Informativity in cooperative communication

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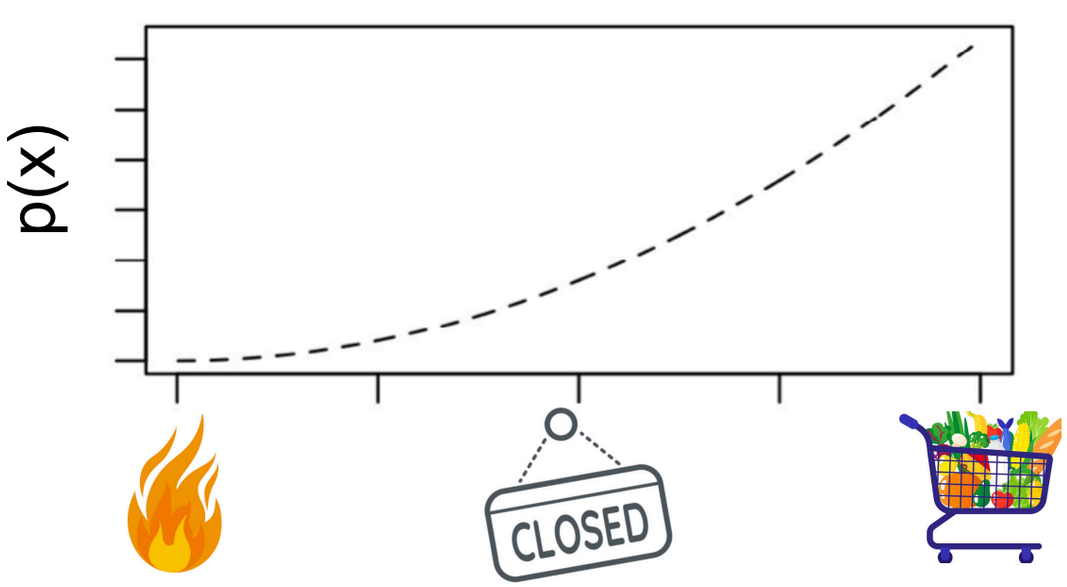
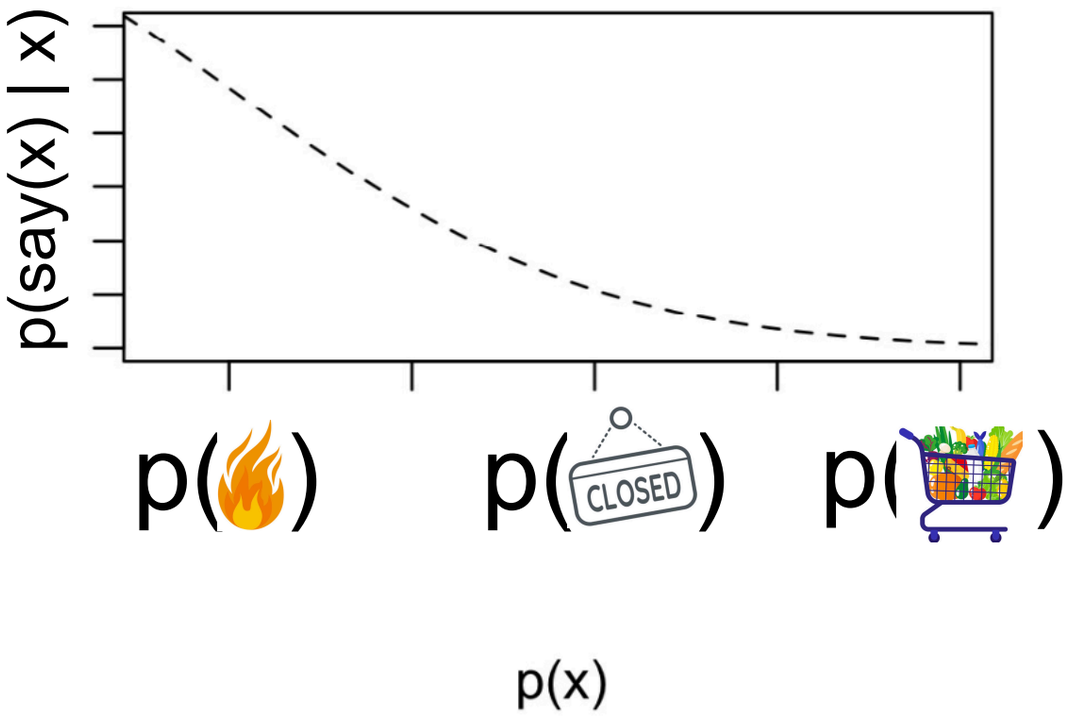
Today the supermarket is …

- closed
- open late
- having a sale on bananas
- on fire?
- selling food?

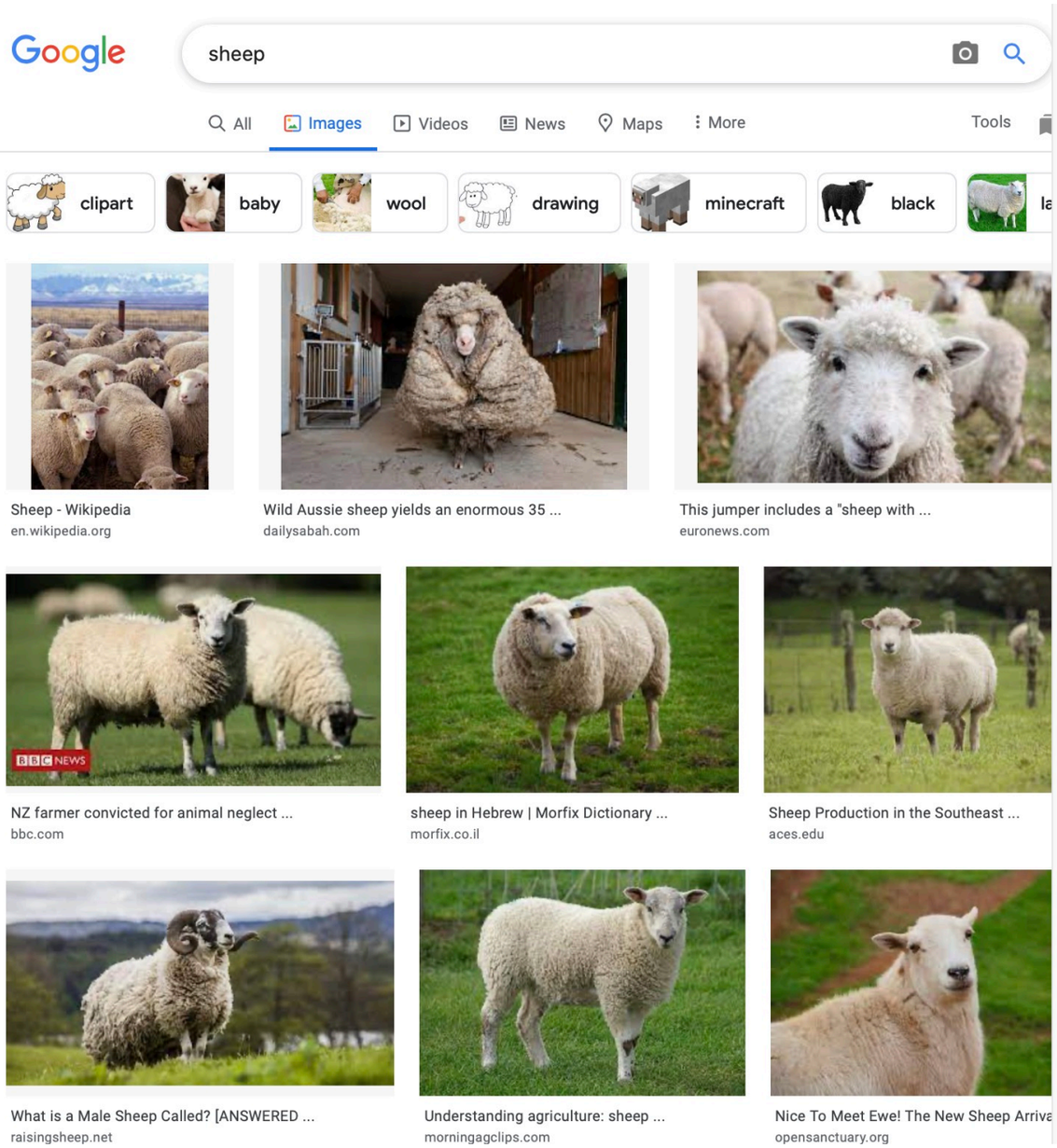
Situation knowledge

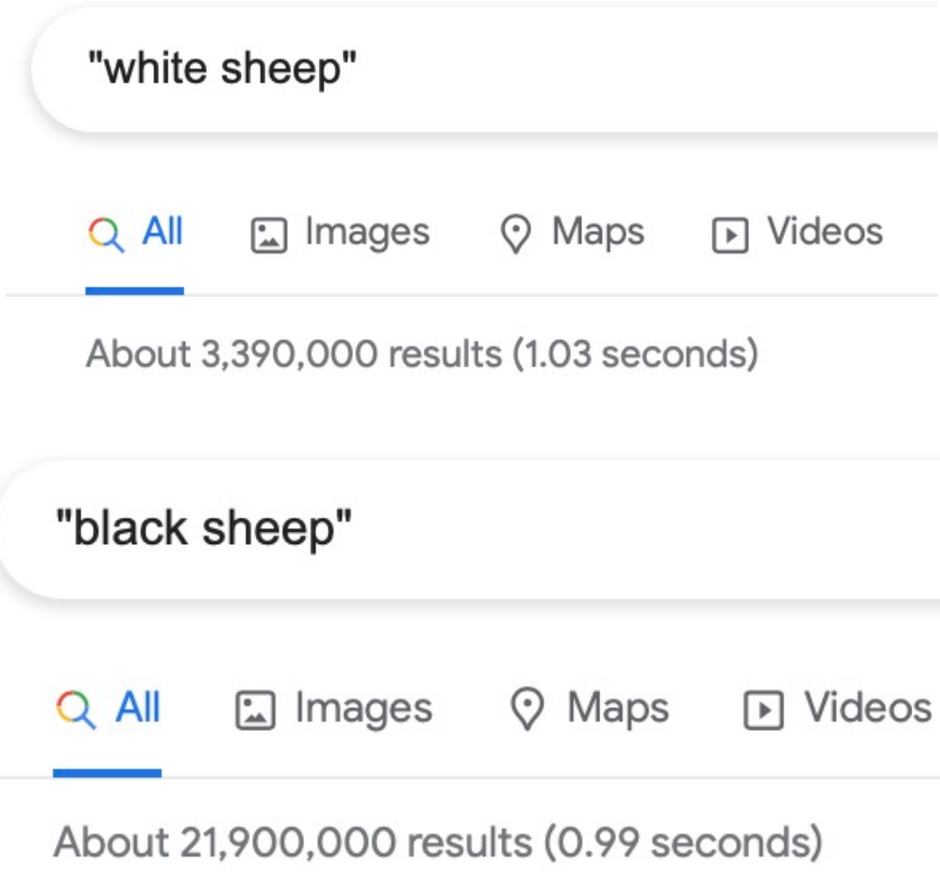


Linguistic knowledge



Preaching to the choir this afternoon





→ Distinction between what we know about the world and what we say about the world (Silberer, Zarrieß, & Boleda 2020; Misra, Ettinger, & Taylor Rayz 2021)

→ Challenge: Understand if a speaker is using language transparently (to talk about how the world is) or with a filter (to be informative)

Why does this matter?

- Language understanding: Build systems that take natural language and use it to understand the world
  - What model of the world do computational systems learn from the text they are trained on?
- Language production: Capture what kind of language humans find interesting in order to build systems that say interesting things
  - What upcoming content do computational systems predict?

This talk is about recovering speaker meaning:

Do speakers mention newsworthy content?

Do comprehenders expect newsworthy content?

What happens when content is not newsworthy?

How do speakers select meanings?

- **Hypothesis 1: Truth**
  - *p(meaning):* Situations that arise often are mentioned often
  - Speakers produce sentences to describe the world; listeners expect sentences about typical situations

- **Hypothesis 2: Truth & likelihood of speech**
  - Meaning selection combines two components
  - Speakers use language to describe the world, filtering meanings for those worth conveying

Prior work in psycholinguistics

- **Production**
  - Omit predictable/inferable in favor of atypical information

pink banana **yellow banana**

wool bowl **ceramic bowl**

stabbing with an icepick **stabbing with a knife**

  - Information-theoretic models capture relationship between (im)probability and informativeness
    [e.g., Bannard, Rosner, & Matthews 2017; Bergey, Morris, & Yurovsky 2020; Degen, Hawkins, Graf, Kreiss, & Goodman 2020; Greenfield & Smith 1976; Lemke, Hoch & Reich 2017; Lemke, Reich, Schäfer & Drenhaus 2021; Venhuizen, Crocker & Brouwer 2019]

[Brown & Dell 1987; Sedivy 2003; Mitchell et al. 2013; *inter alia*]

Prior work in psycholinguistics

- **Production**
  - → Be informative, omit overly predictable material
    [Grice 1975; Aylett & Turk 2004; Levy & Jaeger 2007]
- **Comprehension**
  - Situation-plausible content eases processing

The Dutch trains are yellow.

The Dutch trains are white.

The Dutch trains are sour.

There are two Beaters on every Quidditch team. Their job is to protect their team from Bludgers.

… from Spellotape.

[Marks & Miller 1964; Walker 1975; Stanovich & West 1979; Morris 1994; Kutas & Hillyard 1980; Nieuwland & Van Berkum 2006; Matsuki et al. 2011; Hagoort et al. 2004; Troyer & Kutas 2018; Warren & Dickey 2021]

Prior work in psycholinguistics

- **Production**
  - → Be informative, omit overly predictable material
    [Grice 1975; Aylett & Turk 2004; Levy & Jaeger 2007]
- **Comprehension**
  - → Favor sentences that describe predictable situations
    [review in Dickey & Warren 2021]

Listener's model of the speaker

- Hypothesis 1: Speaker transparently maps situations to speech

Today the supermarket is on fire. → unexpected utterance

$$p(utterance) \propto p(situation)$$

- Hypothesis 2: Speaker uses language non-transparently with bias in favor of informativity

Today the supermarket is selling food. → unexpected?

$$p(utterance) \propto \sum_{situation} p(situation)\, p(utterance|situation)$$

priors in the world

production choices

Outline

Part I. What will the speaker say next?

Expectations about probable situations vs likely utterances

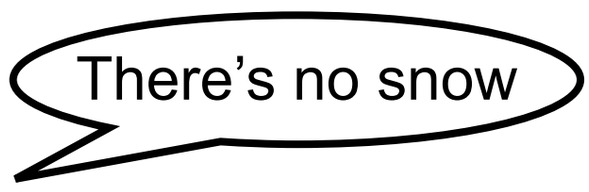
- **Modification:** Likely colors vs likely mention of color

- **Propositions:** Beliefs vs assertions

- **Alignment in production ~ comprehension**

Part II. Why is she telling me this?

Inference of additional meaning beyond what was said



Upshots

→ Distinction between situation plausibility and utterance likelihood

→ Evidence that listeners try to reverse engineer speaker goals

→ Impact of speaker's intention, style, knowledgeability, addressee

Knowledge of color: Hearing mention of an object activates object color

"The boy saw the frog"

"The boy saw the frog"

→ Comprehenders make use of real-world knowledge so that the mention of a typically green object elicits looks to green things

[Huettig & Altmann 2004; Naor-Raz, Tarr & Kertsen 2003; Yee & Sedivy 2006]

What about a color word: Does ‘yellow’ activate typically yellow objects?

“Click on the yellow…”

yellow shirts

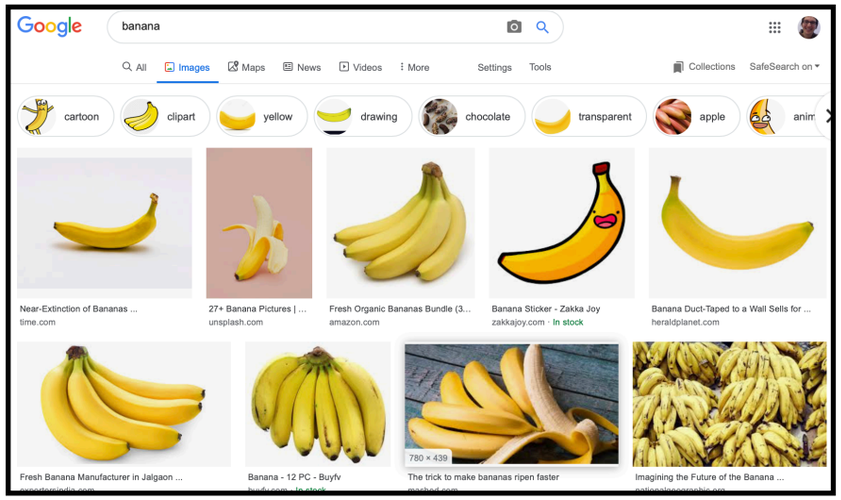
bananas

Biases in production: Speakers produce redundant color adjectives more for objects with no inherent color

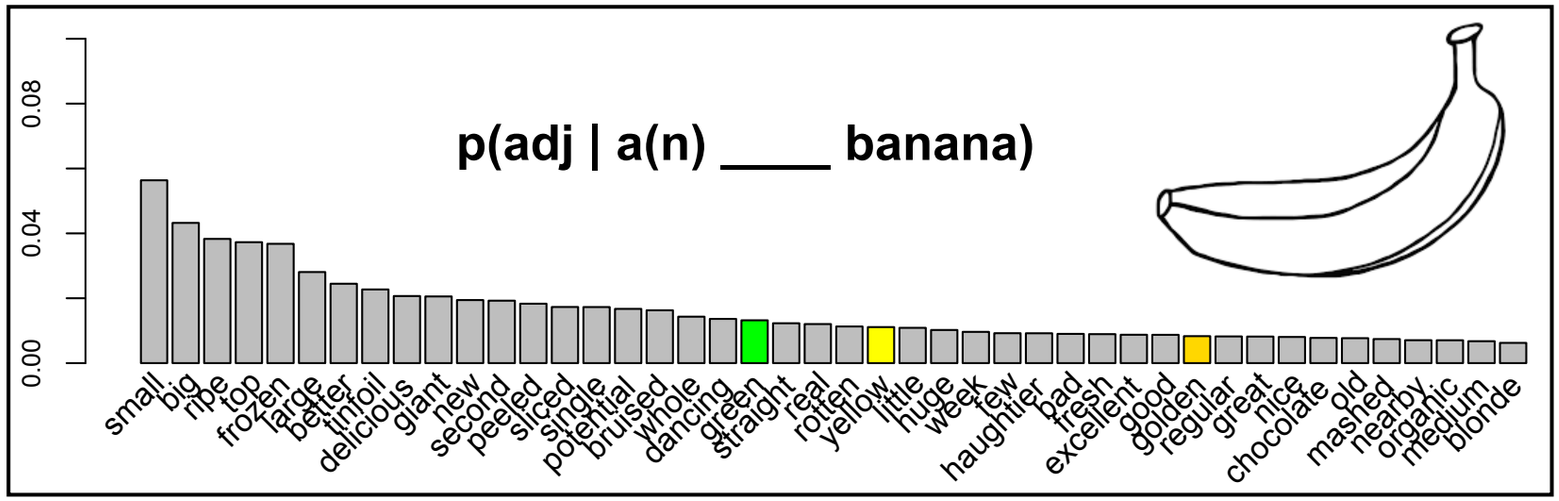
[Sedivy 2003; Westerbeek 2015; Rubio-Fernandez 2016; Degen, Hawkins, Graf, Kreiss & Goodman 2020; see also Tourtouri, Delogu, Sikos & Crocker 2019]

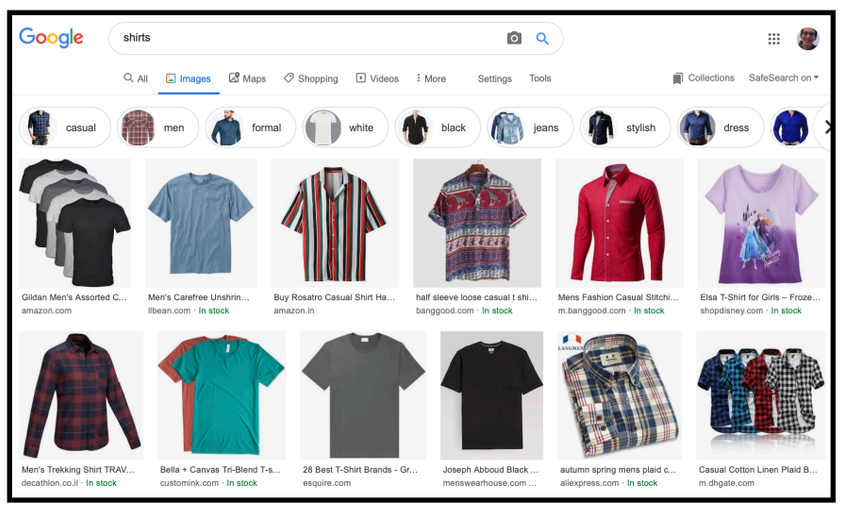
[Rohde & Rubio-Fernandez, *Journal of Memory and Language* 2022]

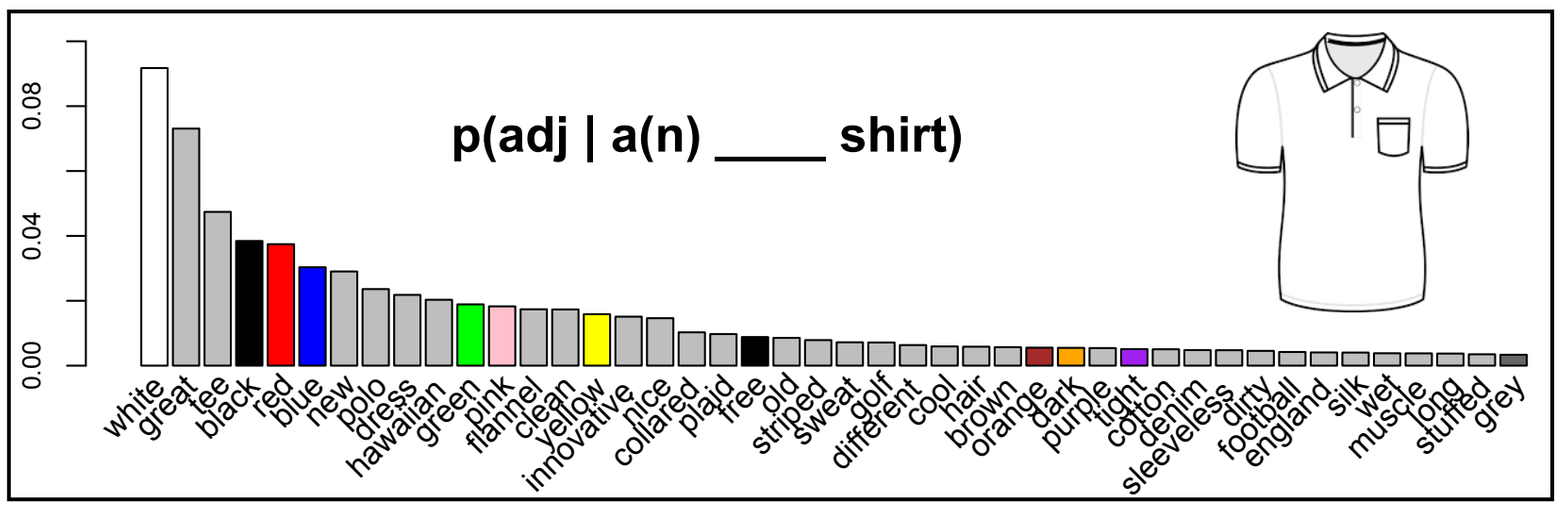
Situation probability



Utterance likelihood







…color is linked to food

…color words are linked to clothing

$$p(utterance) \propto \sum_{situation} p(situation) * p(utterance|situation)$$

[counts from Google ngrams, see also Sedivy 2003]

Knowledge of mention of color

- **Goal:** Test comprehenders' awareness of production likelihood *p(utterance | situation)* in sentences with ambiguous color word
- **Method:** Eye-tracking while listening to incomplete sentences, guess food or clothing (N=38)

Click on the yellow… **[color]**

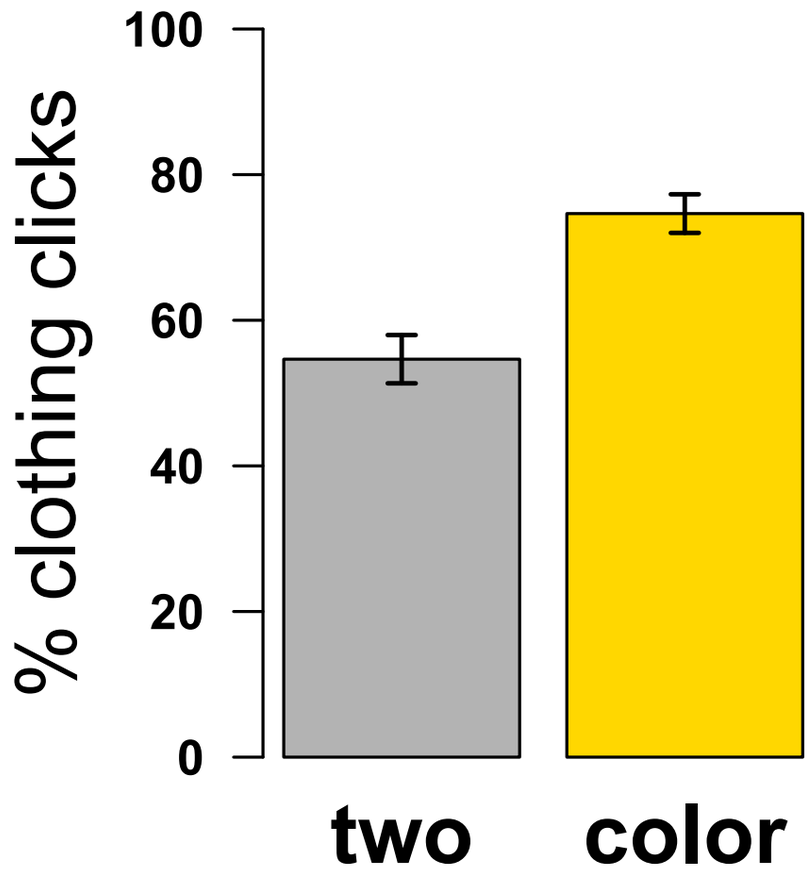
Click on the two… **[two]**

→ **If color/number are ambiguous:** predict 50/50 click rate

→ **If inherent color matters most:** predict **color** will favor **food**

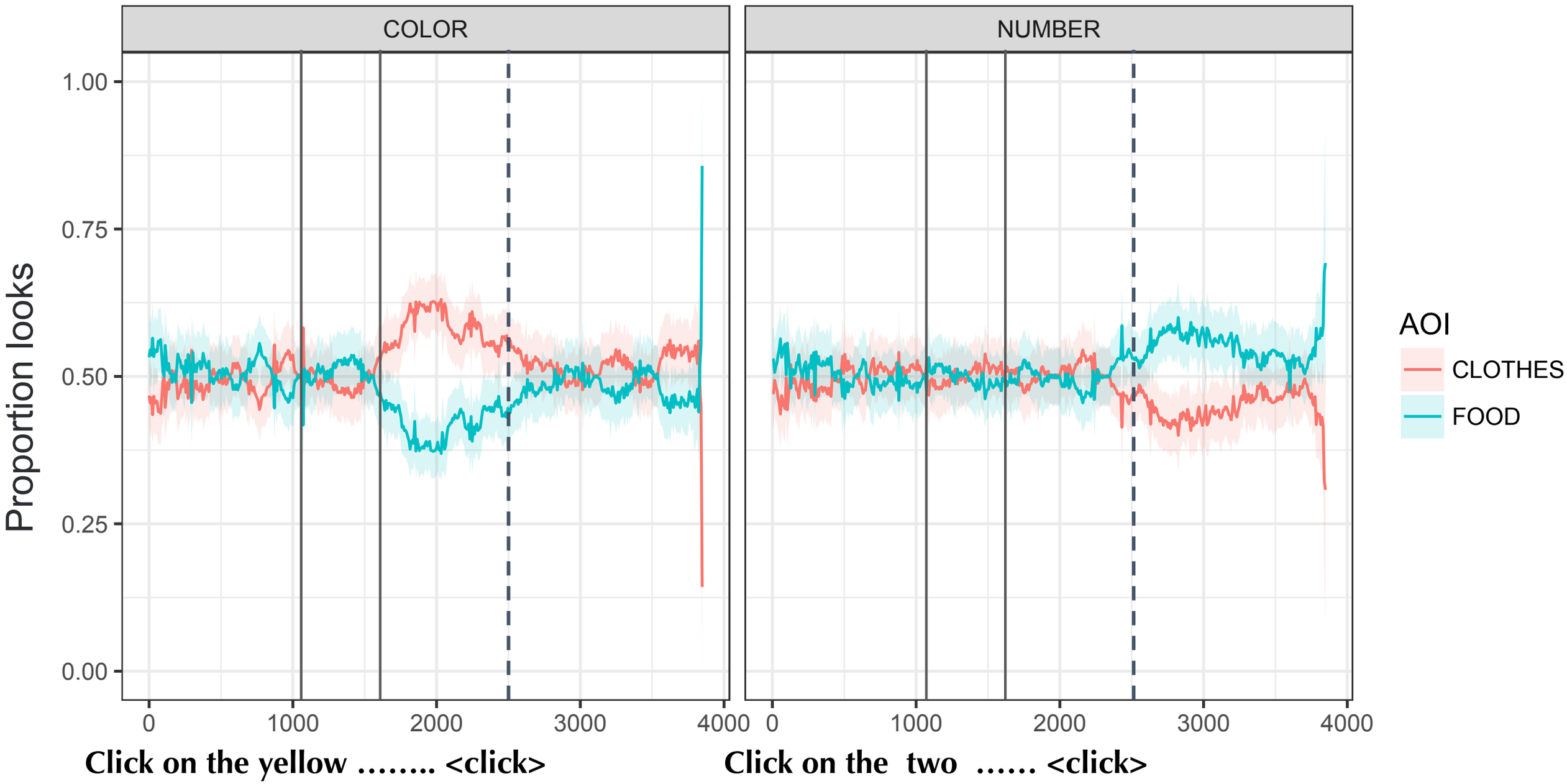
→ **If comprehenders are aware of speakers' use of color:** predict **color** will favor **clothing**

Knowledge of mention of color



→ Comprehenders are informed by “uninformative” color, seeming to reverse engineer the production process

Eye tracking



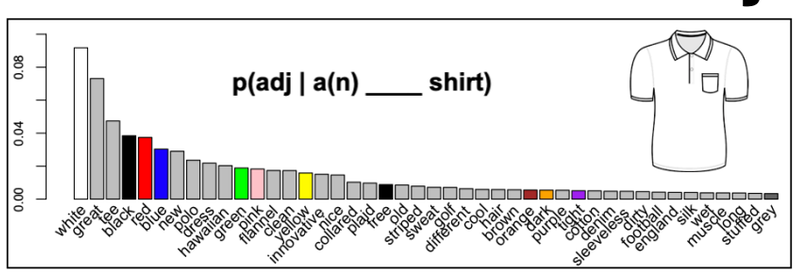
→ Evidence of likelihood-driven looking from earliest moments

What are participants tracking?

- **Real world probability:**


…color should favor food

- **Likelihood of color adjective:**



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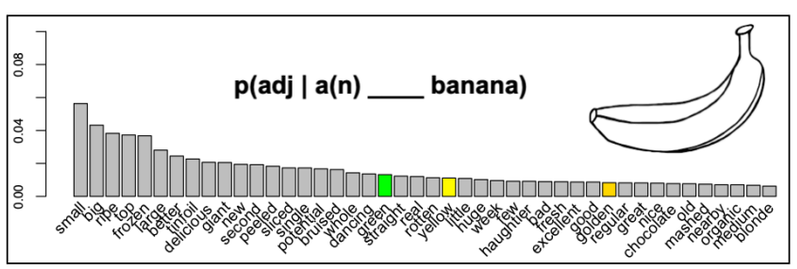


…color should favor clothing

- **Raw frequencies:**

‘yellow shirts’ > **‘yellow bananas’**

‘two shirts’ > **‘two bananas’**

‘shirts’ > **‘bananas’**

…color & two → clothing

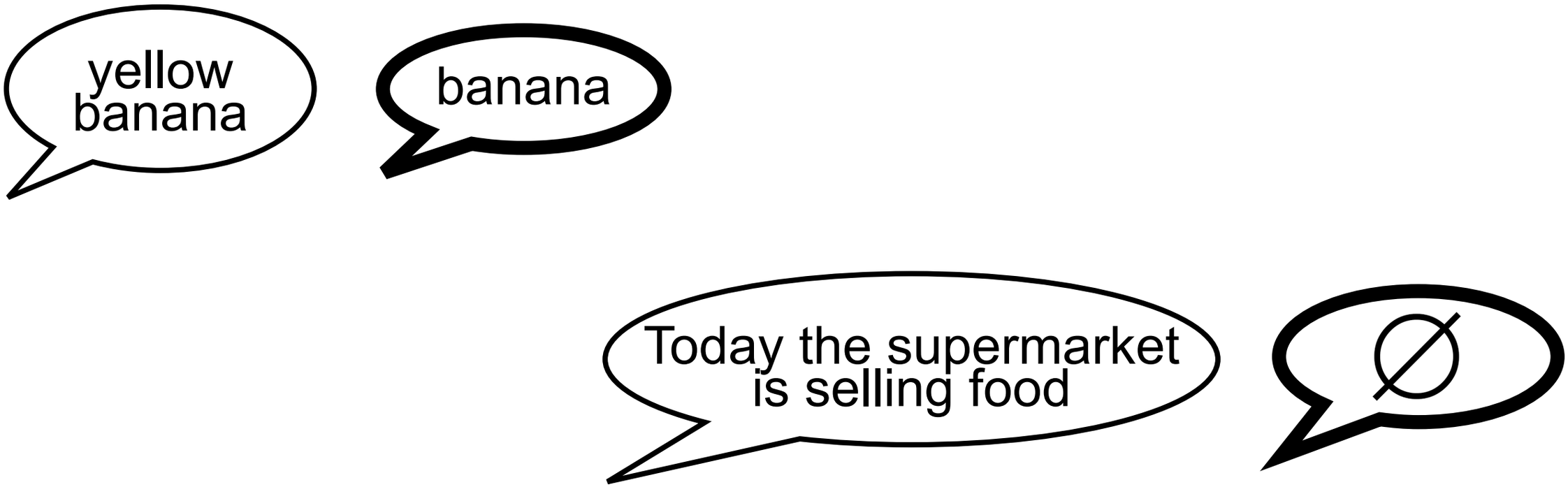
- **Point-wise mutual information:**

PMI(yellow~bananas) > PMI(yellow~shirts)

PMI(red~cherries) > PMI(red~scarves)

PMI(purple~figs) > PMI(purple~heels)

PMI(green~cucumbers) > PMI(green~dresses) …color → food



- **Predictability favors reduction**
  [Aylett & Turk 2004; Frank & Jaeger 2008; Gahl & Garnsey 2004; Hale 2001; Lemke et al. 2021; Levy & Jaeger 2007; Jurafsky et al. 1998; Piantadosi et al. 2011; Zerkle et al. 2017]

- **Implications for comprehension?**
  If situation-typical content can be omitted, does a speaker's choice to speak raise expectations for novel content?

Novel propositional content

$$p(utterance) \propto \sum_{situation} p(situation) * p(utterance|situation)$$

- Guesses about the world (what situations are probable)
- Guesses about speakers' goals (what content would **cooperative speakers** mention)

[Rohde, Hoek, Keshev & Franke *Open Mind* 2022]

What does a speaker think/say?

Andy is a man from the United States.
Andy has an aunt, Hannah.

Hannah thinks Andy drank __ cups of coffee last week. **[think]**

Hannah announced to me that Andy drank __ cups of coffee last week. **[announce]**

Task: forced choice (prior vs higher value)

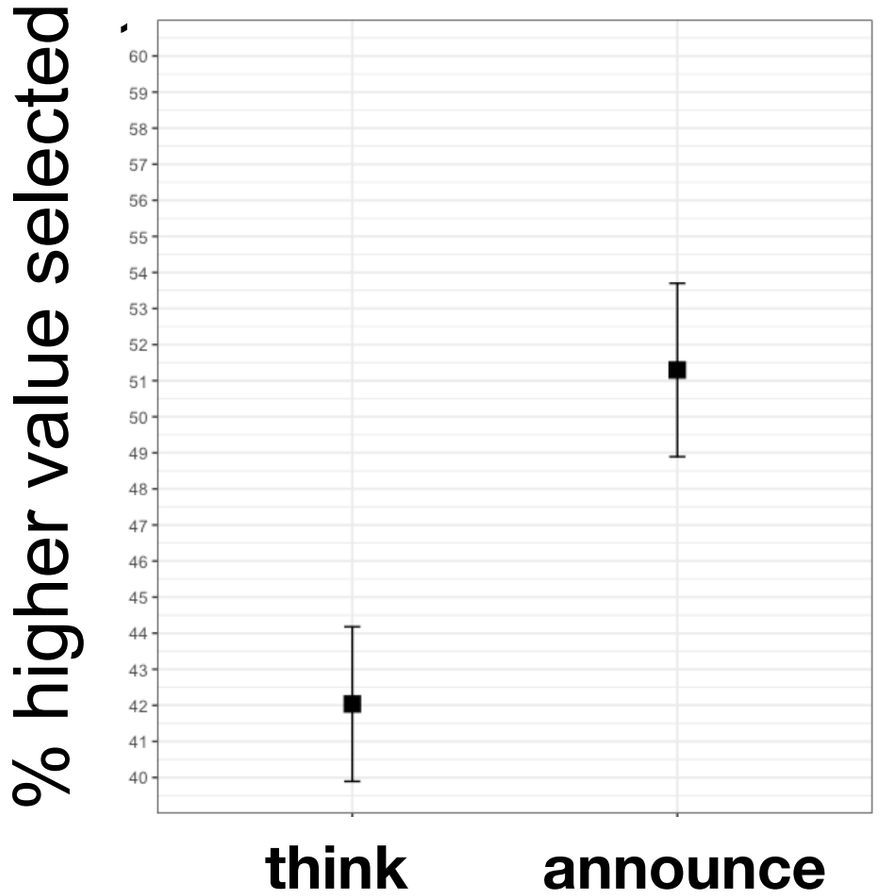
◎ 14 ◎ 20

N=90

→ **If speakers transparently maps situations to speech**
- **think** → prior
- **announce** → prior

→ **If speech is used for reporting atypical content**
- **think** → prior
- **announce** → higher

What does a speaker think/say?



→ Expectations about speakers' beliefs differ from expectations about content a speaker would choose to express

thinking **vs** **speaking**

he drank 2 cups of coffee

---

speaking when spoken to **vs** **speaking out of the blue**

how many?

he drank 2 cups of coffee

hey, guess what?!
he drank 2 cups of coffee

---

speaking to one person **vs** **speaking to a crowd**

he drank 2 cups of coffee

LISTEN UP! ANDY DRANK
2 CUPS OF COFFEE

What to say when?

Andy is a man from the United States.
Andy has an aunt, Hannah.

This afternoon, Hannah, when asked about it,
said that Andy drinks __ cups of coffee per day.

[asked]

This afternoon, Hannah out of the blue
said that Andy drinks __ cups of coffee per day.

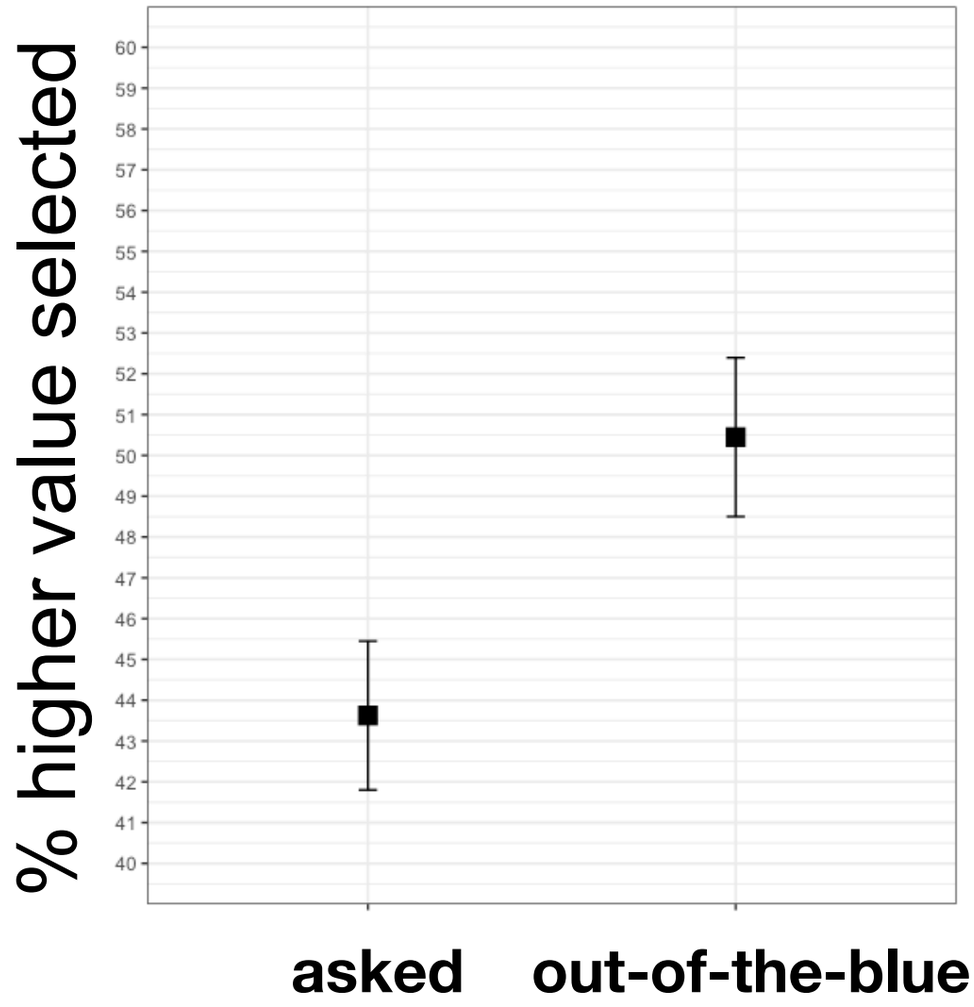
[blue]

Task: forced choice (prior vs higher value)

◎ 2 ◎ 3

N=103

What to say when?



→ Expectations about speakers' answers **when asked** differ from expectations about content speakers **choose themselves**

What to say to who?

Andy is a man from the United States.
Andy has an aunt, Hannah.

This evening at the pub, Hannah said to me that Andy drinks __ cups of coffee per day. [me]

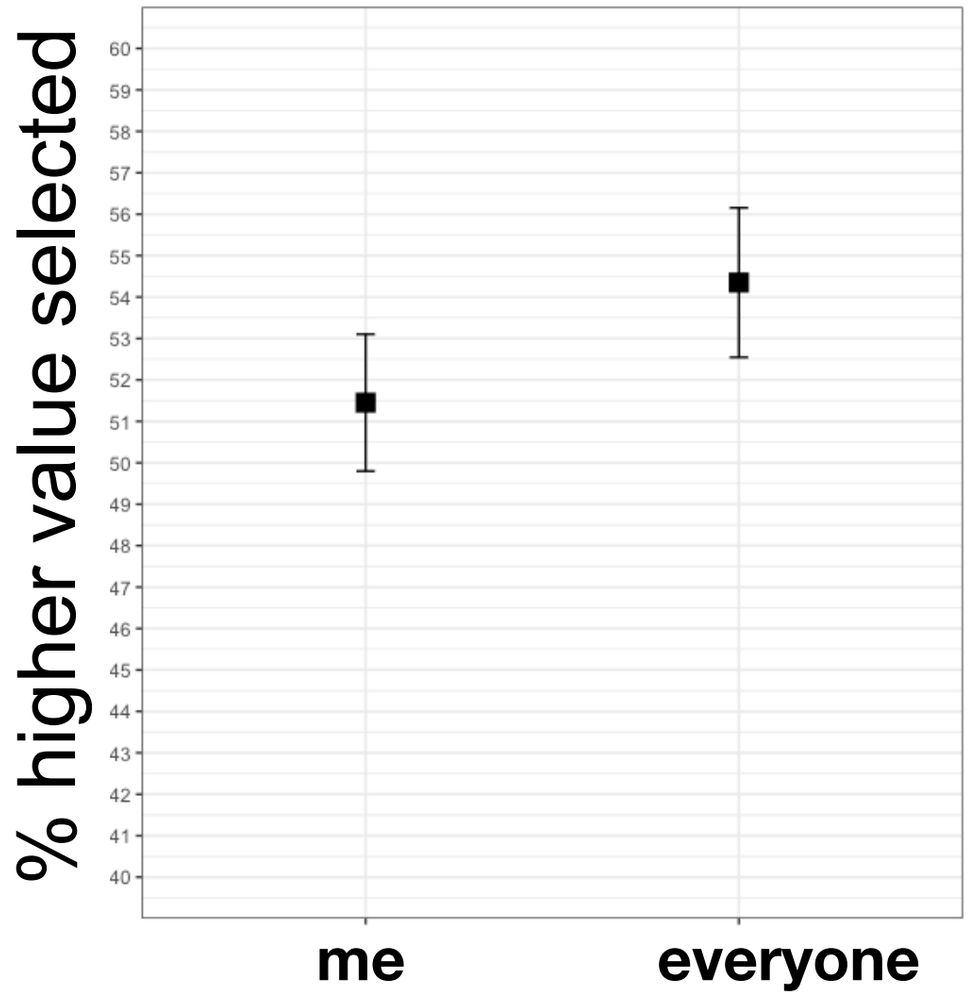
This evening at the pub, Hannah stood up and said to everyone that Andy drinks __ cups of coffee per day. [everyone]

Task: forced choice (prior vs higher value)

◎ 2 ◎ 3

N=152

What to say to who?



→ Preference for higher values varies depending on addressee

Novel propositional content

$$p(utterance) \propto \sum_{situation} p(situation) * p(utterance|situation)$$

- Guesses about the world (what situations are probable)
- Guesses about speakers' goals (what content would **cooperative speakers** mention)

[Vilde Reksnes, Alice Rees, & Chris Cummins, submitted]

Emphasis on the speaker

- **Goal:** Test comprehenders' awareness of production likelihood *p(utterance | situation)* by manipulating salience of the speaker
- **Method:** Cloze task sentence completion on Prolific (N=200), plus typicality pre-test (N=22)

[bare] **At the train station, there's _____**

[3rd person] **They're at the train station, and there's _____**

[1st person] **I'm at the train station, and there's _____**

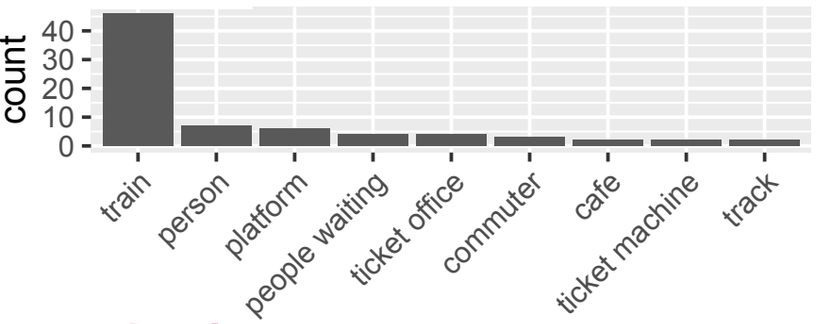
[visible speaker]

Typicality pre-test

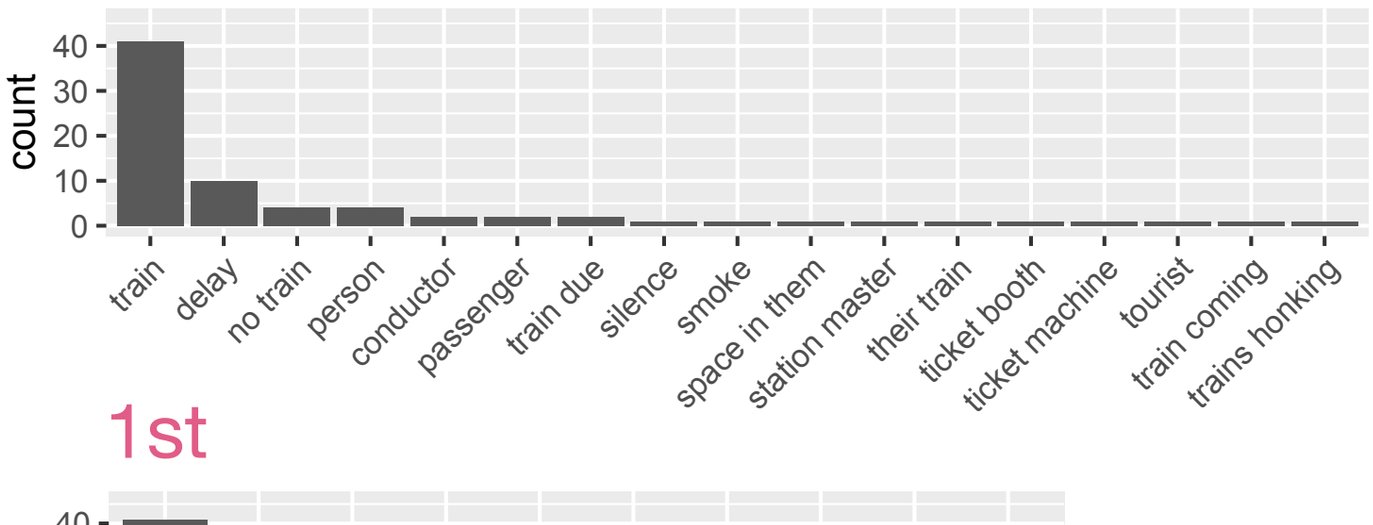
What do you find at a train station? (list 3 or more)

*showing 75% data per condition per location

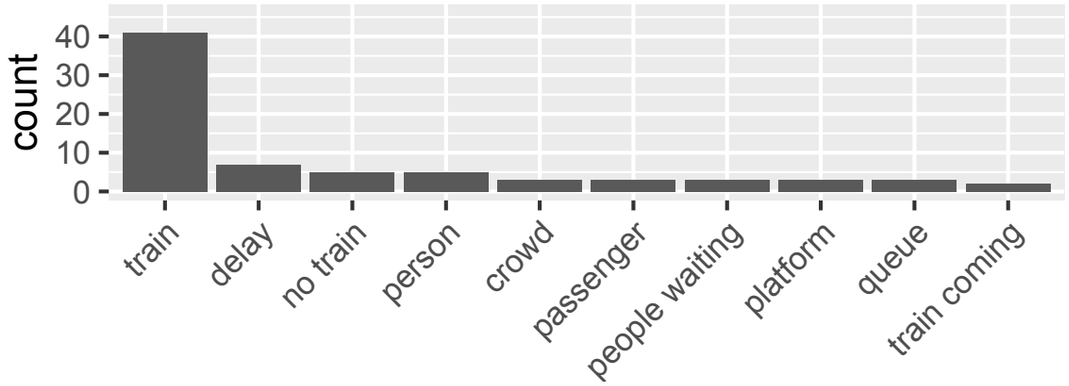
bare



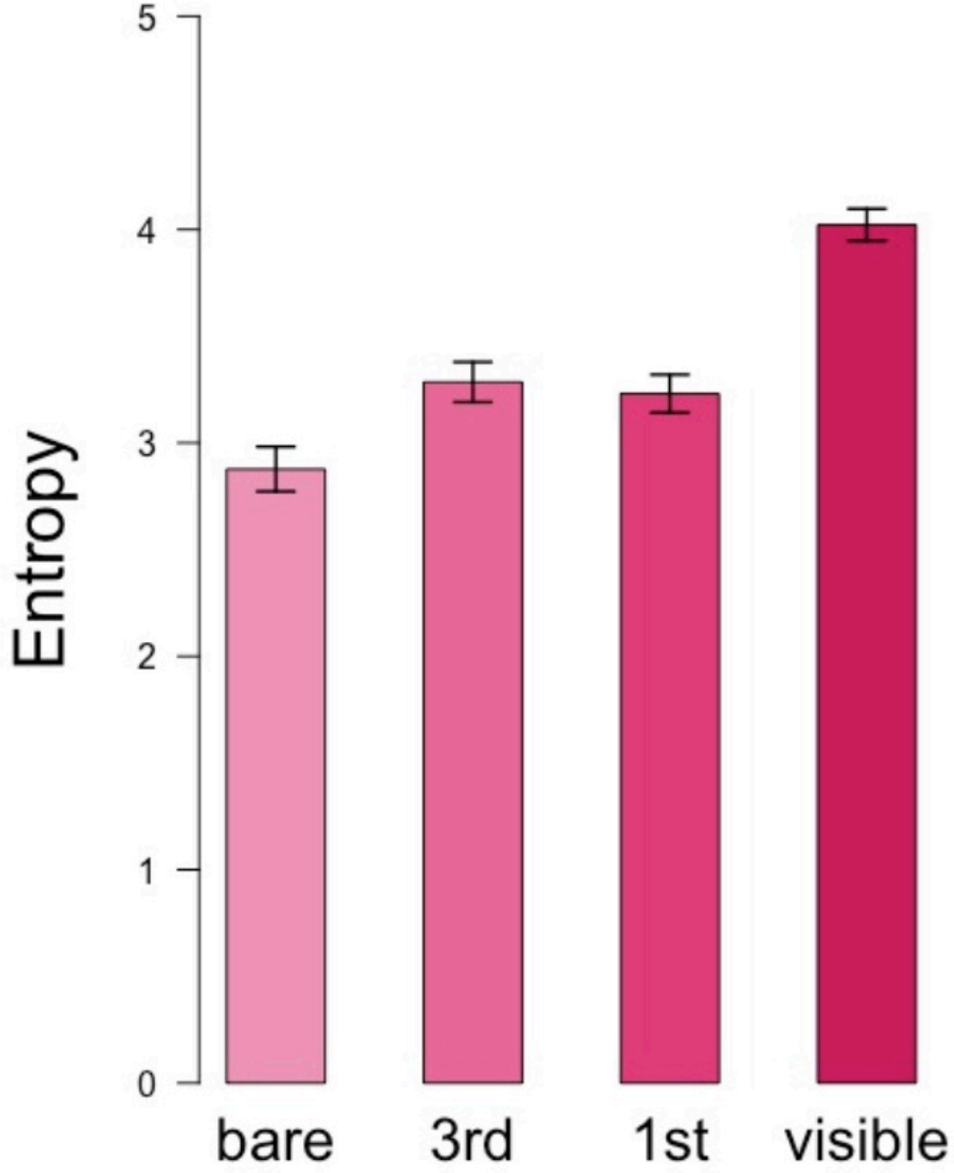
3rd

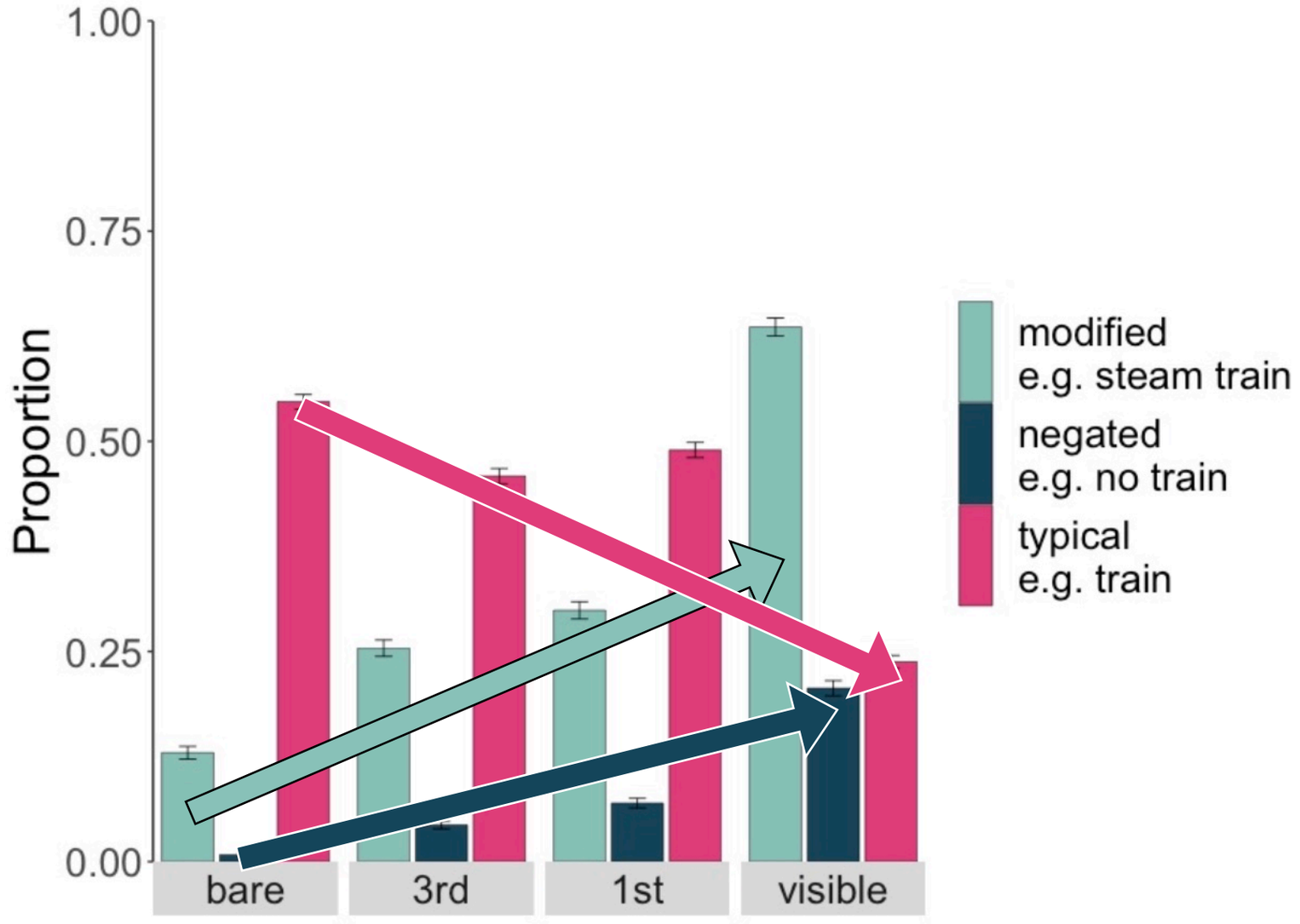


1st



visible speaker





→ The more aware comprehenders are of the speaker, the more informative they expect the speaker's contribution to be

→ But not all speakers are the same. Awareness of speaker style?

Awareness of speaker style

- **Method:** Exposure phase followed by Cloze task sentence completion on Prolific (N=100)

[low inform Suzy]

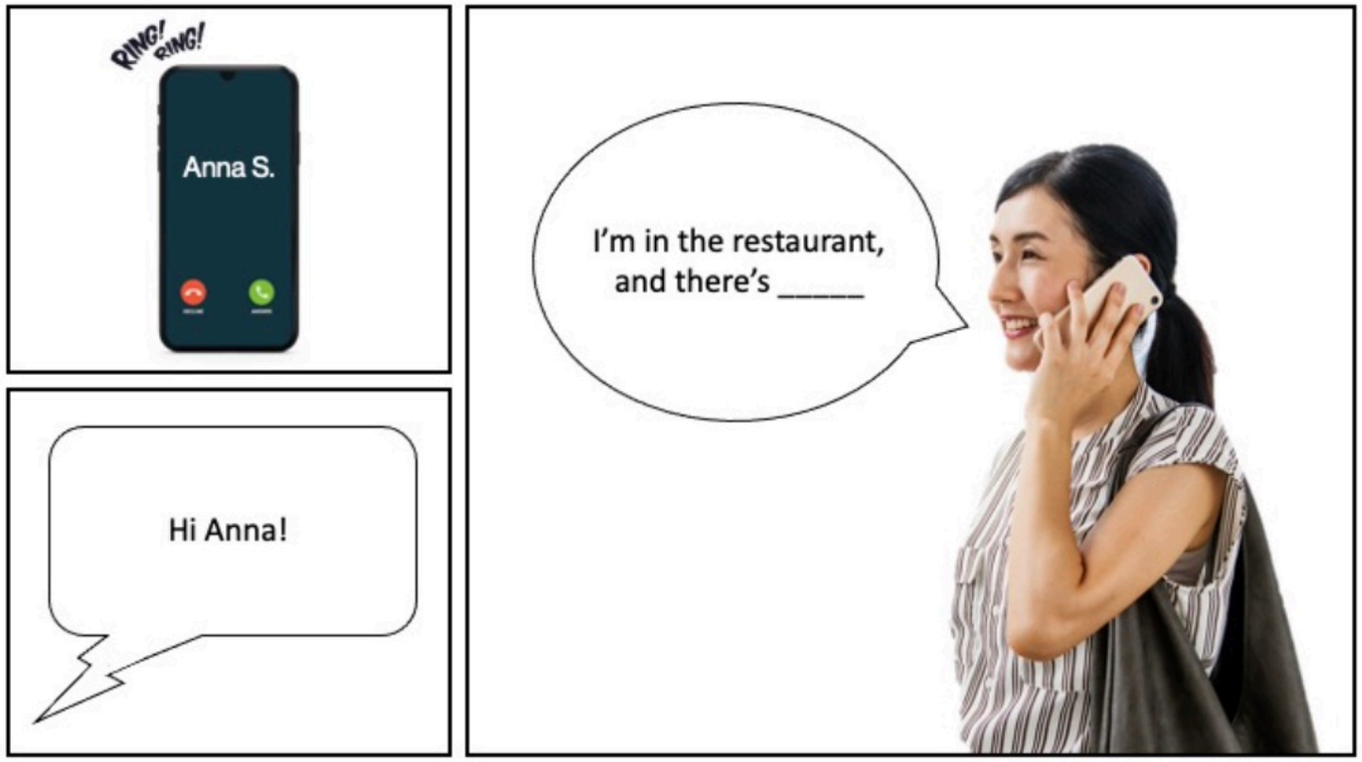
[high inform Anna]

$$p(utterance) \propto \sum_{situation} p(situation) * p(utterance|situation)$$

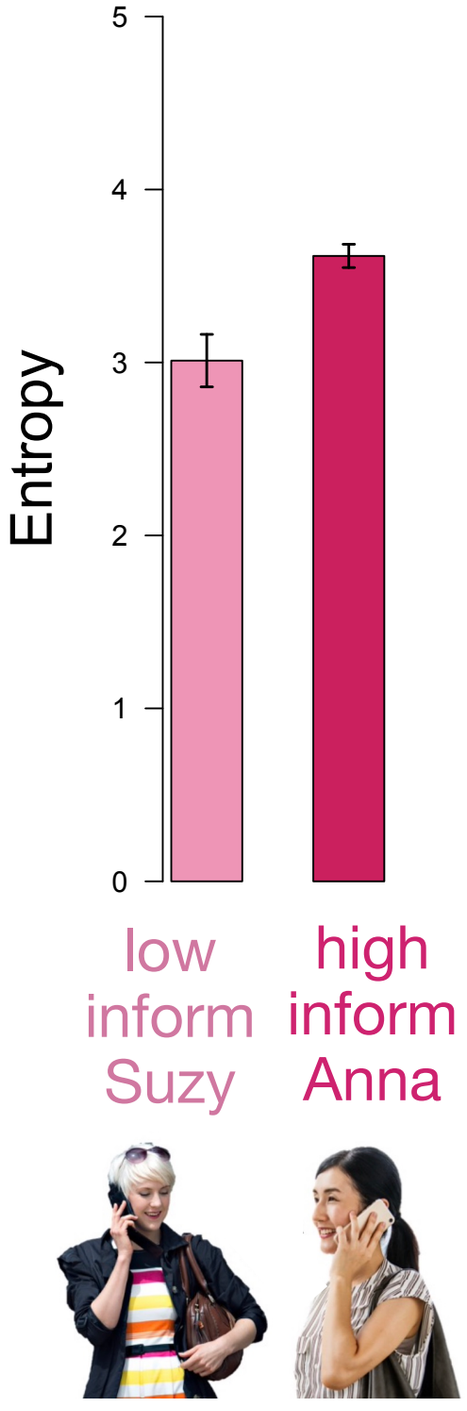
...

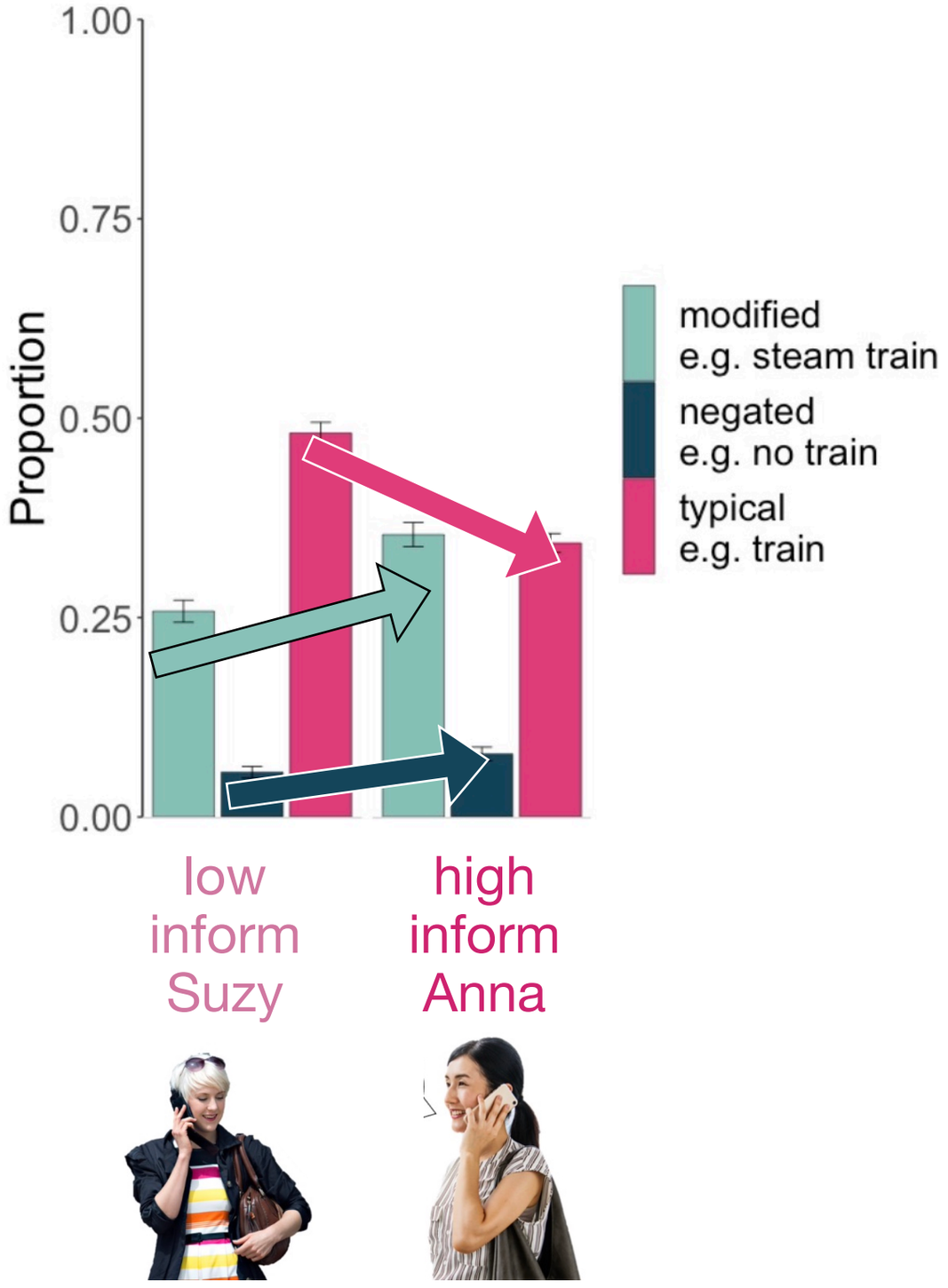
*counterbalanced photos of high/low informativity speakers

*same number non-typical situations for both speakers



Fill in the blank:





→ Participants pay attention to chatty versus reticent style, and expect speaker-specific level of informativity

→ Awareness of speaker matters, as does who the speaker is

Depends who you're talking to

$$p(utterance) \propto \sum_{situation} p(situation) * p(utterance|situation)$$

- If likelihood of mentioning particular content varies by speaker, what about by addressee?
- How do we speak to adults vs children?
  - Addressees may differ in how they estimate situation probability and newsworthiness
  - Speakers may differ in goals: news vs information
  - Child-directed speech uses more situation-typical descriptors for younger children
    [Bergey, Morris & Yurovsky 2020]

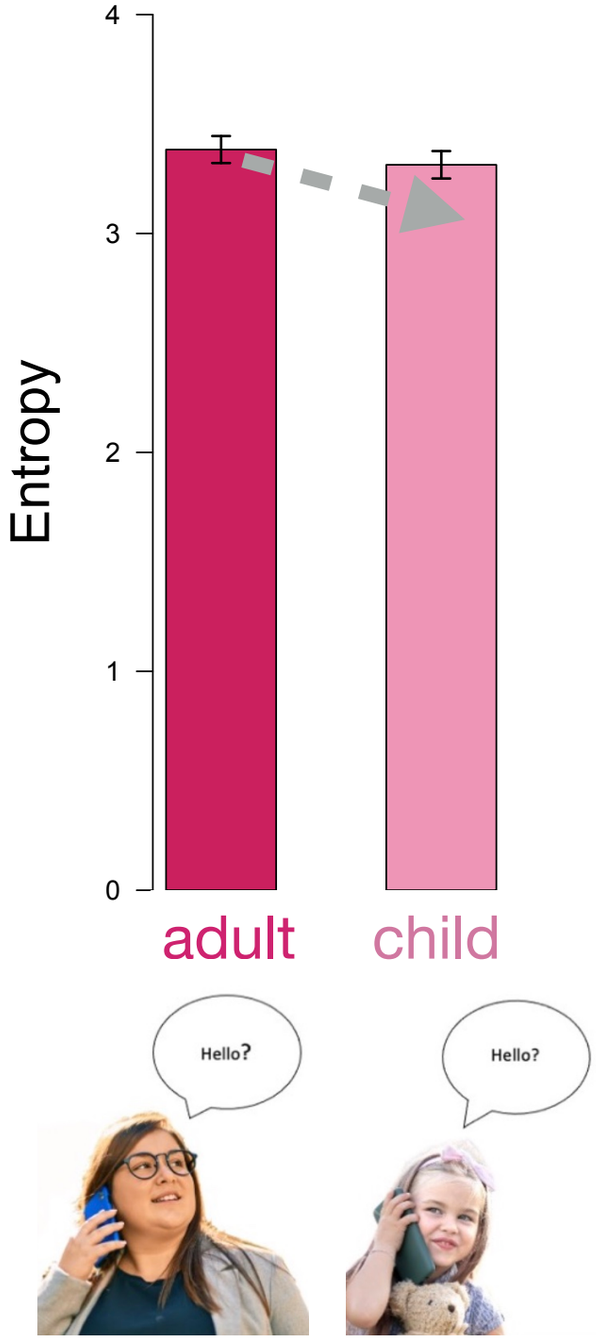
orange carrot **purple carrot**

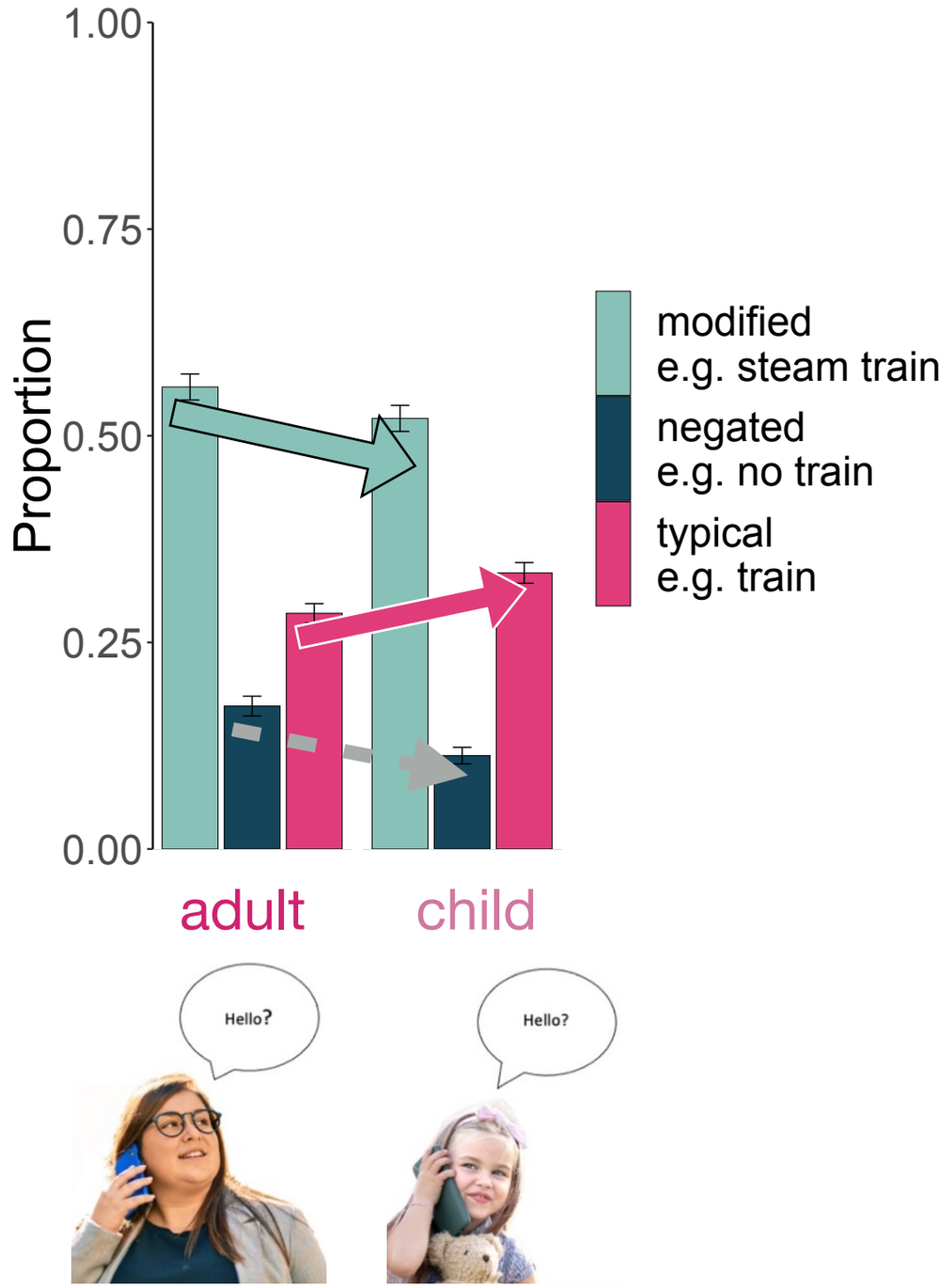
Depends who you're talking to

- **Method:** Cloze task sentence completion on Prolific (N=100)

[adult addressee]

[child addressee]





→ Participants pay (some) attention to the addressee and and addressee-specific level of informativity

Outline

Part I. What will the speaker say next?

Expectations about probable situations vs likely utterances

- **Modification:** Likely colors vs likely mention of color

yellow bananas

- **Propositions:** Beliefs vs assertions

I'm at the train station and there's ____

- **Alignment in production ~ comprehension**

eat soup with a fork

Part II. Why is she telling me this?

Inference of additional meaning beyond what was said

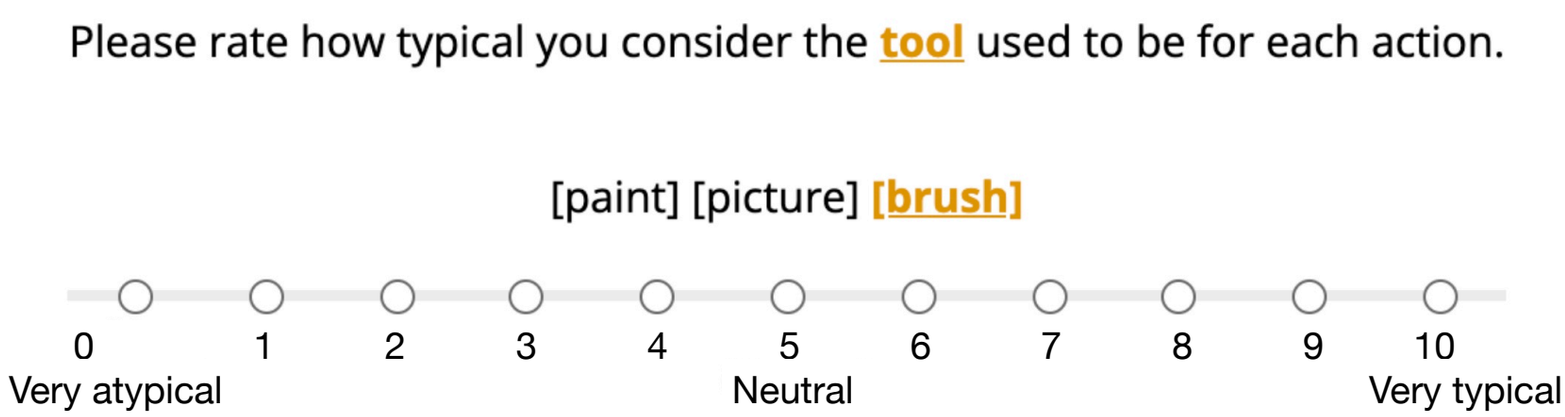
There's no snow

What do speakers talk about?

- **Reddit data:** extract mentions of optional instruments

“eat soup with a spoon”	**“eat soup without a spoon”**
“eat soup with a fork”	**“eat soup without a fork”**

- **Typicality ratings:** Prolific participants (N=206) rated 499 verb/object/instrument triplets



[CDT-NLP students Radina Dobreva, Stephanie Droop, Lauren Fletcher, Anna Kapron-King, Aida Samadzadeh-Targhat]

Mentioning atypical content

- [eat] [soup] [fork]

53 **“eat soup with a fork”**

1 **“eat soup without a fork”**

Typicality rating: 1.25

- [eat] [burger] [hands]

2 **“eat a burger with your hands”**

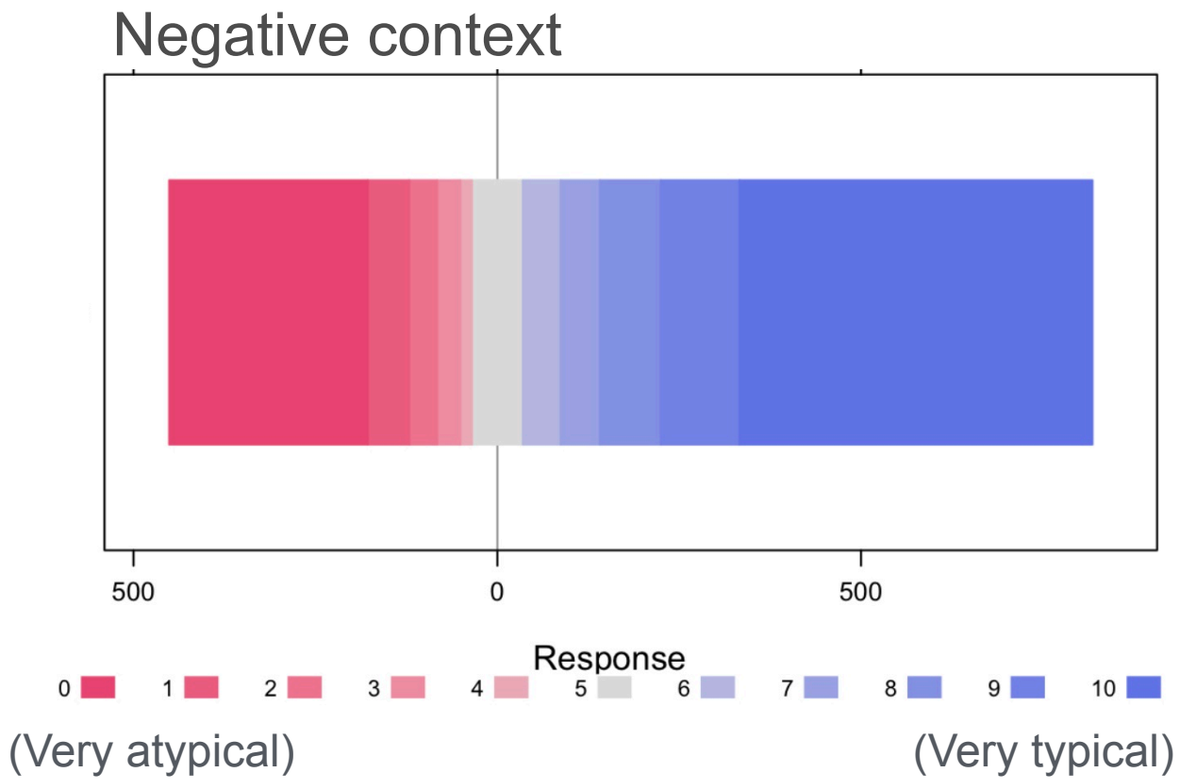
2 **“eat a burger with no hands”**

Typicality rating: 9.6

positive context count ↑
typicality rating ↓

negative context count ↑
typicality rating ↑

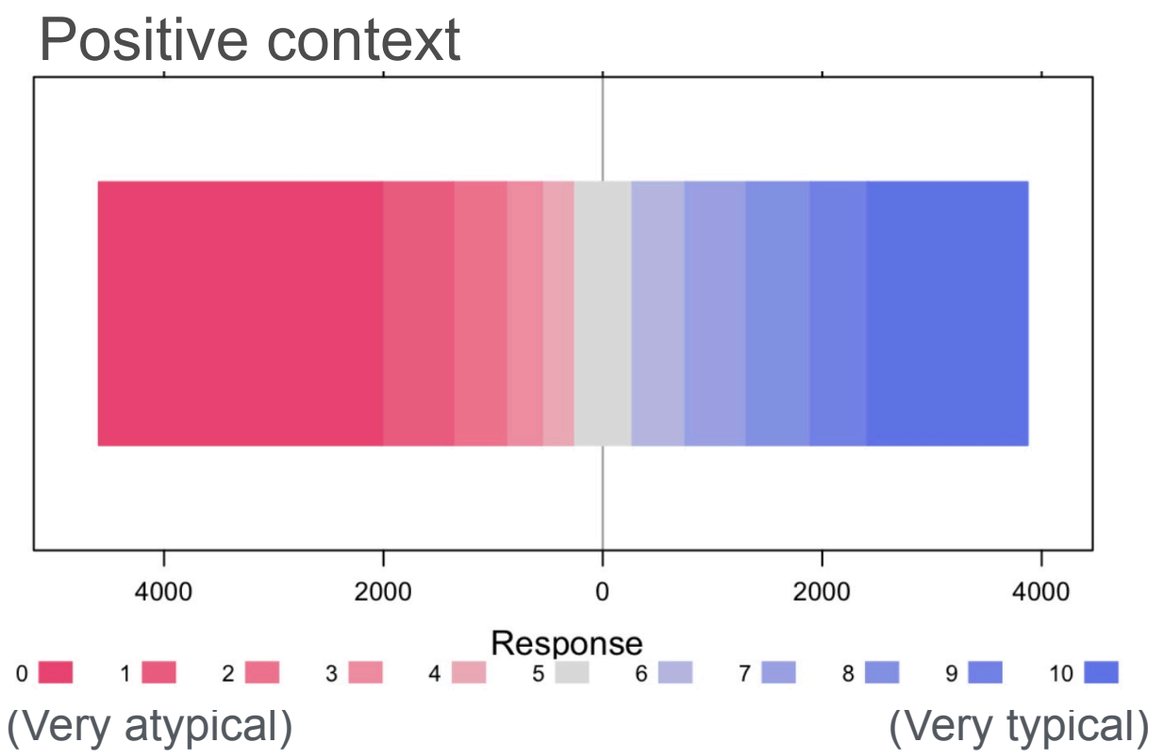
Mentioning atypical content



“eat a burger <u>with no</u> hands”

“eat soup <u>without</u> a spoon”

→ Newsworthy is absence of typical



“eat soup <u>with</u> a fork”

“eat burger <u>with</u> cutlery”

→ Newsworthy is presence of atypical, as seen in lab studies
[Bannard et al. 2017; Brown & Dell 1987]
with changes over development
[Bergey et al. 2020]

What do comprehenders expect?

- Does typicality yield facilitation or difficulty?

“eat soup with a fork”

“eat soup with a spoon”

- Method: Measure reading times at (a)typical instrument

[Rohde, Futrell, & Lucas, *Cognition* 2021]

What do comprehenders expect?

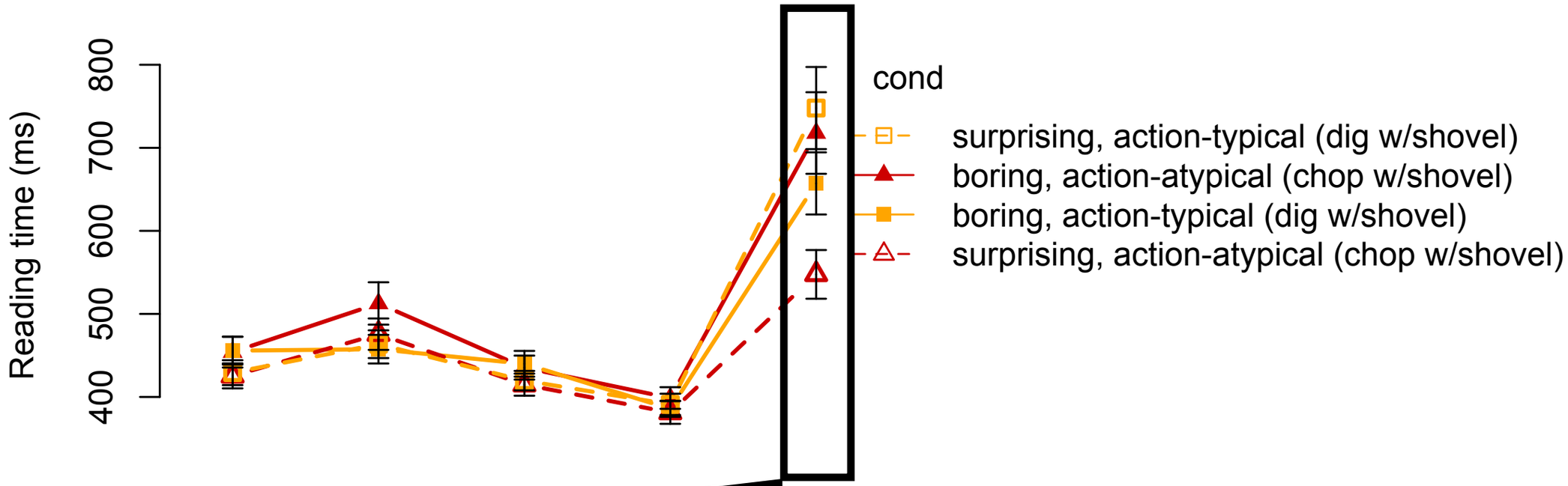
My cousin Mary is a boring person who always does things the way you'd expect.	[boring]
My cousin Mary is a surprising person who never does things the way you'd expect.	[surprising]

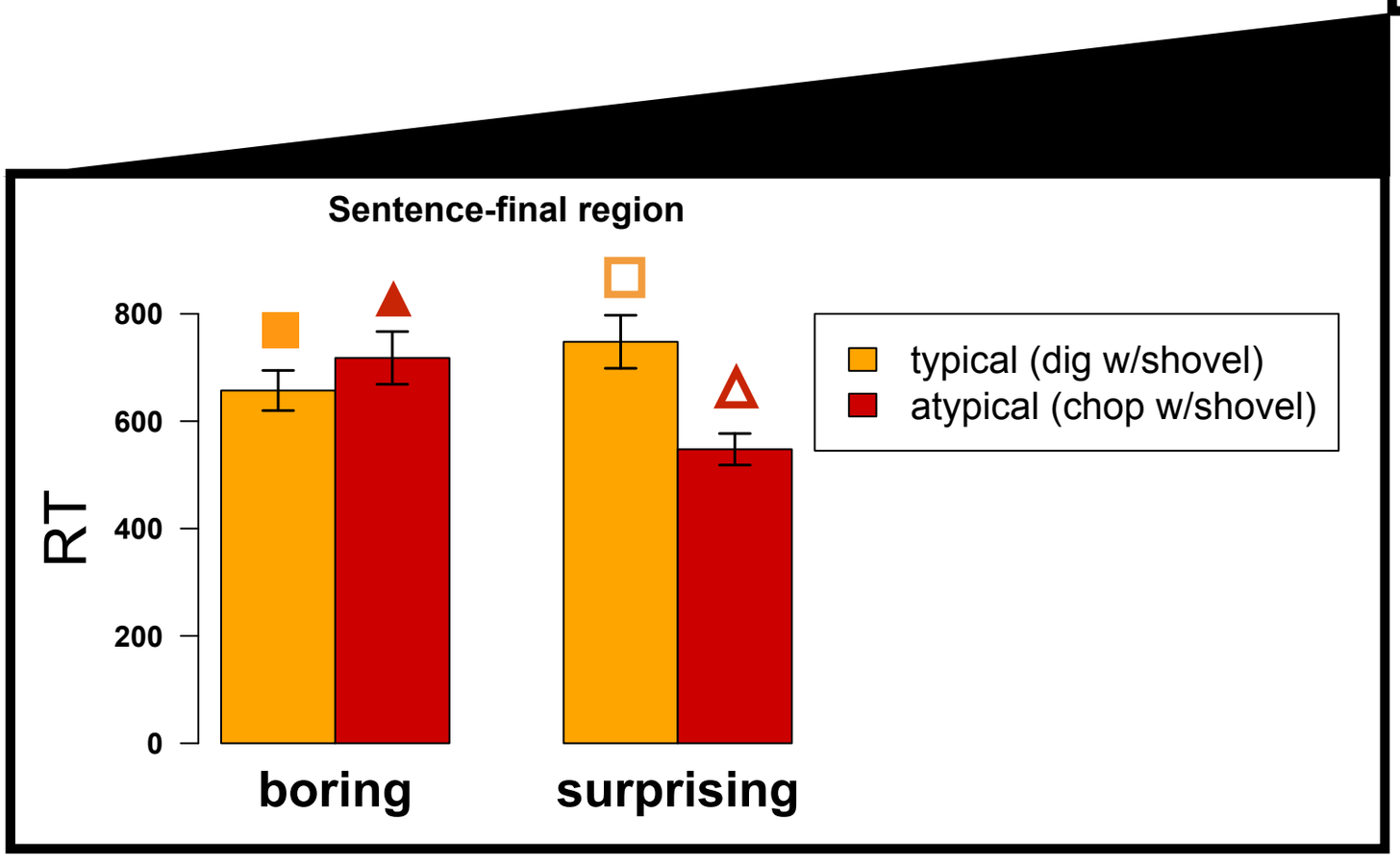
[action-typical]	In order to dig a hole she was using a <u>shovel</u> yesterday in the afternoon.
[action-atypical]	In order to chop some carrots, she was using a <u>shovel</u> yesterday in the afternoon.

Task: self-paced reading
N=136, 1 item per condition on mturk

→ **Prediction:** Boring Mary should yield ease with typical instrument but Surprising Mary should reduce or reverse this effect

Protagonist as cue to informativity





→ Action-atypical content can ultimately be easier than action-typical

→"chop carrots w/shovel" is unexpected as a real-world situation and as a lexical co-occurence

→ But it is expected if you're expecting novelty

“Why is the speaker telling me this?”

- Inappropriate predictability → extra inferences
(Kravtchenko & Demberg 2015, 2022)
- What’s normal for this speaker?
- What’s normal for this listener?
- What’s normal for this world?

Moayed bouzrieba @odibouz · May 6

They left a **#Starbucks** coffee cup on the table

WTF

Outline

Part I. What will the speaker say next?

Expectations about probable situations vs likely utterances

- **Modification:** Likely colors vs likely mention of color

yellow bananas

- **Propositions:** Beliefs vs assertions

I'm at the train station and there's ____

- **Alignment in production ~ comprehension**

eat soup with a fork

Part II. Why is she telling me this?

Inference of additional meaning beyond what was said

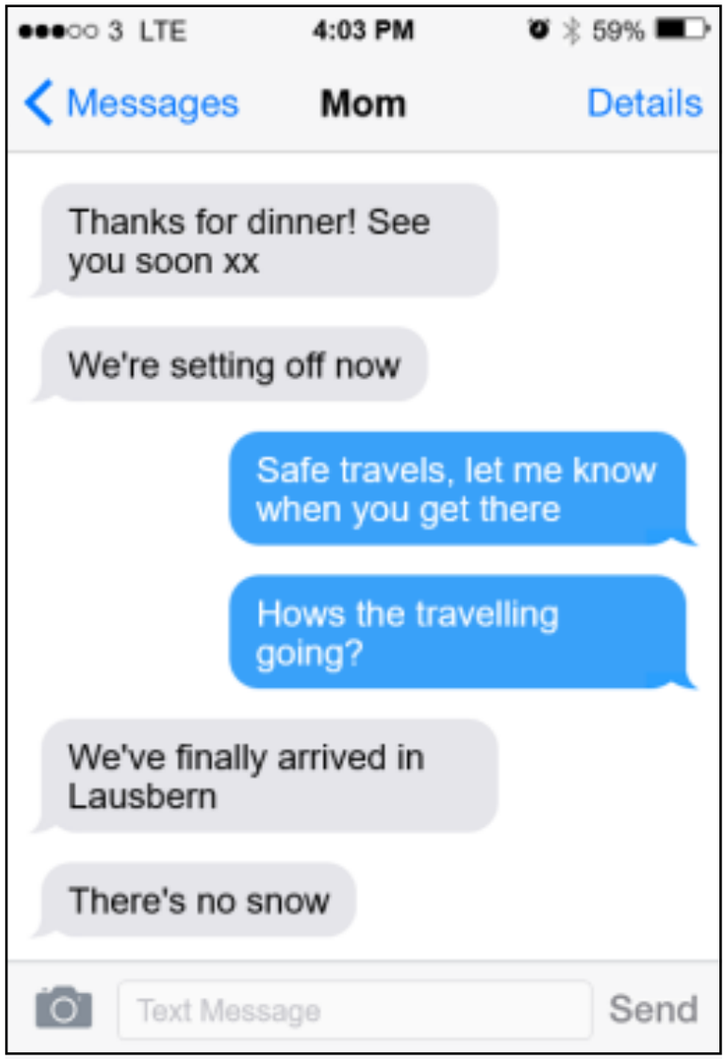
There's no snow

What was said: There’s a woman bus driver.

Inference? Most bus drivers aren’t women.

- Typicality inferences go beyond (in a sense, reverse) what is said
- Inferences depend on listeners’ belief that the speaker is cooperative and knowledgeable

Inference of additional meaning



What was said: There's no snow.

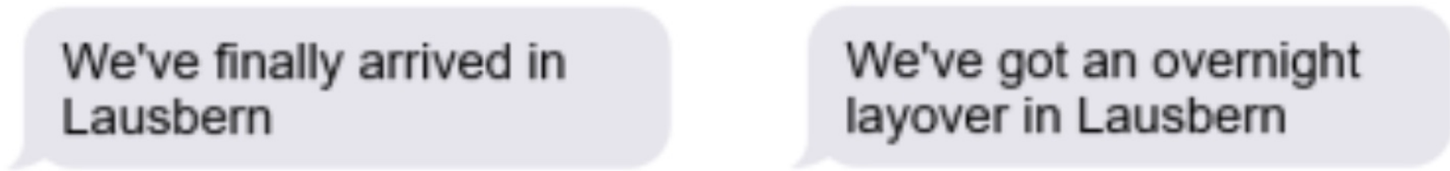
Inference? There's usually snow.

- Inference depends on comprehenders' estimates that:
  - Speaker aims to be informative [cooperativity]
  - Speaker is familiar with the situation [knowledgeability]
  - Speaker notes lack of something [typicality expectation]

[Rees & Rohde, *CogSci Proceedings 2022*]

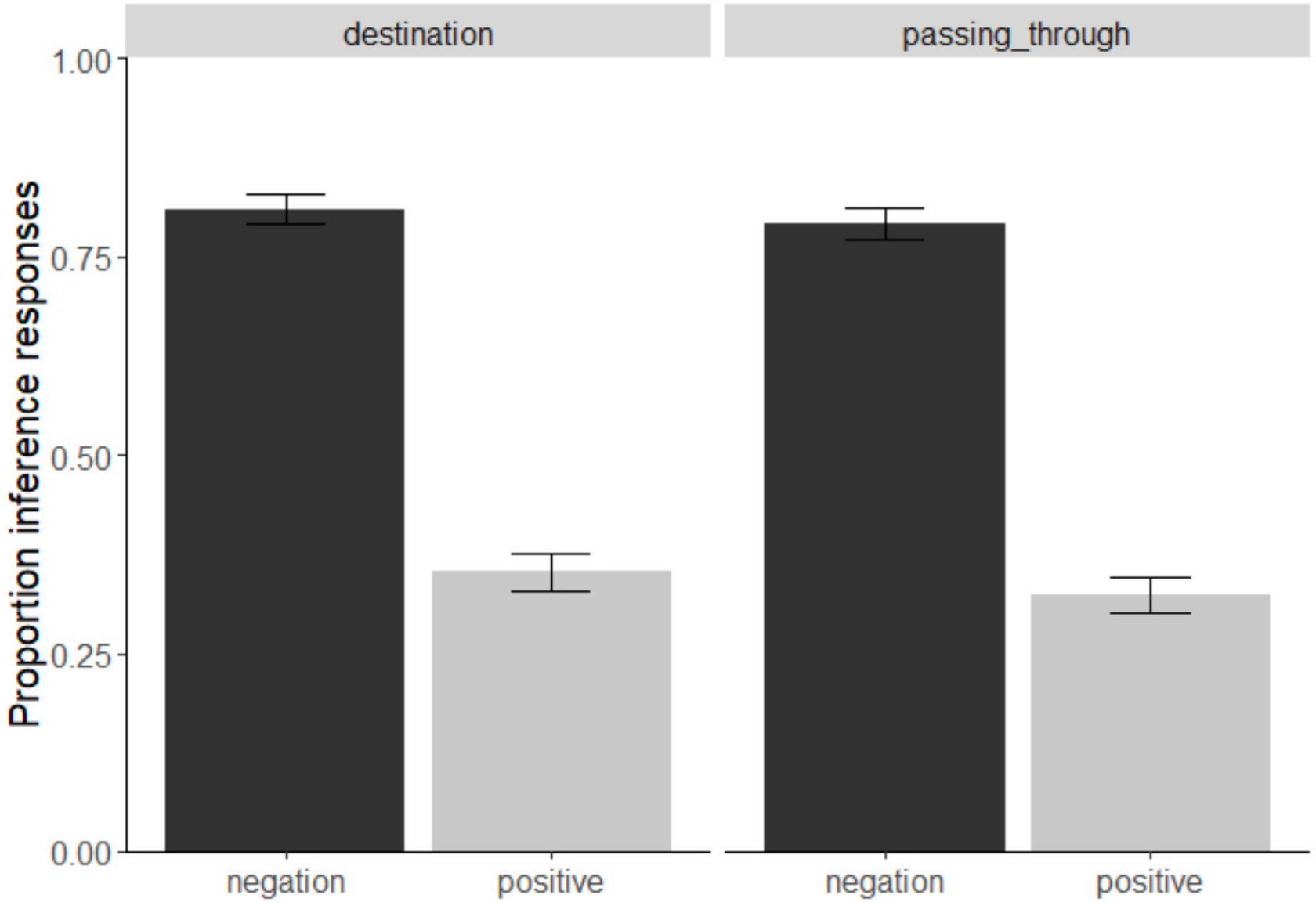
Inference of additional meaning

- **Goal:** Manipulate speaker knowledgeability and typicality expectation to test impact on rate of inference
  - Knowledgeability: familiarity with location



  - Typicality expectation: presence/absence negation

- **Method:** Participants (N=408) read messages and answered questions, e.g., “Does it usually snow in Lausbern?” (Yes/No)
- **Predictions:**
  - Knowledgeability: more inference if familiar
  - Typicality expectation: more inference with negation



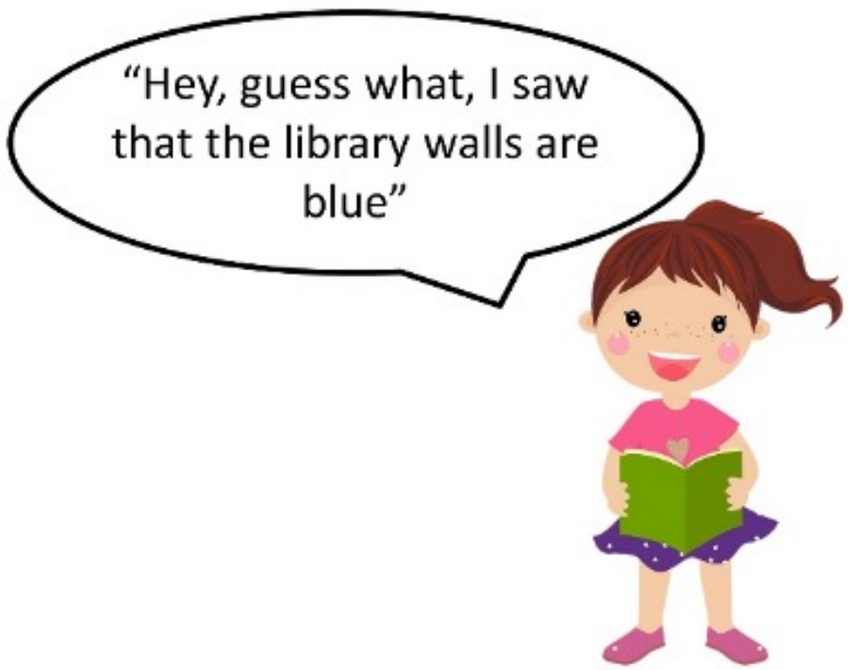
→ More inference with typicality expectation via negation

There's no snow → "Yes, it usually snows"

→ No effect from knowledgeability manipulation

We've finally arrived in Lausbern →? "Yes, it usually snows"

Inference of additional meaning



What was said: The library walls are blue.

Inference? The walls used to not be blue.

- Inference depends on comprehenders' belief that:
  - Speaker aims to be informative [cooperativity]
  - Speaker is familiar with the situation [knowledgeability]
  - Speaker knows trivial content violates expectations [filter]

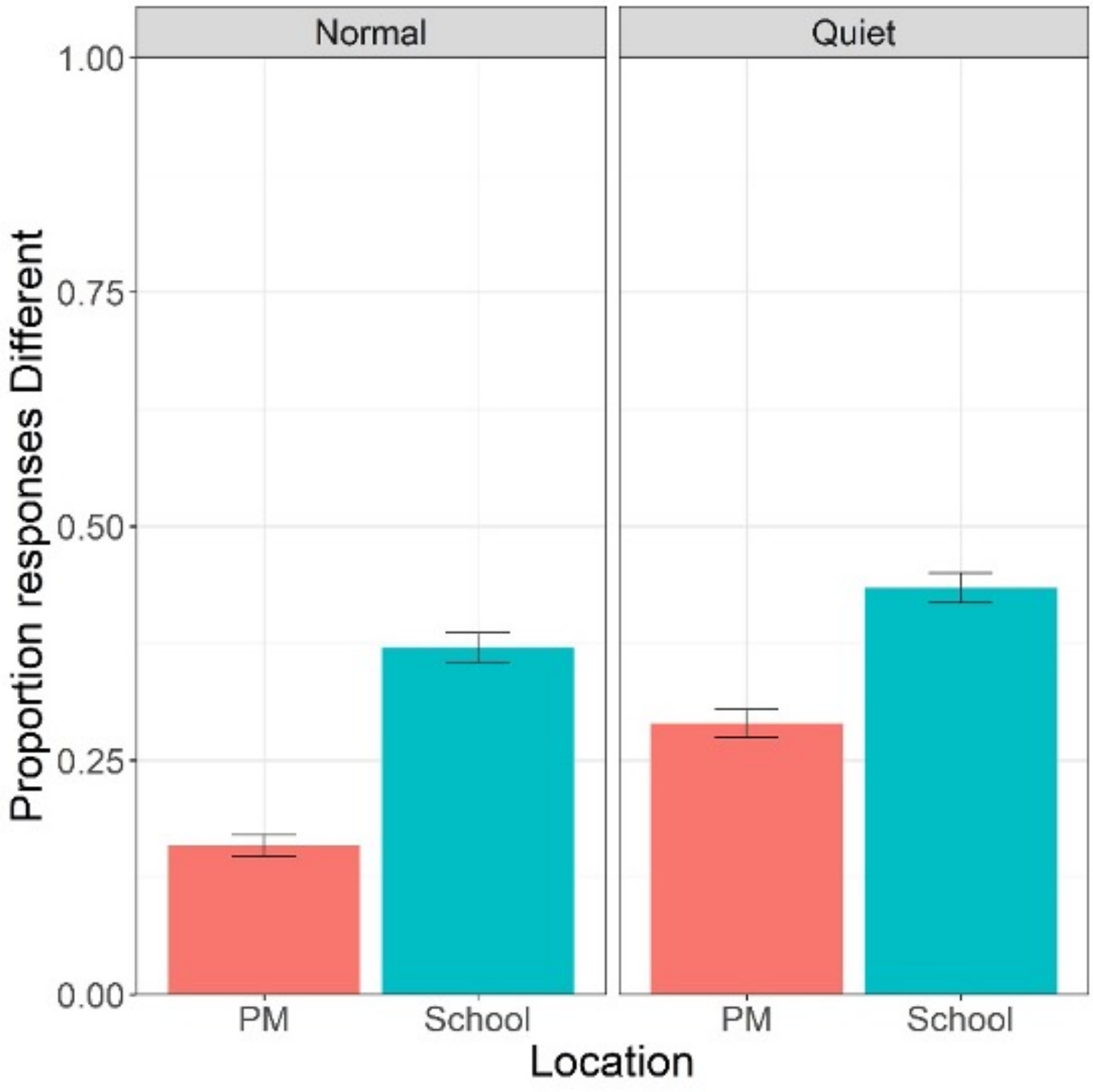
[Rees & Rohde, *CogSci Proceedings 2023*]

Inference of additional meaning

- **Goal:** Manipulate speaker knowledgeability and filter to test impact on rate of inference
  - Knowledgeability: familiarity with location (school or prime minister's office)
  - Speaker filter: normal speaker vs quiet speaker

- **Method:** Participants (N=200) read Suzy's utterances and judged if situation used to be "same or different?"

- **Predictions:**
  - Knowledgeability: more inference if familiar
  - Speaker filter: more inference if quiet



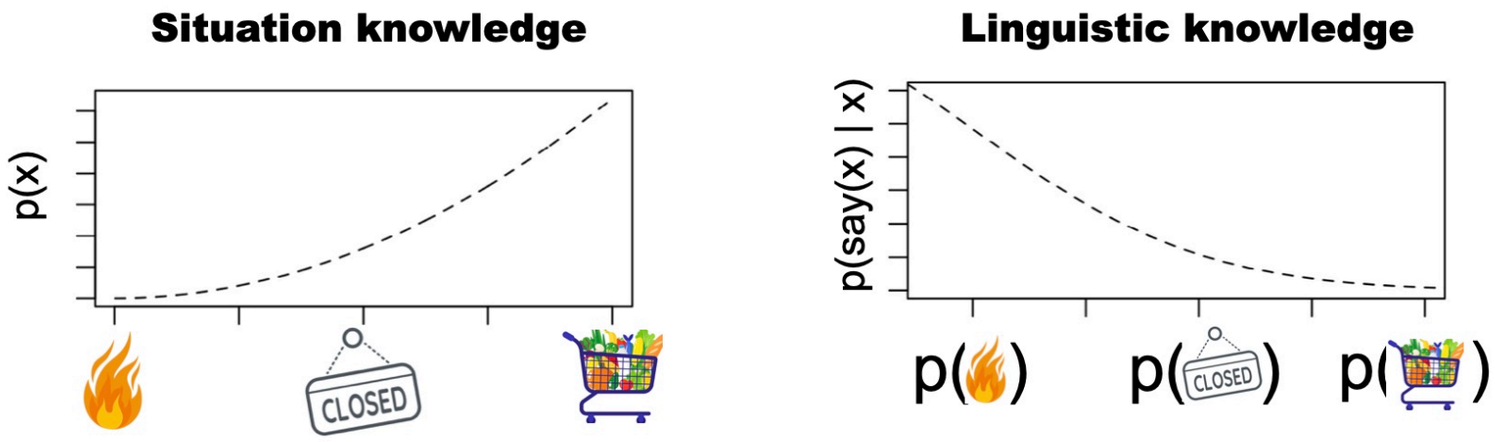
→ More inference if speaker is knowledgeable (school location)

→ More inference if speaker monitors their content (quiet speaker)

In sum

- **Reverse engineering:** What is the speaker's goal in speaking (to be informative, etc.)?

- **The world vs what we say about the world:**



- **Role of pragmatics in interpretation/production:** Understanding what comprehenders track about how & <u>why</u> speakers use language in everyday communication

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