# Grounded language understanding: The Rational Speech Acts model

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CS224u: Natural language understanding







### Additional resources

- 1. Goodman and Frank 2016
- 2. Technical screencast: https://youtu.be/bPd6CNy5UqA
- 3. Associated slides:
   https://web.stanford.edu/class/linguist130a/
   screencasts/130a-screencast-implicature.pdf
- 4. Reference implementation:
   https://web.stanford.edu/class/linguist130a/
   materials/rsa130a.py

#### Literal listener

$$L_{lit}(state \mid msg) = \frac{ [\![msg, state]\!] P(state)}{\sum_{state'} [\![msg, state']\!] P(state')}$$

#### Pragmatic speaker

$$S_{\text{prag}}(msg \mid state) = \frac{\exp\left(\alpha\left(\log L_{\text{lit}}(state \mid msg) - C(msg)\right)\right)}{\sum_{msg'} \exp\left(\alpha\left(\log L_{\text{lit}}(state \mid msg') - C(msg')\right)\right)}$$

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# **Pragmatic listeners**

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## **Pragmatic listener**

 $L_{prag}(state \mid msg) = pragmatic speaker \times state prior$ 

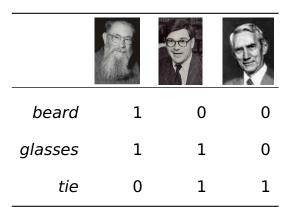
# Pragmatic speaker

 $S_{prag}(msg \mid state) =$ **literal listener** – message costs

#### Literal listener

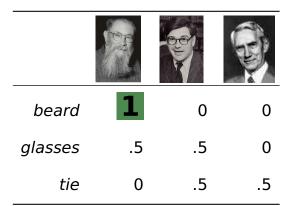
 $L_{\text{lit}}(state \mid msg) = lexicon \times state prior$ 

# A simple example



L<sub>prag</sub>
S<sub>prag</sub>
L<sub>lit</sub>

# A simple example



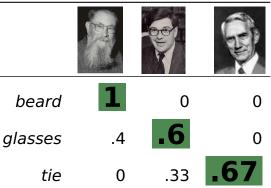
 $L_{\text{prag}}$   $S_{\text{prag}}$   $L_{\text{lit}}$ 

# A simple example

beard	glasses	tie
.67	.33	0
0	.5	.5
0	0	1

L<sub>prag</sub>
S<sub>prag</sub>
L<sub>lit</sub>

# A simple example



L<sub>prag</sub>
S<sub>prag</sub>
L<sub>lit</sub>

[[•]]

#### Literal speaker

$$S_{\text{lit}}(msg \mid state) = \frac{\exp\left(\alpha\left(\log[[msg, state]] - C(msg)\right)\right)}{\sum_{msg'} \exp\left(\alpha\left(\log[[msg', state]] - C(msg')\right)\right)}$$

#### Pragmatic listener

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#### Pragmatic listener

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## Literal speaker

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# Pragmatic speakers

# Pragmatic speaker

 $S_{prag}(msg \mid state) = pragmatic listener - message costs$ 

### Pragmatic listener

 $L_{prag}(state \mid msg) =$ **literal speaker**  $\times$  state prior

## Literal speaker

 $S_{\text{lit}}(msg \mid state) =$ **lexicon** – message costs

#### Limitations

- Hand-specified lexicon
- Reasoning about all possible utterances?

$$S_{\text{prag}}(msg \mid state) = \frac{\exp\left(\alpha\left(\log L_{\text{lit}}(state \mid msg) - C(msg)\right)\right)}{\sum_{msg'} \exp\left(\alpha\left(\log L_{\text{lit}}(state \mid msg') - C(msg')\right)\right)}$$

- · High-bias model; few chances to learn from data
- Cognitive demands limit speaker rationality
- Speaker preferences
- Scalability

### References I

Noah D. Goodman and Michael C. Frank. 2016. Pragmatic language interpretation as probabilistic inference. *Trends in Cognitive Sciences*, 20(11):818–829.