Natural Language Processing (CSEP 517): Computational Pragmatics

Chenhao Tan

University of Washington
chenhao@chenhaot.com

May 22, 2017

What do we use language for?

What do we use language for?

Communicating with other humans

- exchanging emails
- talking to friends
- writing
- giving lectures
- ...

Throw back Monday

Can you pass me the salt?

Pragmatics

The study of meaning as communicated by a speaker to a listener (Yule, 1996).

Pragmatics

The study of meaning as communicated by a speaker to a listener (Yule, 1996).

Or, **contextual meaning**

Pragmatics

The study of meaning as communicated by a speaker to a listener (Yule, 1996).

Or, **contextual meaning**

Pragmatics is important for building conversational agents, understanding human decision making, understanding language, etc.

Pragmatics vs. Syntax, Semantics (Yule, 1996)

- Syntax: the relationships between linguistic forms, how they are arranged in sequences, and which sequences are well-formed.
- Semantics: the relationships between linguistic forms and entities in the world.
- Pragmatics: the relationships between linguistic forms and the users of those forms.

Outline

Speech act theory

The effect of wording choices (big data pragmatics)

Modeling conversations: dialogue act categorization

Rational speech acts model

Outline

Speech act theory

The effect of wording choices (big data pragmatics)

Modeling conversations: dialogue act categorization

Rational speech acts model

Speech act theory

We do not simply produce utterances containing grammatical structures; we perform actions via those utterances.

Speech act theory

We do not simply produce utterances containing grammatical structures; we perform actions via those utterances.
Actions performed via utterances are generally called **speech acts** (Austin, 1975).

Speech act theory

- locutionary act (the actual utterance and its ostensible meaning)
- illocutionary act (its real, intended meaning)
- perlocutionary act (its actual effect, whether intended or not)

Outline

Speech act theory

The effect of wording choices (big data pragmatics)

Modeling conversations: dialogue act categorization

Rational speech acts model

Wording matters

Motivate voter turnout (Bryan et al., 2011)

"How important is it to you to be a voter in the upcoming election?"

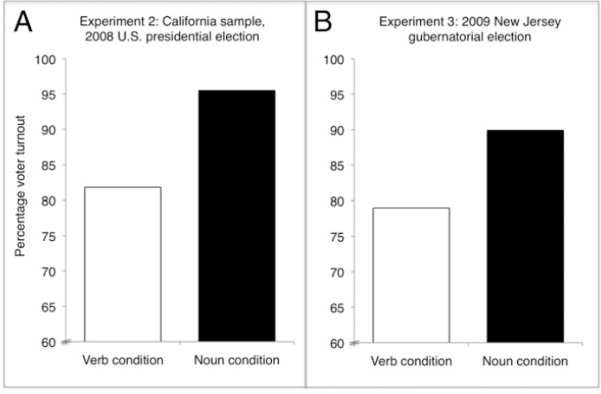
"How important is it to you to vote in the upcoming election?"

Wording matters

Motivate voter turnout (Bryan et al., 2011)

"How important is it to you to be a voter in the upcoming election?"

"How important is it to you to vote in the upcoming election?"



Large-scale natural experiments

Large-scale natural experiments

A large number of social interactions in the format of texts

$\Downarrow$

Potential opportunities for natural experiments

Large-scale natural experiments

The effect of wording on message propagation on Twitter (Tan et al., 2014)

cactus_music
@cactus_music

Food trucks are the epitome of small independently owned LOCAL businesses! Help keep them going! Sign the petition bit.ly/P6GYCq

cactus_music
@cactus_music

I know at some point you've have been saved from hunger by our rolling food trucks friends. Let's help support them! bit.ly/P6GYCq

Large-scale natural experiments

The effect of wording on message propagation on Twitter (Tan et al., 2014)

Large-scale natural experiments

- Millions of topic-author controlled pairs
- Ranking within a pair (classification)
  - Evaluation: the accuracy of predicting which one was retweeted more (random $\rightarrow$ 50%)
  - Classifier: logistic regression

Features

Pronouns

first person singular (i)
first person plural (we)
second person (you)
third person singular (she, he)
third person plural (they)

Features

Pronouns

first person singular (i)	———
first person plural (we)	———
second person (you)	———
third person singular (she, he)	↑↑
third person plural (they)	↑

Features

Pronouns

first person singular (i)	———
first person plural (we)	———
second person (you)	———
third person singular (she, he)	↑↑
third person plural (they)	↑

Referring to other people helps

Features

Generality

indefinite articles (a,an)
definite articles (the)

Features

Generality

indefinite articles (a,an) ↑↑↑
definite articles (the) ———

Features

Generality

indefinite articles (a,an) ↑↑↑
definite articles (the) ———

Generality helps

Features

Language model scores

- similarity with overall Twitter users

twitter unigram
twitter bigram

Features

Language model scores

- similarity with overall Twitter users

twitter unigram ↑↑↑
twitter bigram ↑↑↑

Features

Language model scores

- similarity with overall Twitter users

  twitter unigram ↑↑↑
  twitter bigram ↑↑↑

- similarity with personal history

  personal unigram
  personal bigram

Features

Language model scores

- similarity with overall Twitter users

twitter unigram ↑↑↑
twitter bigram ↑↑↑

- similarity with personal history

personal unigram ↑↑↑
personal bigram ———

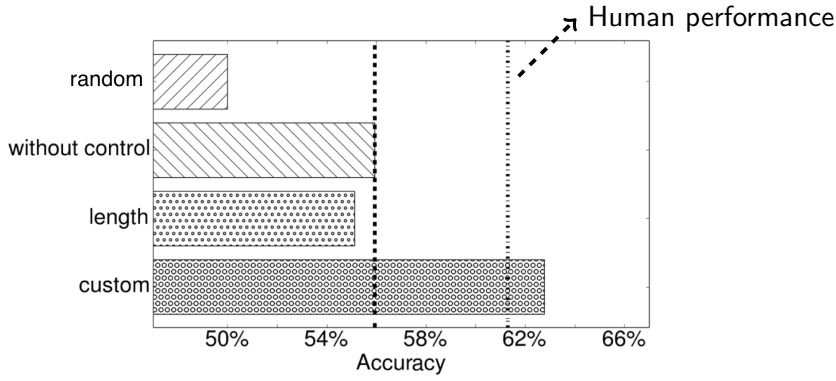
Be like the community & be true to yourself

Baseline without “natural experiments”

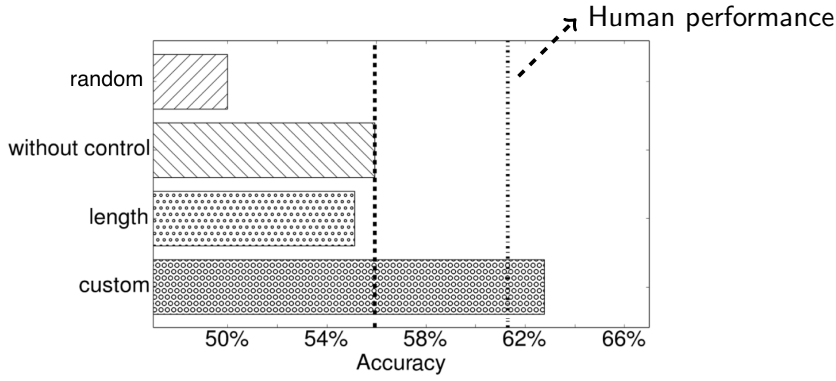
Supervised classification without control

- most-retweeted tweets vs. least-retweeted tweets

Prediction performance



Prediction performance



- Controlling for context is important
- Big data can help understand pragmatics
  `https://chenhaot.com/retweetedmore`

Beyond retweeting

- Persuasive arguments (Tan et al., 2016)
- Memorable (movie) quotes (Danescu-Niculescu-Mizil et al., 2012a)
- Power dynamics (Danescu-Niculescu-Mizil et al., 2012b; Prabhakaran et al., 2014)
- Newsworthiness of research articles and political speeches (Zhang et al., 2016)

Outline

Speech act theory

The effect of wording choices (big data pragmatics)

Modeling conversations: dialogue act categorization

Rational speech acts model

Dialogue act classification/tagging

Define categories and label corpora (Stolcke et al., 2000)

- statement
- question
- backchannel
- agreement
- apology
- ...

Dialogue act classification/tagging

Supervised classification

- SVM
- logistic classification

Structure prediction (sequence tagging)

- Hidden Markov model
- Conditional random field

Speech act theory

The effect of wording choices (big data pragmatics)

Modeling conversations: dialogue act categorization

Rational speech acts model

Cooperative Principle

Make your contribution as is required, when it is required, by the conversation in which you are engaged (Grice, 1975).

Conversational Implicatures

- Maxims of quality
  (Do not say what you believe to be false; do not say that for which you lack adequate evidence)
  e.g., Noah is a nice person

Conversational Implicatures

- Maxims of quality
  (Do not say what you believe to be false; do not say that for which you lack adequate evidence)
  e.g., Noah is a nice person $\Rightarrow$ *I believe that* Noah is a nice person

Conversational Implicatures

- Maxims of quality
  (Do not say what you believe to be false; do not say that for which you lack adequate evidence)
  e.g., Noah is a nice person $\Rightarrow$ *I believe that* Noah is a nice person
- Maxims of quantity
  Make you contribution as informative as is required (for the current purposes of the exchange); do not make your contribution more informative than is required
  - I have two hands

Conversational Implicatures

- Maxims of quality
  (Do not say what you believe to be false; do not say that for which you lack adequate evidence)
  e.g., Noah is a nice person $\Rightarrow$ *I believe that* Noah is a nice person
- Maxims of quantity
  Make you contribution as informative as is required (for the current purposes of the exchange); do not make your contribution more informative than is required
  - I have two hands $\Rightarrow$ I have *no more than* two hands

Rational Speech Acts Model

Reference games (Wittgenstein, 1953; Frank and Goodman, 2012)

- Speaker. Imagine you are talking to someone and want to refer to the middle object. Would you say “blue” or “circle”?

Rational Speech Acts Model

Reference games (Wittgenstein, 1953; Frank and Goodman, 2012)

- Speaker. Imagine you are talking to someone and want to refer to the middle object. Would you say "blue" or "circle"?
- Listener. Someone uses the word "blue" to refer to one of these objects. Which object are they talking about?

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

- $P(s)$: the prior over states
- $[\![u]\!](s)$: a mapping from states of the world to truth values

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

- $P(s)$: the prior over states
- $[\![u]\!](s)$: a mapping from states of the world to truth values

$$\forall s, P(s) = 1/3$$

blue	0.5	0.5	0
green	0	0	1
square	0.5	0	0.5
circle	0	1	0

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto U_{s_1}(u; s)$$

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto U_{s_1}(u; s)$$

- One way is to set the utility function to $P_{l_0}(s \mid u)$:

$$P_{s_1}(u \mid s, C) \propto P_{l_0}(s \mid u) = \exp(\log P_{l_0}(s \mid u))$$

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto U_{s_1}(u; s)$$

- One way is to set the utility function to $P_{l_0}(s \mid u)$:

$$P_{s_1}(u \mid s, C) \propto P_{l_0}(s \mid u) = \exp(\log P_{l_0}(s \mid u))$$

- More generally, we can incorporate message costs:

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

$$\alpha = 1$$

$$\text{cost}(u) = \begin{cases} 0, & u \in \{\text{blue, green, circle, square}\} \\ \infty, & \text{otherwise} \end{cases}$$

	blue	green	square	circle
	0.5	0	0.5	0
	0.33	0	0	0.67
	0	0.67	0.33	0

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

pragmatic speaker

	blue	green	square	circle
	0.5	0	0.5	0
	0.33	0	0	0.67
	0	0.67	0.33	0

vs.

literal listener

			
blue	0.5	0.5	0
green	0	0	1
square	0.5	0	0.5
circle	0	1	0

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

Pragmatic listener (l_1)

$$P_{l_1}(s \mid u) \propto P(s)P_{s_1}(u \mid s)$$

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

Pragmatic listener (l_1)

$$P_{l_1}(s \mid u) \propto P(s)P_{s_1}(u \mid s)$$

blue	0.6	0.4	0
green	0	0	1
square	0.6	0	0.4
circle	0	1	0

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

Pragmatic listener (l_1)

$$P_{l_1}(s \mid u) \propto P(s)P_{s_1}(u \mid s)$$

pragmatic listener

blue	0.6	0.4	0
green	0	0	1
square	0.6	0	0.4
circle	0	1	0

vs.

literal listener

blue	0.5	0.5	0
green	0	0	1
square	0.5	0	0.5
circle	0	1	0

Rational Speech Acts Model

Literal listener (l_0)

$$P_{l_0}(s \mid u) \propto P(s)[\![u]\!](s)$$

Pragmatic speaker (s_1)

$$P_{s_1}(u \mid s, C) \propto \exp(\alpha(\log P_{l_0}(s \mid u) - \text{cost}(u)))$$

Pragmatic listener (l_1)

$$P_{l_1}(s \mid u) \propto P(s)P_{s_1}(u \mid s)$$

pragmatic listener

blue	0.6	0.4	0
green	0	0	1
square	0.6	0	0.4
circle	0	1	0

vs.

literal listener

blue	0.5	0.5	0
green	0	0	1
square	0.5	0	0.5
circle	0	1	0

Live demo: `http://gscontras.github.io/ESSLLI-2016/`

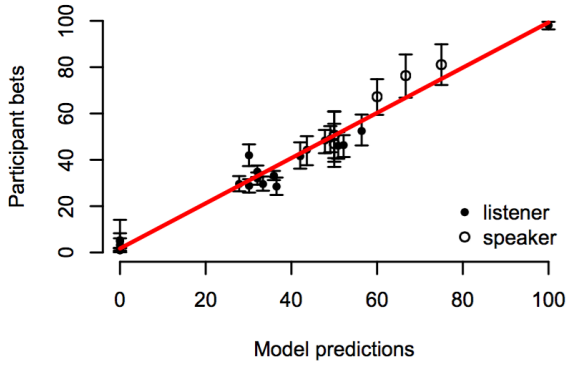
Rational Speech Acts Model

Literal listener (l_0): utterance meaning $\times$ state prior
Pragmatic speaker (s_1): literal listener - utterance costs
Pragmatic listener (l_1): pragmatic speaker $\times$ state prior

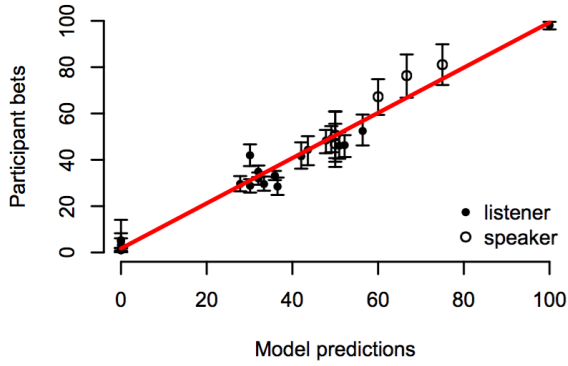
Rational Speech Acts Model

Literal speaker (s_0): utterance meaning - utterance costs
Pragmatic listener (l_1): literal speaker $\times$ state prior
Pragmatic speaker (s_1): pragmatic listener - utterance costs

Experiments



Experiments



Rational speech acts model is a powerful tool for understanding the pragmatic meaning of language.

Extensions and critiques

- Learning based approach by featurizing utterances and states (Monroe and Potts, 2015)
- Neural rational speech acts model (Monroe et al., 2017)

Extensions and critiques

- Learning based approach by featurizing utterances and states (Monroe and Potts, 2015)
- Neural rational speech acts model (Monroe et al., 2017)
- Exceptions: sarcasm, irony, hedging, etc
- Cultural differences

Summary

- Wording matters; we can learn useful insights from social interaction data available nowadays
- Modeling conversations by categorizing speech acts
- Rational speech acts model can achieve pragmatics understanding

Questions?
https://chenhaot.com
chenhao@chenhaot.com

References I

John Langshaw Austin. *How to do things with words*. Oxford university press, 1975.

Christopher J Bryan, Gregory M Walton, Todd Rogers, and Carol S Dweck. Motivating voter turnout by invoking the self. *Proceedings of the National Academy of Sciences*, 108(31):12653–12656, 2011. URL `http://www.pnas.org/content/108/31/12653.abstract`.

Cristian Danescu-Niculescu-Mizil, Justin Cheng, Jon Kleinberg, and Lillian Lee. You Had Me at Hello: How Phrasing Affects Memorability. In *Proceedings of ACL*, 2012a. URL `http://dl.acm.org/citation.cfm?id=2390524.2390647`.

Cristian Danescu-Niculescu-Mizil, Lillian Lee, Bo Pang, and Jon Kleinberg. Echoes of Power: Language Effects and Power Differences in Social Interaction. In *Proceedings of the 21st International Conference on World Wide Web*, 2012b. URL `http://doi.acm.org/10.1145/2187836.2187931`.

Michael C Frank and Noah D Goodman. Predicting Pragmatic Reasoning in Language Games. *Science*, 336 (6084):998–998, 2012.

H Paul Grice. Logic and conversation. *1975*, pages 41–58, 1975.

Will Monroe and Christopher Potts. Learning in the rational speech acts model. In *Proceedings of the 20th Amsterdam Colloquium*, 2015.

Will Monroe, Robert X.D. Hawkins, Noah D. Goodman, and Christopher Potts. Colors in Context: A Pragmatic Neural Model for Grounded Language Understanding. In *Proceedings of ACL*, 2017.

Vinodkumar Prabhakaran, Ashima Arora, and Owen Rambow. Staying on Topic: An Indicator of Power in Political Debates. In *EMNLP*, 2014.

References II

Andreas Stolcke, Klaus Ries, Noah Coccaro, Elizabeth Shriberg, Rebecca Bates, Daniel Jurafsky, Paul Taylor, Rachel Martin, Carol Van Ess-Dykema, and Marie Meteer. Dialogue act modeling for automatic tagging and recognition of conversational speech. *Computational linguistics*, 26(3):339–373, 2000.

Chenhao Tan, Lillian Lee, and Bo Pang. The effect of wording on message propagation: Topic- and author-controlled natural experiments on Twitter. In *Proceedings of ACL*, 2014.

Chenhao Tan, Vlad Niculae, Cristian Danescu-Niculescu-Mizil, and Lillian Lee. Winning Arguments: Interaction Dynamics and Persuasion Strategies in Good-faith Online Discussions. In *Proceedings of WWW*, 2016. URL `http://dx.doi.org/10.1145/2872427.2883081`.

Ludwig Wittgenstein. *Philosophical investigations*. 1953.

George Yule. *Pragmatics*. Oxford, 1996.

Ye Zhang, Erin Willis, Michael J Paul, Nomie Elhadad, and Byron C Wallace. Characterizing the (Perceived) Newsworthiness of Health Science Articles: A Data-Driven Approach. *JMIR medical informatics*, 4(3), 2016.