The influence of event predictability on production and comprehension of referential expressions

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Referential expressions in discourse (RED): Mismatches in anaphoric relations
May 29, 2025
University of Graz, Austria

Question

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1) ***it*** *fell down*

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3) *fell down*

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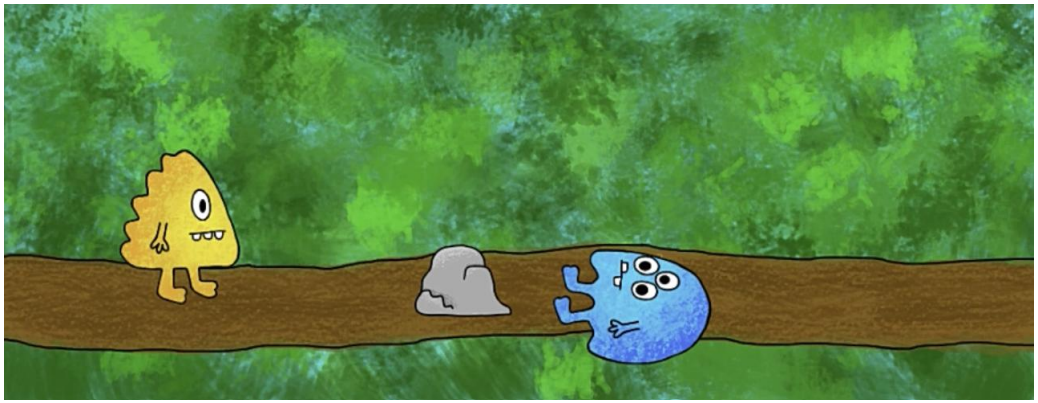

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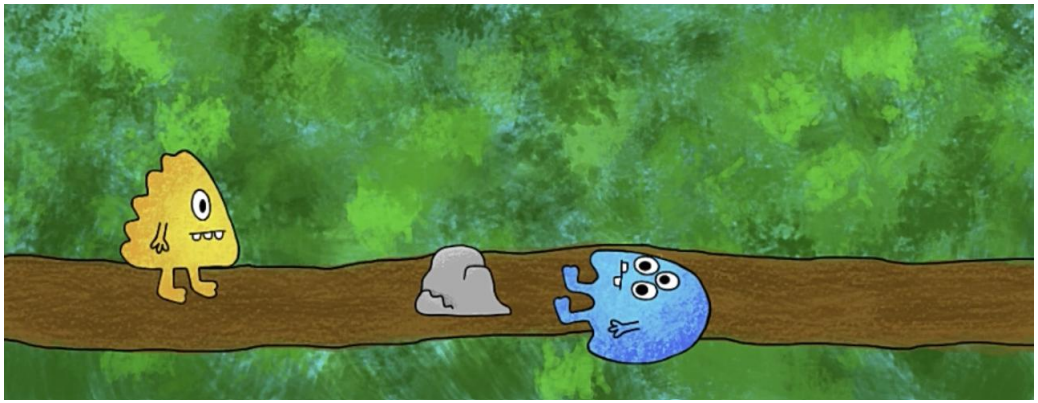

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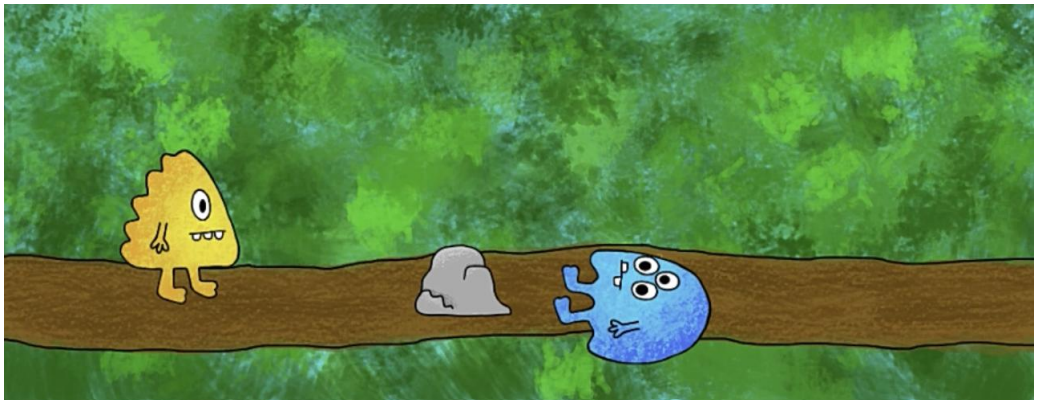

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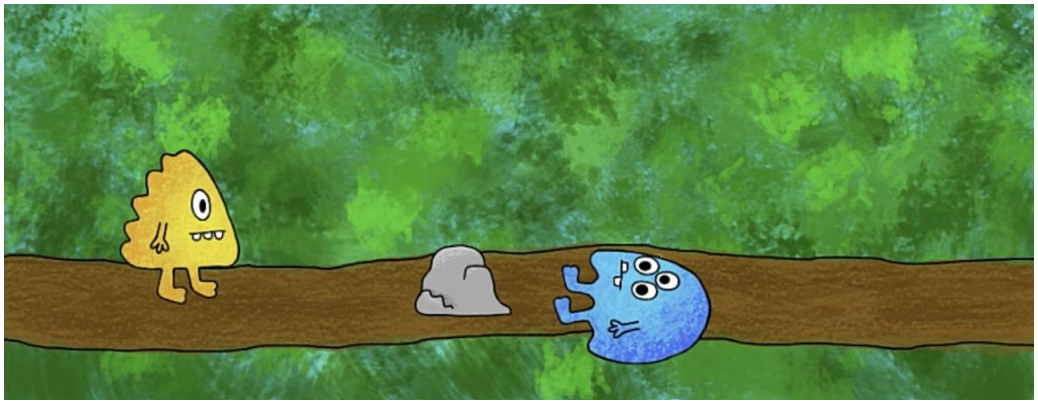

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Our study

- Experimental study in pragmatics
- Explores the effect of background beliefs
  - in the form of prior expectations of predictability of events
  - on the referential expression production and comprehension
- We study predictability as a cognitive category
  - As opposite to the predictability of linguistic material

Referential expressions

- Speakers' challenge:
  - Choose short but informative expression
- Listeners' challenge :
  - Identify the referent, resolve potential ambiguity
- Noisy environment
  - Blurs the distinction between a pronoun and a zero anaphor

Referential expressions

- Processing is guided by various principles:
  - Common morphological features (Fukumura et al. 2011)
  - Topicality (Rohde and Kehler 2014)
  - Accessibility constraints (Chomsky 1993, Kamp et al. 2010)
  - Semantic coherence (Winograd 1972)
  - Maxims of conversation (Grice 1975)
  - Predictability of events (Achimova et al. 2022, Achimova et al. 2024)

Pragmatics

- Grice 1975:
  - Interlocutors reason about each other
- Rational Speech Act (Goodman and Frank 2016)
  - Computational probabilistic realization
    - Probability to choose an utterance is proportional to the listener's probability to choose the right interpretation by that utterance
  - Relies on prior probabilities of utterances and world states
    - Prior expectation
    - Allow us to take into account background beliefs of interlocutors
- We focus on one type of background beliefs:
  - Prior expectations of the predictability of events

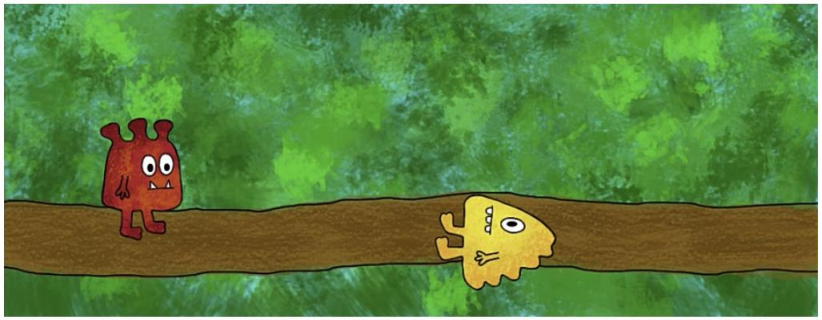
Noisy channel

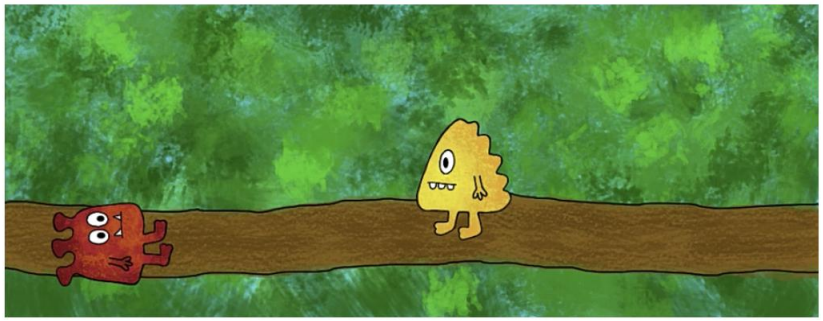
- RSA assumes rational agents
- But people do not always act rationally
  - speakers may produce misleading expressions
  - listeners may misinterpret them
- Noisy communication channel hypothesis (Levy 2008)
  - “Noise” is any disruption that leads to suboptimal choices
  - Interlocutor consider the possibility of noise and adjust for it (Jurafsky 1996, Gibson et al. 2013)
  - In a noisy environment, listeners rely heavily on their prior expectations (Miller et al. 1951, Sohoglu et al. 2012)

Back to our work

- Three online experiments on Prolific:
  - Prior elicitation study
  - Perception of referential expressions under noise
  - Production of referential expressions
- The goal is to investigate:
  - how the prior expectations of the event outcomes interact with the linguistic cues in a noisy environment
  - whether speakers take into account the possible effect of those expectations on the listener's behaviour

Artificial world

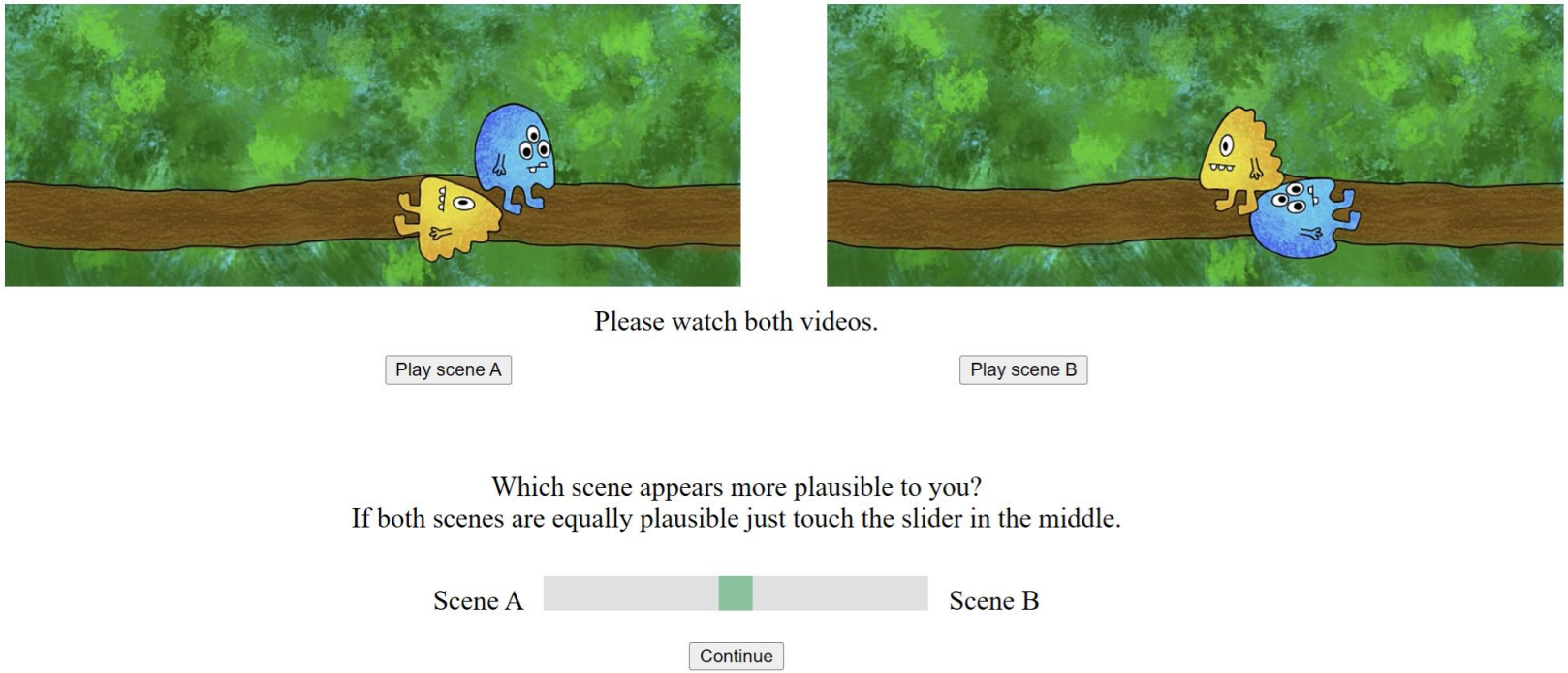




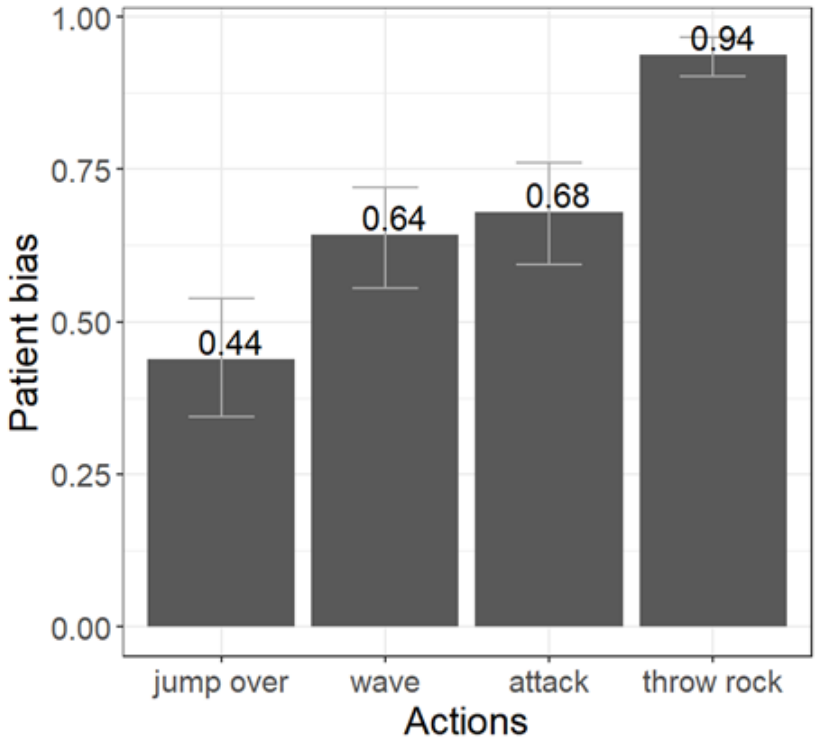
- Actors:
  - Three types of monsters: red, yellow and blue
- Interactions:
  - Four actions: attack, throw a rock, jump over and wave
- Outcome:
  - One of the two monsters falls to the ground
    - Either the agent or the patient of the action

Experiment 1: Priors

- The goal:
  - To obtain prior expectations for different actions
    - How plausible is one or the other outcome?

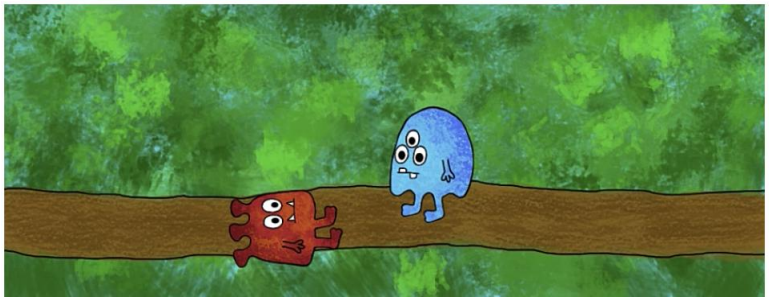


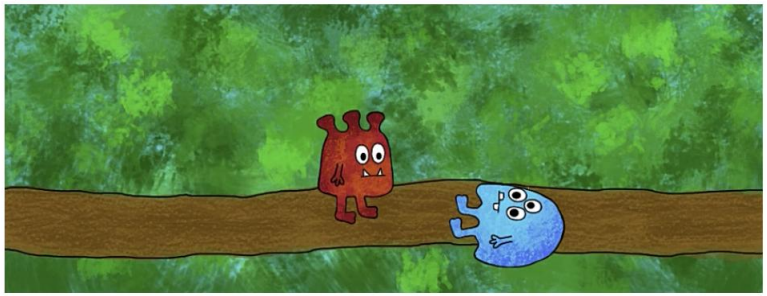
Priors: results



- In the subsequent experiments we use these priors
  - as a continuous predictor

Experiment 2: Speech under noise





Please watch both videos.

Play scene A

Play scene B

After you have seen the scenes, please start the audio sequence and answer the question that appears afterwards.

0:00 / 0:03

Which scene matches the description you have just heard?

Scene A | Scene B

Please type what you heard.

The red monster attacked the blue monster and it fell down

Submit & Continue

Experiment 2: Speech under noise

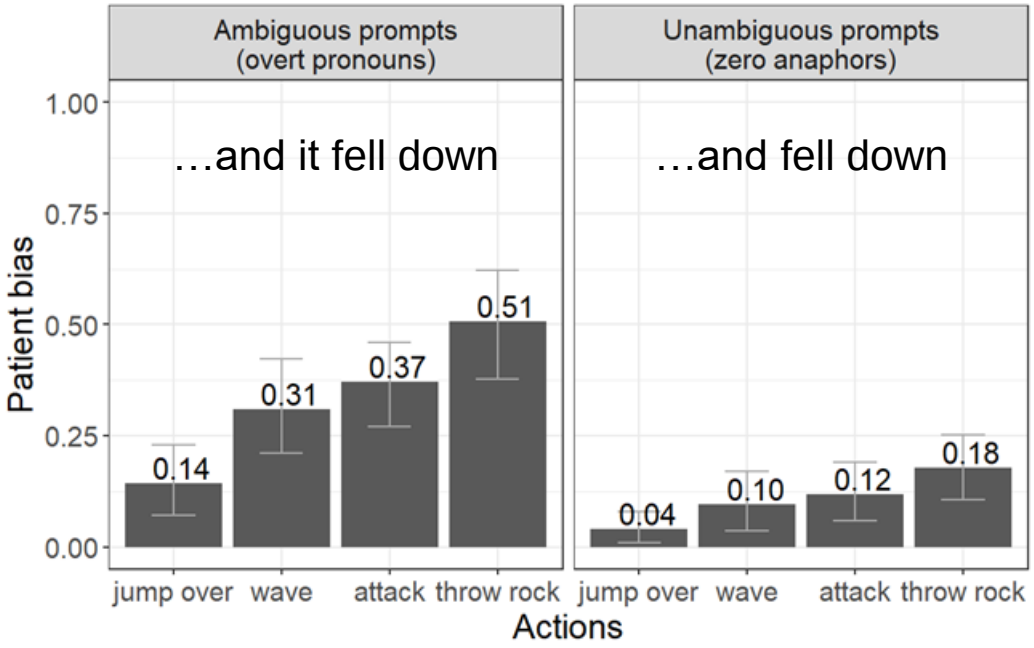
- Participants:
  - Saw two scenes differing in outcomes (agent vs patient)
    - Four trials: one for each action in a random order
    - Colors of the monsters were randomized in each trial
  - Heard a noisy description:
    - *The red monster attacked the blue monster and [it] fell down*
    - Random presence of the pronoun *it* in the prompt
  - Task 1: select the scene that better matches the description
  - Task 2: type what they heard

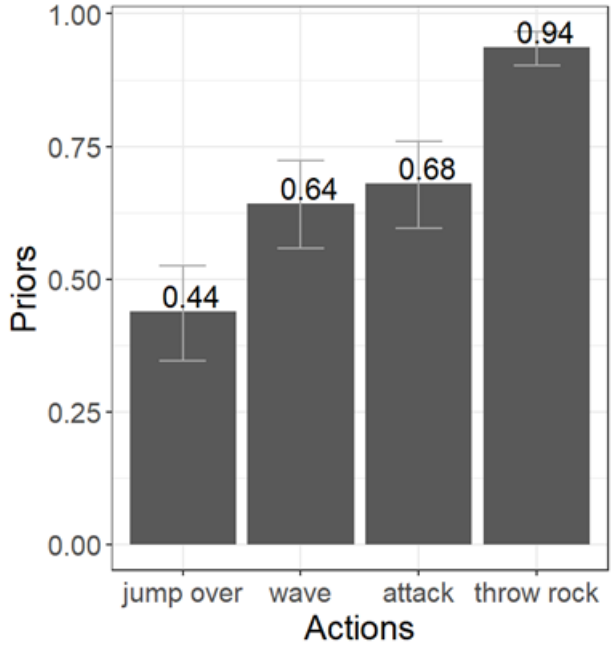
Speech under noise: hypotheses

- Ambiguous prompts:
  - *The red monster attacked the blue monster and **it** fell down*
  - Both outcomes are compatible with the description
  - Priors should influence the outcome selection
    - The more patient bias an action has the more often the patient outcome should be selected
- Unambiguous prompts:
  - *The red monster attacked the blue monster and fell down*
  - Only the agent-falling outcome is compatible
  - But under noise, participants may reconstruct the pronoun
  - Pronoun typing rate should also be affected by priors

Speech under noise: results

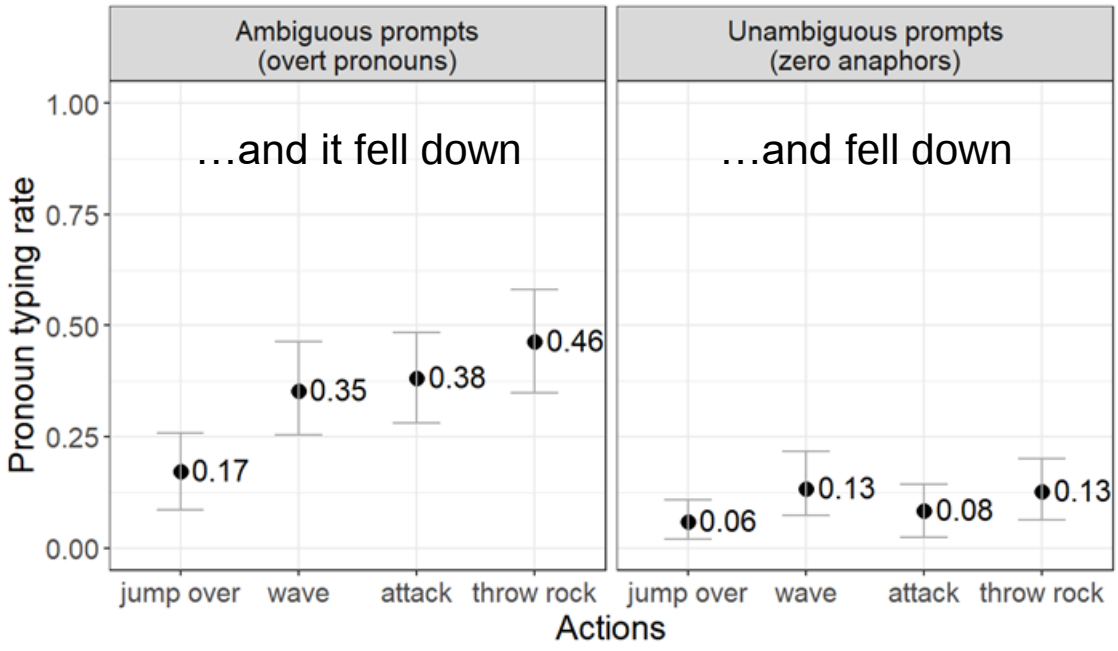
- Event selection (effect of priors):
  - Ambiguous: β = 4.60, CI: [2.63, 6.90], pd = 100%
  - Unambiguous: β = 3.02, CI: [1.16, 5.04], pd = 99.97%

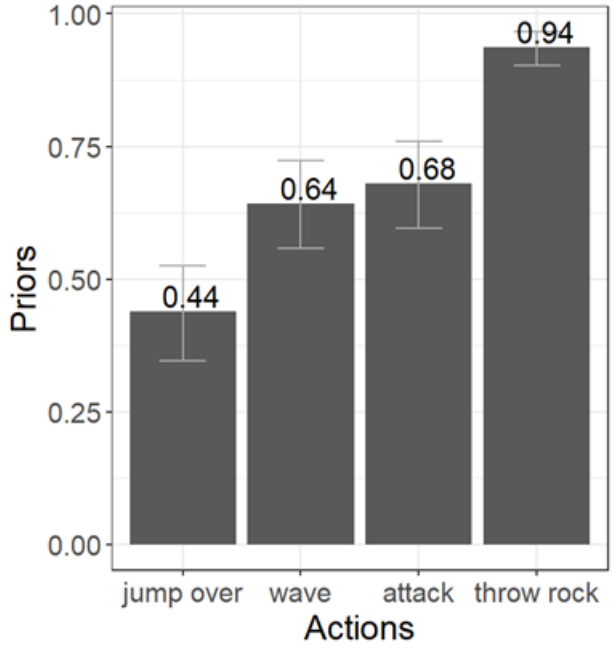




Speech under noise: results

- Pronoun typing rate (effect of priors):
  - Ambiguous: β = 3.22, CI: [1.05, 5.50], pd = 99.89%
  - Unambiguous: β = 2.13, CI: [-0.66, 5.17], pd = 93.29%





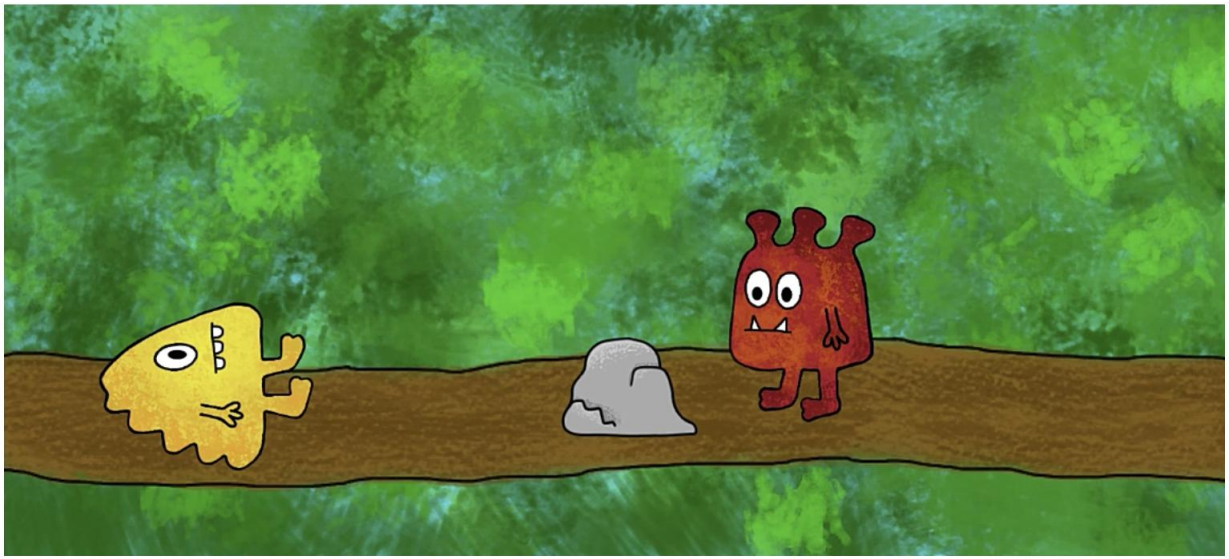
Experiment 3: Production

- The goal is to test that speakers take into account:
  - How listeners interpret ambiguous references according to their prior expectations
  - How listeners perceive expressions under noisy conditions
- Manipulation of priors:
  - Participants first learn which events can be expected
  - We train them to recognize relative monster strength:
    - The red monster is stronger than the yellow one
    - The yellow monster is stronger than the blue one
  - Only the yellow monster initiates interactions
    - It is always the weaker monster who falls down (agent or patient)

Experiment 3: Production

✓ First start recording: start recording
✓ (maybe you have to allow access to your mic)
✓ Now start the video: start the video

Simply describe what is going on!



Audio recording status: RECORDING •

Experiment 3: Production

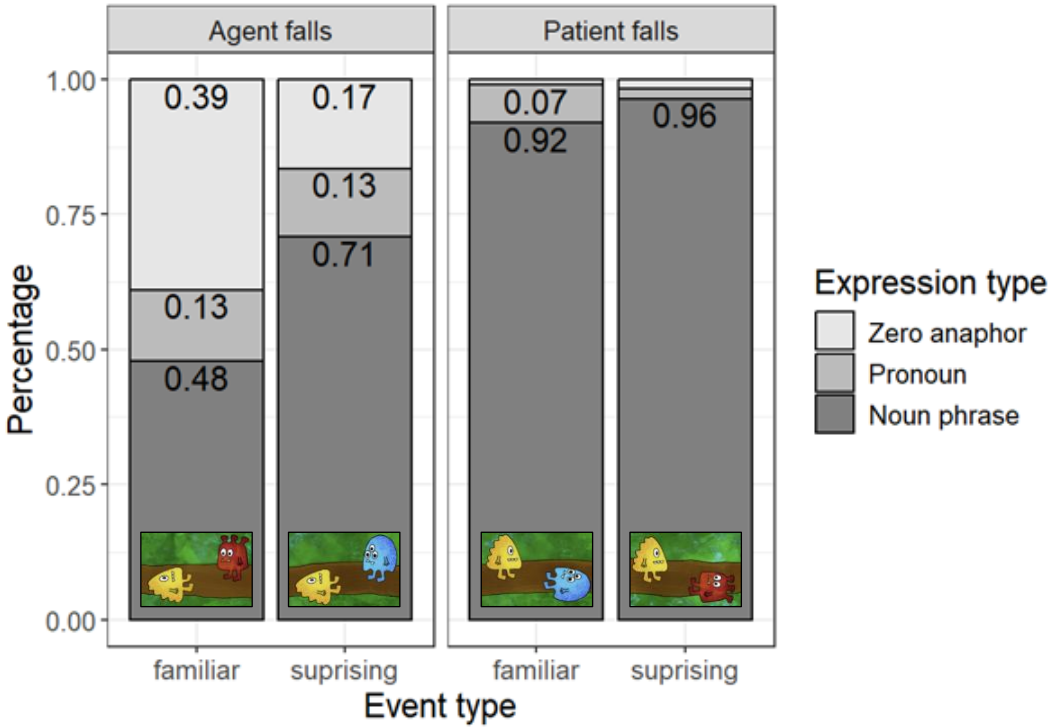
- Design:
  - Each participant was randomly assigned only one action
  - Three phases: training, memory test and production task
  - Main free-production phase contained:
    - Two trials with familiar outcomes
    - Two trials with surprising outcomes
    - Two trials with “familiar” outcomes again
  - Each pair of trials contained one agent-falling outcome and one patient-falling outcome in a random order

Production: hypotheses

- Theory predictions:
  - If speakers use ambiguous expressions, then
    - listeners choose the referent according to their prior expectations
  - When the scene contradicts the expectations, then
    - speakers should prefer more overt expressions (NPs)
    - to avoid the default interpretation according to the priors
    - less zero anaphors to avoid pronoun reconstruction
  - Surprising events => more NPs
  - Familiar events => more reduced forms

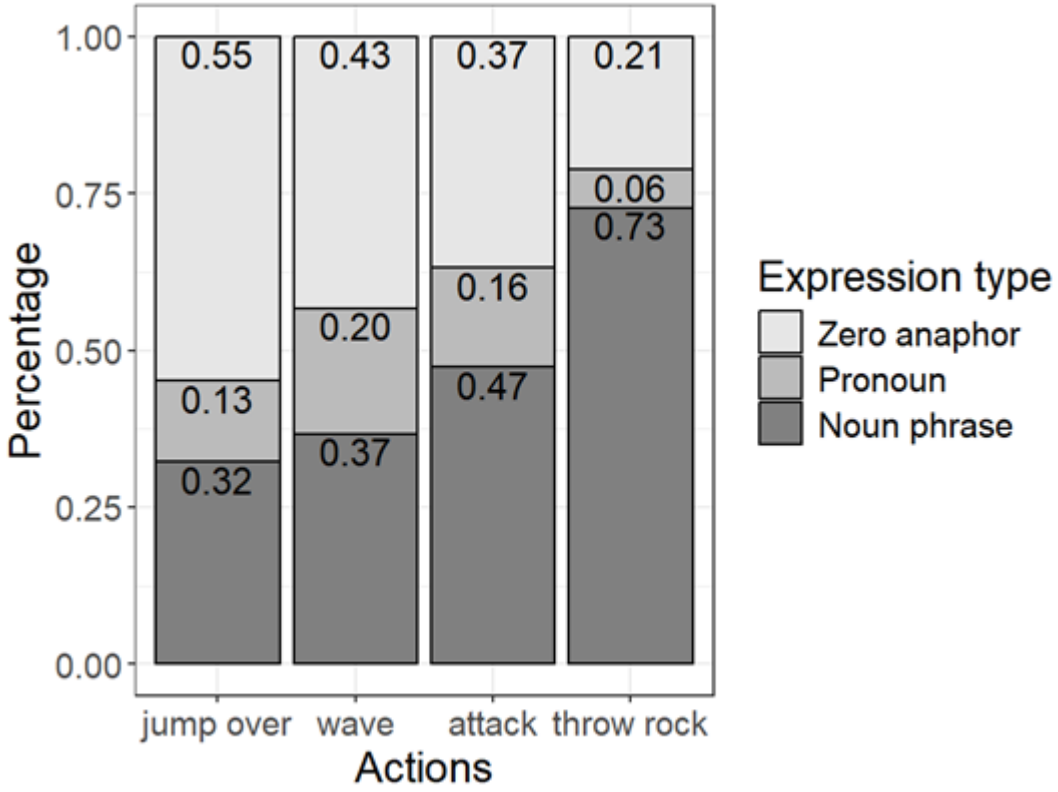
Production: results

- When the agent falls (left panel):
  - Surprising events: β = 1.48, CI: [0.15, 2.79], pd = 98.31%
    - Rate of NPs increased, rate of zero anaphors decreased



Production: results

- When the agent falls (left panel):
  - Action prior effect: β = 4.37, CI: [2.31, 6.53], pd = 100%



Conclusions

- Interlocutors' prior expectations (background beliefs)
  - affect referring expressions production and comprehension
  - both qualitatively and quantitatively
- The greater the patient bias in prior expectations
  - The more listeners tend to take pronouns to refer to patient
    - And even to reconstruct the pronoun when it is missing
  - The more speakers use noun phases to refer to the agent
    - And even avoid potential reconstruction on the listener side
- Training does not override action priors:
  - Both have their own effect

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Thank you!
Questions?