

# 4- and 5-year-olds Use Mental Models of Events in Reference Resolution

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BUCLD 45

# Language is full of ambiguity

- Many referential terms are context dependent.

John was passing a book to Bill. He...

He asked the girl to pass the salt.

# Adults use multiple sources of information to resolve reference

- To determine reference, adults rely on:

**Linguistic heuristics:** E.g., bias to expect pronouns to refer to prior subject (Arnold, 2001)

**John** was passing Bill a book. **He**...

**Pragmatic reasoning** based on model of the situation

# Adults use mental models of events in reference resolution

Adults treat “the nephew” as unambiguous even in a two-nephew discourse, if the story describes one nephew as having left the scene (Nieuwland et al., 2007)

At the family get-together, Jim had been talking to one nephew who was very much into politics and another one who was really into history. But Jim himself was only interested in sports, cars, girls etc. The **nephew** who was into history *left early*, but the nephew who was into politics kept rambling on. Jim didn't understand one bit and got rather bored. He told the **nephew** who was into politics that politicians should not systematically neglect delightful and important subjects like sports and girls.

Do children use a situation model during  
online reference comprehension?

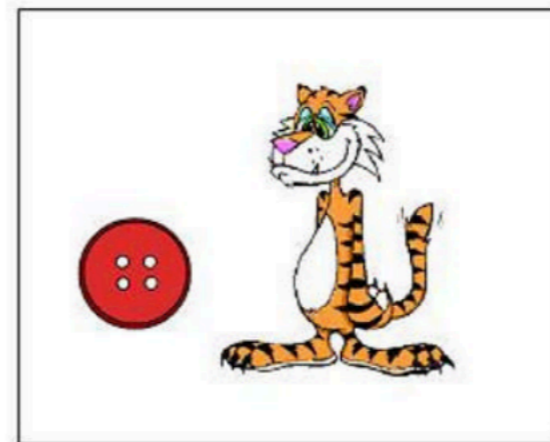
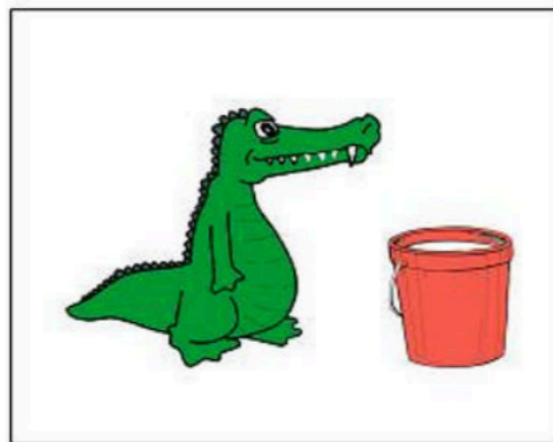
# Linguistic knowledge in children's reference comprehension

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- Children can use information from the prior discourse to constrain the interpretation of ambiguous noun-phrases.
  - Children link ambiguous pronouns with prominently established discourse topics (Bohn et al., preprint; Hartshorne, Nappa, & Snedeker, 2015; Song & Fisher, 2005, 2007)

On a sunny day, the alligator went outside.  
And he went to the tiger's yard.



And what did he find? Look, he found a bucket!

# Linguistic knowledge in children's reference comprehension

- Children can use information from the prior discourse to constrain the interpretation of ambiguous noun-phrases.
  - 18-months-olds can use an expectation of discourse continuity to disambiguate an anaphoric expression (Lidz, Waxman, & Freedman, 2003; Saylor, Ganea, & Vazquez, 2011)



*Look! A yellow bottle!*



*Do you see another one?*



# Linguistic knowledge in children's reference comprehension

- Children can use information from the prior discourse to constrain the interpretation of ambiguous noun-phrases.
- Children can learn words through their introduction in the linguistic discourse.

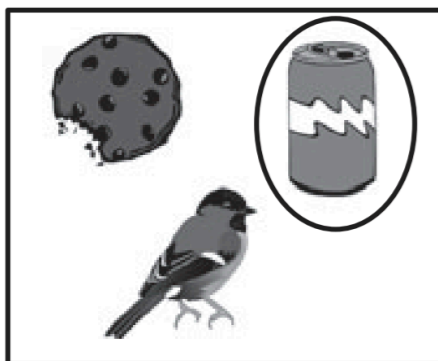
# Linguistic knowledge in children's reference comprehension

- Children can use information from the prior discourse to constrain the interpretation of ambiguous noun-phrases.
- Children can learn words through their introduction in the linguistic discourse.
  - 3- to 6-year-olds assigned a novel label to a toy when the label was embedded between descriptions of the toy's features (Horowitz & Frank, 2014)



# Linguistic knowledge in children's reference comprehension

- Children can use information from the prior discourse to constrain the interpretation of ambiguous noun-phrases.
- Children can learn words through their introduction in the linguistic discourse.
  - Children as young as 2 years old can make a bridging inference about the content of the discourse to infer the referent of a novel word (Sullivan & Barner, 2016; Sullivan et al., 2019)



*I'm thirsty! Can you show me the pliff?*

# Linguistic vs. Pragmatic Inference?

- Children recruit **linguistic knowledge**, but *the evidence on pragmatic reasoning is less clear*
  - Children use the semantic prominence of event participants to interpret pronouns (Kehler et al., 2011; Pykkonen et al., 2010)

**Mrs. Horse** skipped to Mrs. Sheep. **She** ...

Mr. Seal handed a gift to **Mr. Penguin**. **He** ...

# Linguistic vs. Pragmatic Inference?

- Children recruit **linguistic knowledge**, but *the evidence on pragmatic reasoning is less clear*:
  - Effects of semantic prominence can also be attributed to use of linguistic representations, which include semantic information (Arnold, 2001; Willits et al., 2015)
  - Reference comprehension involves *high-level causal inferences based on the representation of the situation as well as knowledge of language*.

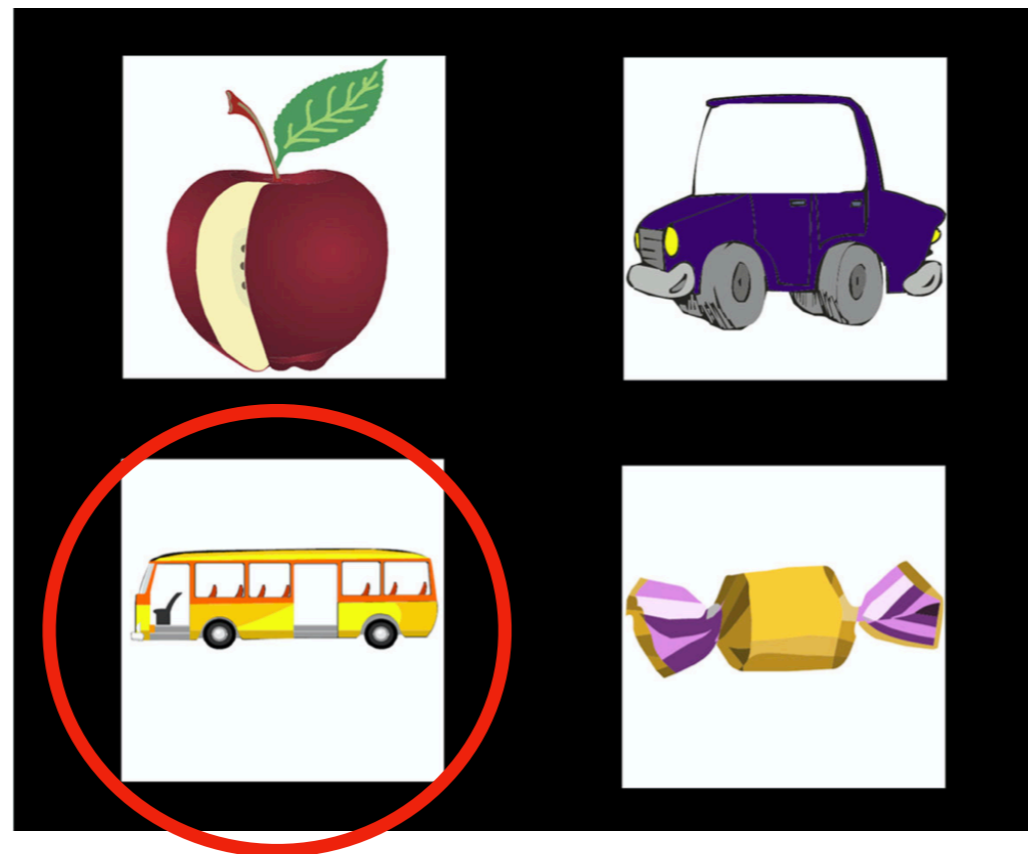
# Children build situation models

- Children are sensitive to the causal structure of narratives (Lynch et al., 2008)
- Children track the spatial perspective of a protagonist during narrative comprehension (Rall & Harris, 2000)
  - *Cinderella was sitting on the chair by the fireplace, dreaming about the ball. Then her fairy godmother **came (went)** into the cottage.*

# Children use discourse-provided event information online

- School-aged children use recently encoded event associations to predict an upcoming argument (Borovsky et al., 2014)

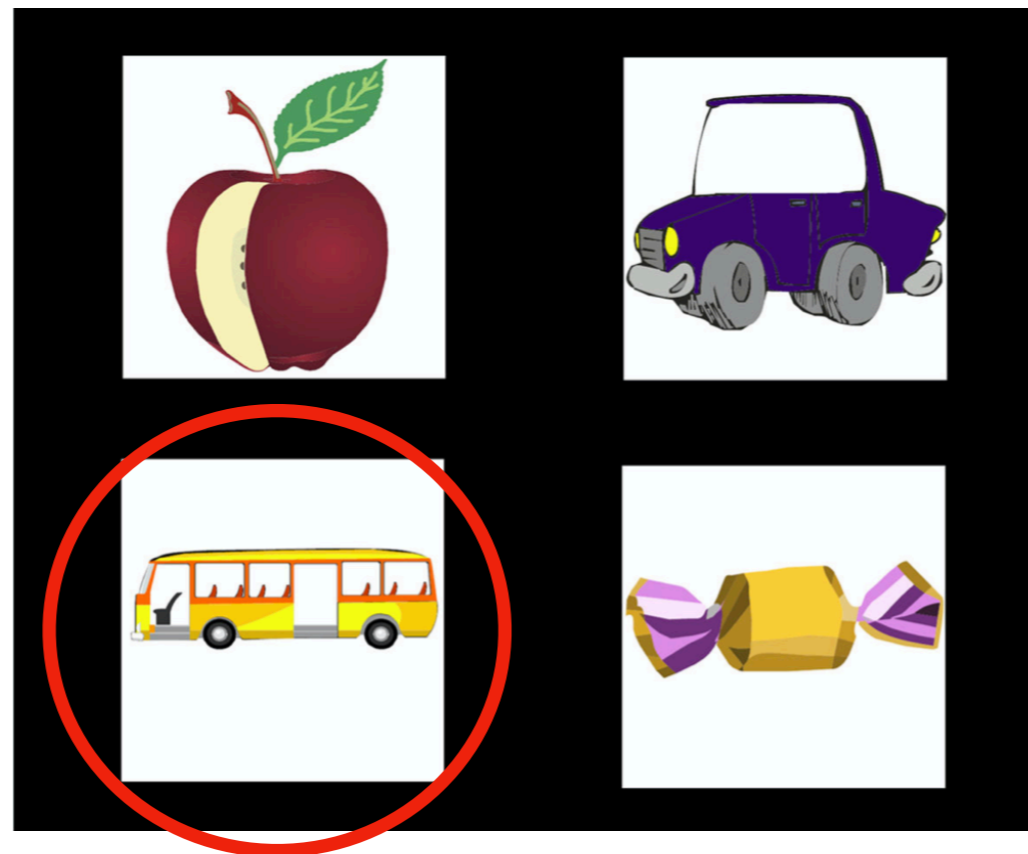
*The monkey rides in the bus.*



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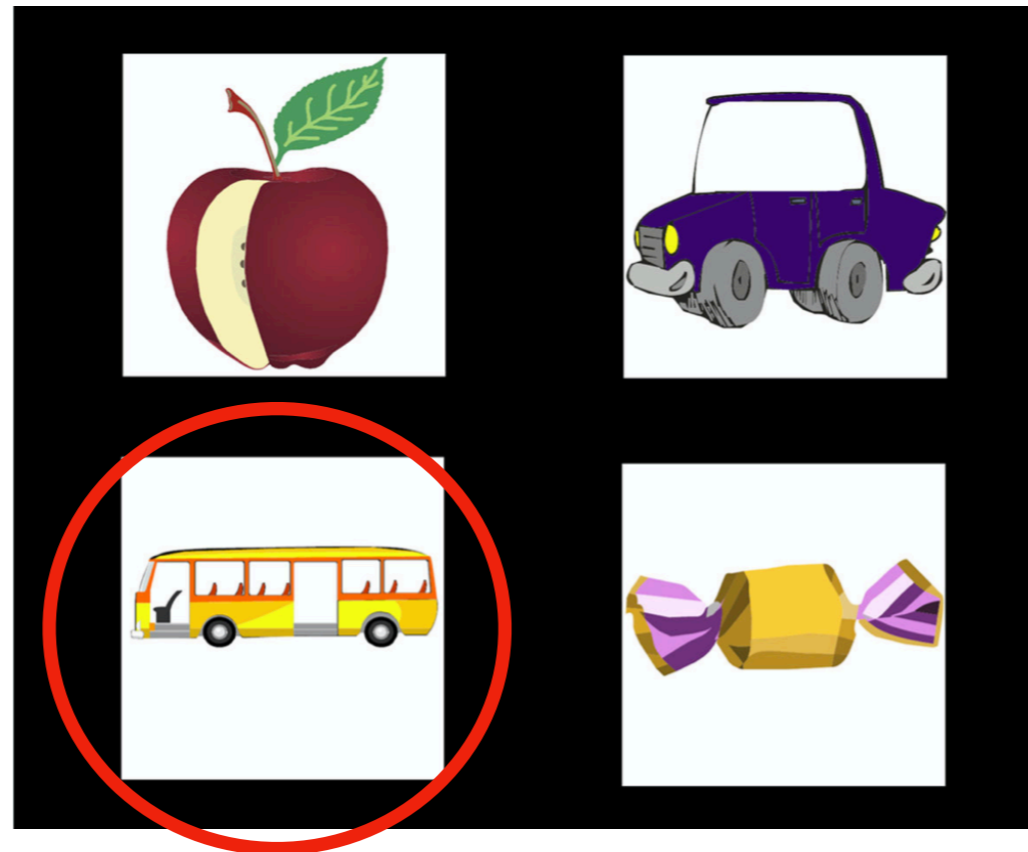




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*The monkey rides in **the bus**.*



# Do children use a situation model during online reference comprehension?

- Children construct situation models during language comprehension (Lynch et al., 2008; Rall & Harris, 2000)
- Children activate recently encoded event information to predict an upcoming argument online (Borovsky et al., 2014)
- **Our Question:** *But can children use the situation model to generate new inferences about upcoming information during online comprehension?*

# Methods

Can children use the situation model to constrain their interpretation of a referentially ambiguous noun?

- **Eye-tracking narrative comprehension task**
  - Stories modeled after Nieuwland et al., “the nephews”
- 80 native English-speaking 4- and 5-year-old children (*M* age = 57 months, 44 female)

# Example Story



One afternoon Maisy was at the beach. She was with her friends the bunny (turtle) with the necklace and the bunny with the crown. Maisy was wearing her polka dot shorts.

*Ambiguous:* The bunny with the necklace was flying a kite and so was the bunny with the crown.

*One-referent unambiguous:* The turtle with the necklace had to leave early, but the bunny with the crown was flying a kite.

*Two-referent unambiguous:* The bunny with the necklace had to leave early, but the bunny with the crown was flying a kite.

Maisy didn't like flying kites; she liked splashing in the water. **She asked the bunny with the crown to splash in the water with her.** And then they splashed in the water together.

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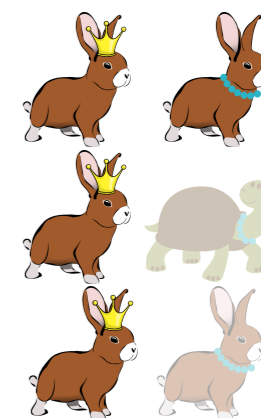
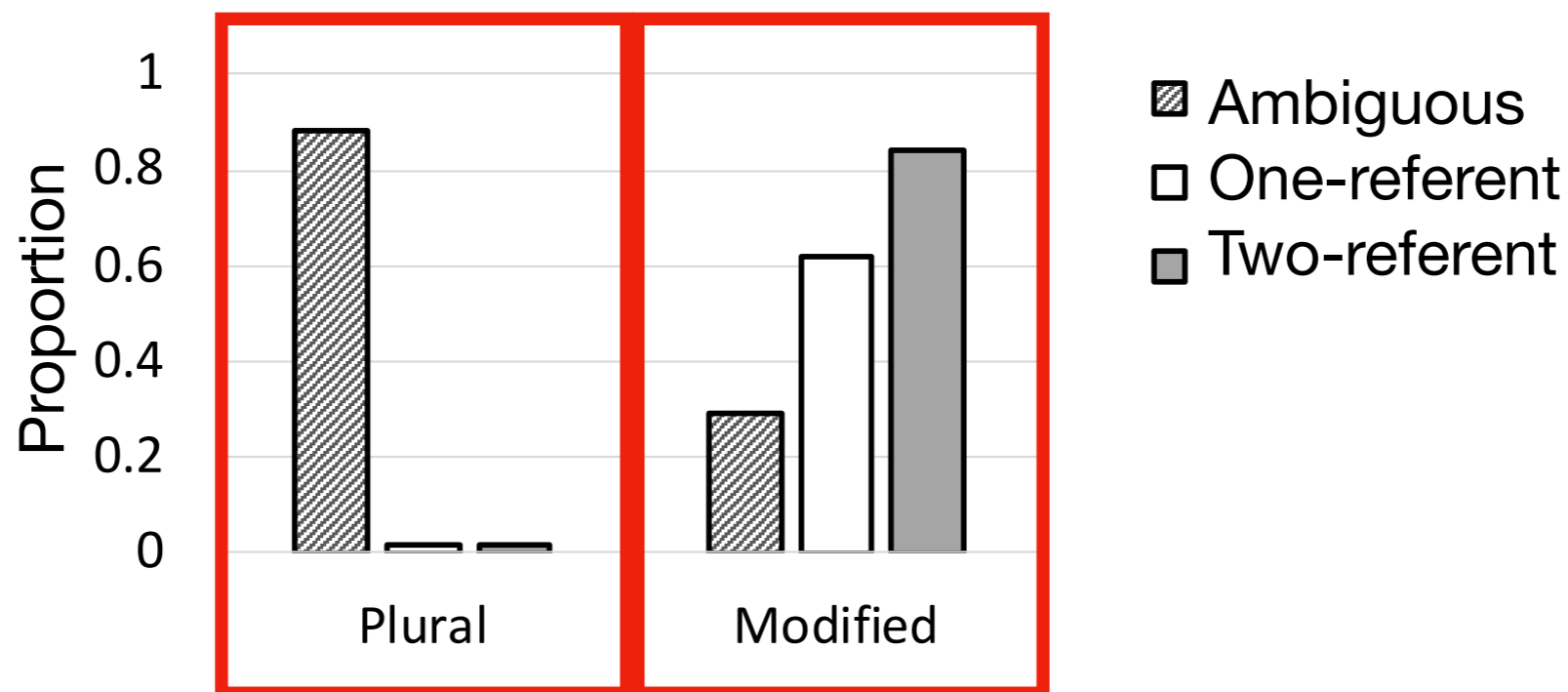
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# Sentence completion norming experiment

AIM: Ensure our materials had the intended structure.

- 30 native English speaking adults ( $M$  age = 22.5 years)
- Stories were truncated at the verb in the critical sentence; each story ended with “***She asked...***”

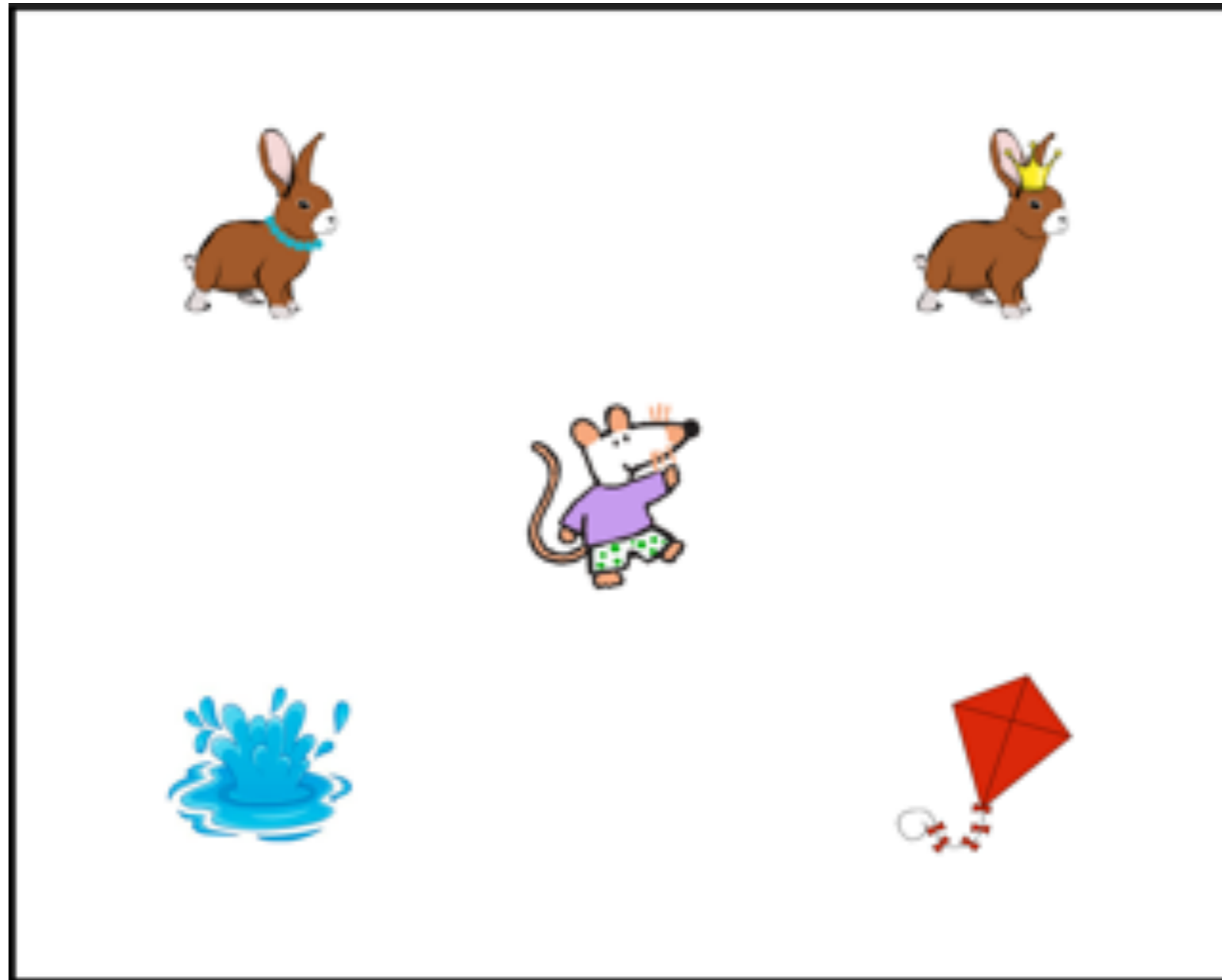


“***the bunnies***” “***the bunny with the crown***”

# Methods

- 24 total stories:
  - 8 Ambiguous
  - 8 One-referent unambiguous
  - 8 Two-referent unambiguous
- Trials were blocked by story condition (in counterbalanced order)

# Example trial screen



# Memory Questions

- After each story, participants were asked 2-3 questions to probe memory of the story:

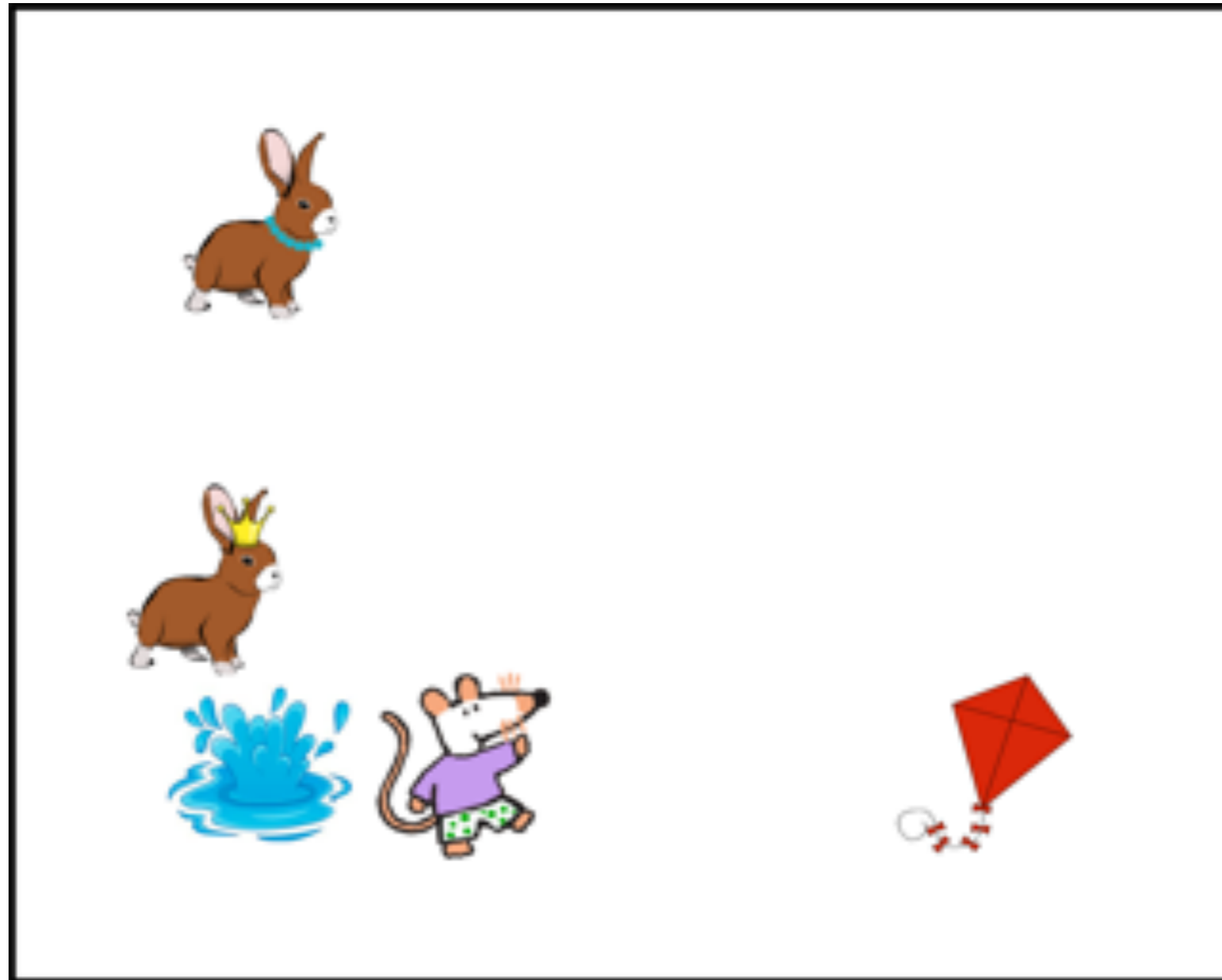
*1. What did Maisy do [at the end of the story]?*

*2. Who did Maisy do it with?*

If One-referent or Two-referent unambiguous...

*3. Who had to leave early?*

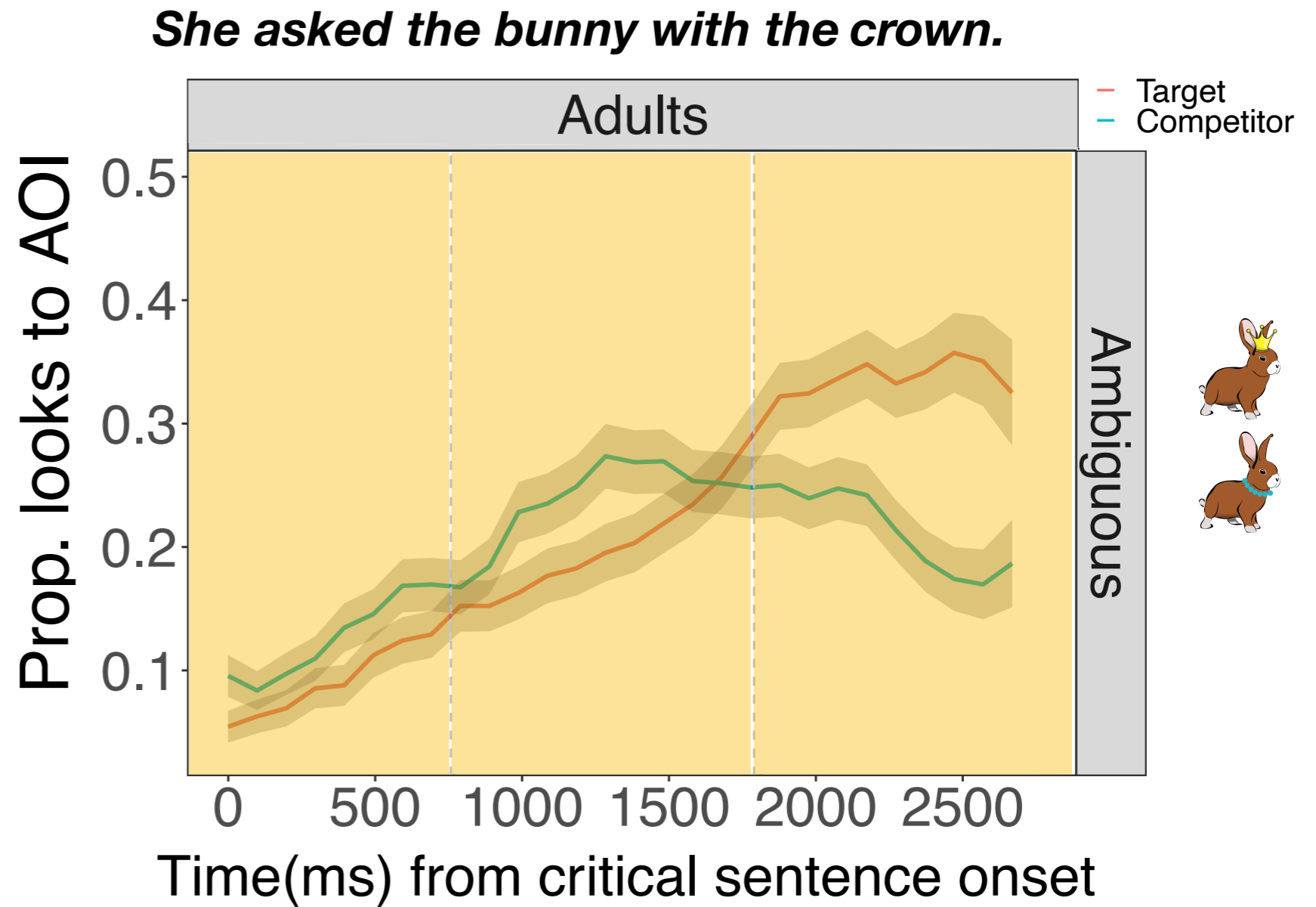
# Example act-out screen



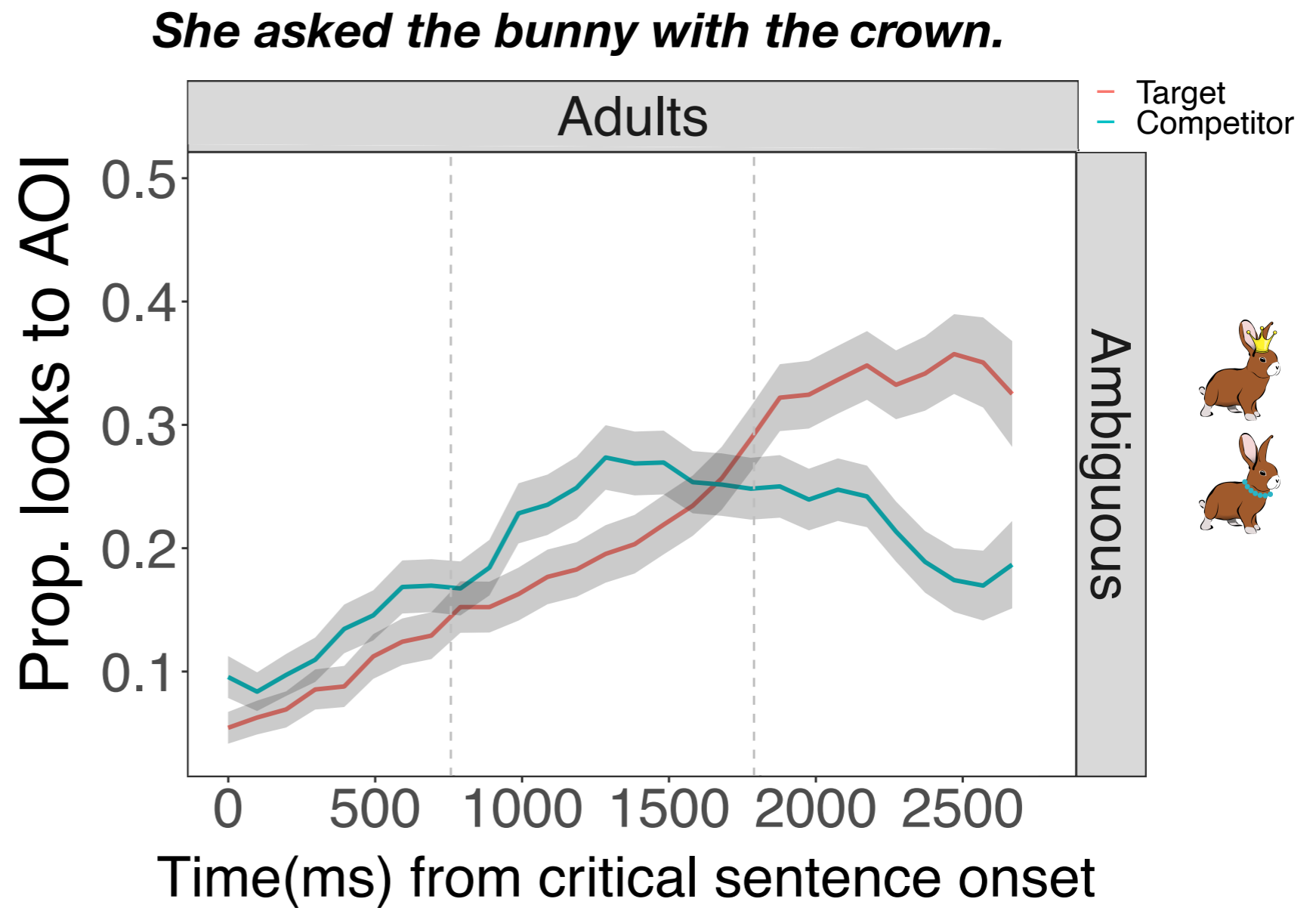
# Eye-tracking narrative comprehension experiment with adults

- 42 native English-speaking adults (*M* age = 19.7 years)
- Trials were presented in a random order
- No memory questions; adults acted out the final event of the story by moving the images

# Results

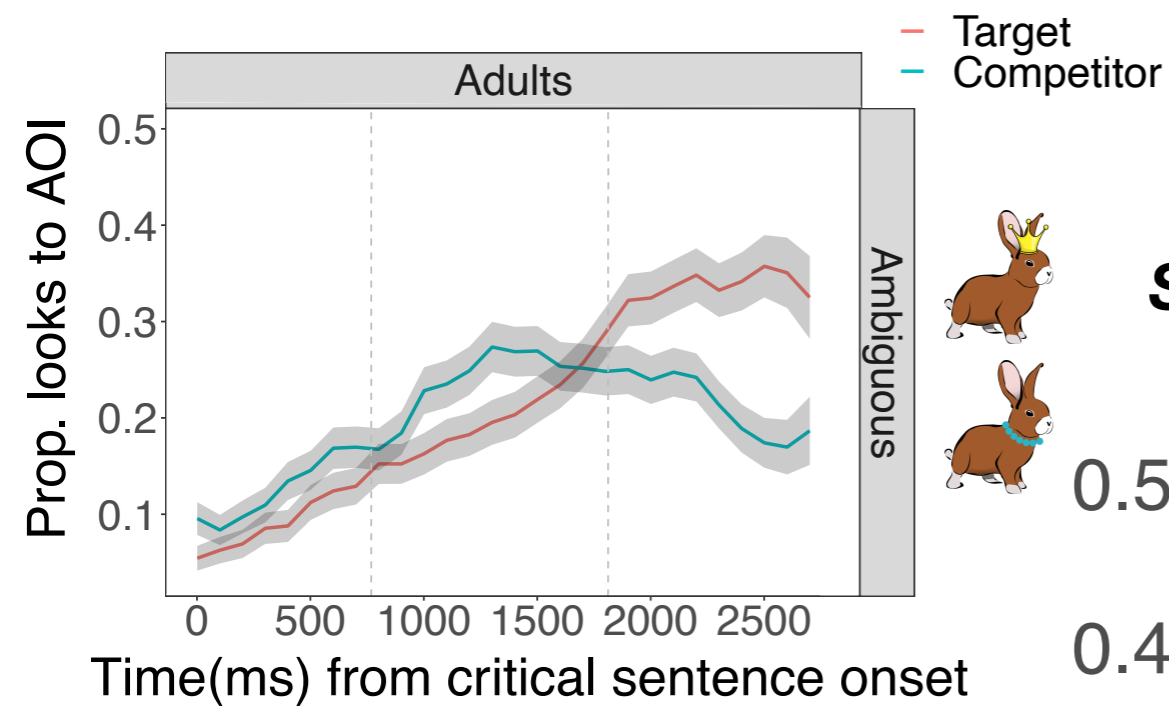


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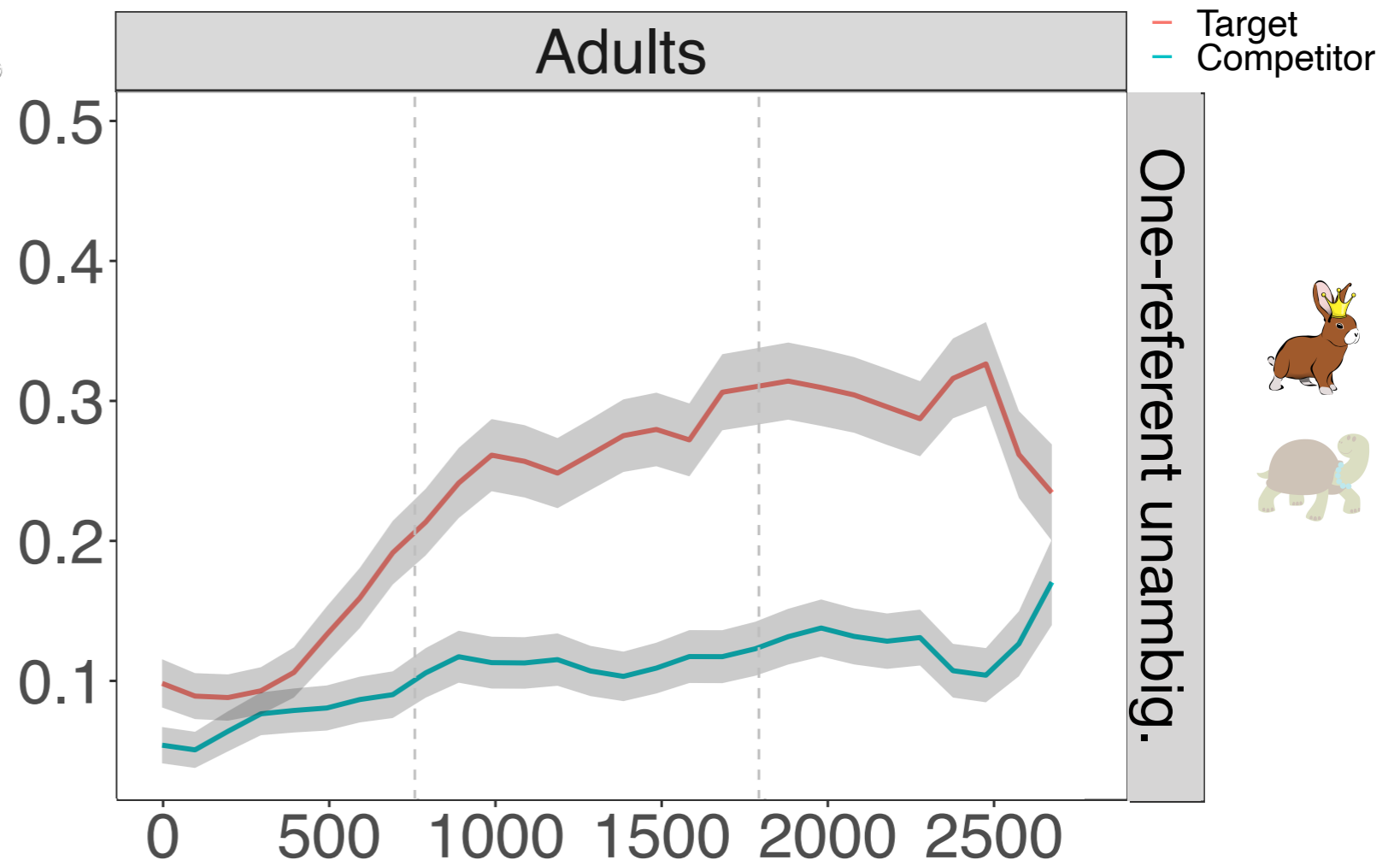




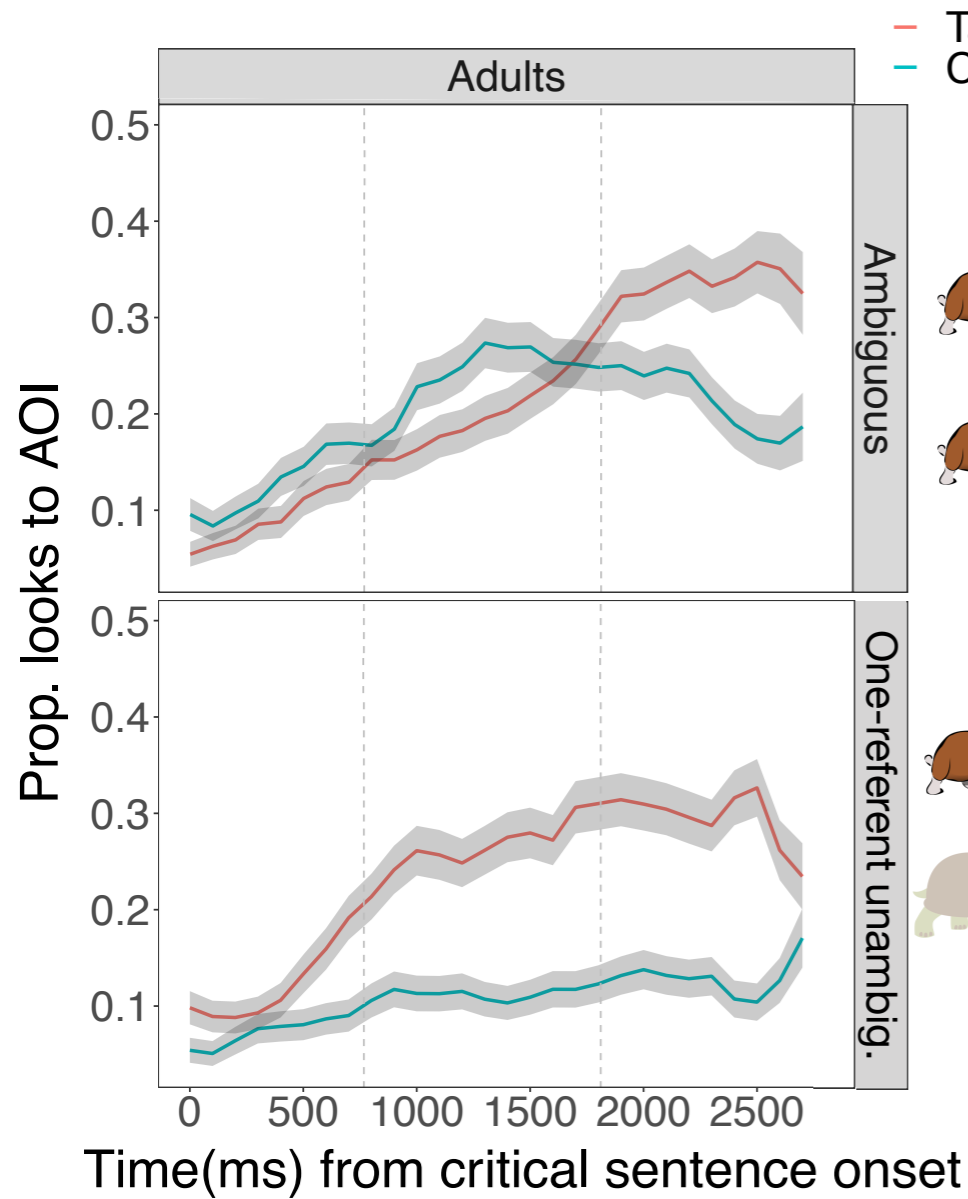
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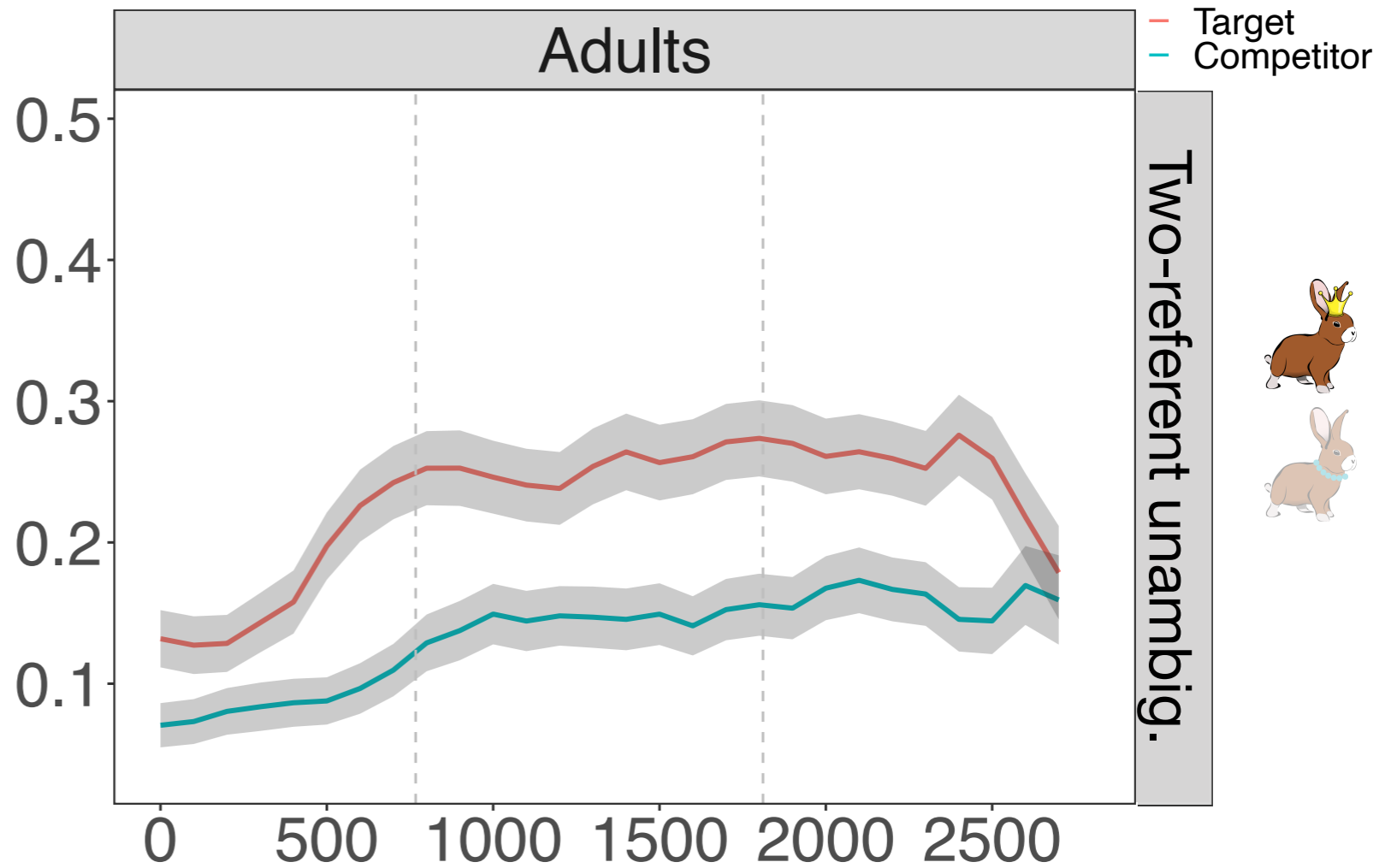
***She asked the bunny with the crown.***



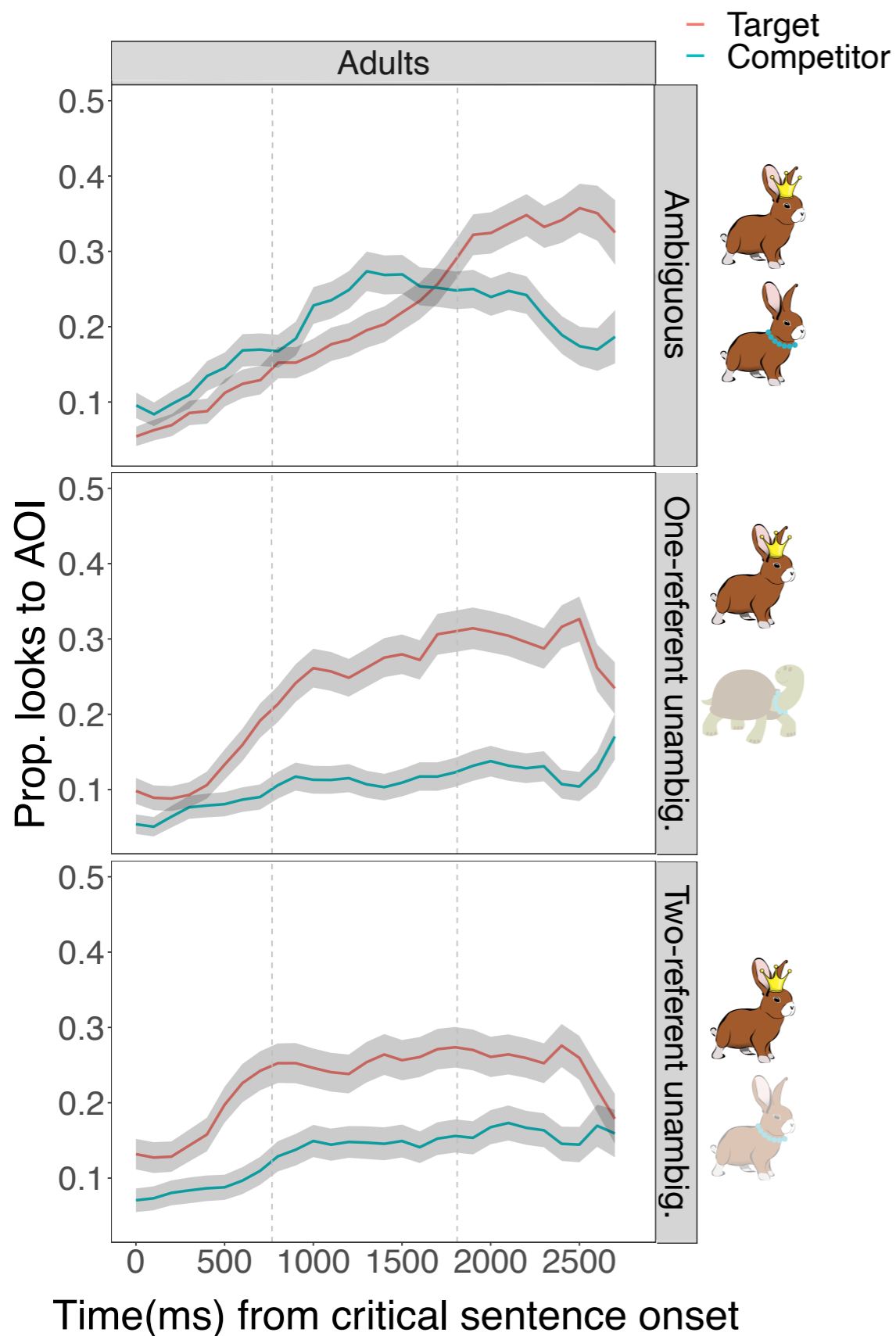
# Results



***She asked the bunny with the crown.***



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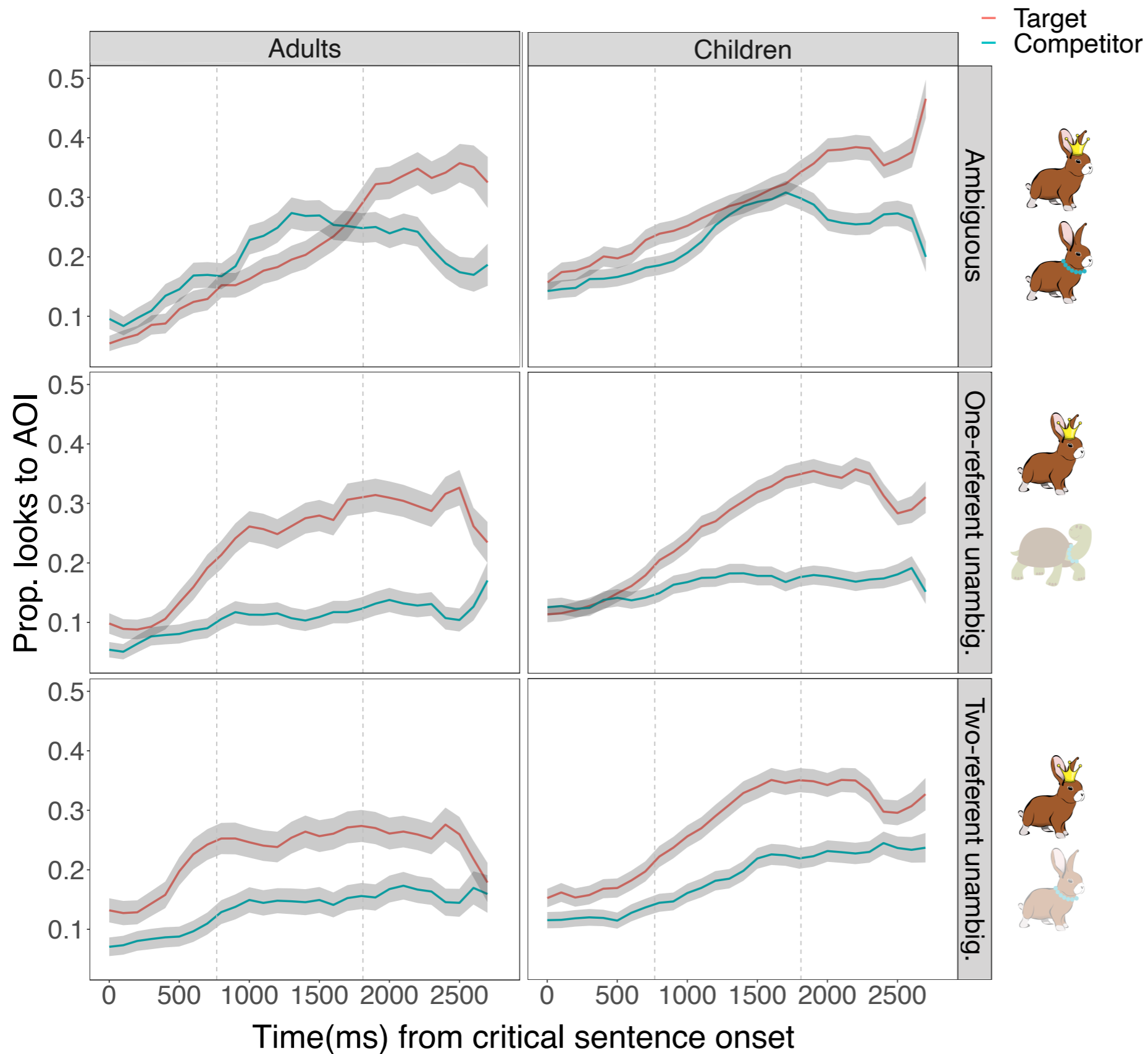


**Maisy** didn't like flying kites;

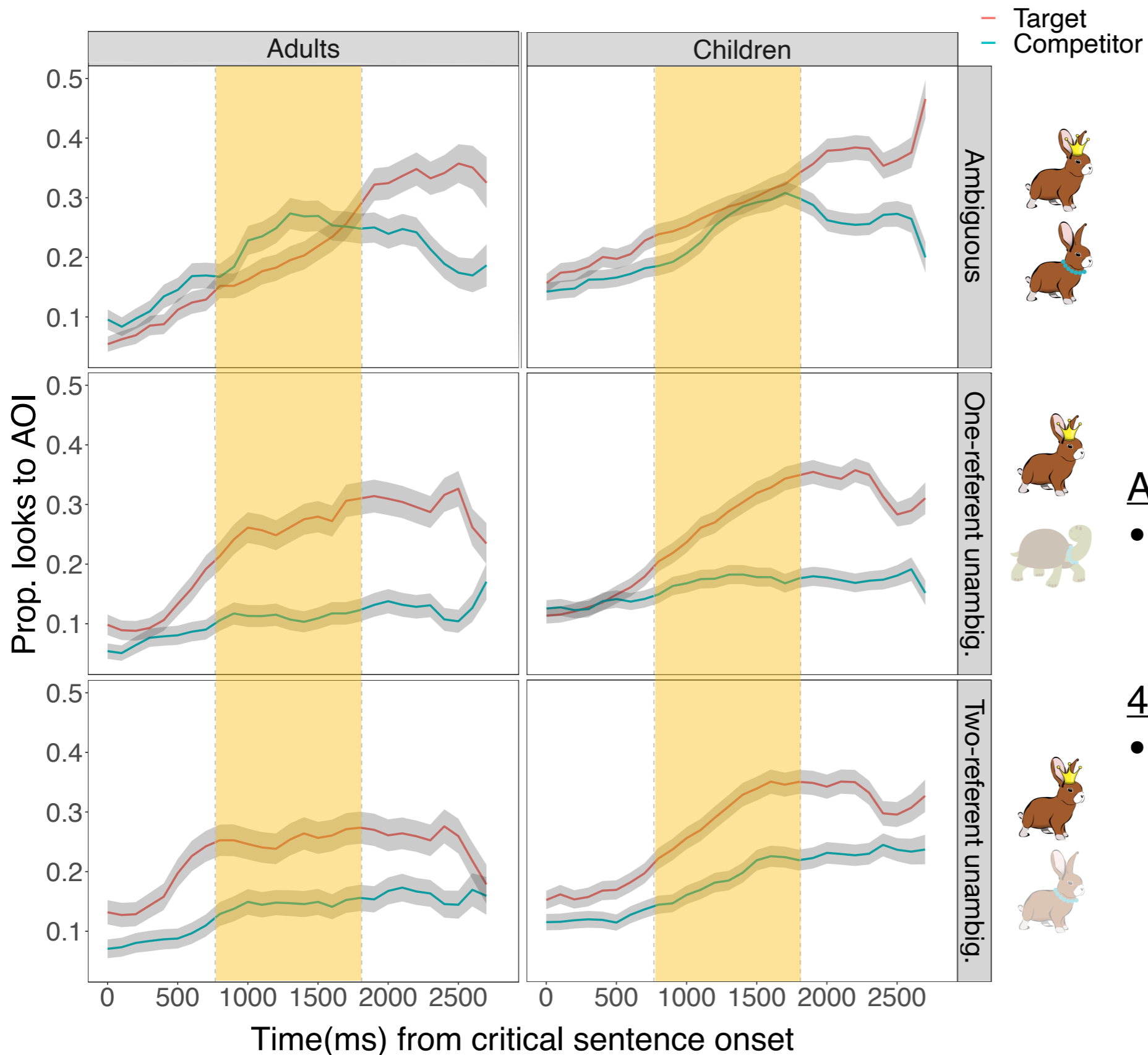
**she** liked splashing in the water.

**She** asked the bunny with the **crown** to splash in the water with **her**.

# Results



# Results



***“the bunny with the”***

*Do participants exploit  
the constraints of the  
situation model?*

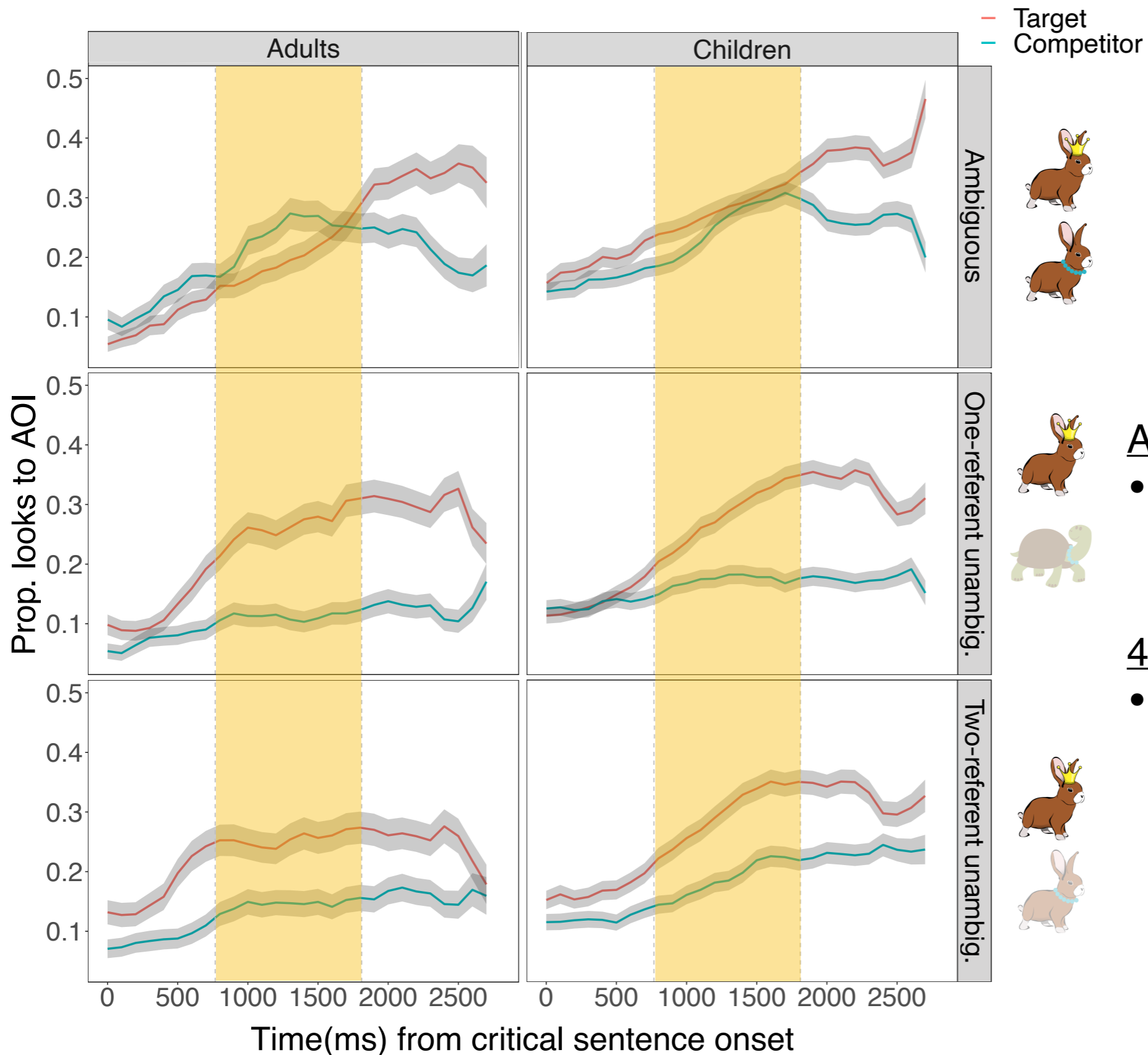
Adults:

- Two-ref. > Ambiguous,  
 $p < .001$

4- and 5-year-olds:

- Two-ref. > Ambiguous,  
 $p = .028$

# Results



***“the bunny with the”***

*Are stories with 2 referents more ambiguous than 1?*

Adults:

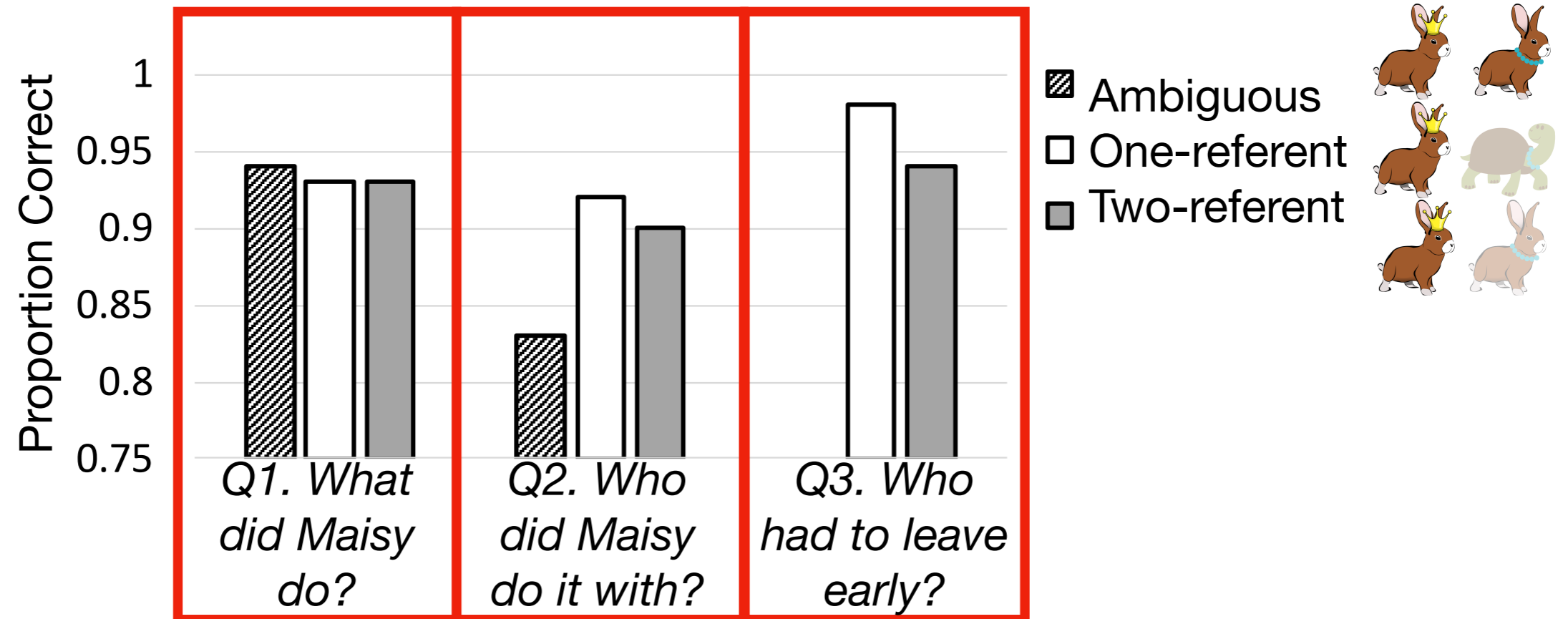
- One-ref. > Two-ref.,  
 $p < .001$

4- and 5-year-olds:

- One-ref. > Two-ref.,  
 $p = .012$

# Memory Question Accuracy

4- and 5-year-olds



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# Do children use a situation model during online reference comprehension?

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- Children activate recently encoded event information to predict an upcoming argument online (Borovsky et al., 2014)
- Children use the situation model to constrain the interpretation of an ambiguous noun during online reference comprehension.

# Discussion

- Under what circumstances can children integrate discourse-provided facts with the presuppositions of verbs in referent prediction?
- Would listeners make a referential prediction if they heard *'remembered'* instead of *'asked'*?

*She remembered that the bunny with the crown...*

- Adults predictively look to objects that have previously moved when they hear an instruction with the verb *'return'* (Chambers & San Juan, 2008)

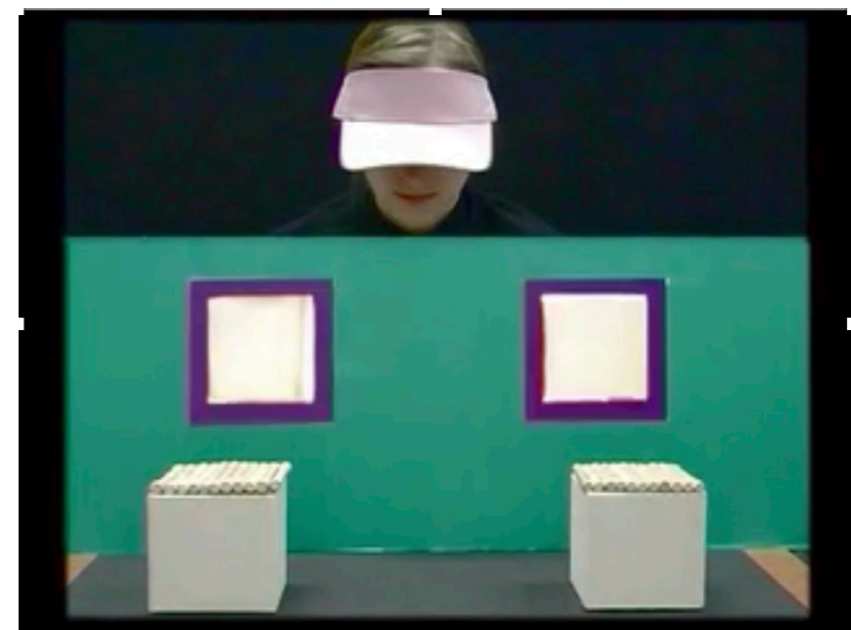
# Discussion

- Why do children succeed in this case, when they struggle to draw other pragmatic inferences during online comprehension?
- 7-year-old children find it difficult to predict information provided in fictional discourses when the information conflicts with their world knowledge (Lee et al., 2017)



# Discussion

- Could a situation model be involved in earlier language comprehension and learning?
  - Situation model is a workspace that permits:
    - integration and uniform reasoning over multiple sources of knowledge (e.g., conceptual, linguistic)
    - generation of online predictive inferences based on causal reasoning
  - Causal reasoning over event knowledge is also essential to non-linguistic domains!  
(Southgate, Senju, & Csibra, 2007)



# Thank you!

- Cynthia Fisher
- Families who participated
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- Renée Baillargeon for helpful feedback



## **Language Acquisition Lab**

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