise for CoMS veridicals

(48) a. Jo doesn’t **figure out** (whether) Bo left.
b. Jo doesn’t **know** (whether) Bo left.

\[
\begin{align*}
\llbracket \text{know whether } S \rrbracket &= \lambda x. \text{KNOW}(x, \llbracket \text{whether } S \rrbracket) \\
&= \lambda x. \exists p \in \llbracket \text{whether } S \rrbracket : \text{KNOW}(x, p)
\end{align*}
\]
Upshot
Only target certain event types (e.g. intentions) in CoMS structure
**Question embedding and CoMS**

**Upshot**
Only target certain event types (e.g. intentions) in CoMS structure

**Proposal**
Make interrogative-taking dependent on CoMS
Minimal requirements

For **decide to**, something of the form in (49)

\[
\text{(49)} \quad \ldots \neg \text{INTEND}(x, [S], < t) \land \text{INTEND}(x, [S], \geq t)
\]

For **decide whether to**, something of the form in (50)

\[
\text{(50)} \quad \ldots \forall p \in Q : \neg \text{INTEND}(x, p, < t) \land \exists p \in Q : \text{INTEND}(x, p, \geq t)
\]
Core idea

*Q*-agnostic predicates undergo a regular polysemy

Lexical abstraction

Polysemy rules

Lexicon

DECIDE

DECIDE₀

DECIDE₁
Core idea

Q-agnostic predicates undergo a regular polysemy

Lexical abstraction

Polysemy rules

Lexicon

DECIDE

DECIDE_Q

DECIDE_p
Goal
A polysemy approach for Q-agnostics

Elementary relations

Lexical templating

Lexicon
Lexical templates

Proposition-taking variant passes \( p \) to elementary relations

\[
R_{\text{PROP}} \equiv \lambda w. \lambda x. \lambda p. R_{\forall}(x, p, w) \land R_{\exists}(x, p, w)
\]

Question-taking variant passes \( p \in Q \) to elementary relations

\[
R_{\text{QUEST}} \equiv \lambda w. \lambda x. \lambda Q. \forall p \in Q : R_{\forall}(x, p, w) \land \exists p \in Q : R_{\exists}(x, p, w)
\]

Veridicality arises from \( R_{\forall} \)

\[
\text{KNOW}_{\forall}(x, p, w) \equiv \text{BELIEVE}(x, p, w) \rightarrow p(w)
\]
\(R_{PROP}\) corresponds to the form we need for \textit{decide to}, and
\(R_{QUES}\) corresponds to the form we need for \textit{decide whether to}

\[(51)\quad \text{DECIDE}_\forall = \neg \text{INTEND}\]

\[(52)\quad \text{DECIDE}_\exists = \text{INTEND}\]

\(R_\forall = R_{pre}\) characterizes pre-states
\(R_\exists = R_{post}\) characterizes post-states
Hacquard’s (2010) neo-Davidsonian event content approach

(cf. Kratzer, 2006; Moulton, 2009; Bogal-Allbritten, 2016)
Hacquard’s (2010) neo-Davidsonian event content approach

\[
(53) \text{CON}(e) = \{ w : w \text{ is compatible with the contents of } e \}
\]

\[
(54) \llbracket [V S]_{VP} \rrbracket = \lambda e. P_V(e) \land \forall w \in \text{CON}(e) : [S](w)
\]
**Basic approach**

Hacquard’s (2010) neo-Davidsonian event content approach

(cf. Kratzer, 2006; Moulton, 2009; Bogal-Allbritten, 2016)

\[(53) \text{CON}(e) = \{w : w \text{ is compatible with the contents of } e\} \]

\[(54) \llbracket [V S]_{VP} \rrbracket = \lambda e. P_V(e) \land \forall w \in \text{CON}(e) : \llbracket S \rrbracket (w)\]

Champollion’s (2015) verb-as-event-quantifier approach

\[(55) \llbracket VP \rrbracket = \lambda f. \exists e : f(e) \land \ldots\]
Basic approach

Hacquard’s (2010) neo-Davidsonian event content approach
(cf. Kratzer, 2006; Moutlon, 2009; Bogal-Allbritten, 2016)

(53) \( \text{CON}(e) = \{w : w \text{ is compatible with the contents of } e\} \)

(54) \( [[V S]_{VP}] = \lambda e. P_V(e) \land \forall w \in \text{CON}(e) : [S](w) \)

Champollion’s (2015) verb-as-event-quantifier approach

(55) \( [[VP]] = \lambda f. \exists e : f(e) \land \ldots \)

Attitude denotations

(56) \( [[V S]_{VP}] = \lambda f. \exists e : P_V(e) \land f(e) \land \forall w \in \text{CON}(e) : [S](w) \)
Implementation

\[ e_{pre} \xrightarrow{\text{DECIDE}} e_{post} \]
Implementation

\[ e_{\text{pre}} \xrightarrow{\text{DECIDE}} e_{\text{post}} \]

\[ \text{CONTENT} \]

\{\text{INTEND } p_1, \text{ INTEND } p_2, \ldots\} \text{ INQUISITIVE}
Implementation

\[ e_{pre} \xrightarrow{\text{DECIDE}} e_{post} \]

CONTENT

\{\text{INTEND } p_1, \text{ INTEND } p_2, \ldots\}

INQUISITIVE

CONTENT

\text{INTEND } p_i

INFORMATIVE
Defining decision

Define DECISION to relate a pre-state and a post-state

\[(57)\] \( \text{DECISION}(e, e_{pre}, e_{post}) \equiv e \) is a decision with
\[\text{pre-state } e_{pre} \text{ and post-state } e_{post} \]

Define constraint on inquisitive pre-state

\[(58)\] \( R_{pre}(e, p) = \neg \forall w \in \text{CON}(e) : p(w) \)

Define constraint on informative post-state

\[(59)\] \( R_{post}(e, p) = \forall w \in \text{CON}(e) : p(w) \)
Defining lexical templates

As expected for a change-of-state verb

\[(60) \forall e, p : R_{pre}(e, p) \leftrightarrow \neg R_{post}(e, p)\]
Defining lexical templates

As expected for a change-of-state verb

\[(60) \ \forall e, p : R_{\text{pre}}(e, p) \iff \neg R_{\text{post}}(e, p)\]

Extend George’s lexical templates to events

\[(61) \ a. \ \llbracket \text{decide}_{\text{PROP}} \rrbracket = R_{\text{PROP}}(\text{DECISION}) = (62-a)\]
\[b. \ \llbracket \text{decide}_{\text{QUES}} \rrbracket = R_{\text{QUES}}(\text{DECISION}) = (62-b)\]
Defining lexical templates

As expected for a change-of-state verb

\[ (60) \forall e, p : R_{pre}(e, p) \leftrightarrow \neg R_{post}(e, p) \]

Extend George's lexical templates to events

\[ (61) \quad \text{a. } \llbracket \text{decide}_{\text{PROP}} \rrbracket = R_{\text{PROP}}(\text{DECISION}) = (62\text{-a}) \]
\[ \quad \text{b. } \llbracket \text{decide}_{\text{QUES}} \rrbracket = R_{\text{QUES}}(\text{DECISION}) = (62\text{-b}) \]

\[ (62) \quad \lambda p. \lambda f. \exists e, e_{pre}, e_{post} : \text{DECISION}(e, e_{pre}, e_{post}) \land f(e) \]
Defining lexical templates

As expected for a change-of-state verb

(60) \( \forall e, p : R_{pre}(e, p) \leftrightarrow \neg R_{post}(e, p) \)

Extend George’s lexical templates to events

(61) a. \([\text{decide}_{\text{PROP}}] = R_{\text{PROP}}(\text{DECISION}) = (62-a)\)

b. \([\text{decide}_{\text{QUES}}] = R_{\text{QUES}}(\text{DECISION}) = (62-b)\)

(62) a. \(\lambda p. \lambda f. \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land f(e) \land R_{\text{pre}}(p)(e_{\text{pre}}) \land R_{\text{post}}(p)(e_{\text{post}})\)
Defining lexical templates

As expected for a change-of-state verb

\[(60) \ \forall e, p : \neg R_{\text{post}}(e, p) \iff R_{\text{pre}}(e, p)\]

Extend George’s lexical templates to events

\[(61) \ a. \ \llbracket \text{decide}_{\text{PROP}} \rrbracket = R_{\text{PROP}}(\text{DECISION}) = (62-a) \]
\[\quad \ b. \ \llbracket \text{decide}_{\text{QUES}} \rrbracket = R_{\text{QUES}}(\text{DECISION}) = (62-b) \]

\[(62) \ a. \ \lambda p. \lambda f. \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land f(e) \land R_{\text{pre}}(p)(e_{\text{pre}}) \land R_{\text{post}}(p)(e_{\text{post}}) \]
\[\quad \ b. \ \lambda Q. \lambda f. \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land f(e) \]
Defining lexical templates

As expected for a change-of-state verb

\[(60) \ \forall e, p : R_{pre}(e, p) \leftrightarrow \neg R_{post}(e, p)\]

Extend George’s lexical templates to events

\[(61) a. \ \llbracket \text{decide}_{\text{PROP}} \rrbracket = R_{\text{PROP}}(\text{DECISION}) = (62-a)\]
\[\ \quad b. \ \llbracket \text{decide}_{\text{QUES}} \rrbracket = R_{\text{QUES}}(\text{DECISION}) = (62-b)\]

\[(62) a. \ \lambda p. \lambda f. \exists e, e_{pre}, e_{post} : \text{DECISION}(e, e_{pre}, e_{post}) \land f(e)\]
\[\quad \land R_{pre}(p)(e_{pre}) \land R_{post}(p)(e_{post})\]

\[\ \quad b. \ \lambda Q. \lambda f. \exists e, e_{pre}, e_{post} : \text{DECISION}(e, e_{pre}, e_{post}) \land f(e)\]
\[\quad \land \forall p \in Q : R_{pre}(p)(e_{pre})\]
\[\quad \land \exists p \in Q : R_{post}(p)(e_{post})\]
Full denotations

When `decide` takes a declarative...

\[
[Jo \ \text{decide}_{\text{PROP}} \ S] = \exists e, e_{pre}, e_{post} : \text{DECISION}(e, e_{pre}, e_{post}) \land \text{AGENT}(j, e)
\]
When \texttt{decide} takes a declarative...

$$\llbracket \text{Jo decide}_{\text{PROP}} \ S \rrbracket = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \land \neg \forall w \in \text{CON}(e_{\text{pre}}) : \llbracket S \rrbracket (w)$$
When \texttt{decide} takes a declarative...

\[ \llbracket \text{Jo decide}_{\text{PROP S}} \rrbracket = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \land \neg \forall w \in \text{CON}(e_{\text{pre}}) : \llbracket S \rrbracket(w) \land \forall w \in \text{CON}(e_{\text{post}}) : \llbracket S \rrbracket(w) \]
When \textit{decide} takes a declarative...

\[ [\text{Jo decide}_{\text{PROP}} \ S] = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \land \neg \forall w \in \text{CON}(e_{\text{pre}}) : [S](w) \land \forall w \in \text{CON}(e_{\text{post}}) : [S](w) \]

When \textit{decide} takes an interrogative...

\[ [\text{Jo decide}_{\text{QUEST}} \ ?S] = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \]
Full denotations

When \textit{decide} takes a declarative...

\[ [\text{Jo \, decide} \text{\_PROP \, S}] = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \land \neg \forall w \in \text{CON}(e_{\text{pre}}) : [S](w) \land \forall w \in \text{CON}(e_{\text{post}}) : [S](w) \]

When \textit{decide} takes an interrogative...

\[ [\text{Jo \, decide} \text{\_QUEST \, ?S}] = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \land \forall p \in [\text{?S}] : \neg \forall w \in \text{CON}(e_{\text{pre}}) : p(w) \]
When \texttt{decide} takes a declarative...

\[
\text{[Jo decide}_{\text{PROP} \ S]} = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \\
\quad \land \neg \forall w \in \text{CON}(e_{\text{pre}}) : \text{[S]}(w) \\
\quad \land \forall w \in \text{CON}(e_{\text{post}}) : \text{[S]}(w)
\]

When \texttt{decide} takes an interrogative...

\[
\text{[Jo decide}_{\text{QUES} \ ?S]} = \exists e, e_{\text{pre}}, e_{\text{post}} : \text{DECISION}(e, e_{\text{pre}}, e_{\text{post}}) \land \text{AGENT}(j, e) \\
\quad \land \forall p \in \text{[?S]} : \neg \forall w \in \text{CON}(e_{\text{pre}}) : p(w) \\
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\]
Remaining question
Where does the **intention** entailment come from?
Remaining question
Where does the intention entailment come from?

Possible answer
Decision pre-states just are intentional states
Evidence
Always(?) intention for infinitivals

(63) Jo \{determined, decided, chose\} whether to leave.
Evidence

Always(?) intention for infinitivals

(63) Jo {determined, decided, chose} whether to leave.

Otherwise dependent on content of finite complement

(64) a. Jo decided whether she would leave.
    b. Jo decided whether Bo could leave.
Remaining question
Where does the intention entailment come from?

Possible answer
Decision pre-states just are intentional states

Answer
Modality in the embedded clause (Bhatt, 1999; Grano, 2012; Wurmbrand, 2014; White, 2014)
Question
Why would pre-state entailments be like veridicality entailments?
Question
Why would pre-state entailments be like veridicality entailments?

Relevant observation
Pre-state entailments are generally backgrounded (cf. start, stop)

(Roberts, 1996; Simons, 2001; Abusch, 2002; Simons et al., 2010; Abusch, 2010; Abrusán, 2011; Romoli, 2011; Anand and Hacquard, 2014)
Tentative generalization

No monomorphemic verb characterizes a relation between an informative pre-state and an inquisitive post-state (*undecide)
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Possible exception: forget
A generalization

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Relevance
Suggests an asymmetry between pre-states and post-states that we don’t currently encode
A generalization

Tentative generalization
No monomorphemic verb characterizes a relation between an informative pre-state and an inquisitive post-state (*undecide)

Possible exception: forget

Relevance
Suggests an asymmetry between pre-states and post-states that we don’t currently encode

Suggestion
Whatever gives rise to pre-state backgrounding for other CoS predicates also gives rise to this asymmetry
Future directions

Direction 1
Reducing the relationship between veridicality and Q-agnosticism to a relationship between CoMS and Q-agnosticism
Future directions

**Direction 1**
Reducing the relationship between veridicality and Q-agnosticism to a relationship between CoMS and Q-agnosticism

**Direction 2**
Explaining remaining nonveridicals in terms of event structure
Observation
Many verbal veridicals besides the stative *know* are CoMS
remember, forget, discover, find out, figure out, realize, recognize, ...
Reducing to CoMS

Observation
Many verbal veridicals besides the stative \textit{know} are CoMS
remember, forget, discover, find out, figure out, realize, recognize, ...

Timid reduction
Most verbal veridicals explained by CoMS; \textit{know} stipulated
Reducing to CoMS

Observation
Many verbal veridicals besides the stative know are CoMS
remember, forget, discover, find out, figure out, realize, recognize, ...

Timid reduction
Most verbal veridicals explained by CoMS; know stipulated

Aggressive reduction
Know has a bipartite structure involving a knowledge state (fact contents) and a belief state (proposition contents) (Kratzer, 2002)
Conclusion
How are a verb’s **semantic properties** related to its **syntactic distribution**? Gruber 1965; Fillmore 1970; Zwicky 1971; Jackendoff 1972; Grimshaw 1979, 1990; Pesetsky 1982, 1991; Pinker 1989; Levin 1993
Overarching question

How are a verb’s **semantic properties** related to its **syntactic distribution**? Gruber 1965; Fillmore 1970; Zwicky 1971; Jackendoff 1972; Grimshaw 1979, 1990; Pesetsky 1982, 1991; Pinker 1989; Levin 1993

**Semantic Properties**

\[
\begin{array}{c}
+ \text{TELIC} \\
- \text{DURATIVE} \\
- \text{STATIVE} \\
\ldots \\
\end{array}
\]
How are a verb’s **semantic properties** related to its **syntactic distribution**? Gruber 1965; Fillmore 1970; Zwicky 1971; Jackendoff 1972; Grimshaw 1979, 1990; Pesetsky 1982, 1991; Pinker 1989; Levin 1993

**Semantic Properties**

- **TELIC**
- **DURATIVE**
- **STATIVE**
  
- **...**

**Syntactic Distribution**

\[
\begin{aligned}
&[\__\text{NP}] \\
&[\__\text{S}] \\
&[\__\text{VP}] \\
&... \\
\end{aligned}
\]
What could matter?

Factors claimed to affect the distribution of nominals
Sensitive to event structural properties like stativity, telicity, durativity, causativity, transfer, etc. (see Levin and Rappaport Hovav 2005)
Factors claimed to affect the distribution of **nominals**
Sensitive to event structural properties like **stativity**, **telicity**, **durativity**, **causativity**, **transfer**, etc. (see Levin and Rappaport Hovav 2005)

Factors claimed to affect the distribution of **clauses**
Hypothesis
The distribution of clauses is determined by the same semantic properties as the distribution of nouns (cf. Koenig and Davis 2001)
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Not properties dependent on having propositional content

(White and Rawlins, 2017, 2018)
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The distribution of clauses is determined by the same semantic properties as the distribution of nouns (cf. Koenig and Davis 2001)

Not properties dependent on having propositional content

(White and Rawlins, 2017, 2018)

Intuition

Predicates that take clauses characterize neo-Davidsonian eventualities, like any other verb. (Kratzer 2006; Hacquard 2006; Moulton 2009; Anand and Hacquard 2013, 2014; Rawlins 2013; Bogal-Allbritten 2016; White and Rawlins 2016b a.o.)
Case study

Question
How direct is the relationship between content-dependent properties and syntactic distribution?
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Focus
Two content-dependent properties – factivity and veridicality – that are argued to determine selection of interrogatives & declaratives.
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Two content-dependent properties – factivity and veridicality – that are argued to determine selection of interrogatives & declaratives

Claim
There is no direct relationship between factivity and veridicality (qua semantic properties) and syntactic distribution
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The relationship is mediated by event structural properties.
Thanks!
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Data available at

megaattitude.io decomp.io


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