

# Unit 3: Learning from other people

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## 3. Rational speech acts

11/5/2020

# Rational speech acts

- 1. Reasoning about language involves reasoning about communicative goals**
- 2. Communicative goals can be complex**
- 3. Communicative goals can interface with perception**

# Three different kinds of sampling

**Weak sampling:** the samples you get are generated from the prior (or from you), and then the machine tells you which ones are consistent with the hypothesis

**Strong sampling:** the samples you get generated from hypothesis

**Pedagogical sampling:** the samples you get generated to maximize your likelihood of inferring the hypothesis

# The gavagai problem



Quine (1960)

# The size principle!

$$P(\text{ } \mid \text{dog})$$
$$<$$
$$P(\text{ } \mid \text{dalmation})$$


# What kind of action is communication?

$$P(\text{dalmation} | \text{dog}) \propto P(\text{dog} | \text{dalmation})P(\text{dalmation})$$



Unintentional Effect,  
not Knowledgeable Actor,  
Unknown/no goal



Intentional Effect,  
Knowledgeable Actor,  
Non-social Goal



Intentional Effect,  
Knowledgeable Actor,  
Social Goal

# Communication is a kind of “teaching”

$$P_{teacher}(d|h) \propto P_{learner}(h|d)^{\alpha}$$

$$P_{learner}(h|d) \propto P_{teacher}(d|h) P(h)$$

**This is a recursive reasoning process!**

# Pragmatic inference (Goodman & Frank, 2016)

Suppose you heard me say: “**My friend has glasses**”



Which one of these people is my friend?

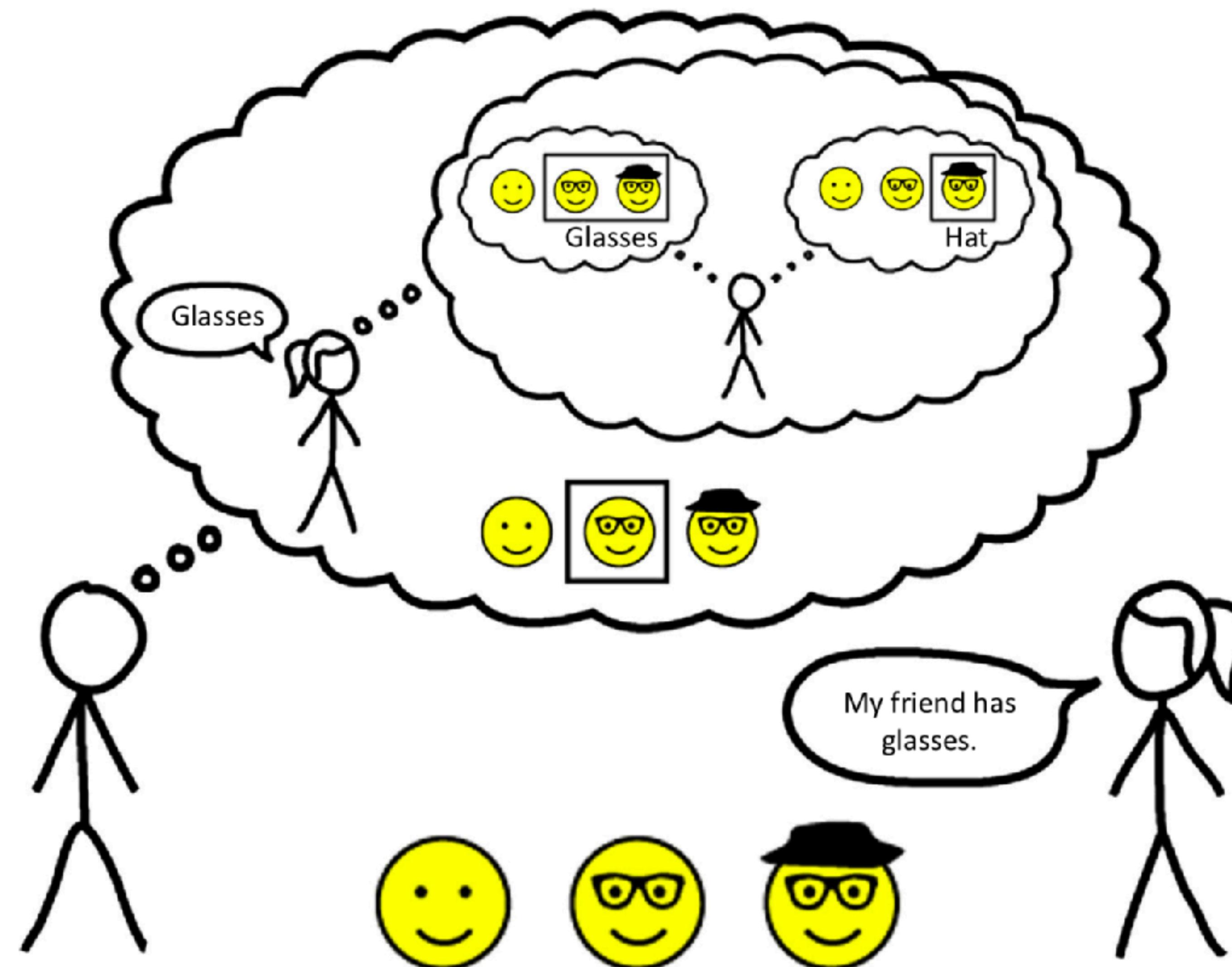
# Pragmatic inference (Goodman & Frank, 2016)

Suppose you heard me say: “**My friend has glasses**”

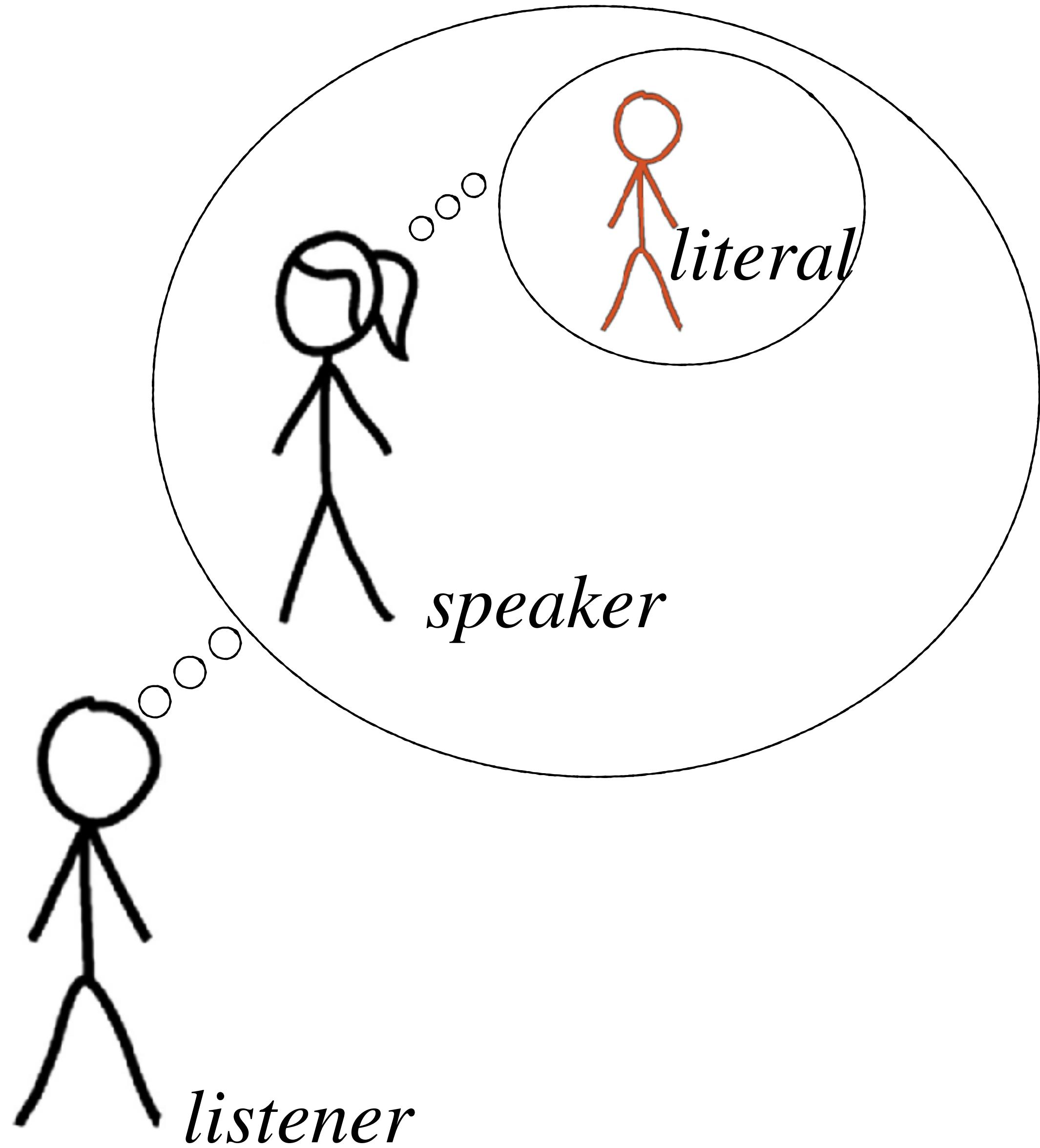


Why not guess randomly from these two?

# Pragmatic inference as recursive reasoning



# The literal listener

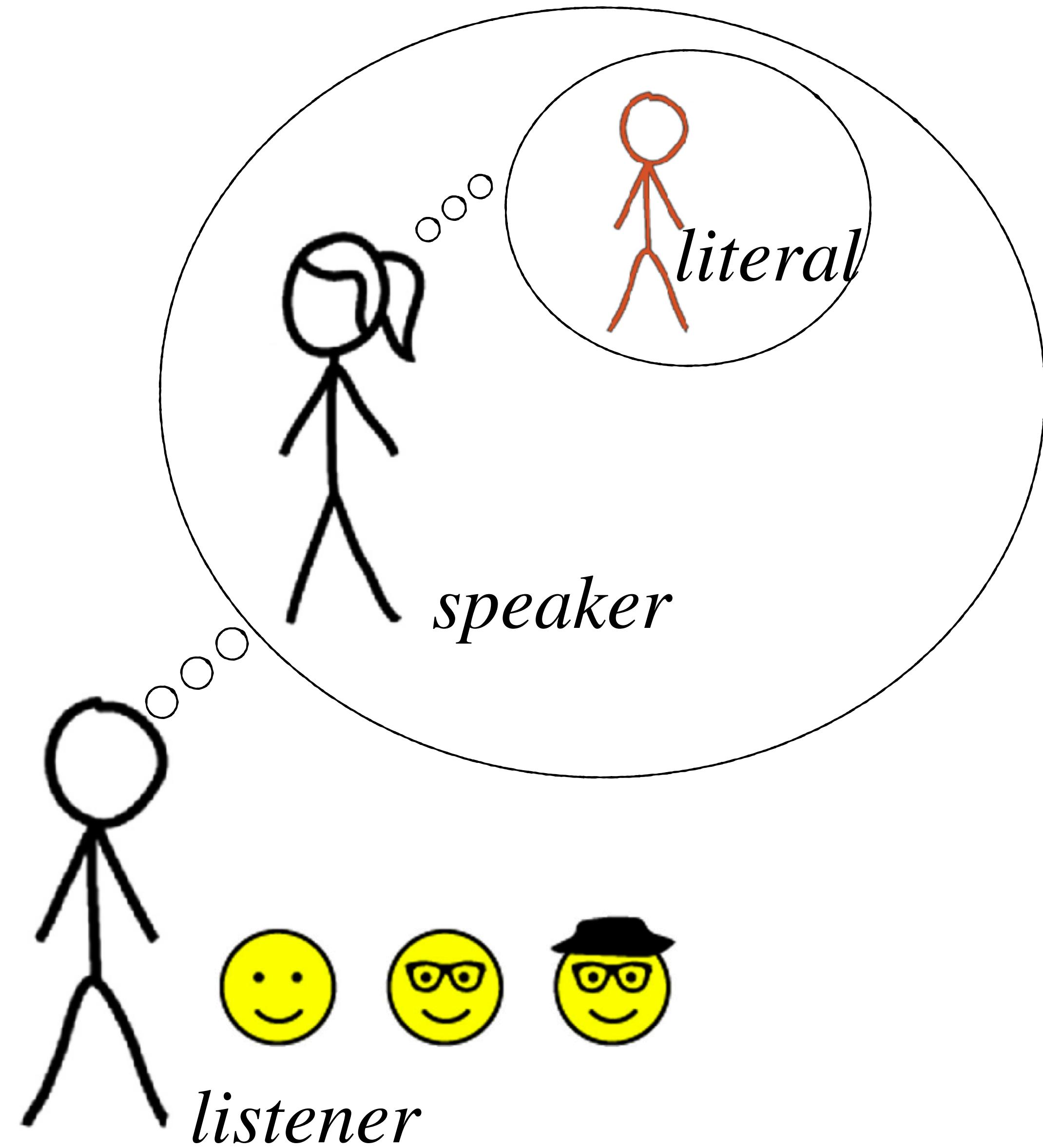


The Literal listener randomly chooses a face that matches the description

$$P(\bullet | \text{word}) = \frac{\delta(\bullet, \text{word})}{\sum_{\bullet'} \delta(\bullet', \text{word})}$$

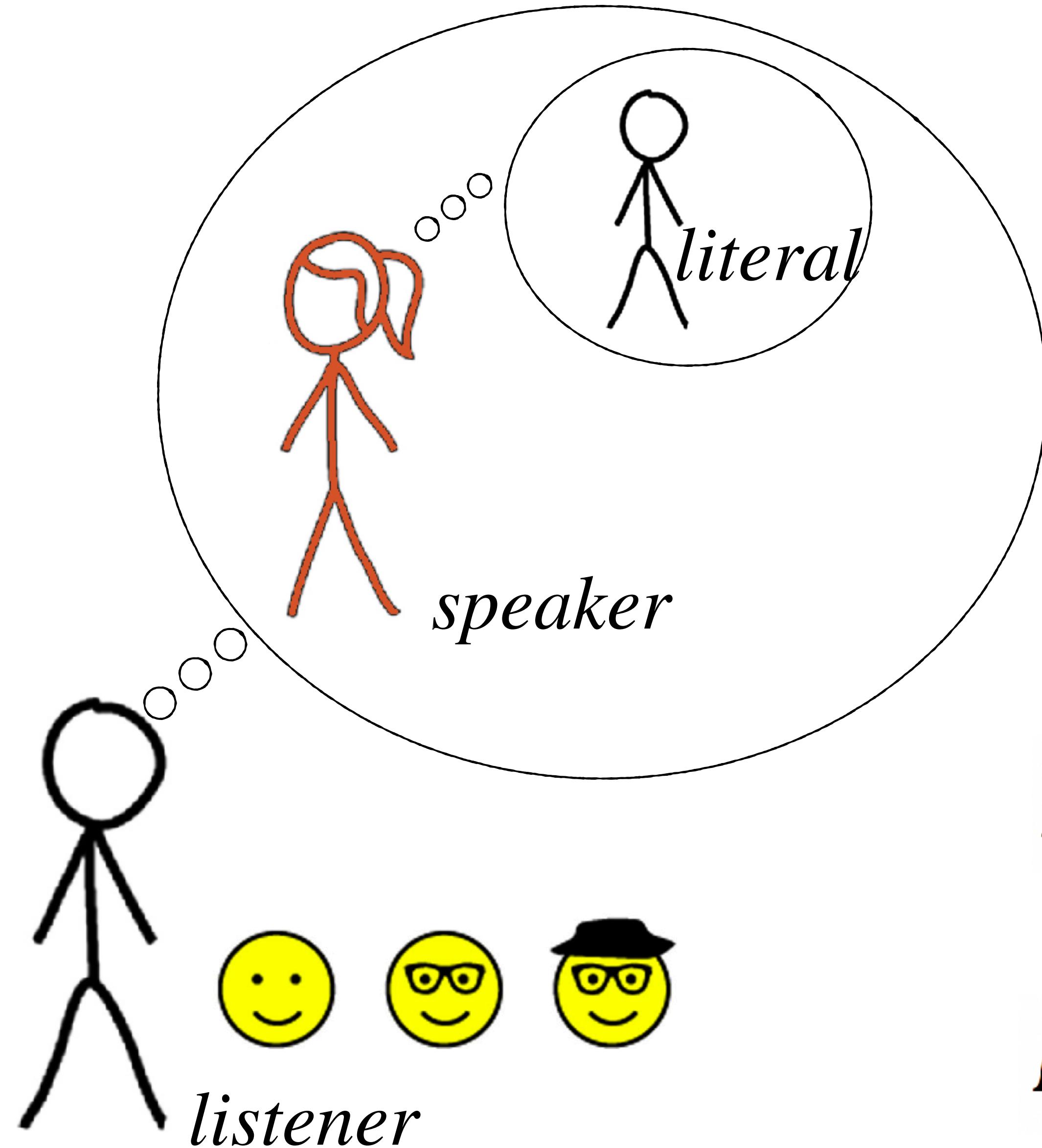
$$\delta(\bullet, \text{word}) = \begin{cases} 1 & \text{if True} \\ 0 & \end{cases}$$

# Checking our intuition about the literal listener



$$P(\text{hat} | \text{hat}) =$$

# The speaker



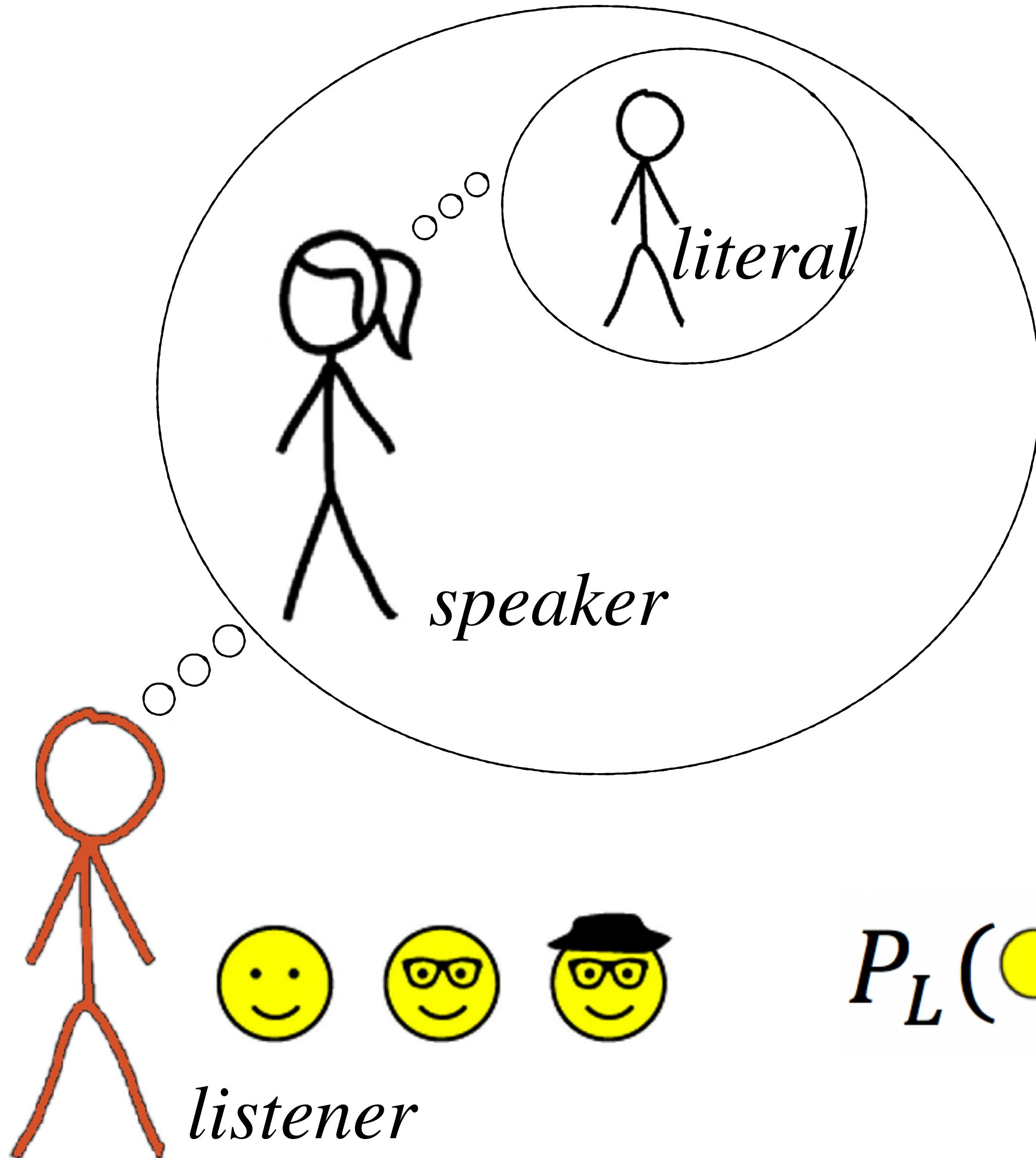
The Speaker chooses a word in proportion to informativeness to the Literal listener

$$P_s(\text{word}|\bullet) \propto P_{\text{lit}}(\bullet|\text{word})$$

$$P_s(\text{glasses}|\bullet) \propto P_{\text{lit}}(\bullet|\text{glasses}) = \frac{1}{2}$$

$$P_s(\text{hat}|\bullet) \propto P_{\text{lit}}(\bullet|\text{hat}) = 1$$

# The pragmatic listener



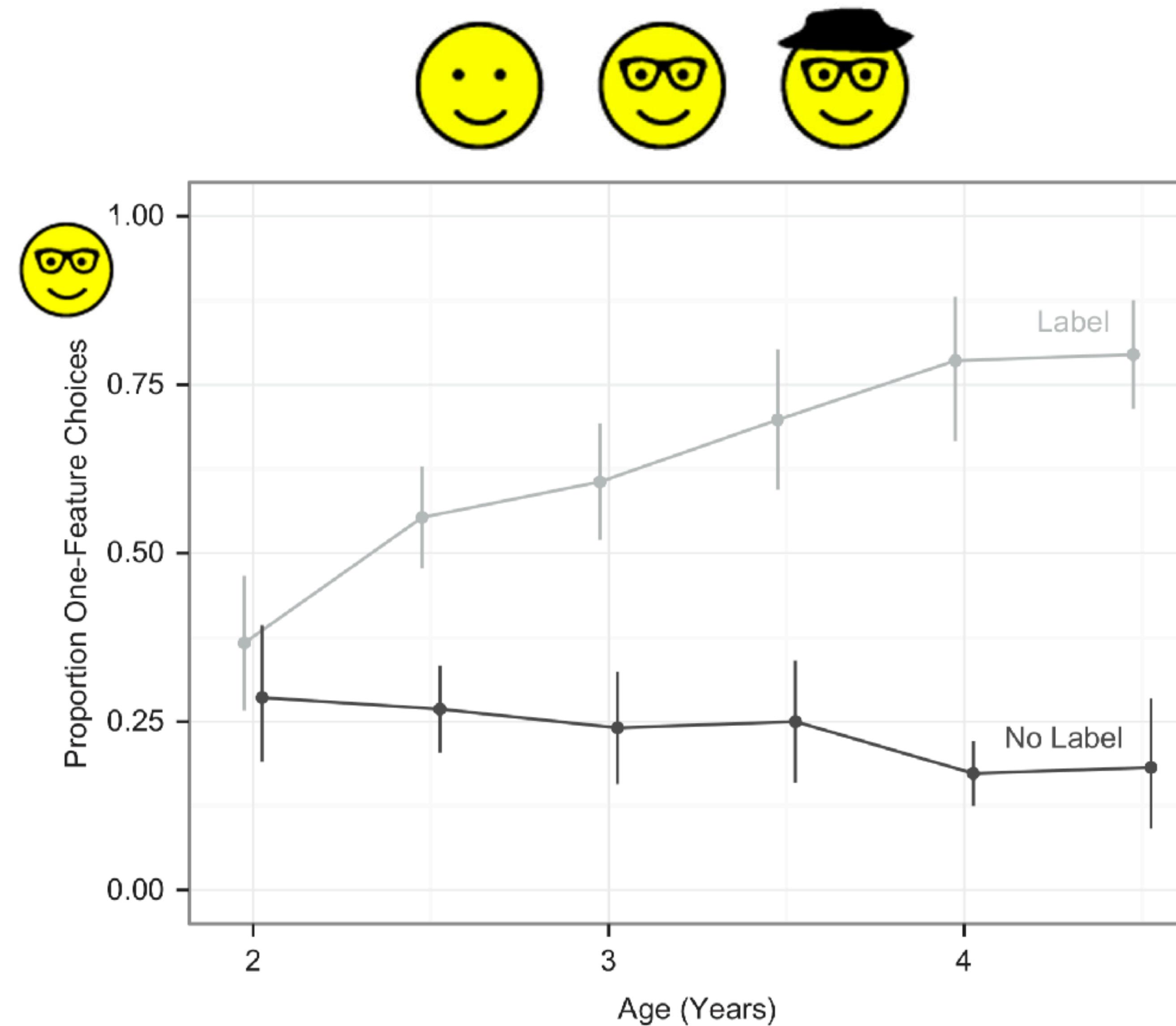
The Listener chooses a referent in proportion to how likely the Speaker is to have used that word to refer to it

$$P_s(\text{word} | \bullet) \propto$$

$$P_{\text{lit}}(\bullet | \text{word})$$

$$P_L(\bullet | \text{word}) \propto P_s(\text{word} | \bullet) P(\bullet)$$

# Pragmatic inference in young children



# Using pragmatic inference to learn words



*This is a dinosaur with a dax*

# Using pragmatic inference to learn words



*This is a friend  
with a **dax***



$$P_L(\text{以人为对象}|\text{glasses}) \propto$$

$$P_S(\text{glasses}|\text{以人为对象}) P(\text{以人为对象})$$

↓ By the power of  
Bayes' rule!

$$P_L(\text{glasses}|\text{以人为对象}) \propto$$

$$P_S(\text{人为对象}|\text{glasses}) P(\text{glasses})$$

# Working through this model



$$P_L \left( \text{---} \mid \text{---} \right) \propto P_S \left( \text{---} \mid \text{---} \right) P \left( \text{---} \right)$$



*This is a dinosaur with a **dax***

# The gavagai problem is a communicative inference problem



Quine (1960)

# What else can pragmatic inference solve for us?

$$P(h | a, e, \underline{g}) \propto P(e | a, h) P(a | \underline{g}, h) P(h)$$

Pragmatic inference is about the relationship between what people say and what their goals are

So far, we have taken the goal to be successful reference

But is that all we do with language?

# Nonliteral understanding of number words (Kao, Wu, Bergen, & Goodman, 2014)

- 1.“It took 30 minutes to get a table”
- 2.“It took 32 minutes to get a table”
- 3.“It took a million years to get a table”

**What do these utterances mean?**

# Rational Speech acts might have multiple goals

**G<sub>1</sub>:** Communicate about the state of the world (s)

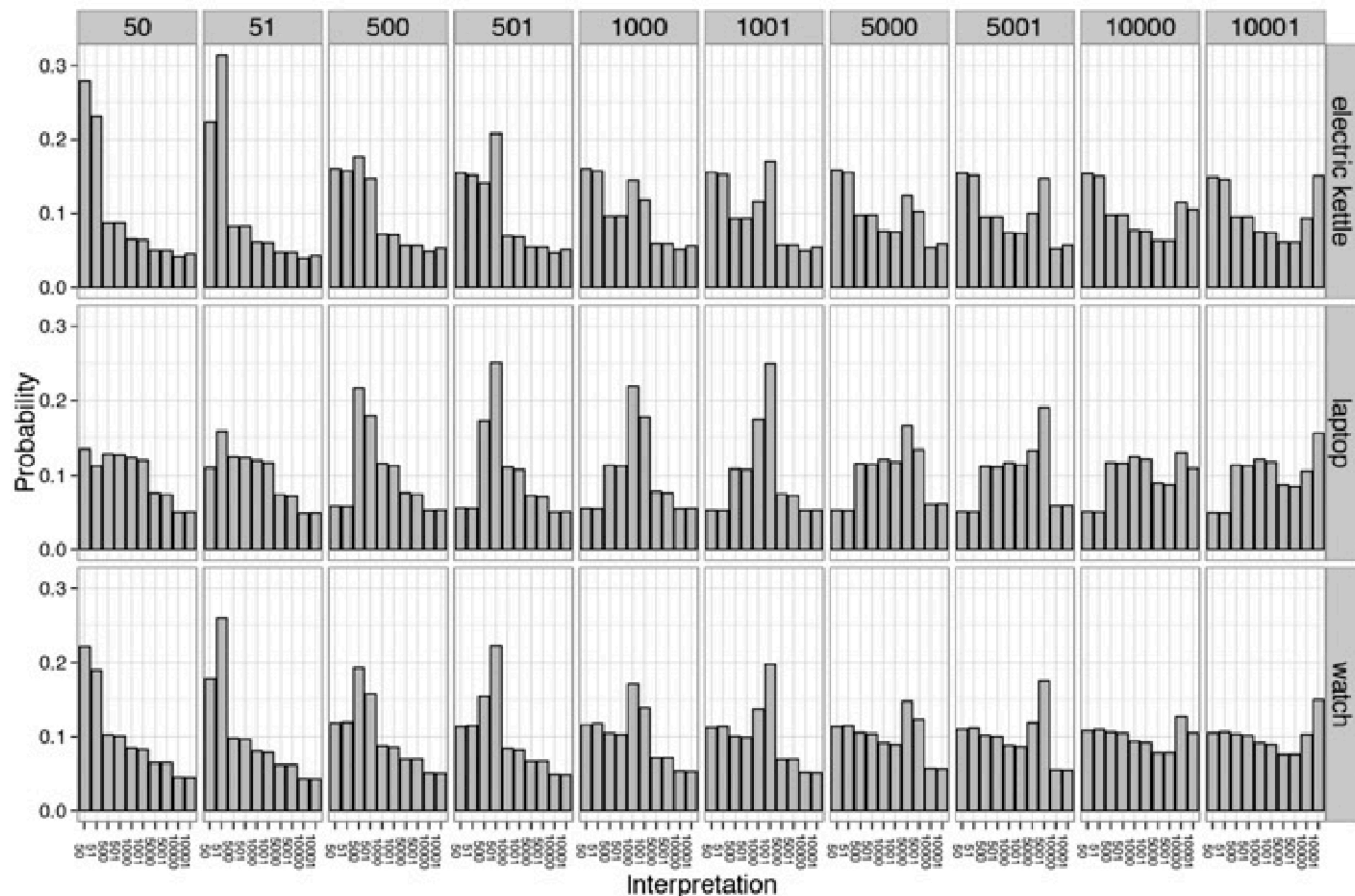
**G<sub>1e</sub>:** Communicate about the state of the world **exactly**

**G<sub>1a</sub>:** Communicate about the state of the world **approximately**

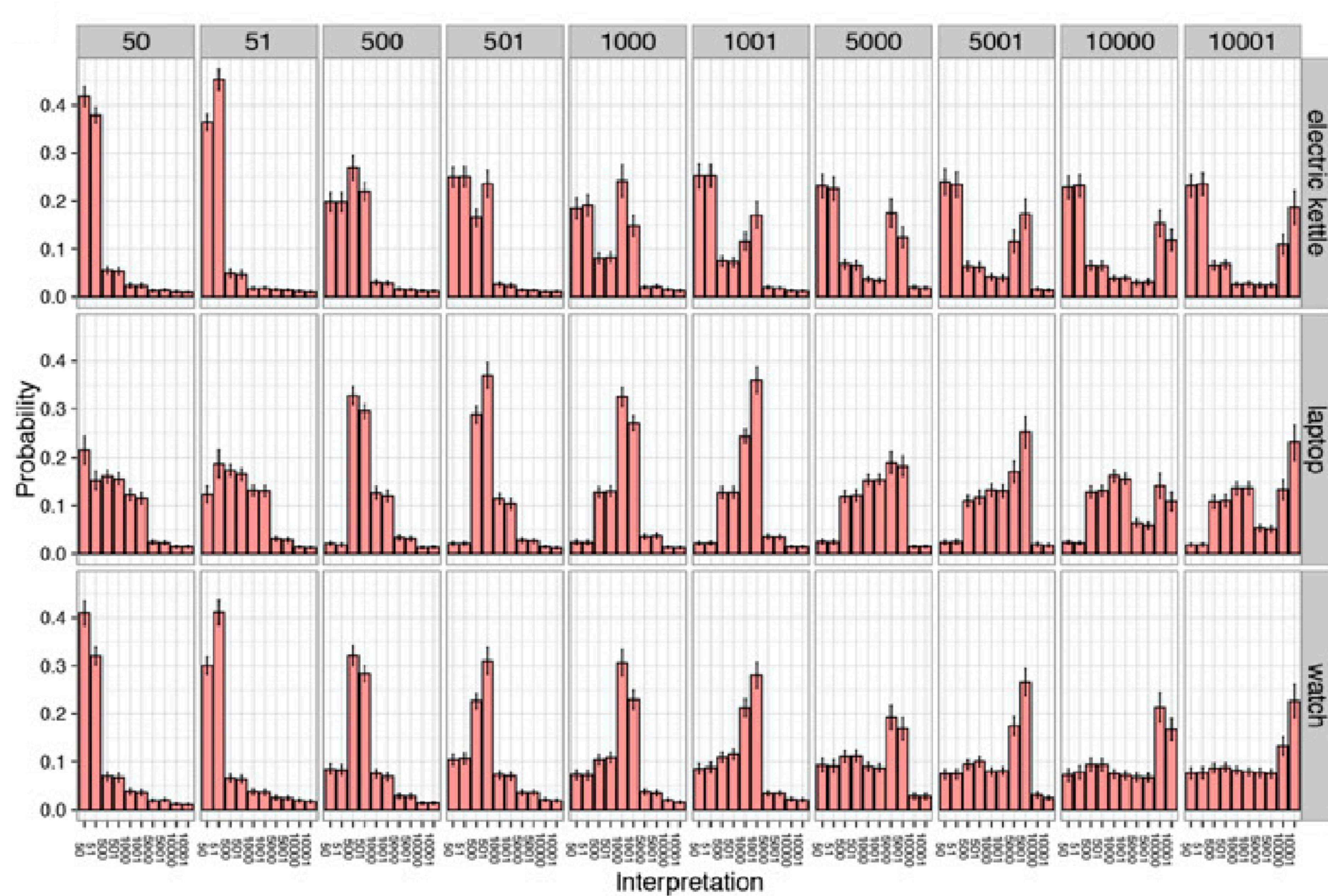
**G<sub>2</sub>:** Communicate about the speaker's affect (a)

$$P_{\text{listener}}(s, a | u) \propto \sum_g P_S(s) P_A(a | s) P_G(g) P_{\text{speaker}}(u | s, a, g)$$

# Predictions from this joint state and affect model



# People's judgments are qualitatively predicted by the model



# Competing social goals

Suppose you were in CMU's improv troupe Scotch and Soda, and you just put on your final show

You ask a friend how the show was and she says “it was great!”

**How well do you think show went?**

terrible

amazing



# Competing social goals

Suppose you were in CMU's improv troupe Scotch and Soda, and you just put on your final show

You ask a friend how the show was and she says "it was ok"

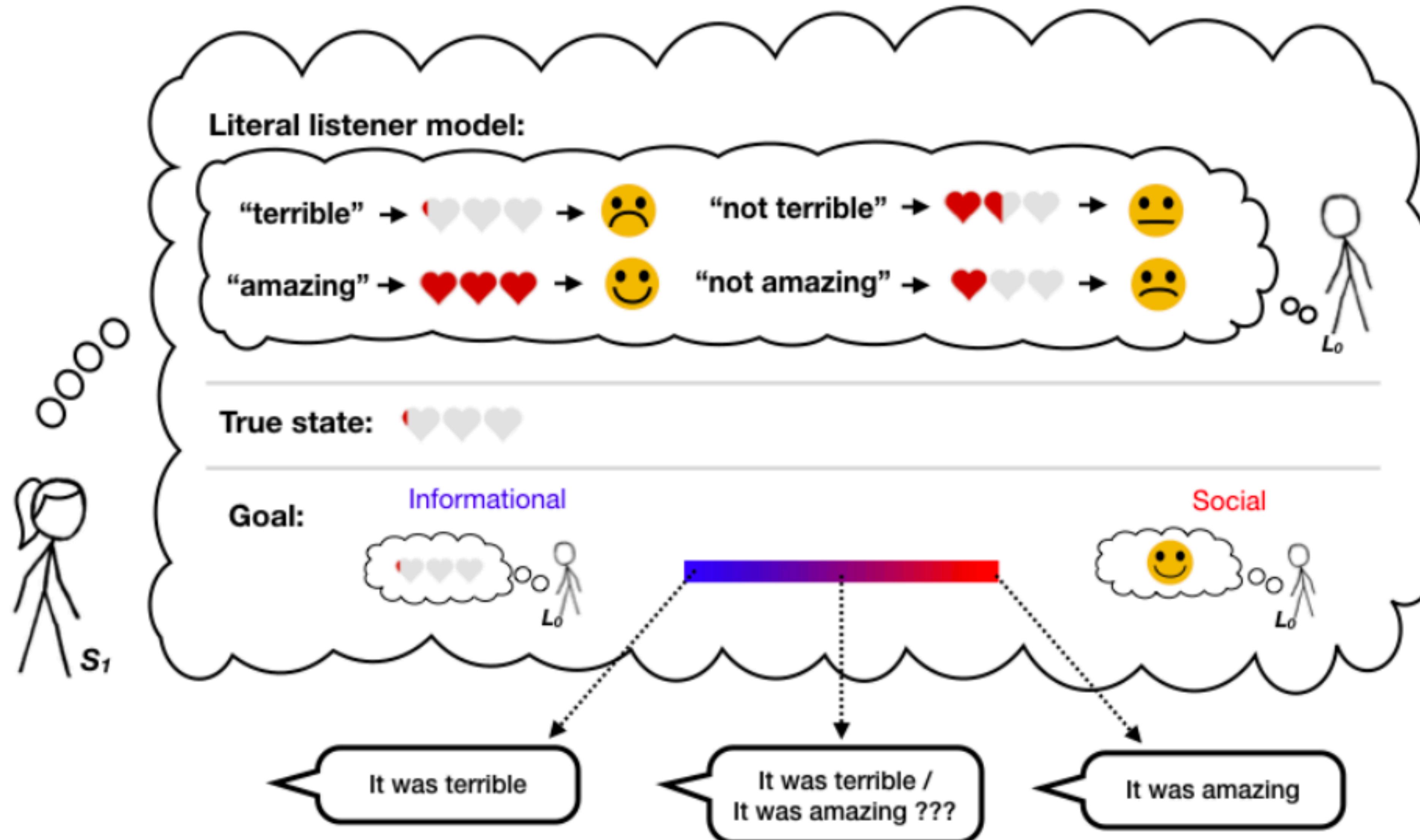
**How well do you think show went?**

terrible

amazing



# Modeling polite speech (Yoon, Tessler, Goodman, & Frank, 2018)



# People hedge when they want to be polite

Imagine that Justine wrote a review for a book, but Justine didn't know how good it was. Justine approached Kelly, who knows a lot about writing reviews, and asked "How was my review?"

Here's how Kelly **actually** felt about Justine's review:

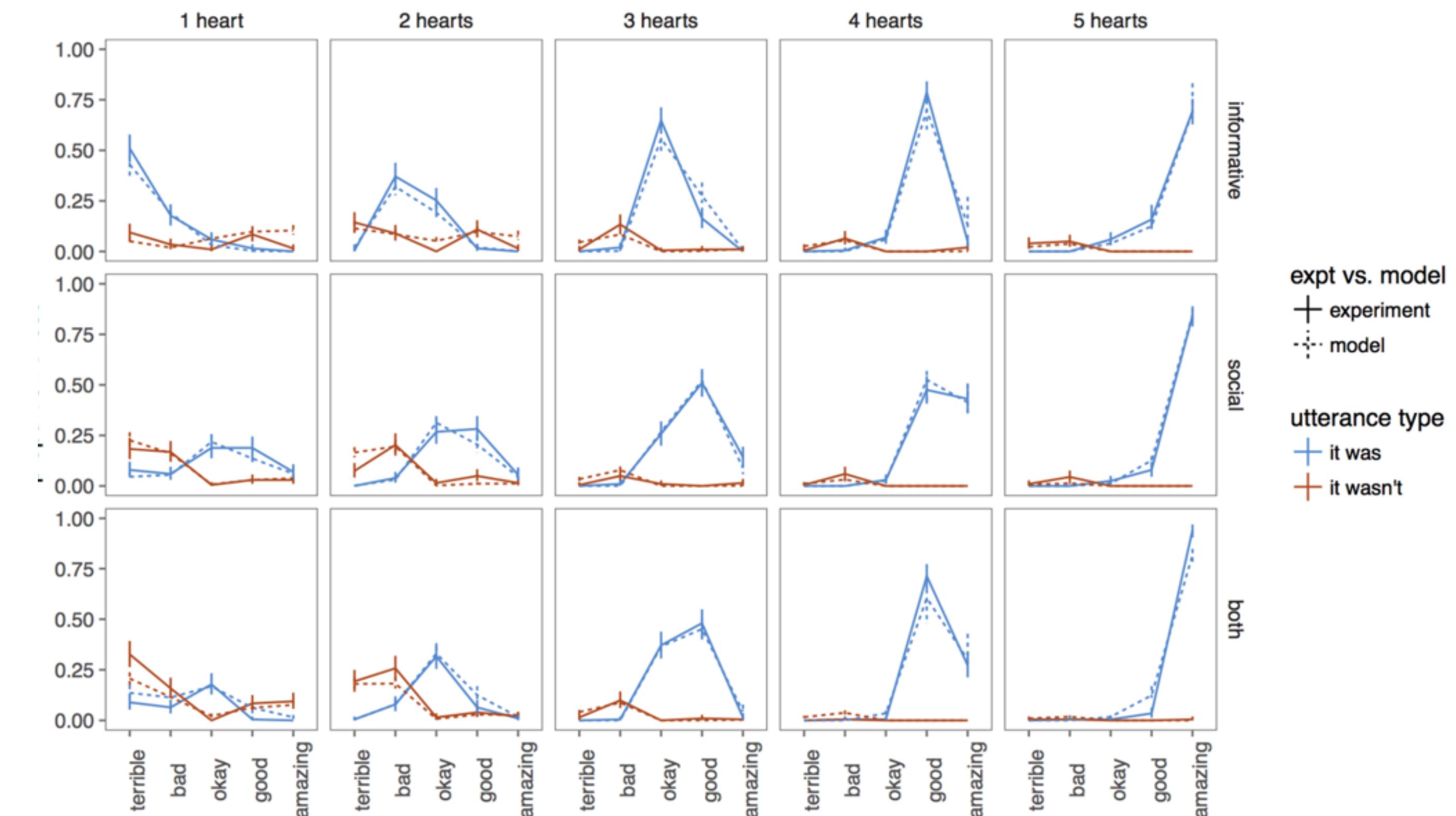


If Kelly wanted to make Justine feel good, but not necessarily give informative feedback,

What would Kelly be most likely to say?

"It **wasn't** **amazing** "

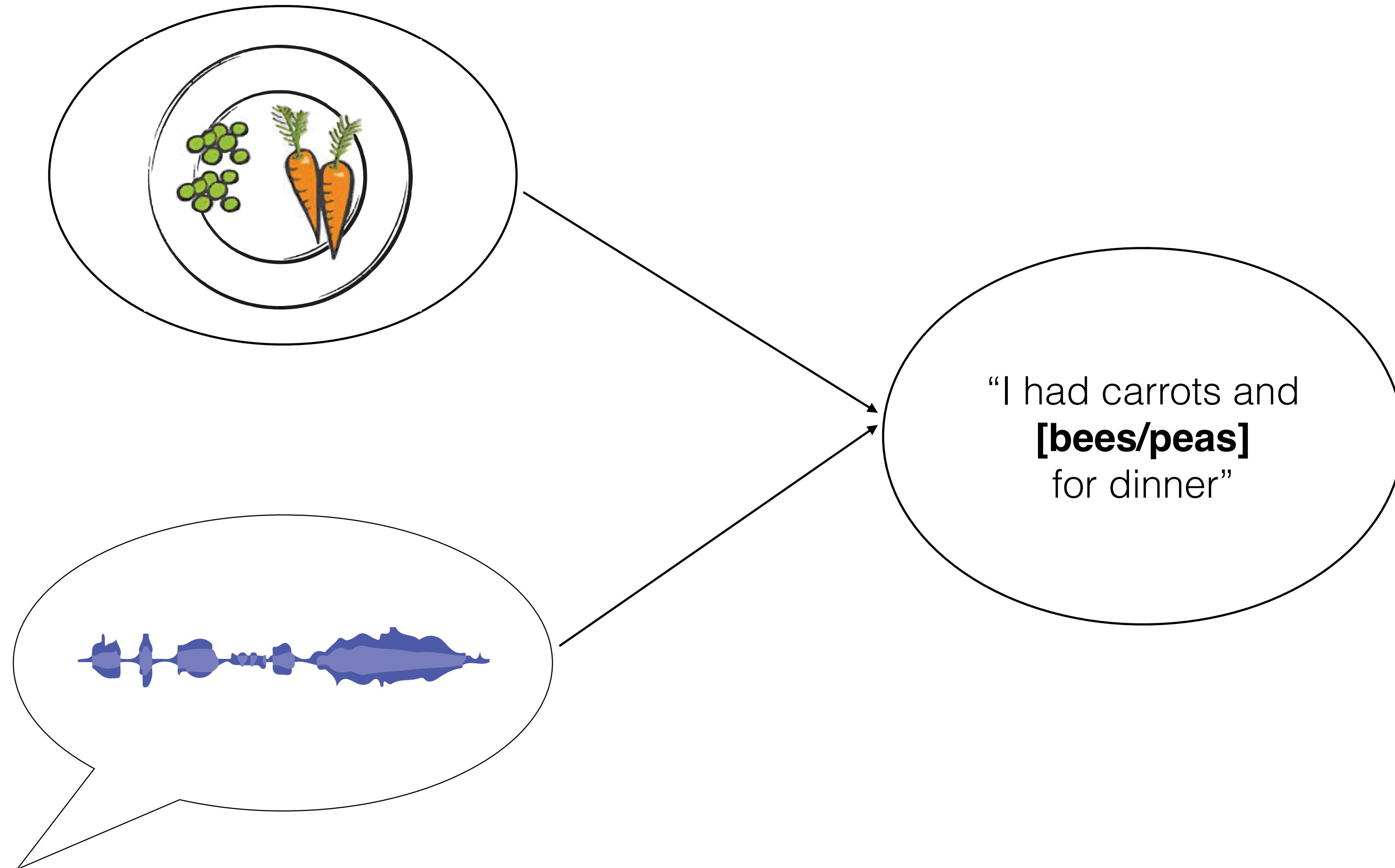
Next



# Inferring a speaker's meaning from what they said



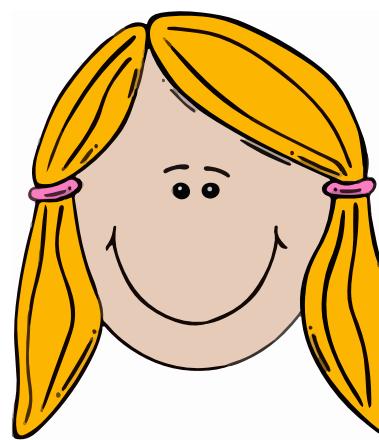
# Integrating top-down and bottom-up cues



# A noisy-channel model of language processing

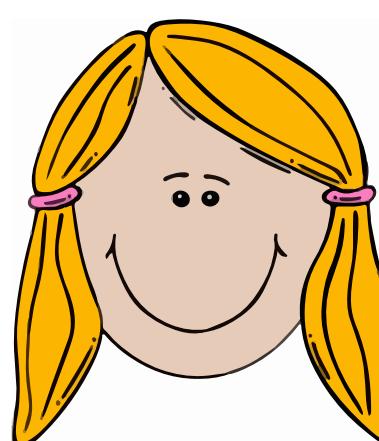


1  “carrots and bees” → SP: “carrots and bees”



“carrots and bees” → Sp: “carrots and bees”

2      “carrots and peas” → SP: “carrots and bees”



“carrots and peas” → SP: “carrots and bees”

# Adults are sensitive to the reliability of the speaker and the channel

The ball was kicked by the girl

The ball kicked the girl

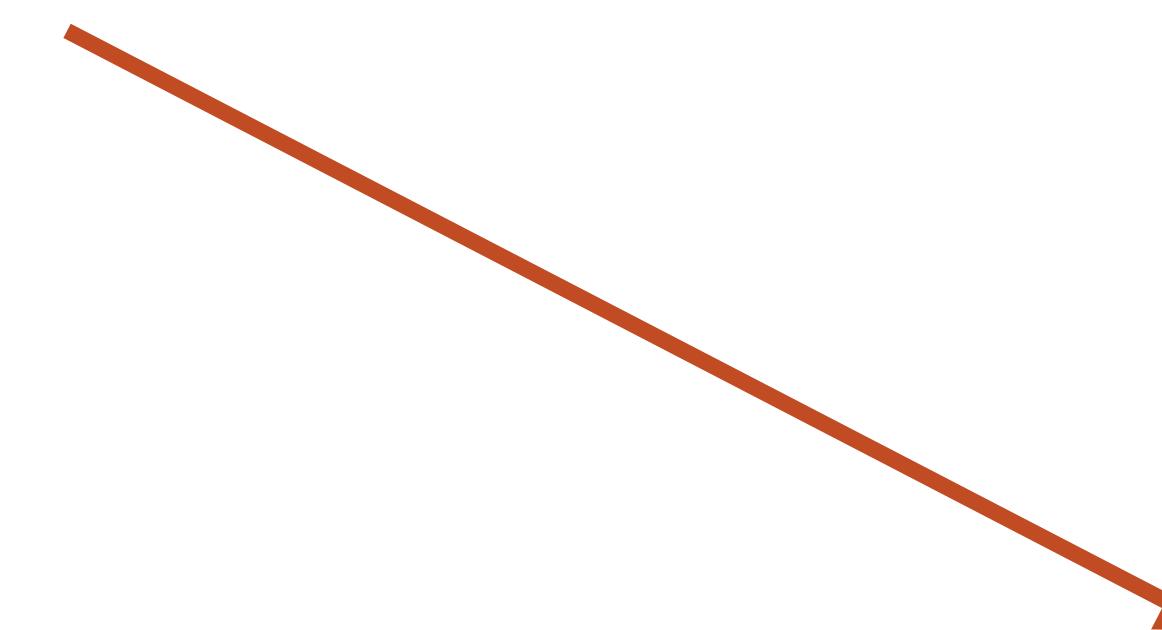
The cat jumped onto the table

Onto the cat jumped the table

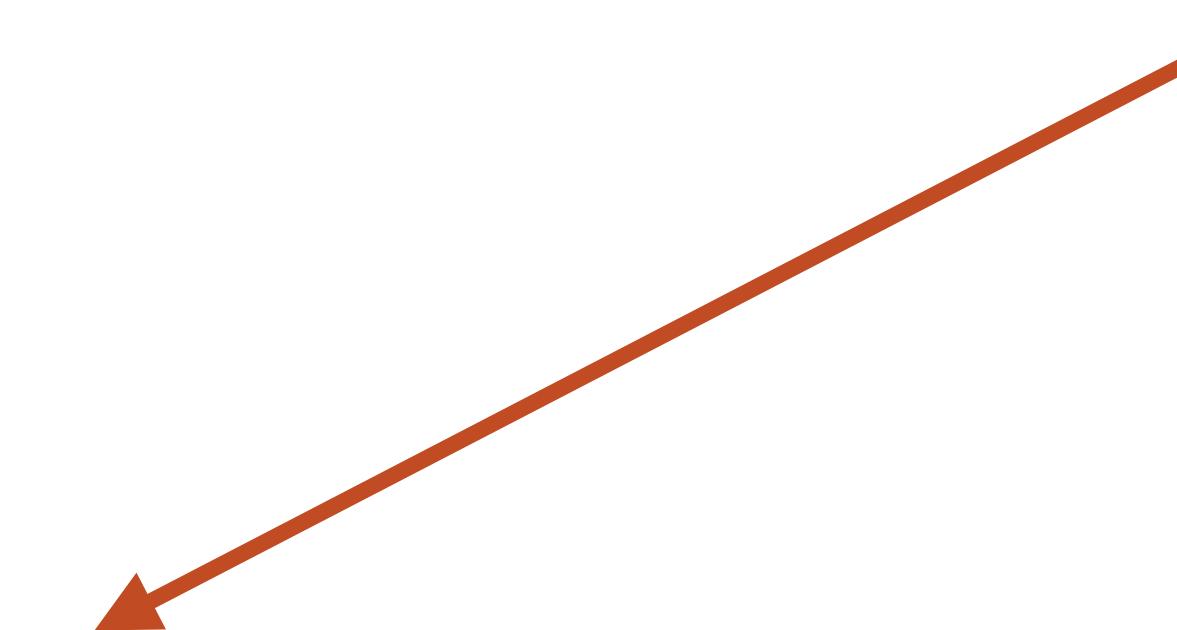
The cook baked Lucy a cake

The cook baked Lucy for a cake

:



:



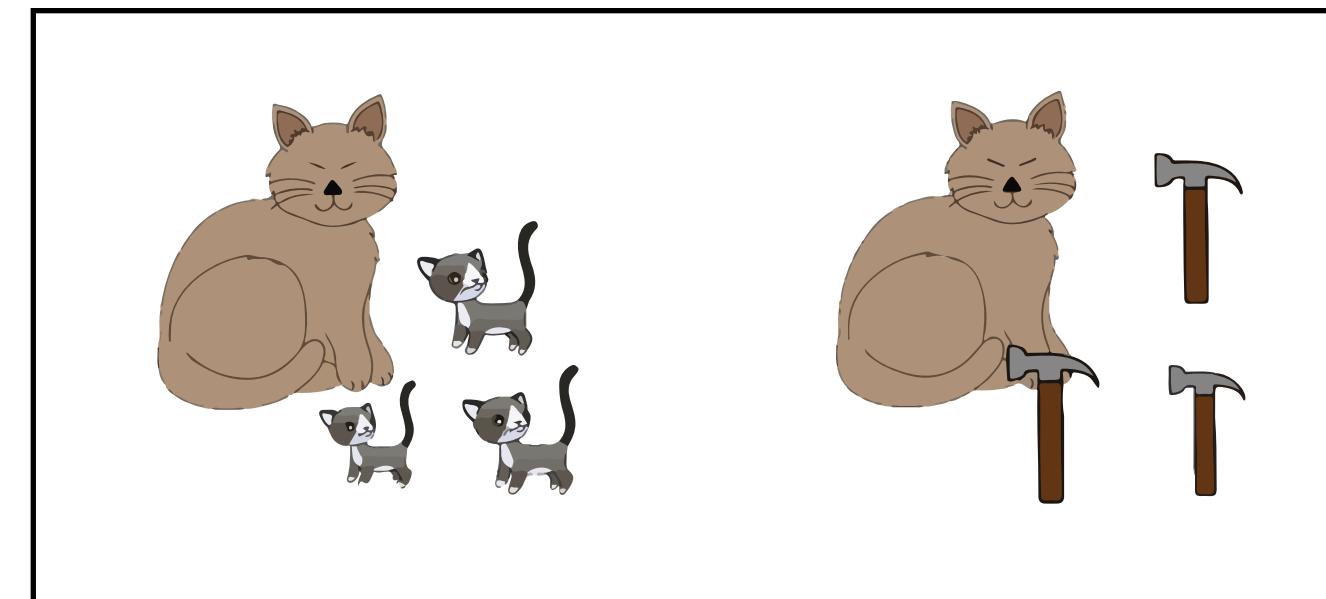
“The mother gave the candle the daughter”

# Testing noisy-channel integration in 4- and 5-year-olds (Yurovsky, Case, & Frank, 2015)

**Plausible**

“My cat has three little  
**kittens**”

**Exposure (x8)**



**Implausible**

“My cat has three little  
**hammers**”

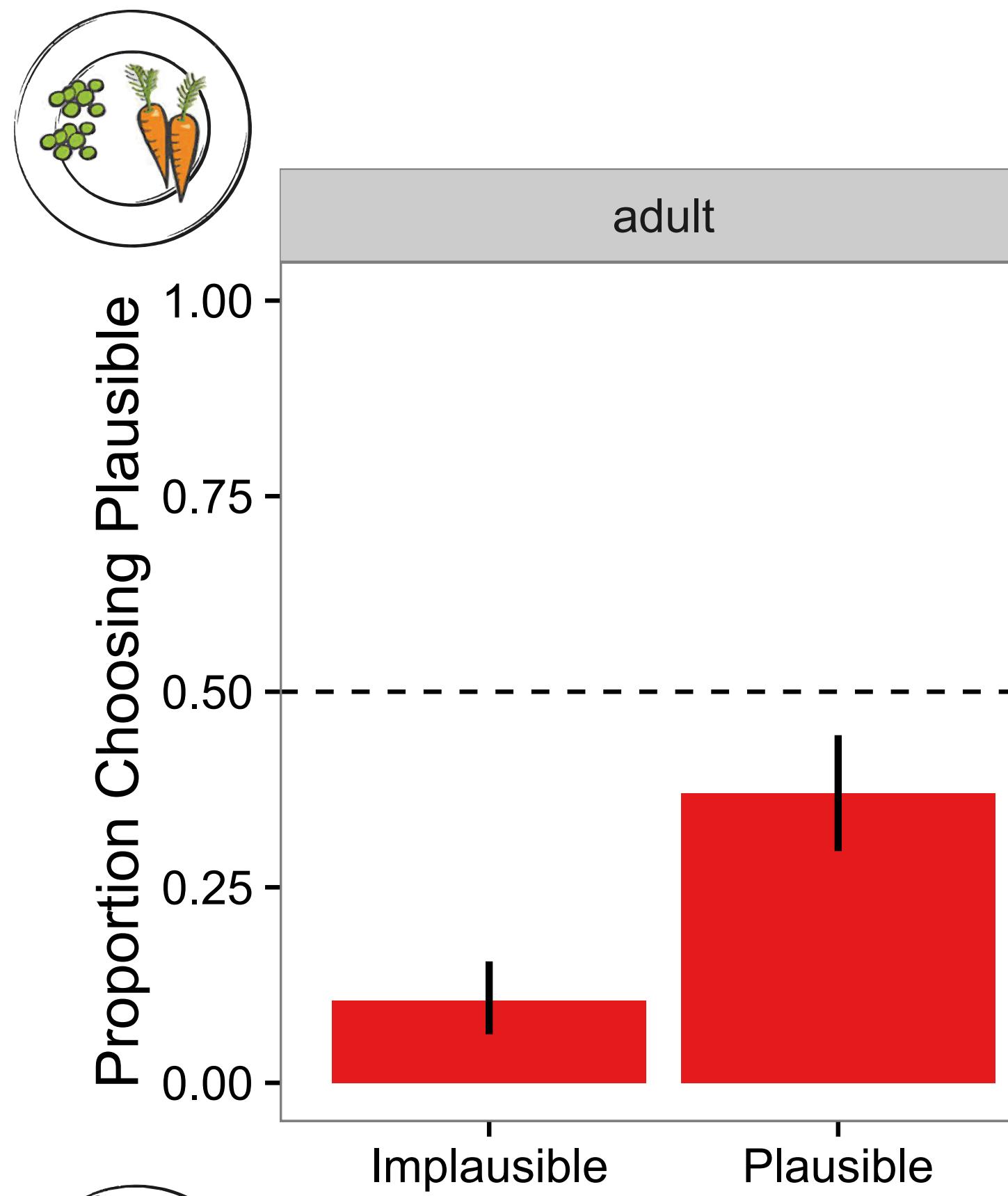
**Test (x8)**



“I had carrots and **bees**  
for dinner”

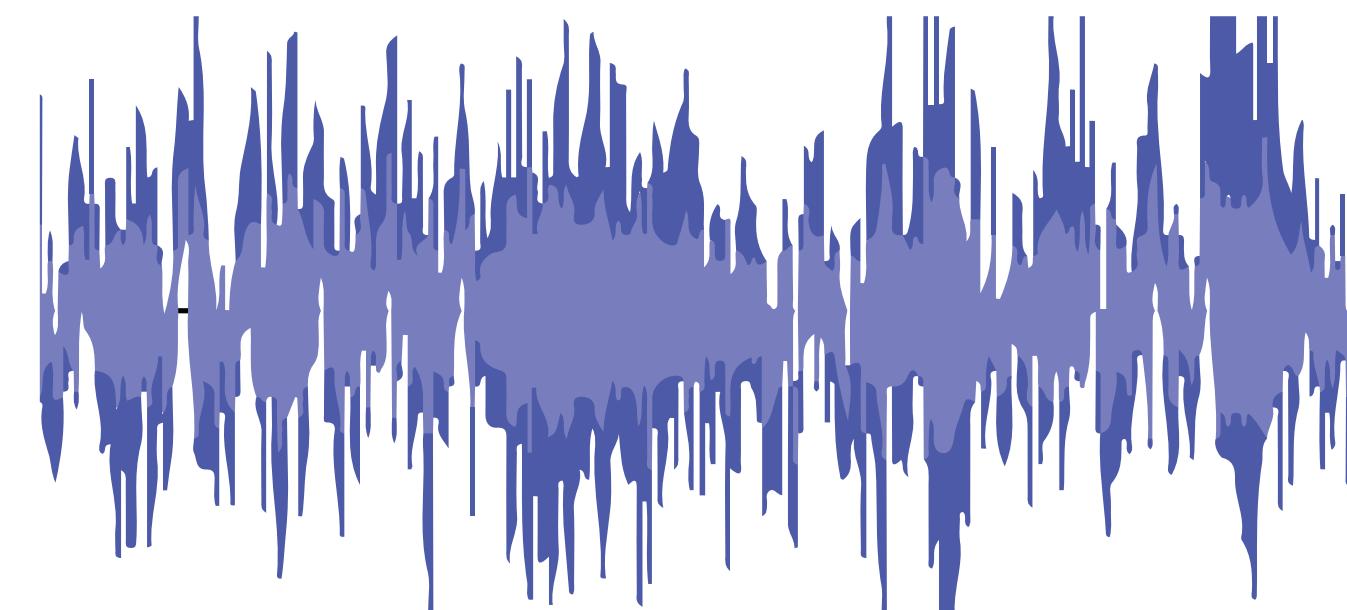
“I had carrots and **bees**  
for dinner”

# Adults and children correct more when exposed to the Plausible Speaker

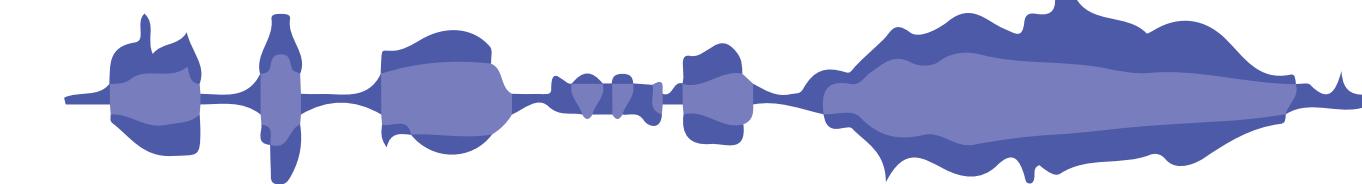


# As speech gets noisier, listeners should rely more on expectations

## Noisy Speech



## No Noise



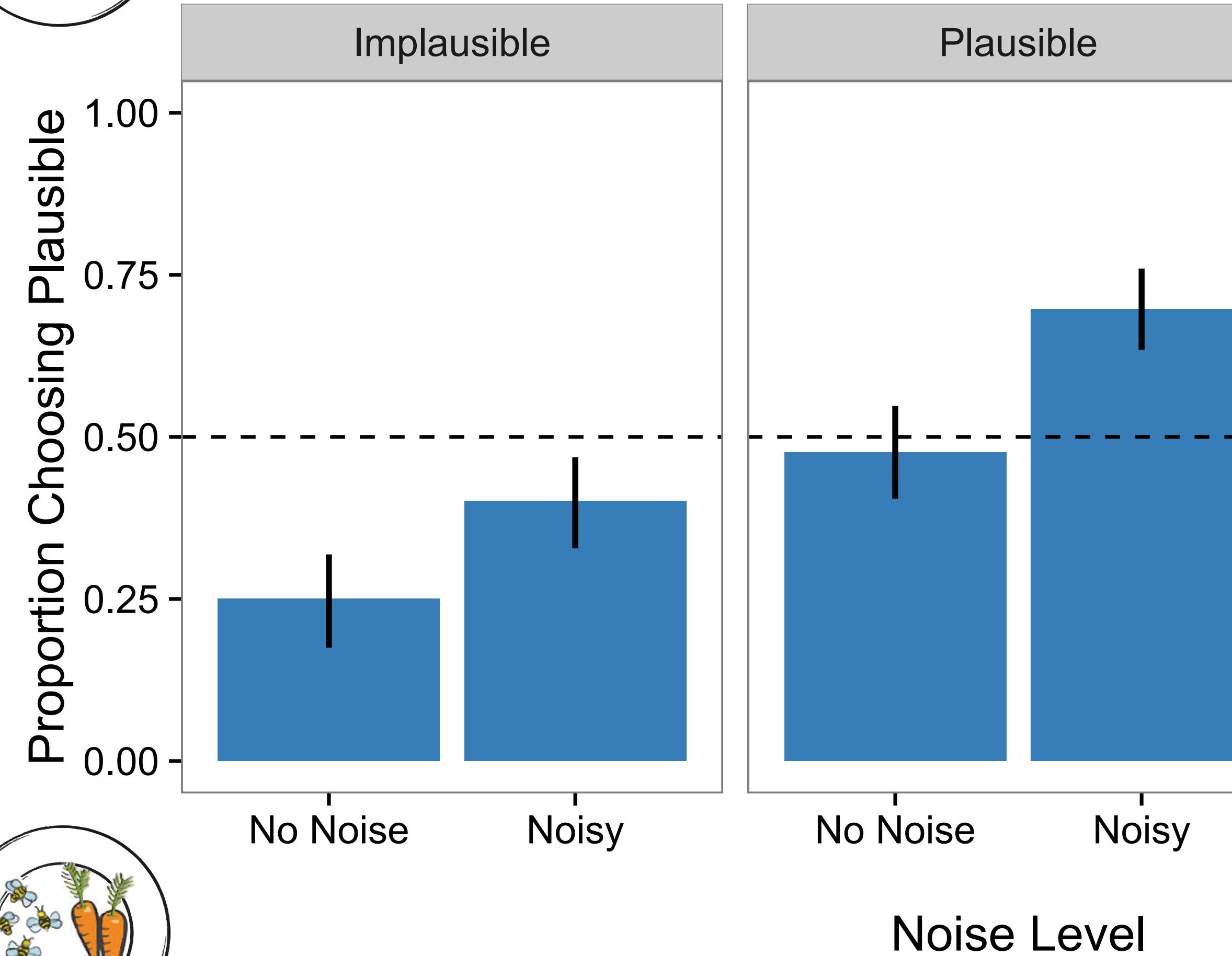
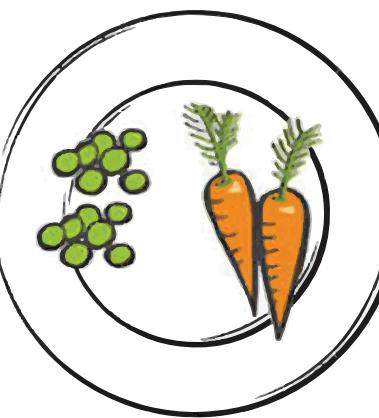
Test (x8)



"I had carrots and **bees** for dinner"

"I had carrots and **bees** for dinner"

# Noisier speech leads to greater reliance on expectations



# Rational speech acts

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