The interplay of linguistic & contextual inferences

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Overview

The original task for pragmatics

- Investigate the way language shapes, and is shaped by, the Questions Under Discussion (QUDs).
- Integrate the results with those of syntax and semantics, machine learning, and robotics.

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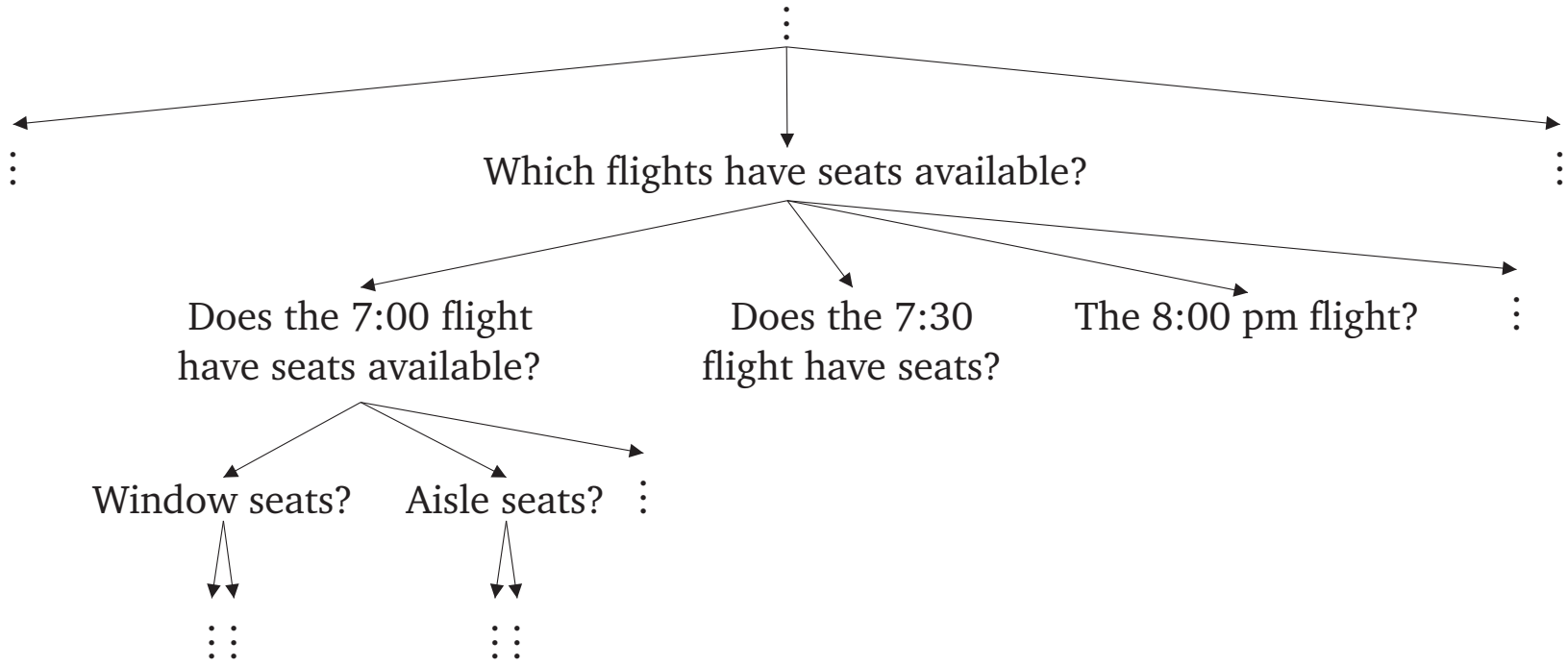
Progress

- Ongoing corpus collection efforts provide the emprical foundations.
- We implement pragmatic theories as sets of weighted logical statements, which are interpreted in graphical models.
- The theories provide inferences about both directions of influence: language to context, context to language.
- They also support large-scale lexical pragmatics.

Outline

1. QUDs and robust utterance understanding
2. Pragmatics in Markov Logic
3. Lexical pragmatics
4. Connections with other team members
5. Prospects

Questions Under Discussion



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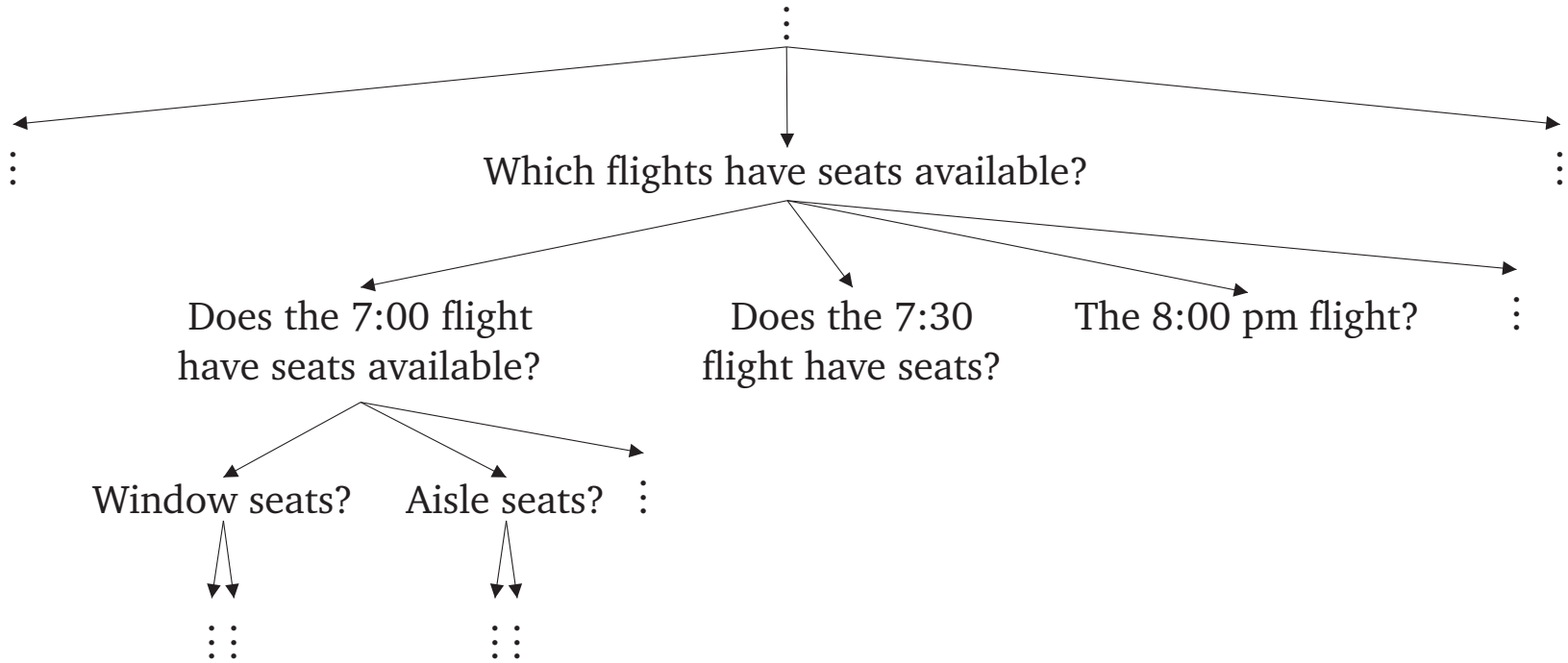


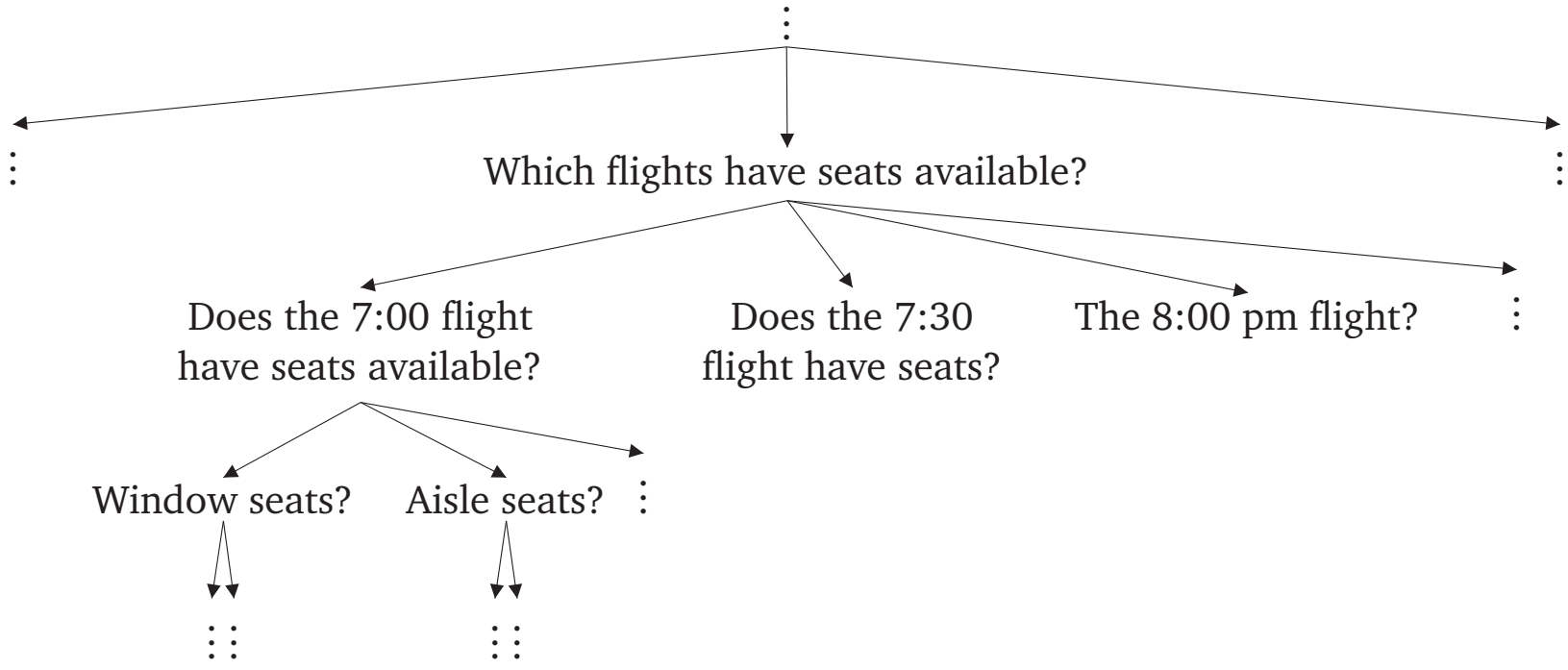
Example

Traveler: Does the 7:30 flight have seats available?

Agent: No, but the 7:00 flight has some window seats.

Traveler: Are they in an exit row?

Questions Under Discussion



Example

Traveler: Are there aisle seats available on the 7:30 flight?

Agent: There are **seats** available.

Partition semantics and lattice structures

Definition (Declaratives)

$$[\![\varphi]\!]^g = \{\langle w, w' \rangle \mid \forall d \in D^n : [\![\varphi]\!]^{g[\vec{x}^n \mapsto d]}(w) = [\![\varphi]\!]^{g[\vec{x}^n \mapsto d]}(w') = \mathsf{T}\}$$

Definition (Interrogatives)

$$[\![?\vec{x}^n\varphi]\!]^g = \{\langle w, w' \rangle \mid \forall d \in D^n : [\![\varphi]\!]^{g[\vec{x}^n \mapsto d]}(w) = [\![\varphi]\!]^{g[\vec{x}^n \mapsto d]}(w')\}$$

Definition (Entailment)

$$Q \text{ entails } Q' \text{ iff } Q \subseteq Q'$$

Definition (Granularity)

$$Q \sqsubseteq Q' \text{ iff } \forall q \in Q \; \exists q' \in Q' \; q \subseteq q'$$

Implicit QUDs and quantificational domains

Fast and cheap corpus collection

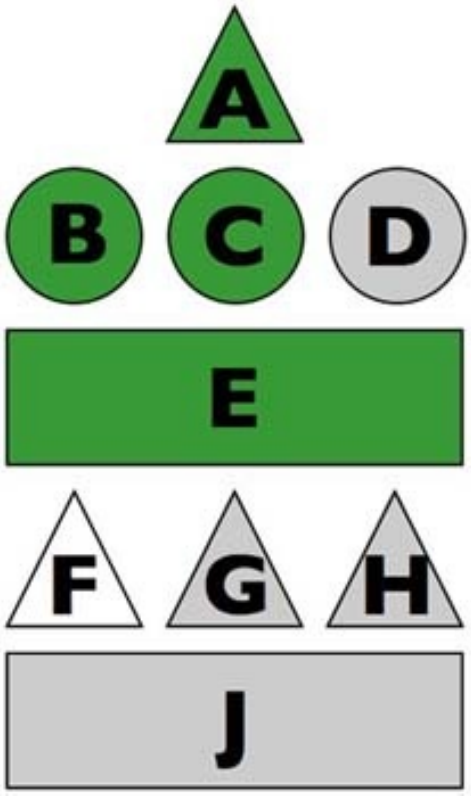
5,000 question–answer pairs concerning the simple context at right.

1. Are the triangles green?

"Yes":	10%
"No":	16%
Other:	24%

2. I am curious about the things above shape C. Are the triangles green?

"Yes":	36%
"No":	4%
Other:	9%

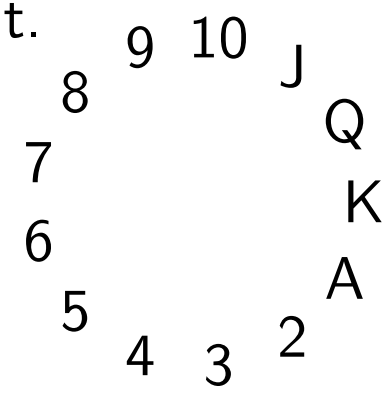


Task-like QUDs and referential underspecification

```
Player 2:  Look for 2.
Player 1:  and the 3?
```

Task-like QUDs and referential underspecification

Task: Find six consecutive cards of the same suit.

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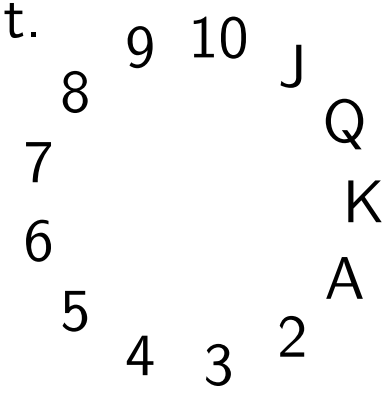


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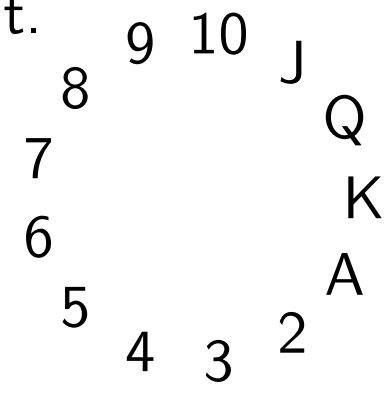

Basic method

For any nominal, pick the referent(s) that maximize relevance with respect to the task.

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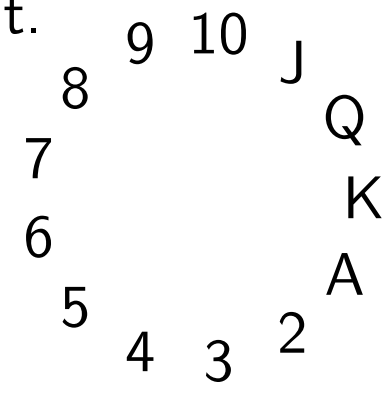

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Results (Potts 2009)

Correct inference	164	(95%)
Incorrect inference	8	(5%)
Total	172	

Intonation and implicit QUD structure

Bart passed BART$_{\mathbf{F}}$ passed. Bart PASSED$_{\mathbf{F}}$

Intonation and implicit QUD structure

Did Bart pass?	Who passed?	What did Bart do?
↑	↑	↑
Bart passed	BART$_{\mathbf{F}}$ passed.	Bart PASSED$_{\mathbf{F}}$

Intonation and implicit QUD structure

Pragmatics in Markov Logic

Alchemy

- Software developed by Pedro Domingos and colleagues to conduct experiments with probabilistic weighted logics.
- Performs a variety of tasks in structured learning.
- Efficiently searches large spaces of possible worlds.
- Delivers formulae with probabilities attached.

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Advantages

- Quick for running experiments.
- Can grapple with large numbers of predicates (assuming they are not too interconnected).
- Intelligible; theories take the form of sets of logical formulae.
- Permits an analytic devision between general pragmatic pressures and context-specific information.

Model

Given a set of constants, the probability of a given context c is defined in terms of the logical statements j and their associated weights w_j:

$$P(X = c) = \frac{1}{Z} \exp\left(\sum_j w_j f_j(c)\right)$$

A simple example

Switchboard example (de Marneffe, Grimm & Potts 2009)

A: Are they [your kids] little?

B: I have a seven-year-old and a ten-year-old.

Learning weights

```
Little(x)
Age(x, y) ^ Little(x)
Age(x, u) ^ Age(y, v) ^ (v >= u) ^ Little(y) => Little(x)
```

⇒ Stanford typed dependencies ⇒

```
Age(X21, 10)    Little(X21)
Age(X22, 7)     Little(X22)
Age(X23, 8)     Little(X23)
Age(X35, 10)   !Little(X35)
Age(X36, 18)   !Little(X36)
Age(X37, 14)   !Little(X37)
```

General pragmatic pressures

- Domain independent, but subject to reweighting in different contexts.
- Delimit the set of admissible contexts, by governing inferences based on shared assumptions about cooperative linguistic behavior rather than basic world knowledge.
- Center around the QUDs.
- Govern hearer inferences and, in turn, speaker utterances.
- Weights should be estimated in human-subjects experiments.

General pragmatic pressures: Some examples

```
// Quality
AssertTrue(p) => True(p).
True(p) => AssertTrue(p).


// Relevance
AssertTrue(p) => (Qud(q) ^ About(p, q)).
10 (Qud(q) ^ About(p, q)) => AssertTrue(p)


// Quantity
AssertTrue(p) => !AddresseeBelieve(p).
10 !AssertTrue(p) => AddresseeBelieve(p)
```

General pragmatic pressures: Some examples

```
// Addressee correction (quality).
10 AssertFalse(p) => (AddresseeBelieve(p) ^ !True(p))
10 (AddresseeBelieve(p) ^ !True(p)) => AssertFalse(p)


// Addressee correction (relevance).
10 AssertFalse(p) =>
   (AddresseeBelieve(p) ^ !True(p) ^ Qud(q) ^ About(p, q))


10 (AddresseeBelieve(p) ^ !True(p) ^
                  Qud(q) ^ About(p, q)) =>
                                   AssertFalse(p)
```

Challenges

Pragmatics is not first-order

Pragmatics involves reasoning about higher-order objects, in particular, QUDs, but Alchemy is not equipped for this. Over finite domains, the difficulties are surmountable but cumbersome.

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Defining complex properties

$$\varphi \Leftrightarrow (\psi_1 \cdots \psi n)$$

Tractable if n is small (around 2), but often intractable if n is around 8. This makes it hard to define complex properties.

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SUBTLE team to the rescue

FACTORIE is expressively unconstrained and allows the user to write intelligent search functions to deal with constraints like the above.

Lexical pragmatics: Vague predicates

What is likely to count as *little* for kids?

10 **year-old** mourned: 'He was just a good **little kid**'
<p>BLOOMINGTON -- It was a typical summer day for 10 **year-old** Travell Arrington: Out riding bikes with his siblings, cousin and
pantagraph.com/news/local/article_36ab118c-6bf8-11de-bd26-001cc4c03... - Cached

Democrats Forced 12-**Year-Old** to Lie
So you got a little 12 **year-old** going out there, telling a falsehood because the ... You made this **little kid** lie, you and your party. ...
rushlimbaugh.com/home/daily/site_101207/content/01125113.guest.html - Cached

What do you get a 14 **year old** boy who acts like a **little kid**?
A gift certificate to his favorite store.
answers.yahoo.com/question/index?qid=20081117151744AAngMdJ - 95k

Help creating a welcome to tell a minor league baseball team on ...
I am coaching 7-10 **year old** kids baseball team this summer and i am playing on taking them to see Midland Loons later this month. ...
answers.yahoo.com/question/index?qid=20090604142841AAoqSvr

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Age(X21, 10)    Little(X21)
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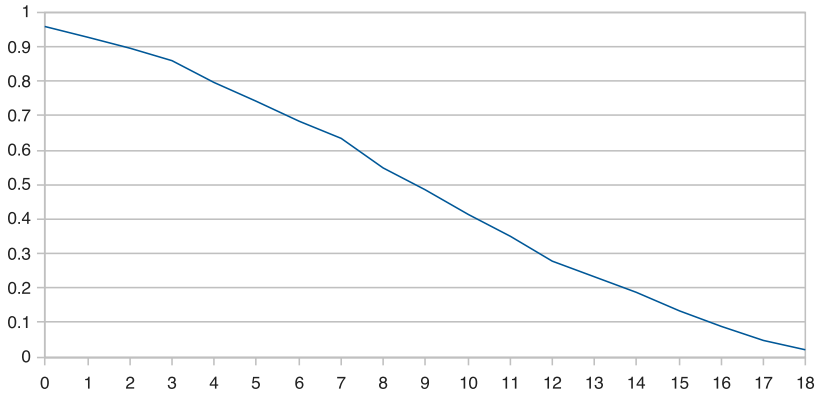
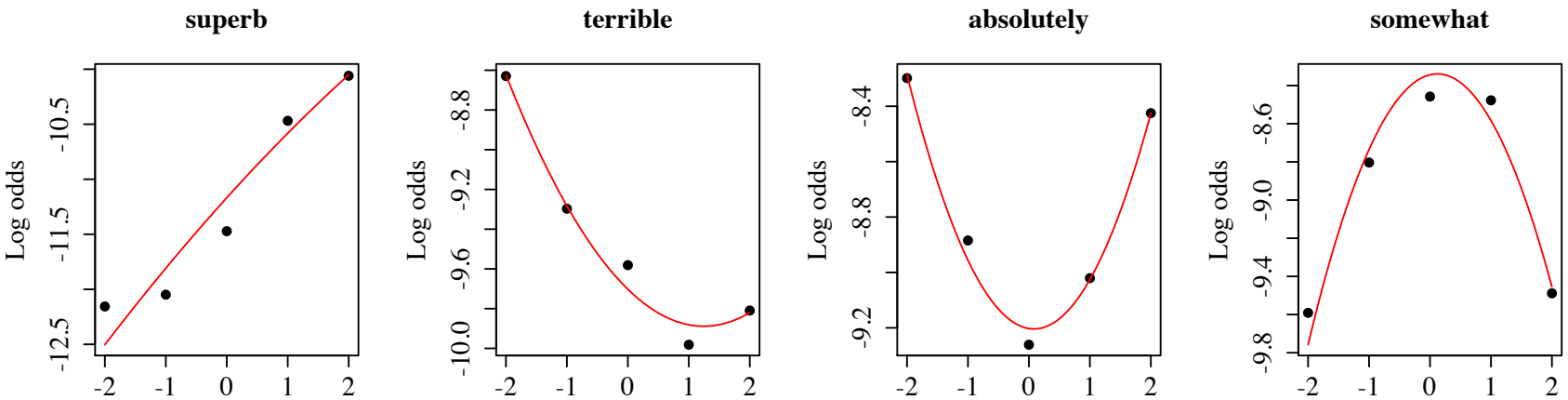


(a fragment of ongoing work by Marie-Catherine de Marneffe)

Scalar modifiers

What is the emotive contribution of scalar modifiers?

(Potts & Schwarz 2008; Constant, Davis, Potts et al. 2008)




```
Utter(S1, Superb) HighlyPositive(Superb)
Utter(S2, Superb) HighlyPositive(Superb)
Utter(S3, Superb) Positive(Superb)
Utter(S4, Superb) HighlyPositive(Superb)
Utter(S5, Superb) Positive(Superb)
Utter(S6, Superb) HighlyPositive(Superb)
Utter(S7, Superb) HighlyNegative(Superb)
```

```
Utter(S1, Somewhat)  Neutral(S1)
Utter(S8, Somewhat)  Positive(S1)
Utter(S9, Somewhat)  Neutral(S1)
Utter(S10, Somewhat) Neutral(S1)
Utter(S11, Somewhat) Positive(S1)
Utter(S11, Somewhat) Neutral(S1)
...
```

Epistemic (un)certainty

6 **sqlman**

There are an estimated 100,000+ cases in the U.S., 30,000+ in the UK, and today Australia's top doc said 2 million of that country's people could be affected. With the way it's taken off in the Southern Hemisphere in the past few days, this seems totally possible.

posted 19 weeks ago

38 **bookie** 14

I note that 6.7 million is more than 3 times as many as the 20 lakh figure. If vaccinations do start soon, it is possible that - unless we see significant spread in asia or africa - this pandemic may yet be halted or slowed. Worth a punt on no...

posted 12 weeks ago

```
Utter(bookie, Possible, m41529)      Bet(bookie, 25, m41529)
Utter(sqlman, Possible, m41529)      Bet(sqlman, 10000, m41529)
Utter(tuff_sledding, sure, m25339)   Bet(sqlman, 500000, m25339)
...
```

SUBTLE connections

- We'll soon transition from Alchemy to UMass Amherst's FACTORIE for its expressivity and efficiency.
- Ongoing collaboration with UMass Lowell to bring pragmatic inference on board the Lowell ATRV-Jr.
- Future data collection using Penn's Pragbot 2.0, which elicits more realistic expressions concerning location and field of vision (among other things) than Pragbot 1.0 does.

Immediate plans

1. Additional experiments on resolving underspecification, using the richer Pragbot 2.0 environment for data collection.
2. Additional experiments using explicit and implicit prosody to infer what the presumed QUD structure is like.
3. Richer modeling of intermediate QUDs in task oriented dialogue.
4. Fuller integration of general pragmatic pressures with lexical information.
5. Weight setting and evaluation with real users.

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