The typology of veridicality inferences

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Slides available at aaronstevenwhite.io

Data available at megaattitude.io

Introduction

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

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Semantic Properties

$$\begin{bmatrix} + & \text{TELIC} \\ - & \text{DURATIVE} \\ - & \text{STATIVE} \\ & \ldots \end{bmatrix}$$

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Semantic Properties ⟷ Syntactic Distribution

$$\begin{bmatrix} + & \text{TELIC} \\ - & \text{DURATIVE} \\ - & \text{STATIVE} \\ & \ldots \end{bmatrix} \qquad \begin{Bmatrix} [\_\_\_\text{NP}] \\ [\_\_\_\text{S}] \\ [\_\_\_\text{VP}] \\ \ldots \end{Bmatrix}$$

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)

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Factors claimed to affect the distribution of clauses

Sensitive to 'content-dependent' properties like representationality, preferentiality, factivity/veridicality, communicativity, etc. Bolinger 1968; Hintikka 1975; Hooper 1975; Stalnaker 1984; Farkas 1985; Villalta 2000, 2008; Kratzer 2006; Egré 2008; Scheffler 2009; Moulton 2009; Anand and Hacquard 2013; Rawlins 2013; Portner and Rubinstein 2013; Anand and Hacquard 2014; Spector and Egré 2015; Bogal-Allbritten 2016; Theiler et al. 2017

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Possibly indirectly, via e.g. neo-Davidsonian event decomposition Kratzer 2006; Hacquard 2006; Moulton 2009; Anand and Hacquard 2013, 2014; Rawlins 2013; Bogal-Allbritten 2016; White and Rawlins 2016b a.o.

Our prior work

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

Veridicality and 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.

Veridicality and factivity

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(2) a. Jo didn't **know** that Bo was alive $\rightarrow$ Bo was alive

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(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

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But there are strong empirical reasons to believe they do not.

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

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But there are strong empirical reasons to believe they do not.

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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.

(3) a. Jo_i forgot that she_i bought tofu.

Variability in veridicality

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Variability in veridicality

(3) a. Jo$_i$ forgot that she$_i$ bought tofu. $\rightarrow$ Jo bought tofu.
b. Jo forgot to buy tofu.

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(3) a. Jo_i forgot that she_i bought tofu. $\rightarrow$ Jo bought tofu.
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Is there evidence that this variability correlates with distribution?

Today's talk

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Empirical contributions

1. Dataset capturing the variability of factivity and veridicality across finite and infinitival complement types.

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2. Data-driven typology of inference patterns across comp. types.

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Empirical contributions

1. Dataset capturing the variability of factivity and veridicality across finite and infinitival complement types.
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Analytical contributions

1. Inference pattern typology explains some parts of syntactic distribution reasonably well, but far from perfect.

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Empirical contributions

1. Dataset capturing the variability of factivity and veridicality across finite and infinitival complement types.
2. Data-driven typology of inference patterns across comp. types.

Analytical contributions

1. Inference pattern typology explains some parts of syntactic distribution reasonably well, but far from perfect.
2. More likely that the veridicality-distribution relationship is indirect, mediated by fine-grained verb class.

Outline

Introduction

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A new veridicality dataset

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Predicting distribution using veridicality

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Conclusion

A new veridicality dataset

Aim

Measure syntactic distribution and veridicality inferences across a wide variety of syntactic contexts.

Measuring veridicality and distribution

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MegaAcceptability dataset (White and Rawlins, 2016a)

Ordinal (1-7 scale) acceptability ratings for 1000 clause-embedding verbs in 50 syntactic frames

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MegaVeridicality dataset (White and Rawlins, 2018)

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

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
○	○	○	○	○	○	○

Veridicality judgment task

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
○	○	○	○	○	○	○

Stimuli

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

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- [NP _ed for NP to VP] (184 verbs)

Stimuli

NP _ed for NP to VP

(5) a. Someone wanted for a particular thing to happen.
    b. Someone didn't want for a particular thing to happen.

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

Stimuli

NP _ed for NP to VP

(5) 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]

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

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NP _ed for NP to VP

(5) 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]

(6) 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]

(7) a. Someone believed a particular person to have a particular thing.
    b. Someone didn't believe a particular person to have 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 NP to VP[-ev]] (128 verbs)
- [NP was _ed NP to VP[+ev]] (278 verbs)

Stimuli

NP was _ed to VP[+ev]

(8) a. A particular person was ordered to do a particular thing.
b. A particular person wasn't ordered to do a particular thing.

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

Stimuli

NP was _ed to VP[+ev]

(8) 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]

(9) a. A particular person was overjoyed to have a particular thing.
    b. A particular person wasn't overjoyed to have a particular thing.

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

Stimuli

NP _ed to VP[+ev]

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

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

Stimuli

NP _ed to VP[+ev]

(10) 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]

(11) a. A particular person hoped to have a particular thing.
b. A particular person didn't hope to have a particular thing.

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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)

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Applied to both veridicality and acceptability judgments.

Results

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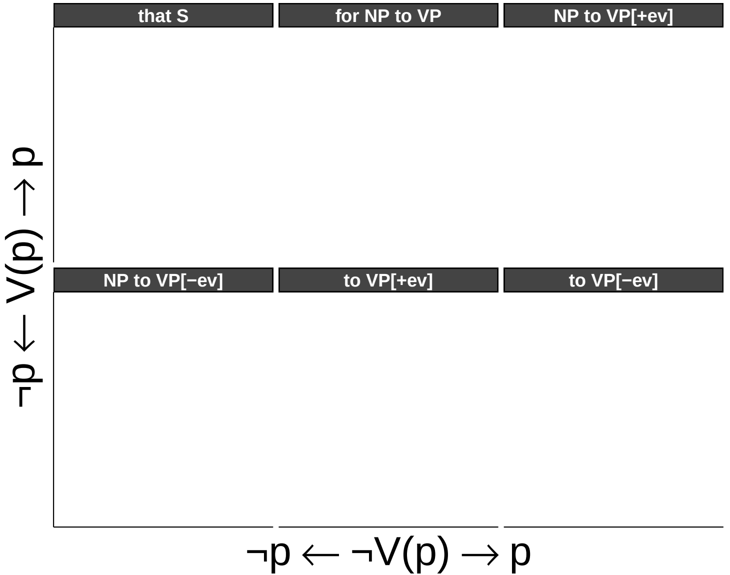
Applied to both veridicality and acceptability judgments.

Intuition

Like *z*-scoring, but better models response behavior.

Data overview

Results

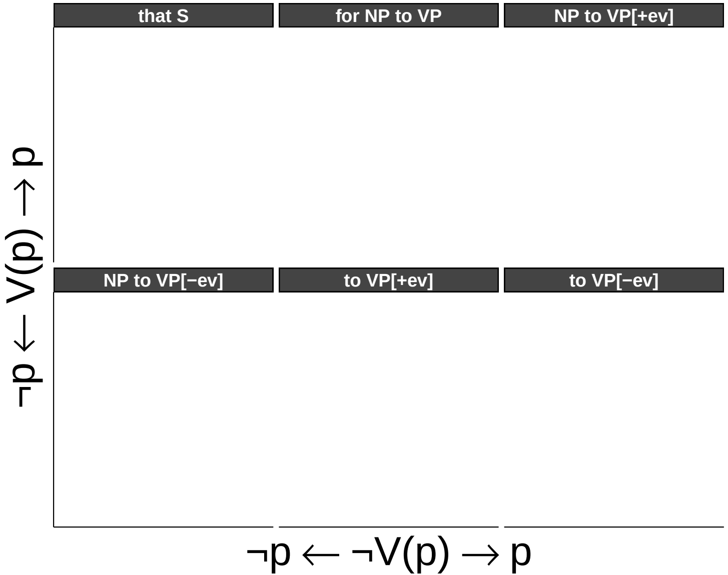

that S
for NP to VP
NP to VP[+ev]
NP to VP[−ev]
to VP[+ev]
to VP[−ev]
¬p ← V(p) → p
¬p ← ¬V(p) → p

Results

Example: x-axis

A particular person didn't forget to do a particular thing.

Results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Results

Example: *x*-axis

A particular person didn't forget to do a particular thing.

Results

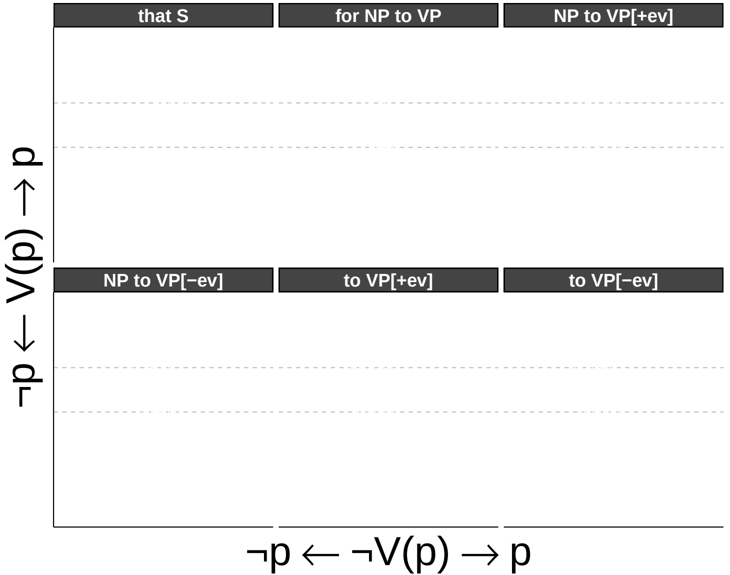
Example: *x*-axis

A particular person didn't forget to do a particular thing.

Example: *y*-axis

A particular person forgot to do a particular thing.

Results



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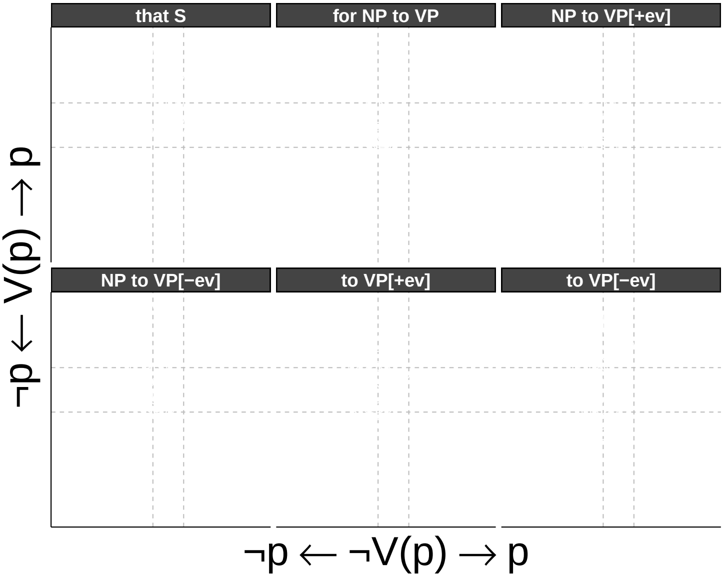

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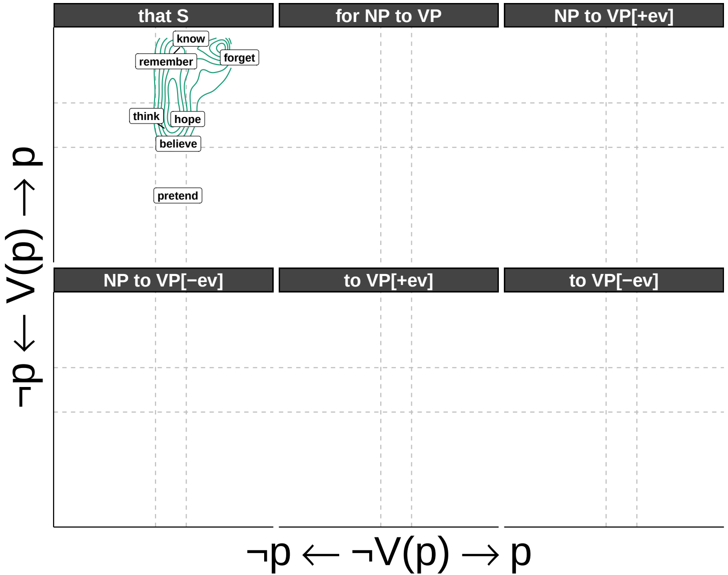
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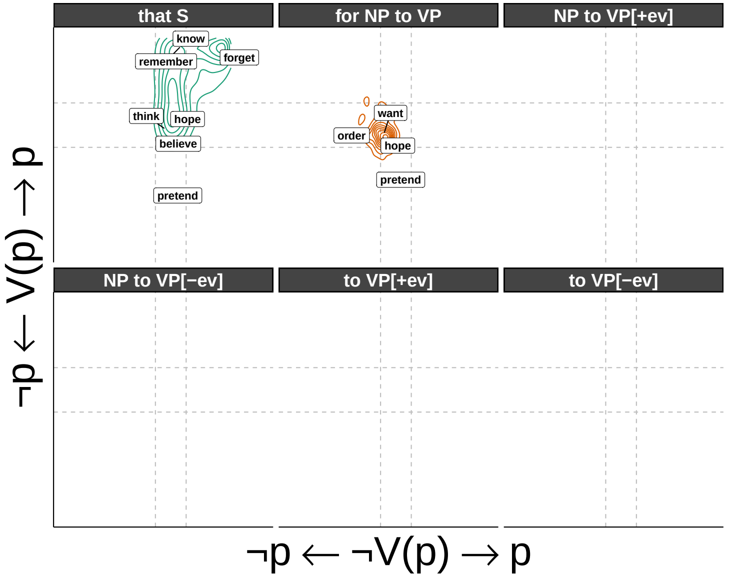
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want
order
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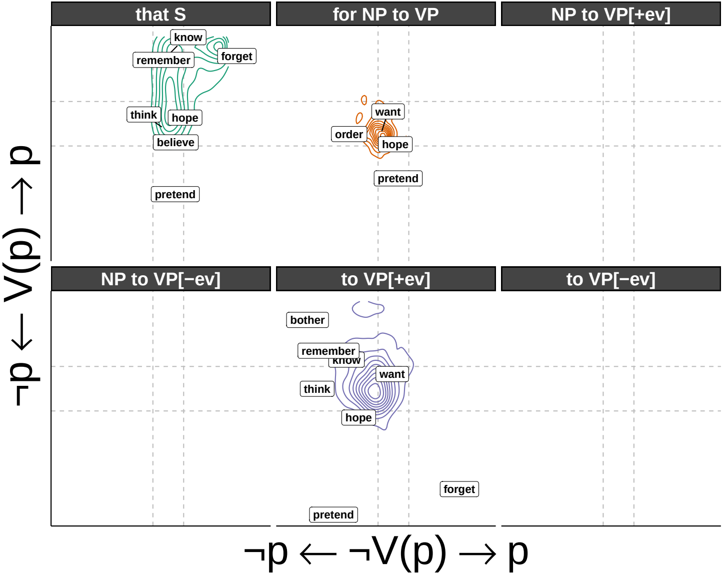

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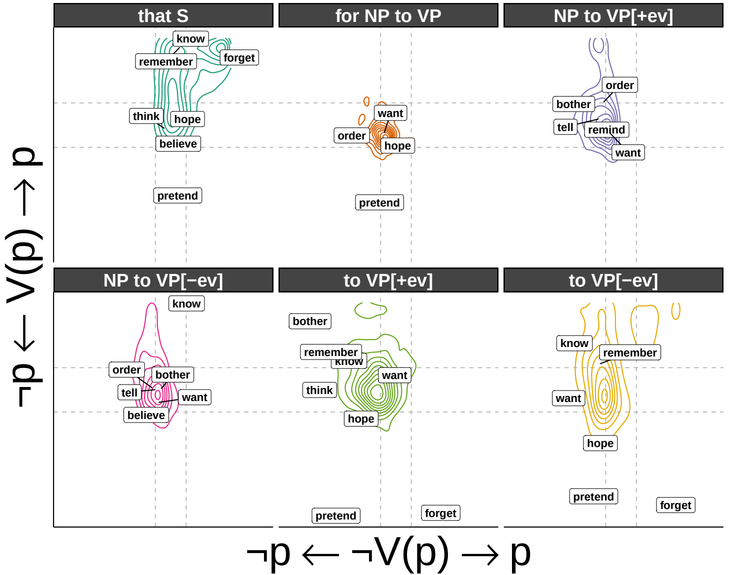

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order
bother
tell
remind
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Predicting distribution using veridicality

Preliminaries

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).

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Method

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.

Preliminaries

Goal

Extract patterns of inference – e.g. factive, veridical, or implicative.

Approach

Use an automated method to discover inference patterns across verbs by decomposing veridical data into underlying factors.

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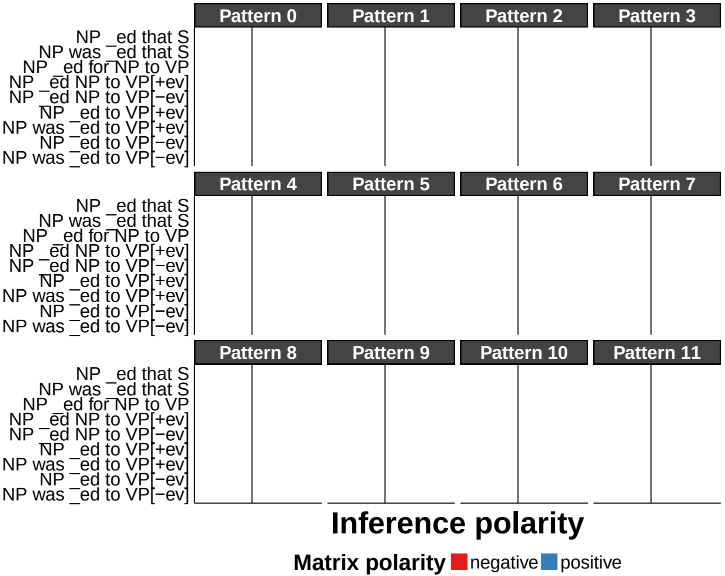
(Ask about specifics after the talk.)

Inference patterns



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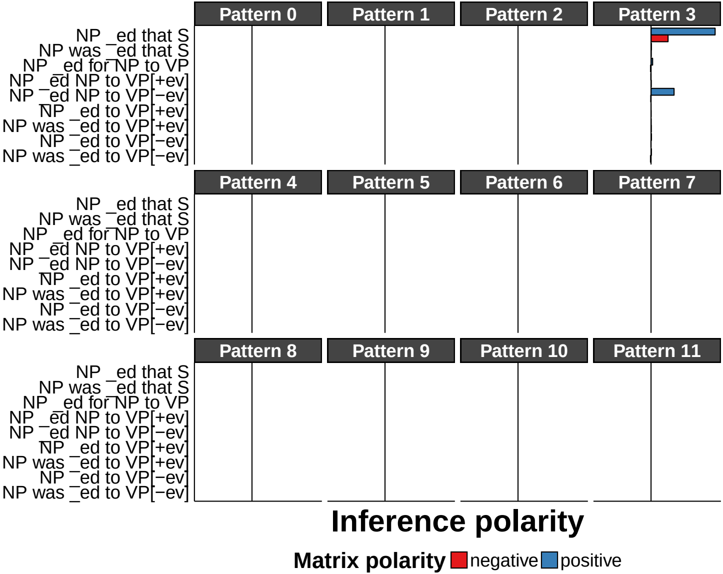

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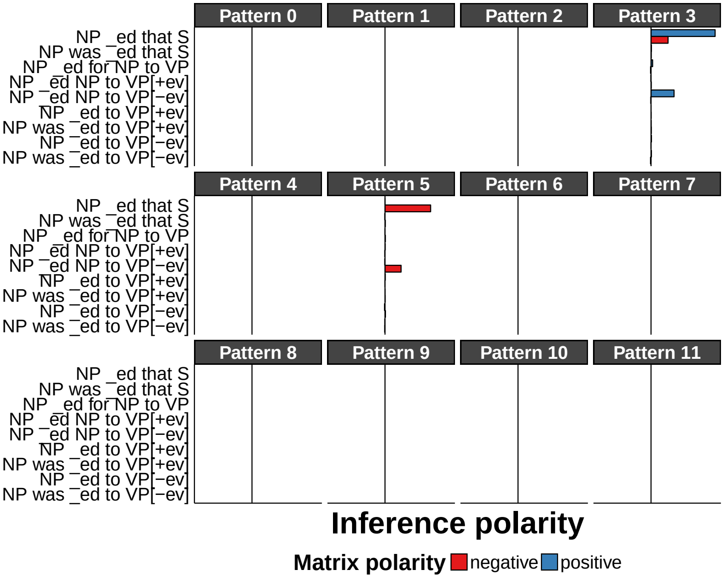

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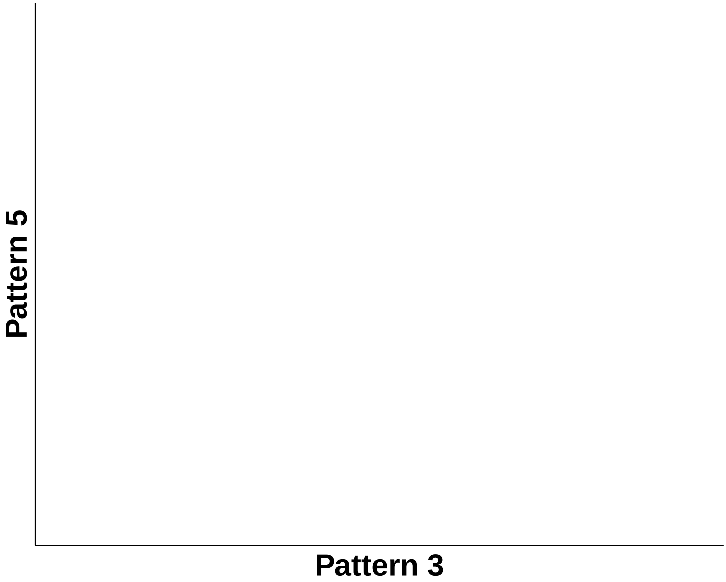

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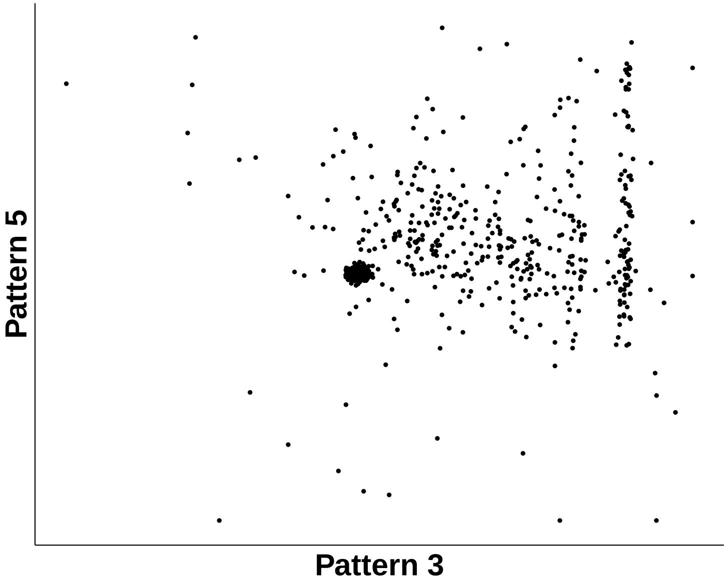
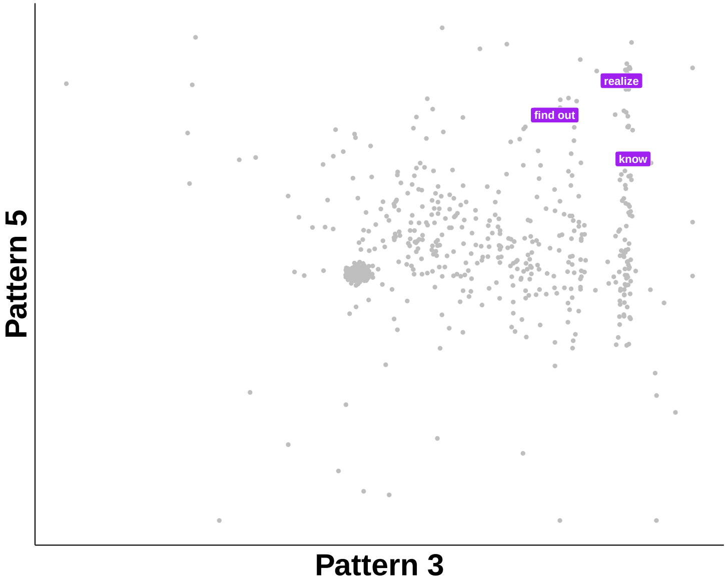


Inference patterns: factivity/veridicality



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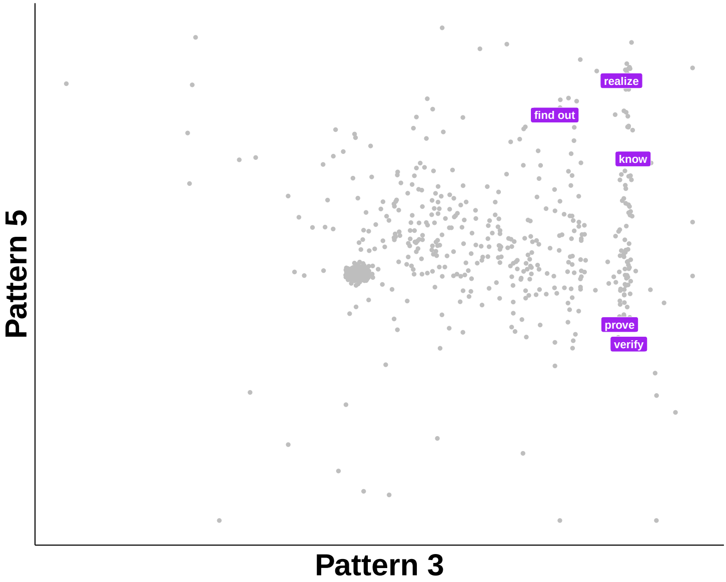

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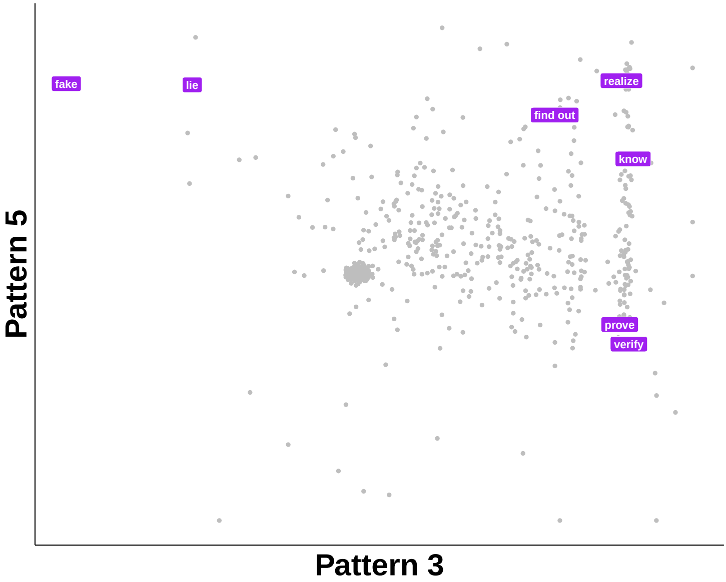

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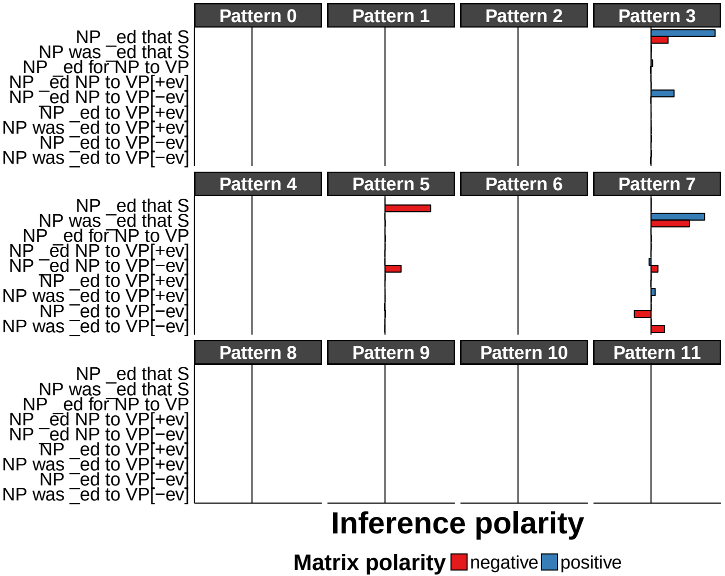

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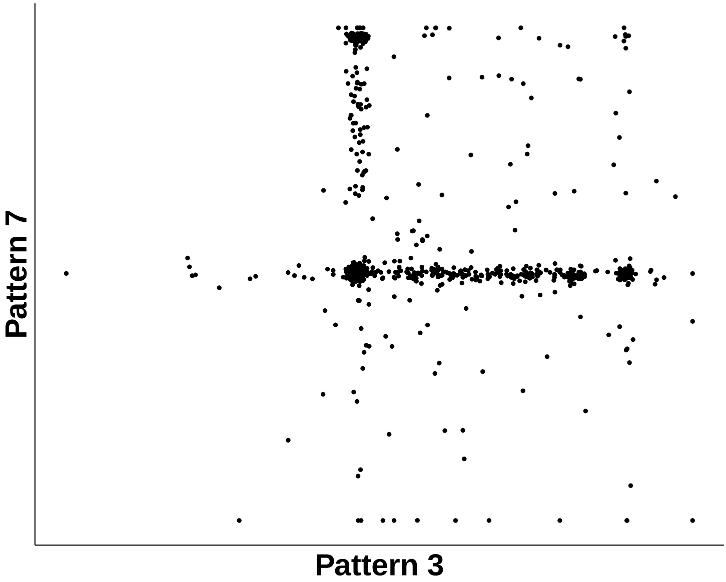

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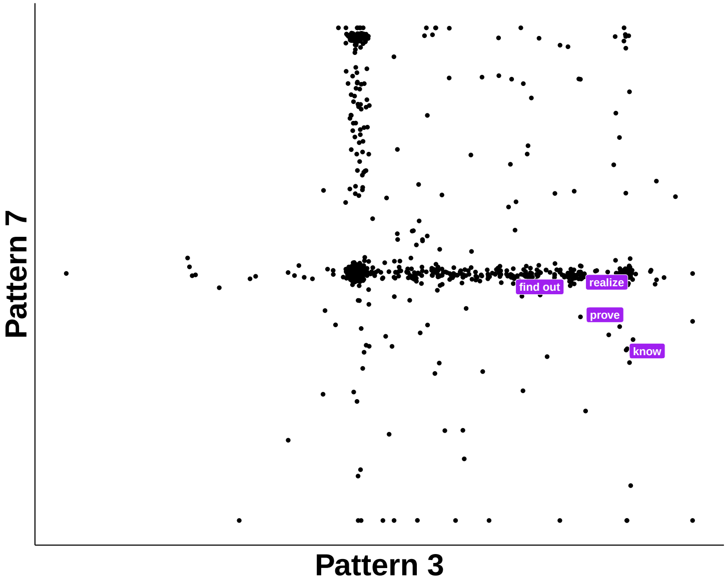

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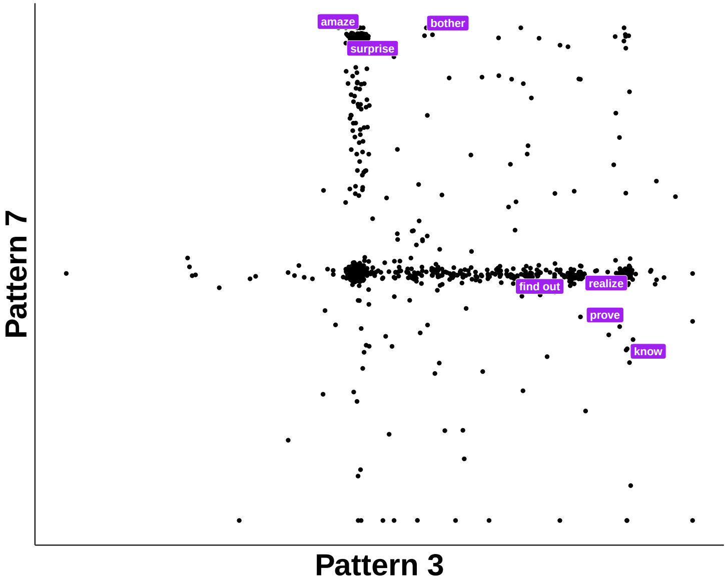

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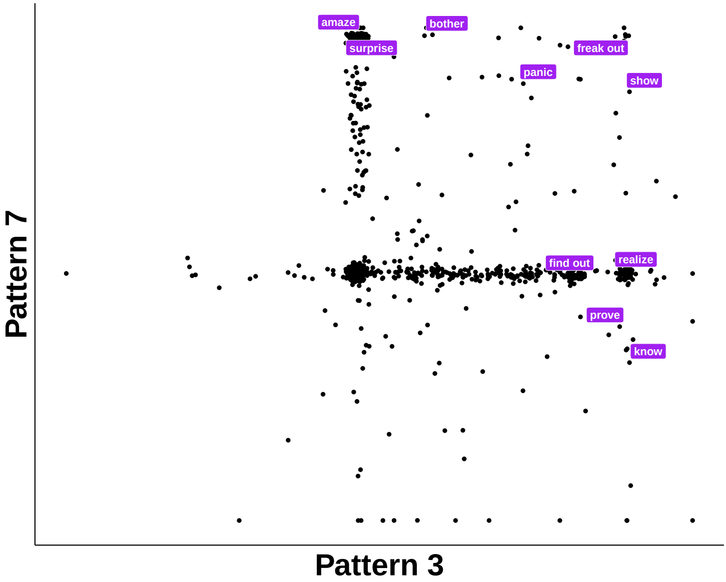

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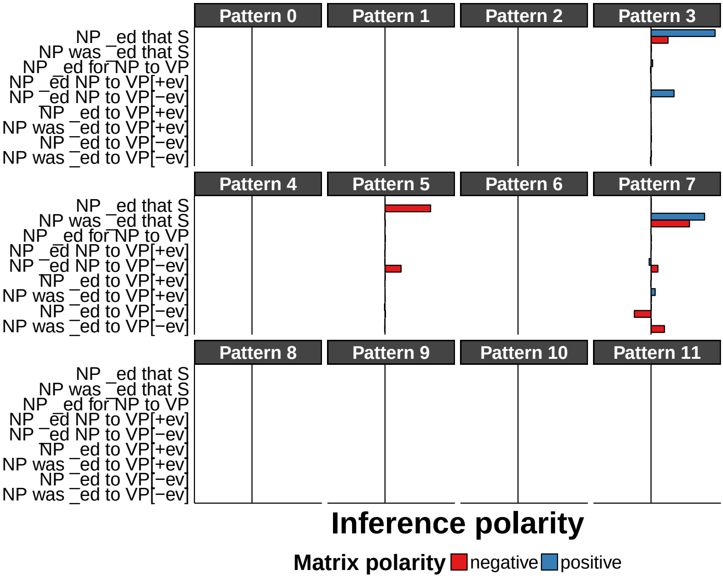

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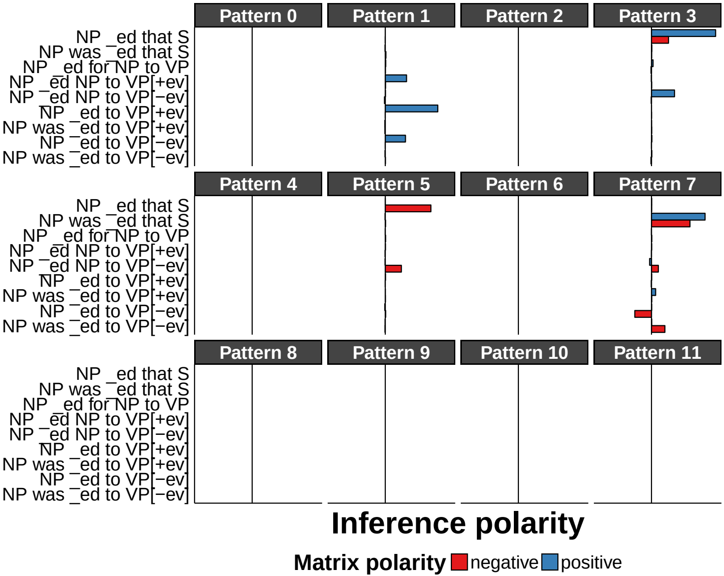

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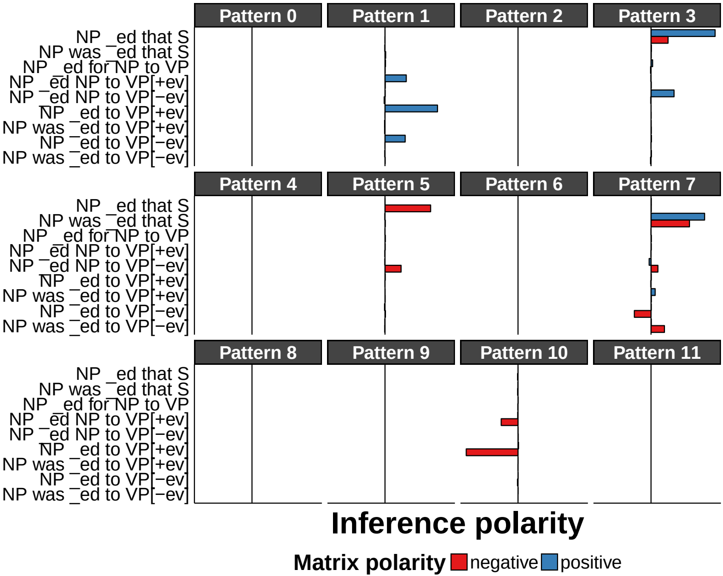

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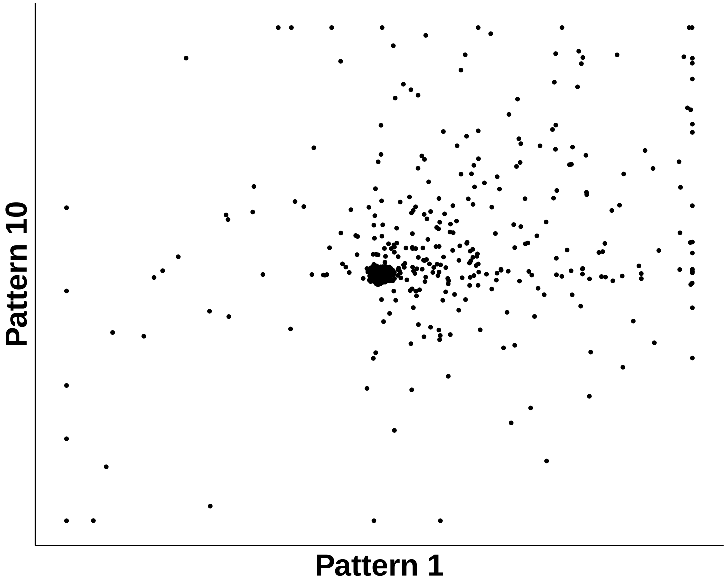

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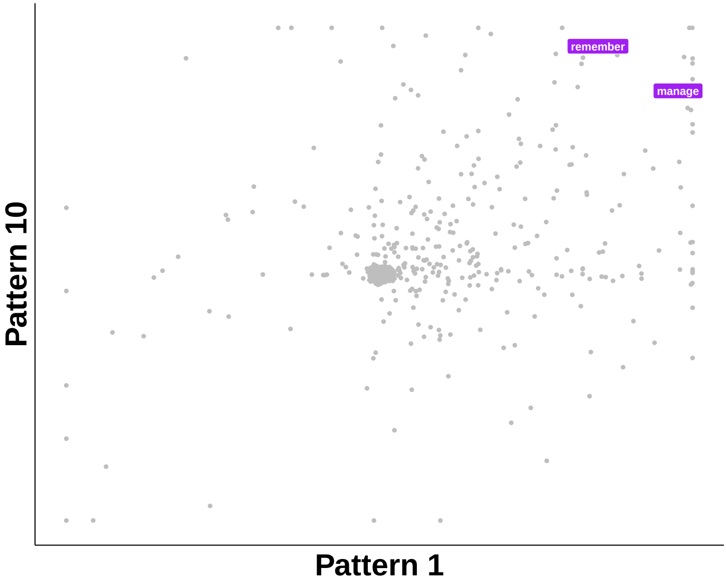

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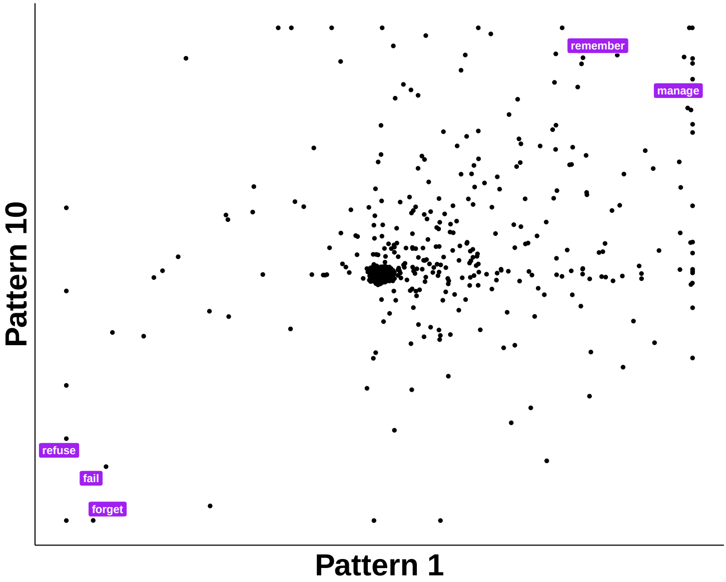

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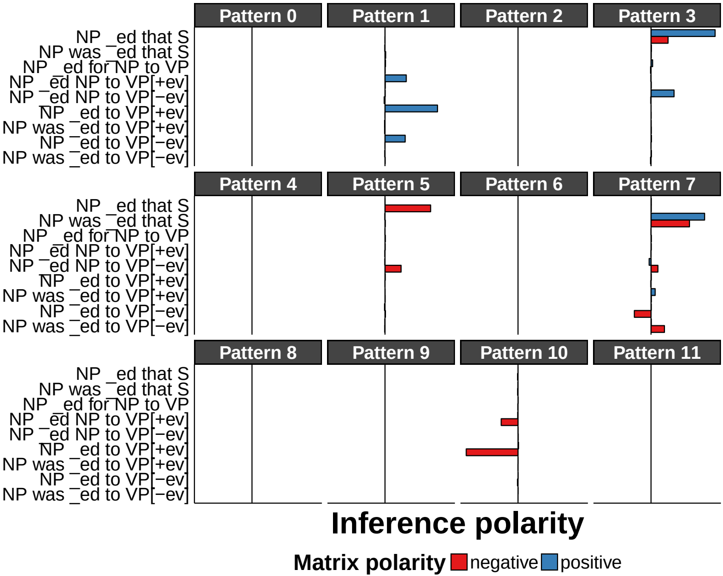

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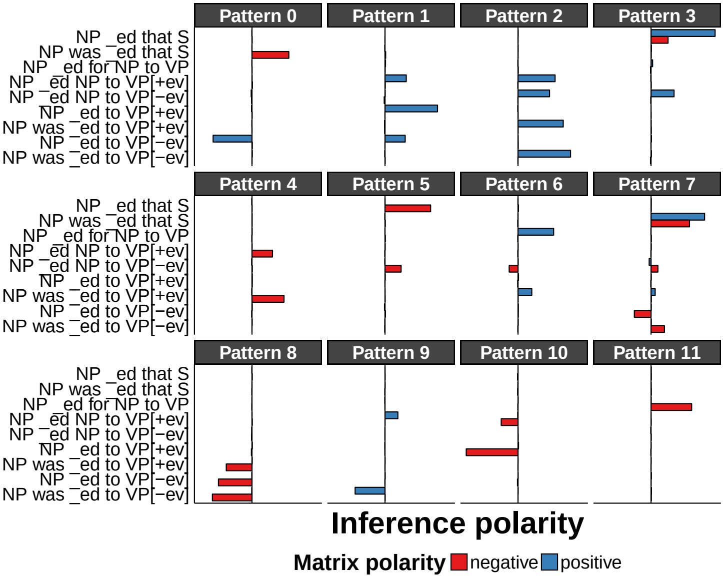

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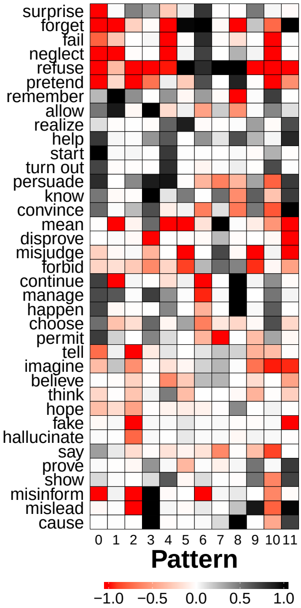

Predicting distribution from inference

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Can we predict syntactic distribution directly from veridicality inference patterns?

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

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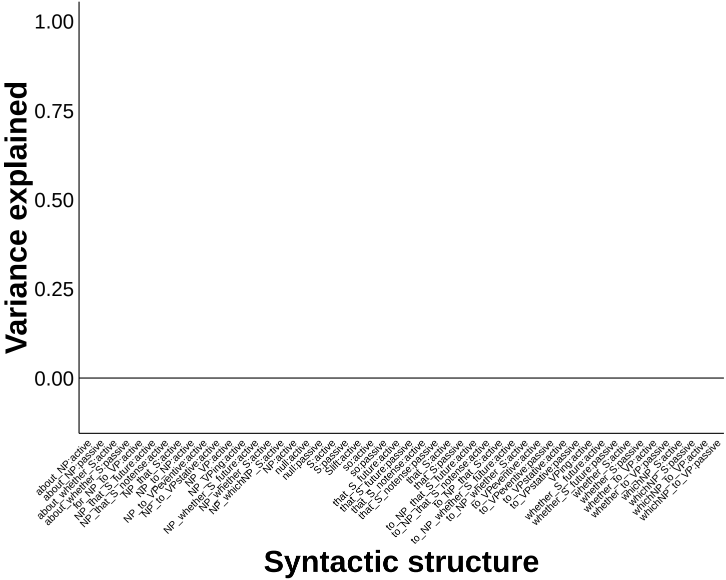
Learn optimal mapping from veridicality inference patterns to syntactic distribution using cross-validated ridge regression.

Finding

Across all frames in MegaAcceptability, this mapping explains about 20% of the variance in the acceptability judgments.

Predicting distribution from inference



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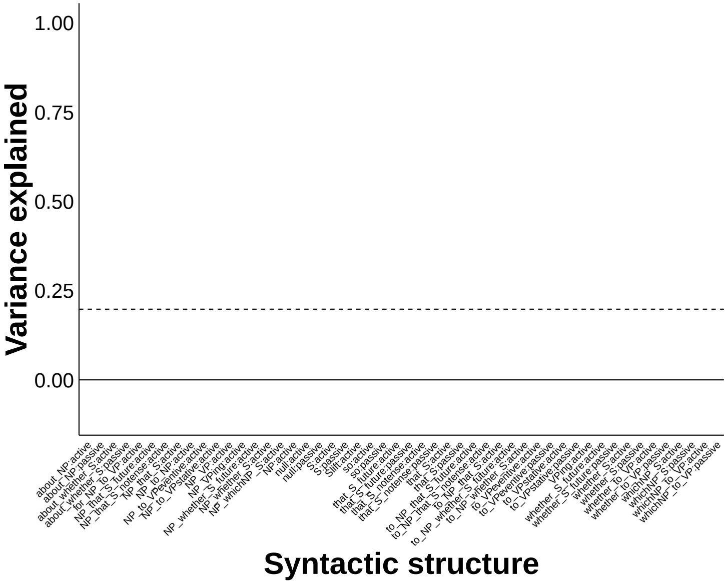

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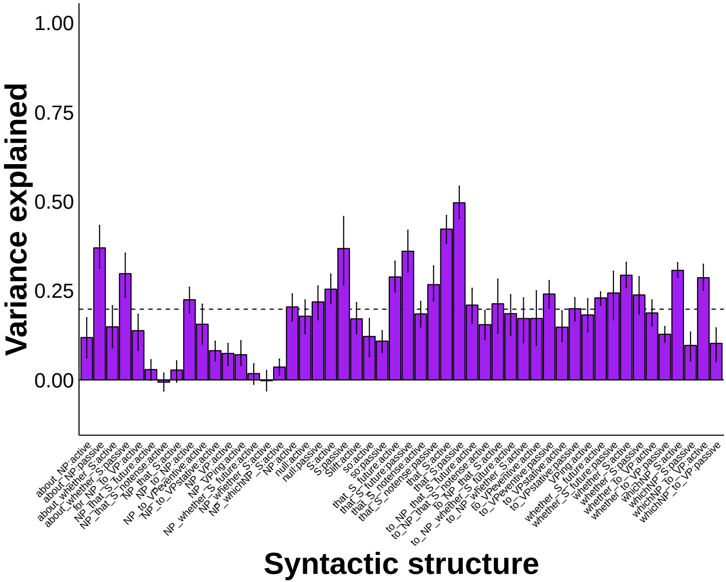

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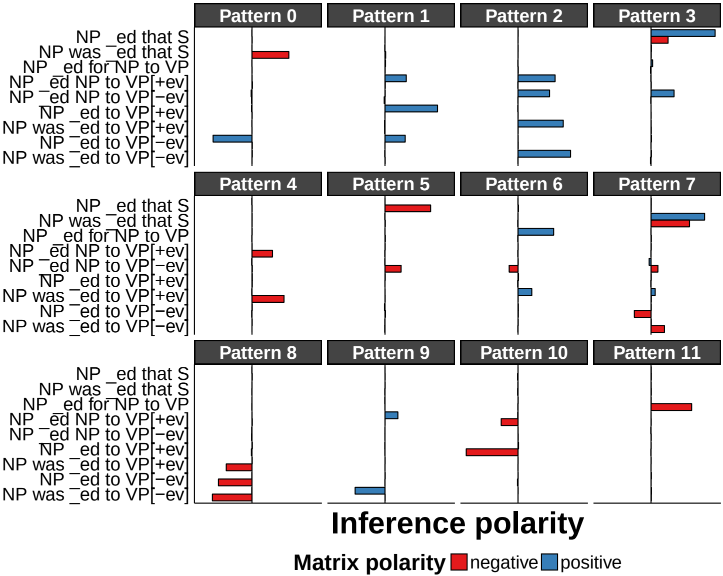

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Predicting distribution from inference

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.
2. Not nearly enough information to base a generalization on.

Exploratory analysis

Question

What drives the relationship between veridicality and distribution?

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

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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.

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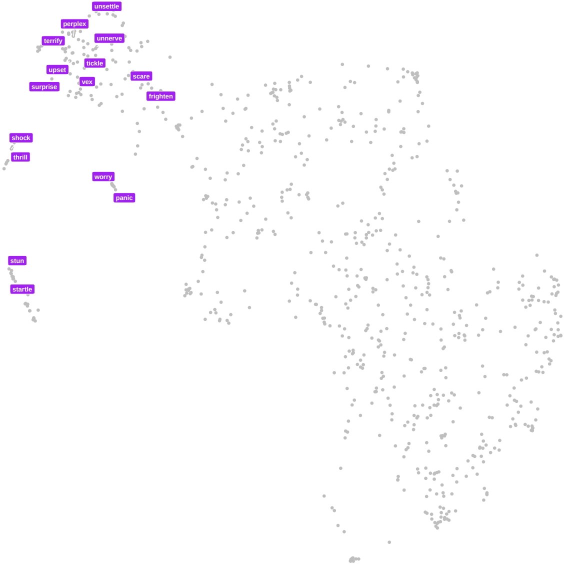
Approach

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



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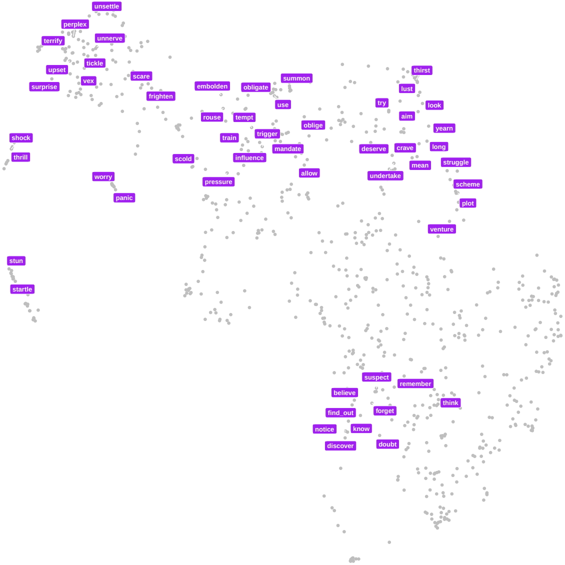

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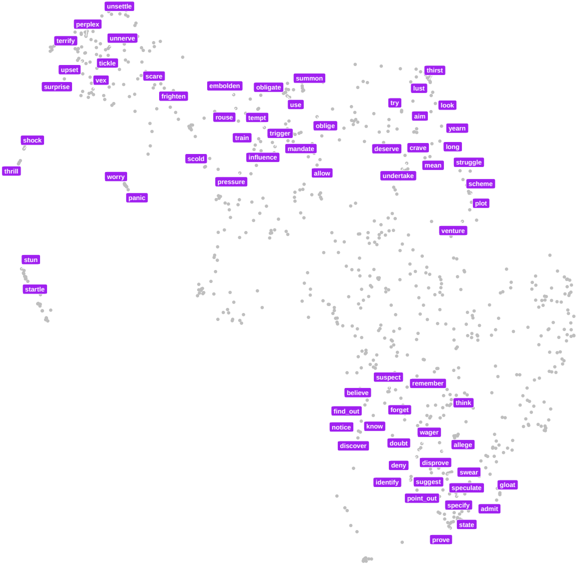

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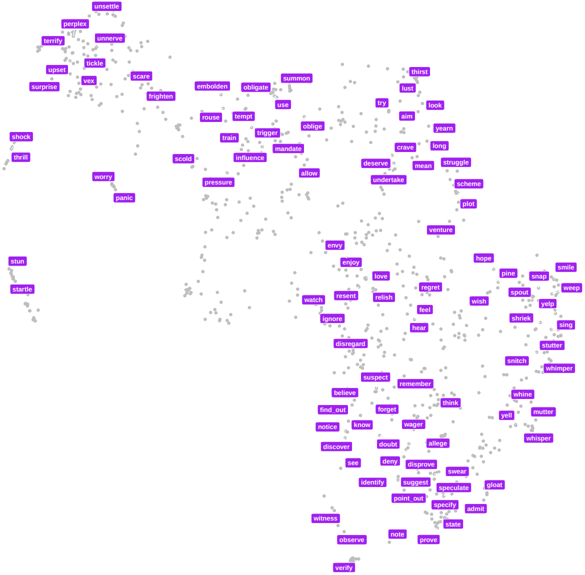

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1. Inference pattern typology explains some parts of syntactic distribution reasonably well, but far from perfect.

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Empirical contributions

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2. Data-driven typology of inference patterns across comp. types.

Analytical contributions

1. Inference pattern typology explains some parts of syntactic distribution reasonably well, but far from perfect.
2. More likely that the veridicality-distribution relationship is indirect, mediated by fine-grained verb class.

Future directions

Big remaining question

How are inference patterns represented in the lexicon?

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Possibility 1

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

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Possibility 2

More abstract semantic properties relevant to thematic roles – e.g. affectedness, existence, creation/destruction, ...

Thanks!

Acknowledgements and resources

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Data available at **megaattitude.io**

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