Delayed structural prediction:
Processing relative clauses in Santiago Laxopa Zapotec

Jack Duff   **Delaney Gomez-Jackson**   **Fe Silva Robles**
Maziar Toosarvandani   **Matt Wagers**

HSP 37 @ UMich
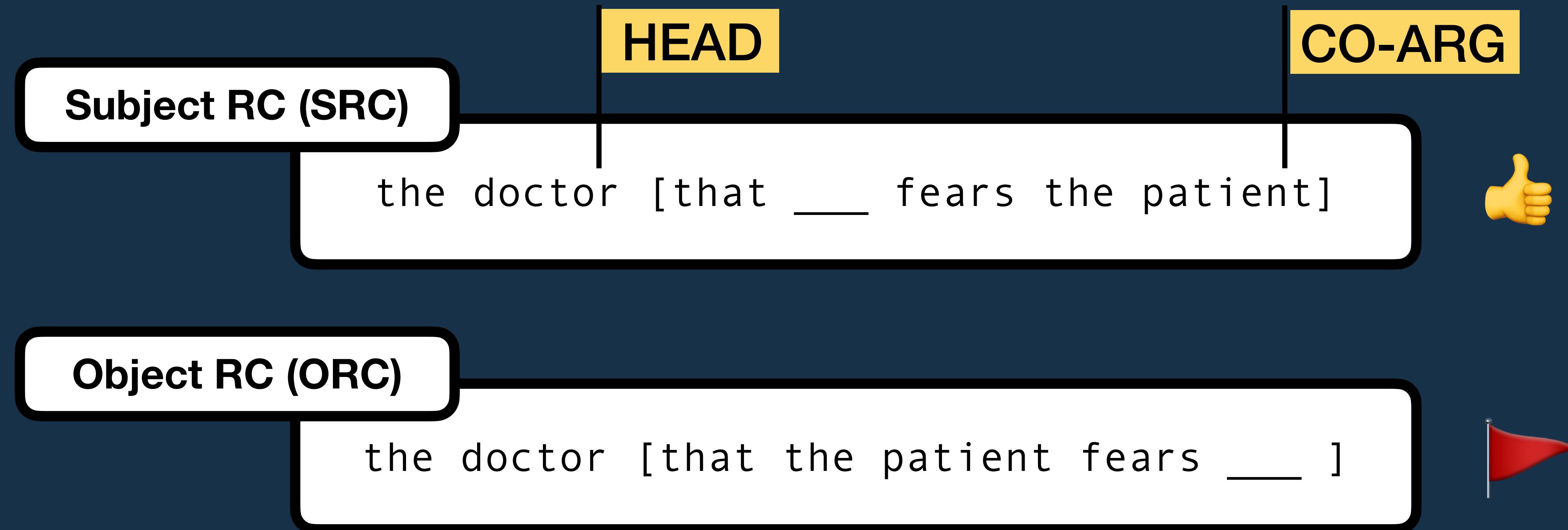
UC SANTA CRUZ

UNIVERSITÄT DES SAARLANDES

SENDEROS
CREATING PATHWAYS

The SRC bias

HEAD   **CO-ARG**

Subject RC (SRC)

the doctor [that ___ fears the patient]   👍

Object RC (ORC)

the doctor [that the patient fears ___]   🚩

SPR: King & Just (1991), ET: Gordon et al. (2001), Preferential interpretation: Frazier (1987)

Animacy asymmetries in ORC difficulty

Head = HU

SRC

the director [that ___ watched the movie] 👍

ORC

the director [that the movie pleased ___] 🚩

**Head = IN**

SRC

the movie [that ___ pleased the director] 👍
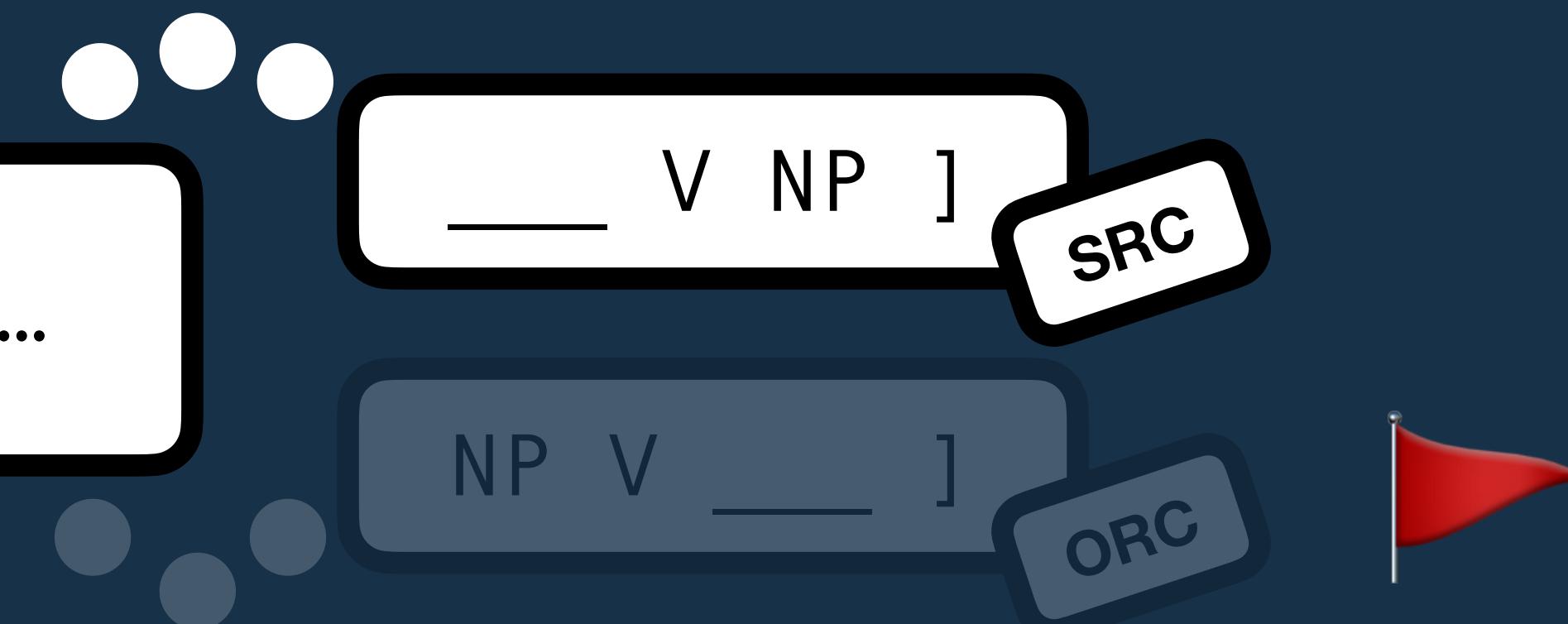
ORC

the movie [that the director watched ___] 👍

SPR: Mak et al. (2002), ET: Traxler et al. (2002)

Animacy asymmetries via structural prediction
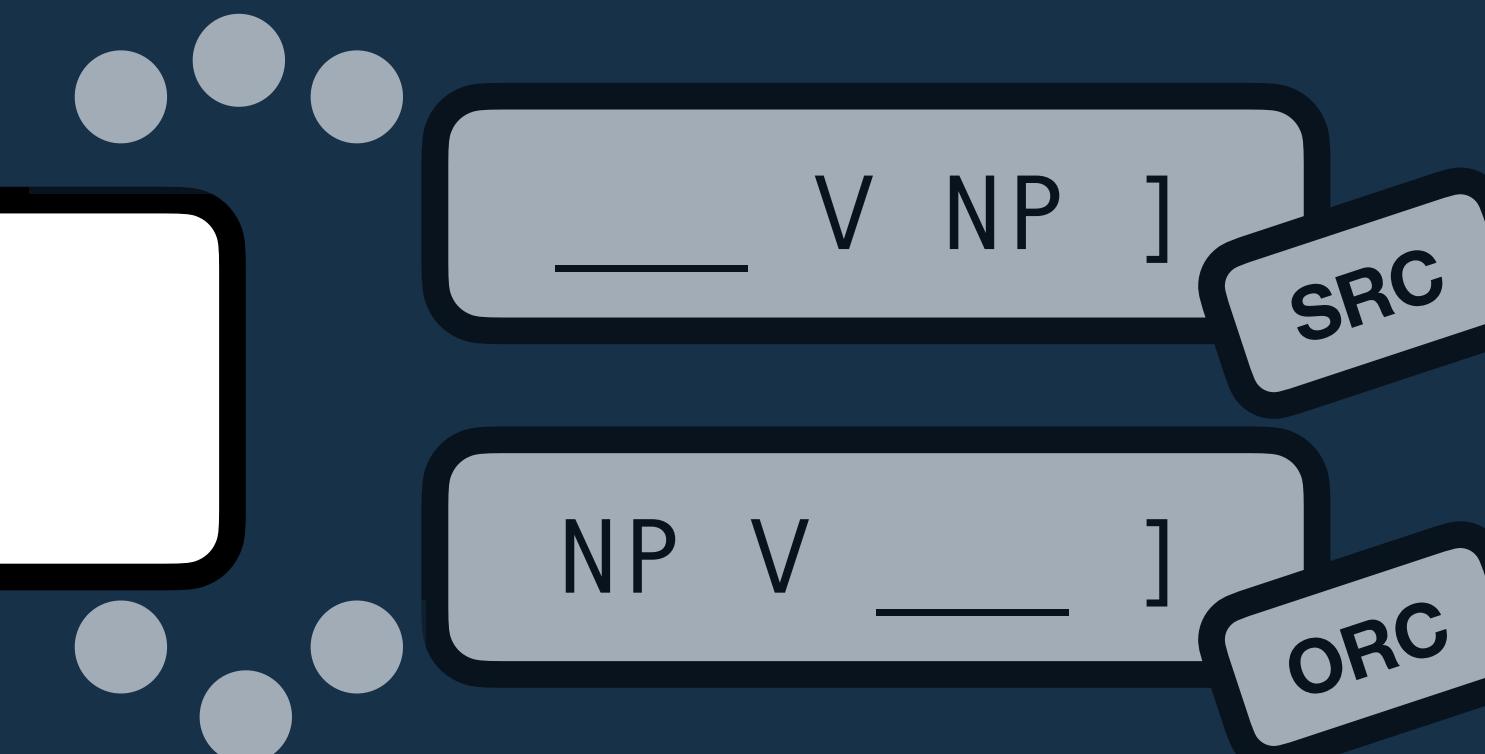
Head = HU

`the director [that …`

`____ V NP ]` SRC

`NP V ____ ]` ORC

Head = IN

`the movie [that …`

`____ V NP ]` SRC

`NP V ____ ]` ORC

Completions: Gennari & MacDonald (2008), SPR: Wagers & Pendleton (2015)

re: animate subjects, see Hopper & Thompson (1980), Bornkessel-Schlesewksy & Schlesewksy (2009)

Cross-linguistic evidence

The basic SRC bias has been investigated and frequently observed across diverse languages.

- Sometimes entangled with morphosyntactic alignment.

- Sometimes modulated by head + RC vs. RC + head order.

Austronesian languages
Chamorro: Wagers et al. (2018)
Niuean: Longenbaugh & Polinsky (2016)*,
Tollan et al. (2019)*
Tagalog: Pizarro-Guevara (2020)
Tongan: Ono et al. (2019)**

Mayan languages
Ch'ol, Q'anjob'al: Clemens et al. (2015)

Algonquian languages
Ojibwe: Hammerly et al. (2022)

Japanese Ueno & Garnsey (2008)

NE Caucasian languages
Avar: Polinsky et al. (2012)

S Caucasian languages
Georgian: Foley (2020), Ellen Lau et al. (2023)

Korean Kwon et al. (2010)

Basque Carreiras et al. (2010)**

Sino-Tibetan languages
Mandarin: Gibson & Wu (2013)**,
Hsiao & MacDonald (2016)

* apparent equibias
** apparent ORC bias

(see Elaine Lau & Tanaka, 2021)

But how widespread are animacy asymmetries?

Austronesian languages
Tagalog: Bondoc & Kush (poster yesterday!)

Algonquian languages
Ojibwe: Hammerly et al. (2022)
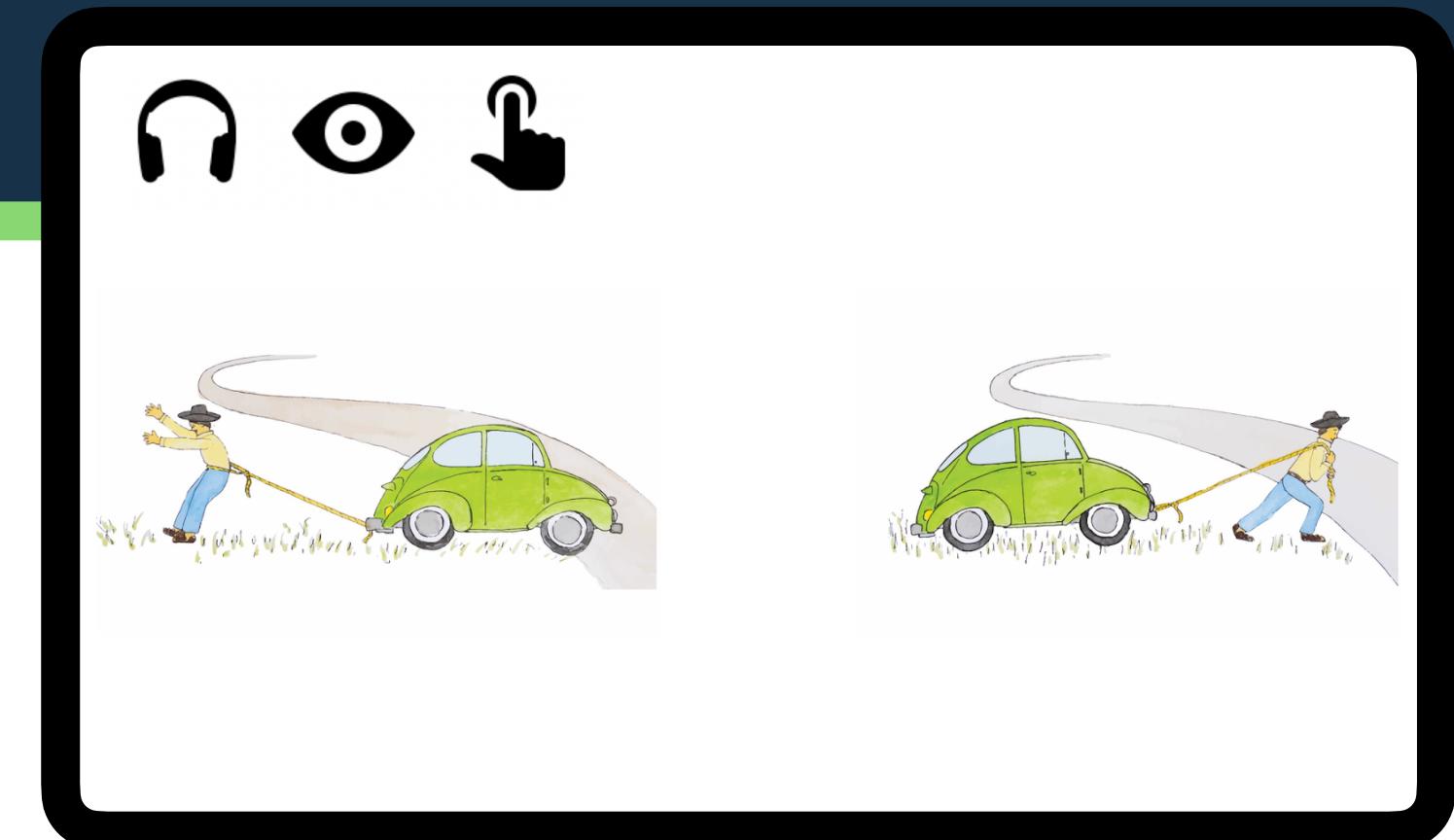
Sino-Tibetan languages
**Mandarin:** Wu, Kaiser & Anderson (2012)
Hsiao & MacDonald (2016)

In this talk…

How does animacy affect RC processing in Santiago Laxopa Zapotec?

- global SRC/ORC ambiguity
- grammatical resumptive pronouns
- no passive-like alternations
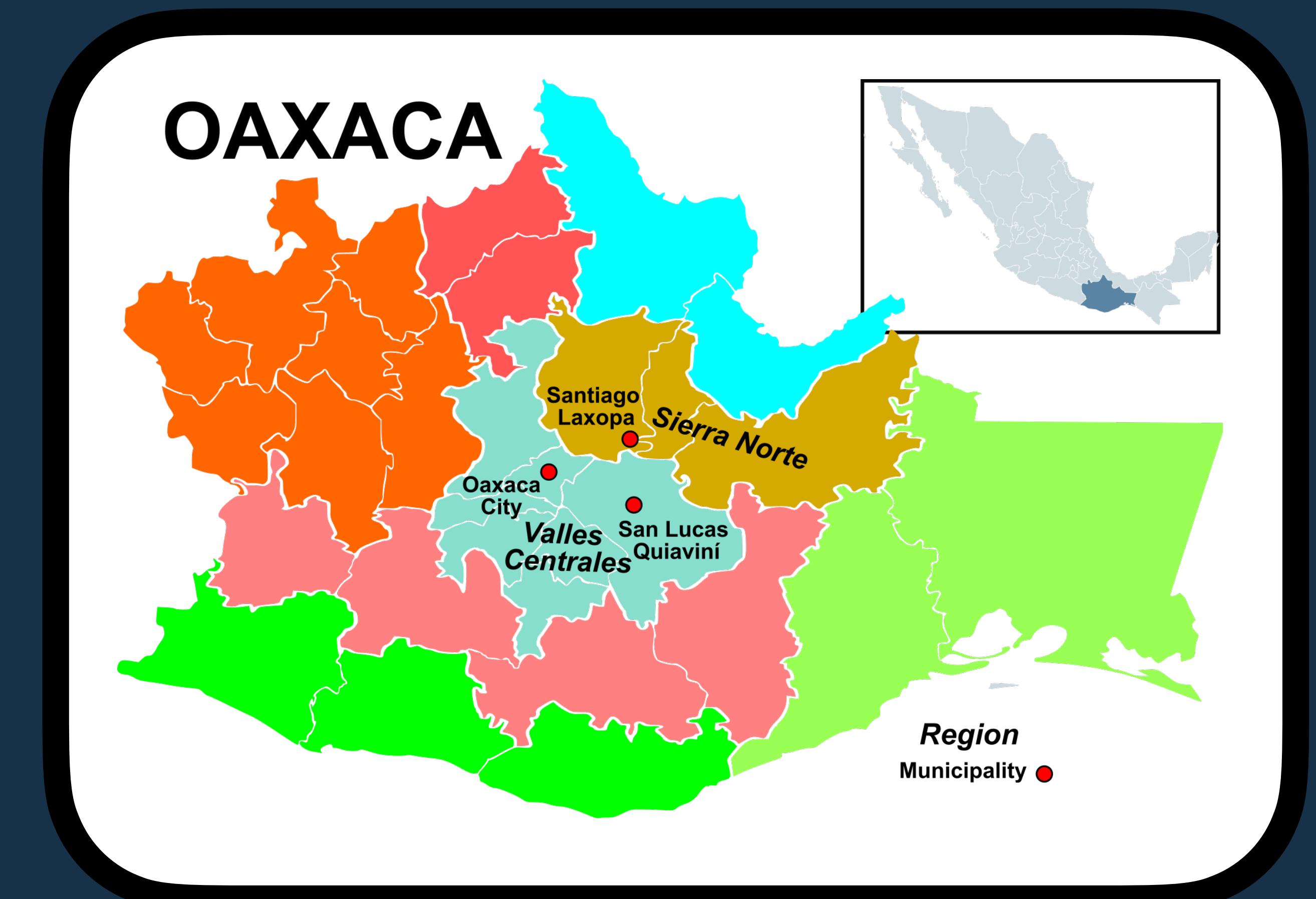
**picture-matching study with eye-tracking:**

- no offline SRC bias or animacy dependency
- no evidence for head-based prediction
- late emergence of prediction based on co-argument animacy

Santiago Laxopa Zapotec

(dille' xhunh Laxup)

- Oto-Manguean

- Spoken by ~1,300 in Santiago Laxopa in Oaxaca, Mexico

OAXACA

Santiago Laxopa

Sierra Norte

Oaxaca City

Valles Centrales

San Lucas Quiaviní

Region

Municipality

Relative Clauses in Santiago Laxopa Zapotec

pull	boy	car

"the boy is pulling the car"

pull	car	boy

"the car is pulling the boy"

boy	pull	car

SRC

"the boy that is pulling the car"

boy	pull	car

ORC

"the boy that the car is pulling"

```
bi'i xyage'nh [txube coche'nh]
the.boy            pull    the.car
```

ambiguous!

Resumptive pronouns (RPs) in Santiago Laxopa Zapotec

| boy | pull | he | car |

"the boy that is pulling the car"

| boy | pull | car | him |

"the boy that the car is pulling"

```
bi'i xyage'nh [txube =ba' coche'nh]
the.boy              pull    he   the.car
```
SRC

```
bi'i xyage'nh [txube coche'nh leba']
the.boy              pull  the.car    him
```
ORC

Both types of RP are used frequently, maybe even preferred.
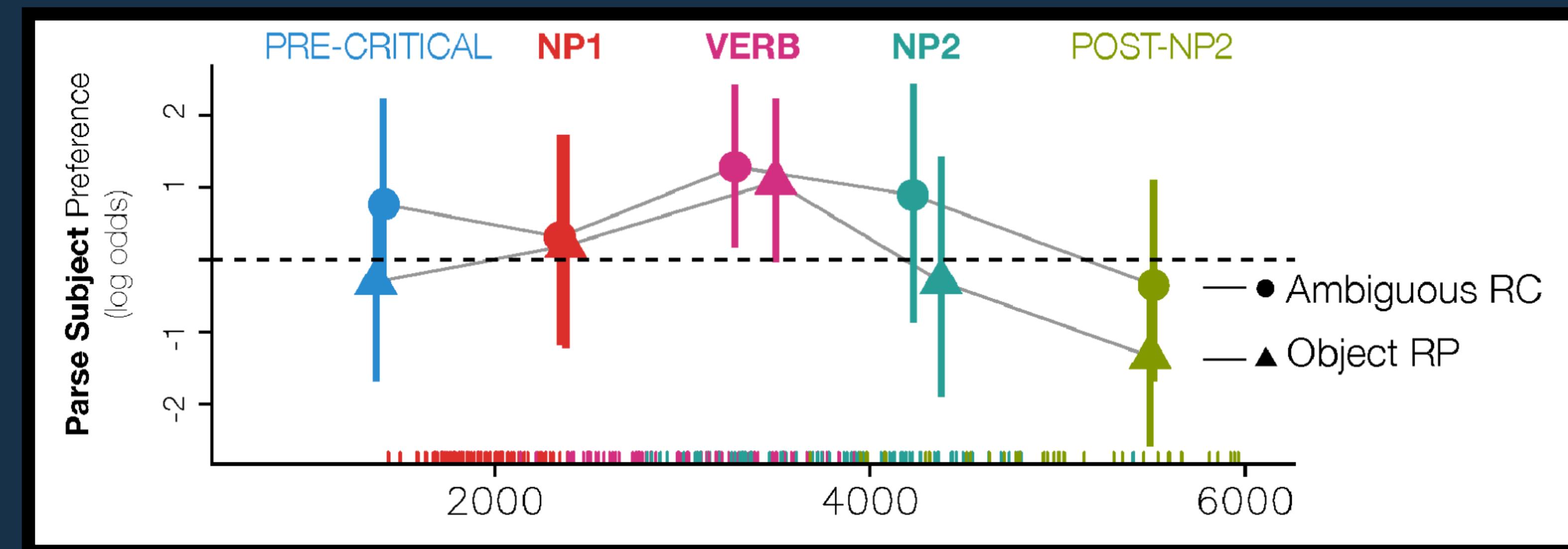
cf. Foreman & Munro (2007) on Macuiltianguis Zapotec

udanh fotografia'nh tse   bi'i xyage'nh [txube coche'nh ...]
touch   the.picture   of   the.boy   pull   the.car

Previous experiments

- Validated picture-matching + eye-tracking paradigm in non-lab setting

- Evidence for weak and temporary SRC bias after the head

- No evidence for gradient predictions over gradient animacy categories

Sasaki, Foley, Pizarro-Guevara, Silva Robles, Toosarvandani & Wagers (ms, 2021)

Head =
HU

Head =
IN

Co-Arg
MISMATCH

	HU	IN
Gap	boy [pull car]	car [pull boy]
ObjRP	boy [pull car him]	car [pull boy it]

Co-Arg
MATCH

	HU	IN
Gap	boy [pull girl]	car [pull truck]
ObjRP	boy [pull girl him]	car [pull truck it]

Each participant saw: 12 HU items, 12 IN items, 6 unambiguous fillers

Data collection

- 102 participants aged 18-85 (med. 40)

- Run on Surface Pro tablet with OpenSesame

- Gaze tracked at 60Hz with Tobii Pro Nano

- Final sample: 62 participants

Offline interpretation choices

logistic m-e. models fit in `brms` with regularizing priors and sum-coded predictors
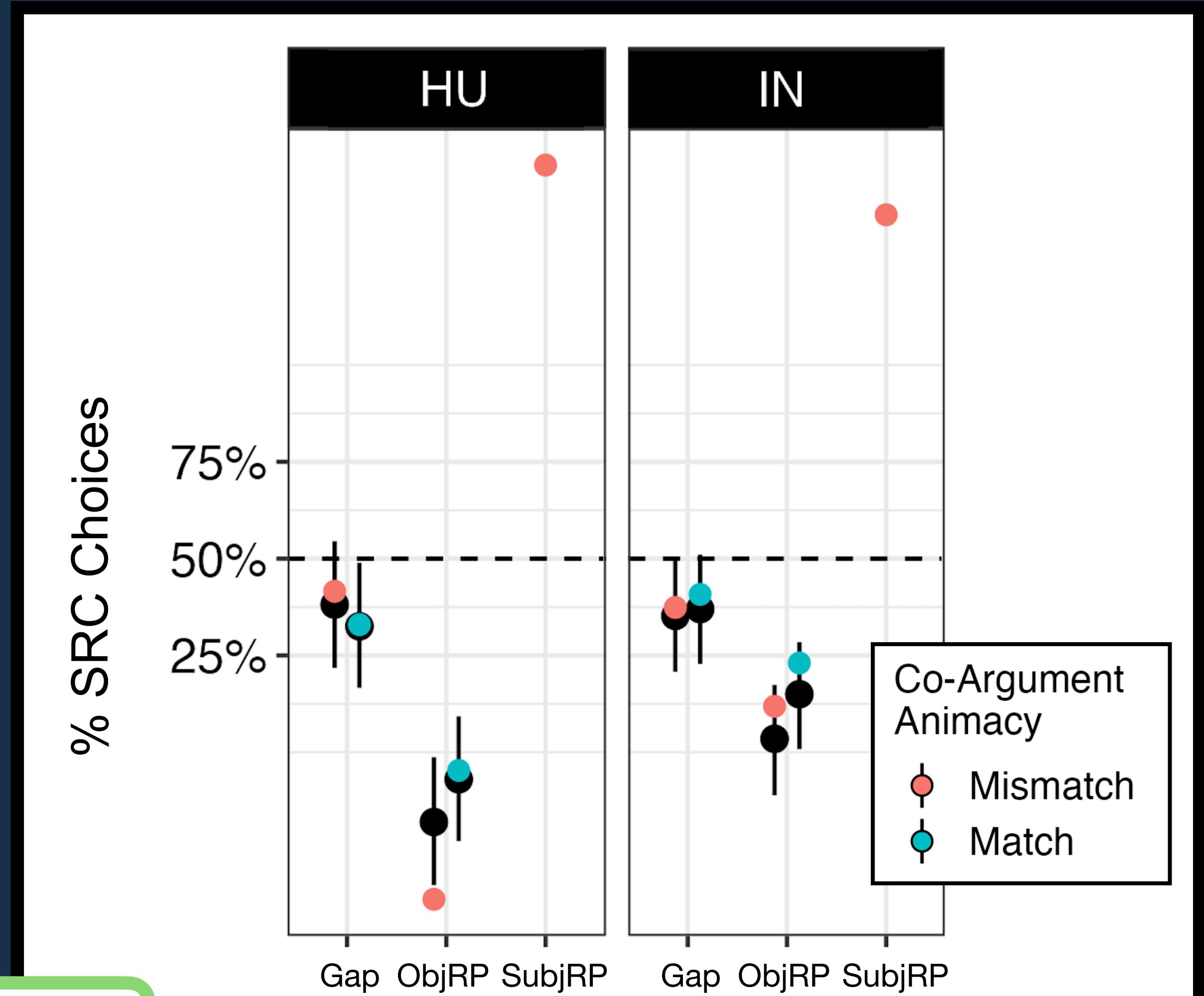
We expect:

- SRC bias:
  SRC choices favored with Gap.

- Sensitivity to RPs:
  Less SRC choices with ObjRP.

- Head animacy:
  More SRC choices when HU.

We observe:
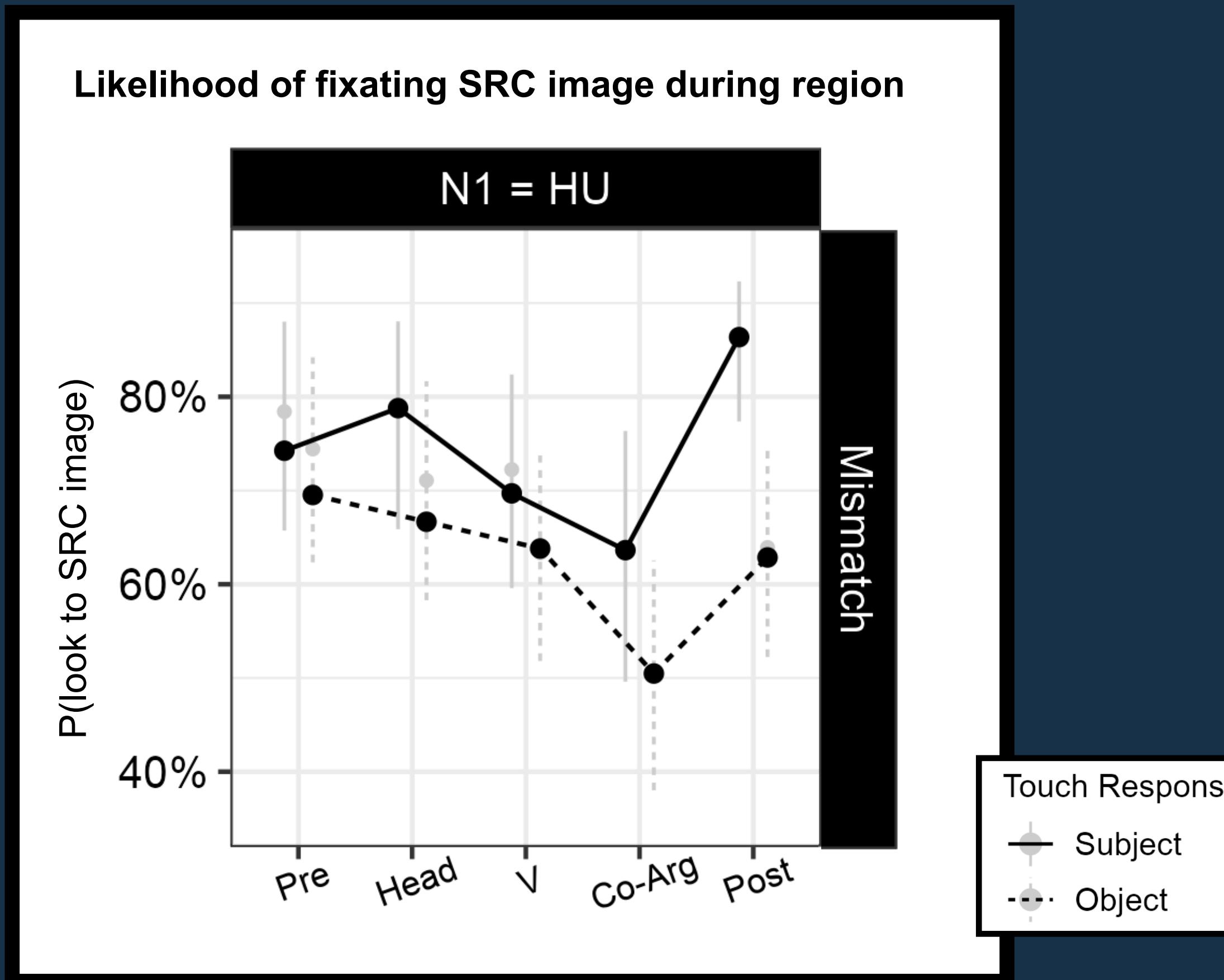
- No SRC bias.

✓ Sensitivity to RPs. $\hat{\beta}_{.95} = (-2.05, -1.20)$

- No animacy effect. $\hat{\beta}_{.95} = (-0.15, 1.11)$

⊙ Added difficulty with RPs if matching co-args or IN head.

Similarity-based interference

observed choices in color, model estimates and 95% CrIs in black.

Fixation likelihoods: Ambiguous RCs

Likelihood of fixating SRC image during region

General patterns:

- Choice preference:
  Favored interpretations diverge early.

- Ebbs and flows, not a bias:
  SRC > ORC, then ORC > SRC.

Fixation likelihoods: Ambiguous RCs

logistic m-e. models fit in `brms` with
regularizing priors and sum-coded predictors

We expect:
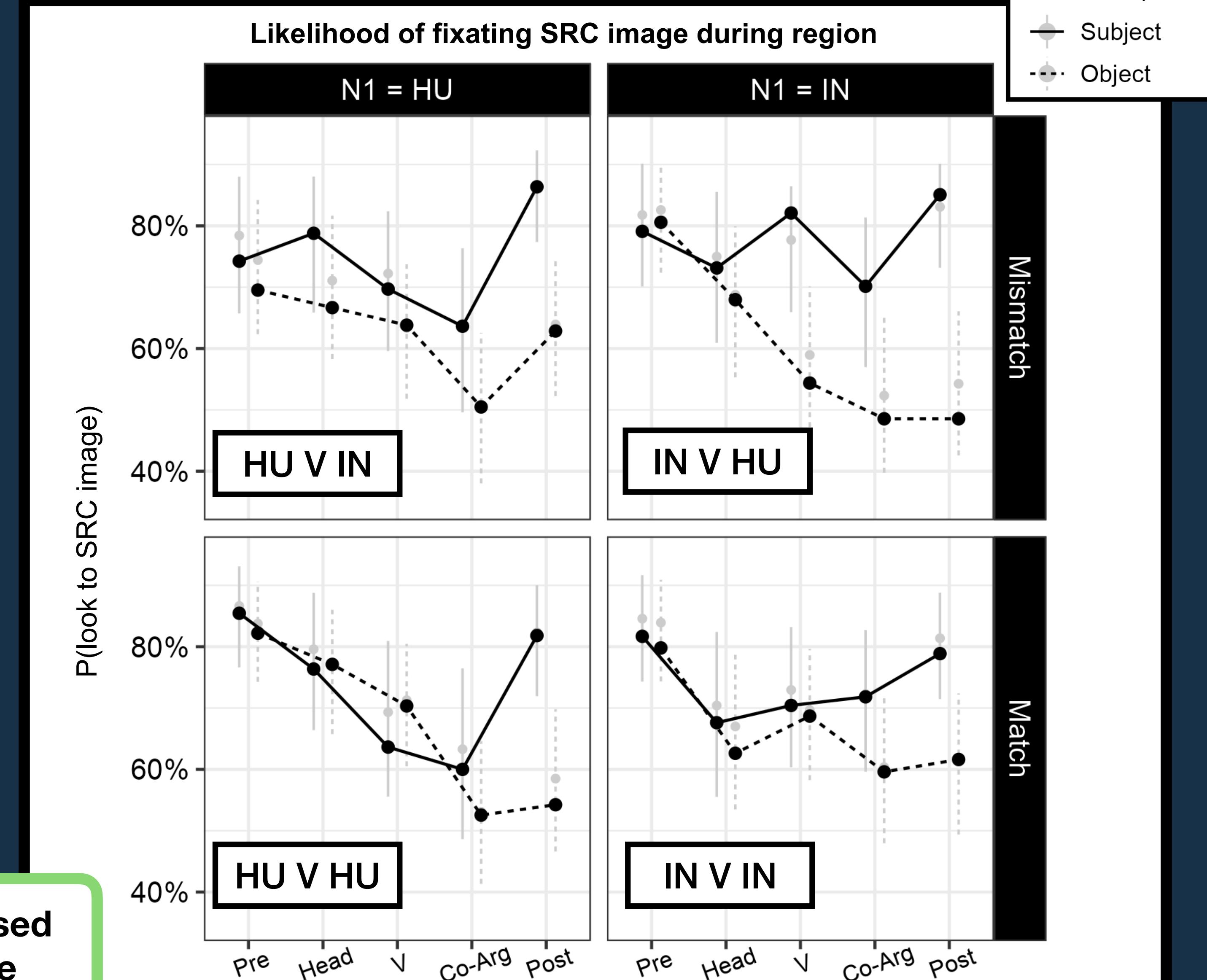
- Choice preference:
  More SRC looks if SRC choice.

- Head animacy:
  More SRC looks when HU head.

We observe:

✓ Choice preference
  by Co-Arg. region.
  $\hat{\beta}_{.95} = (-1.05, -0.11)$

– No animacy effect.
  $\hat{\beta}_{.95} = (-0.84, 0.17)$

◉ Delayed and weaker choice
  preference if matching co-arg.

(similar patterns, reversed, obs...

**Similarity-based
interference**

Likelihood of fixating SRC image during region

Touch Response
— Subject
┄ Object

N1 = HU   N1 = IN

HU V IN   IN V HU   Mismatch

HU V HU   IN V IN   Match

P(look to SRC image)

Pre   Head   V   Co-Arg   Post

Fixation likelihoods: Disambiguating ObjRPs

We expect:

- RP disambiguation:
  Less SRC looks if ObjRP present.

- Head animacy:
  Weaker disambiguation if HU.
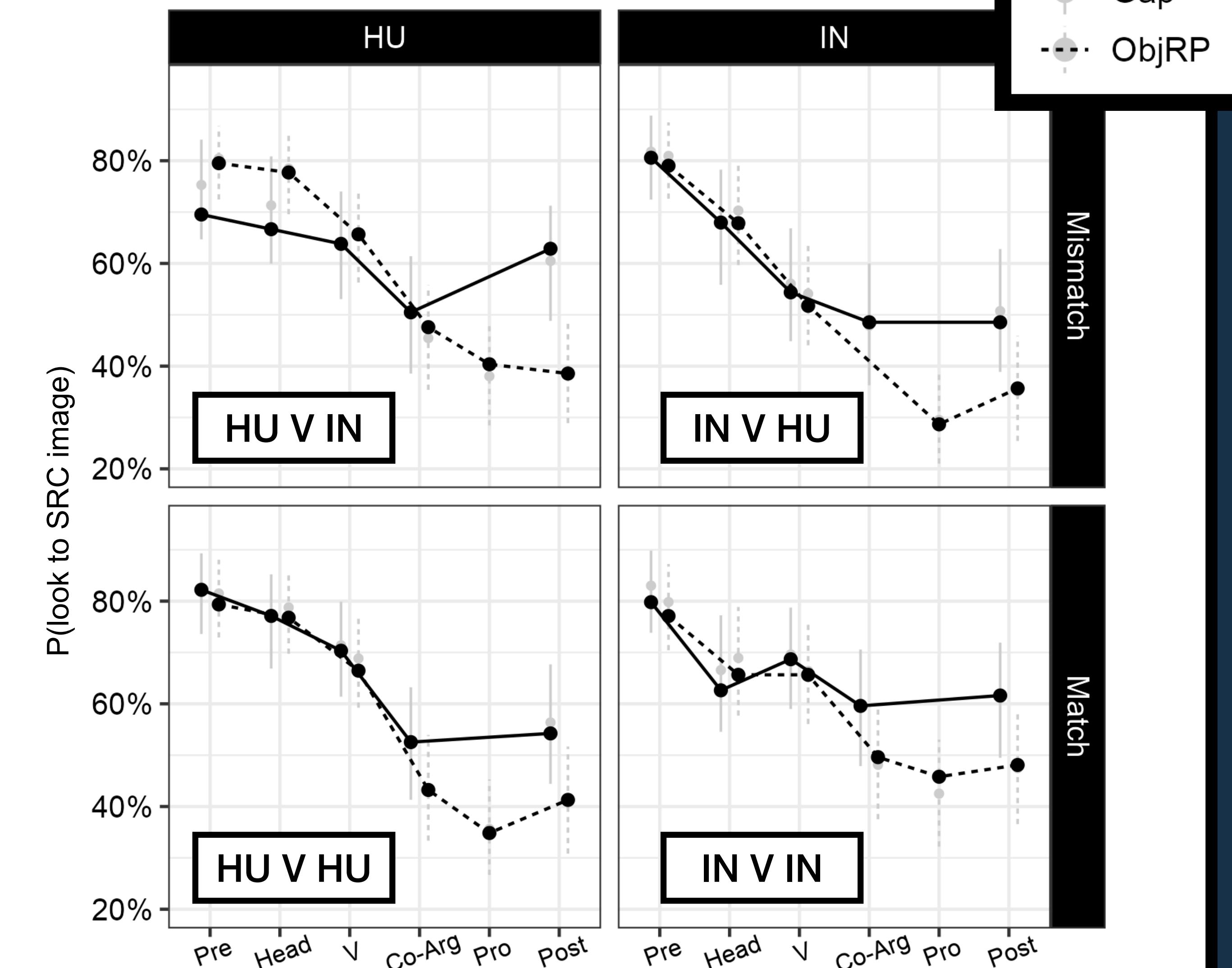
We observe:

✓ RP disambiguation
  by Post-RP region. $\hat{\beta}_{.95} = (-1.02, -0.34)$

– No animacy effect. $\hat{\beta}_{.95} = (-0.39, 0.70)$

◉ Slower disambiguation if
  <u>Co-Arg</u> is Match, or IN. $\hat{\beta}_{.95} = (0.00, 1.32)$

Similarity-based interference **+** **Easier to map HU co-args. as subject**

Likelihood of fixating SRC image during region, ORC choices only

Dependency
— Gap
···· ObjRP

P(look to SRC image)

HU V IN

IN V HU

HU V HU

IN V IN

Mismatch

Match

Pre Head V Co-Arg Pro Post

Pre Head V Co-Arg Pro Post

Our findings

Online and offline, Zapotec comprehenders showed:

rapid sensitivity to disambiguation with Object RPs	difficulty attributable to similarity-based interference	only a transient SRC bias	no special preference or prediction for SRCs with HU heads

Comprehenders did not develop SRC expectations at the head, regardless of animacy.

Instead: Animacy-based expectations developed only after observing the co-argument.
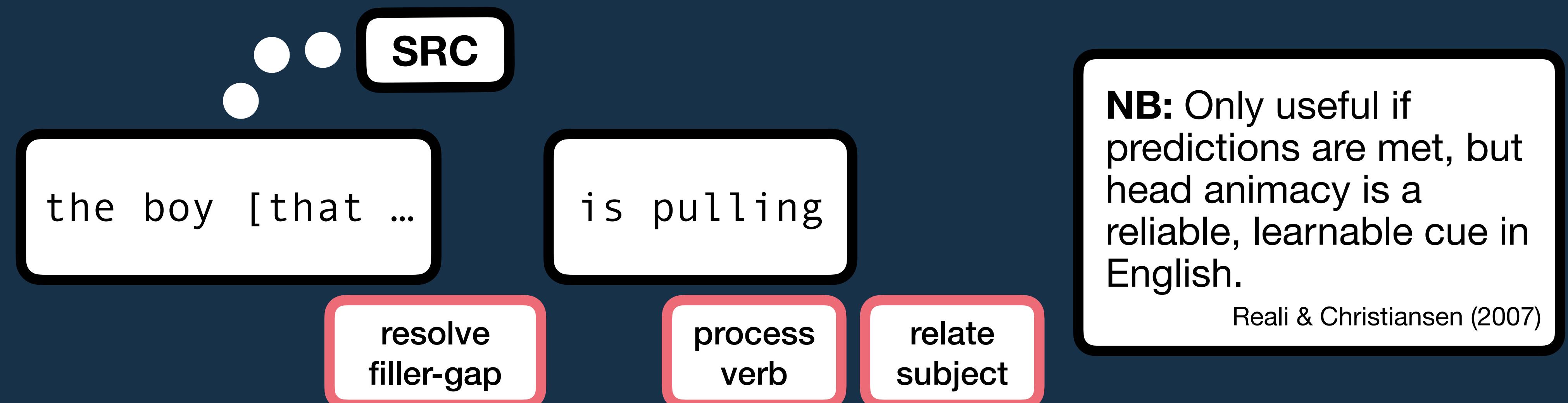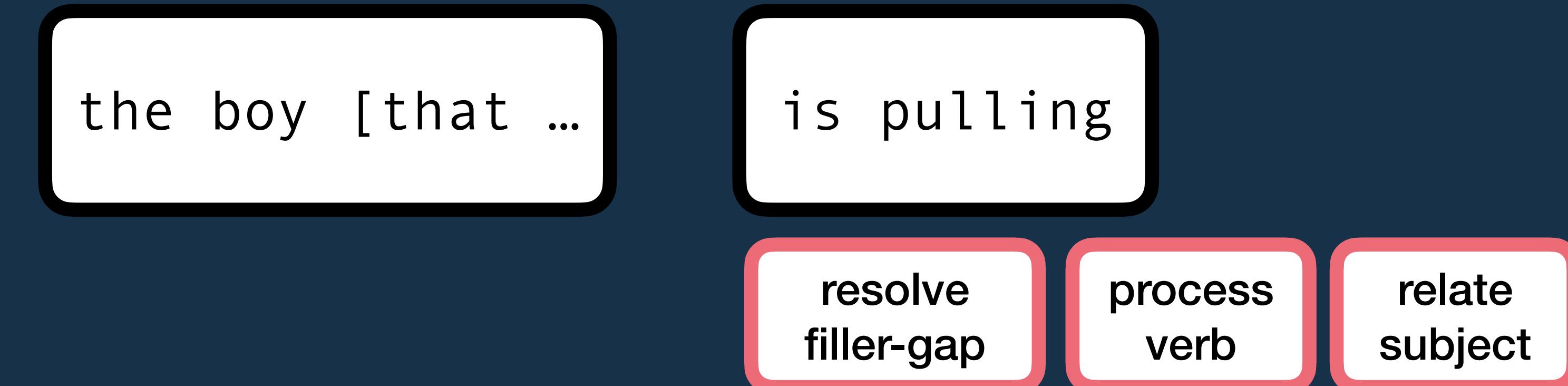
Structural prediction is an acquired strategy

Atkinson et al. (2018): 5-y.o.s comprehending English do not show incremental gap predictions.

| children | + | English | = | Early structural prediction |

| children | + | Zapotec | = | Delayed structural prediction |

Structural prediction is a useful risk in English

the boy [that …

is pulling

resolve filler-gap

process verb

relate subject

SRC

the boy [that …

is pulling

resolve filler-gap

process verb

relate subject

NB: Only useful if predictions are met, but head animacy is a reliable, learnable cue in English.

Reali & Christiansen (2007)

The influence of RPs and global ambiguity

RP

bi'i xyage'nh [...
the.boy

txube
pull

=ba'
he

process
verb

resolve
filler-gap

relate
subject

Gap

bi'i xyage'nh [...
the.boy

txube
pull

coche'nh
the.car

. . .

process
verb

process
noun

resolve
filler-gap

relate
args.

RPs and global ambiguity may decrease the utility of structural prediction.

The influence of passive-like alternations

Passive sentences allow speakers to produce more prominent (animate) arguments as subjects.

Ferreira (1994)

Without a passive, Zapotec comprehenders may not experience an animacy asymmetry in their input.

Passives allow producers to avoid animate-head ORCs in particular.

Gennari & MacDonald (2009), Gennari et al. (2012)
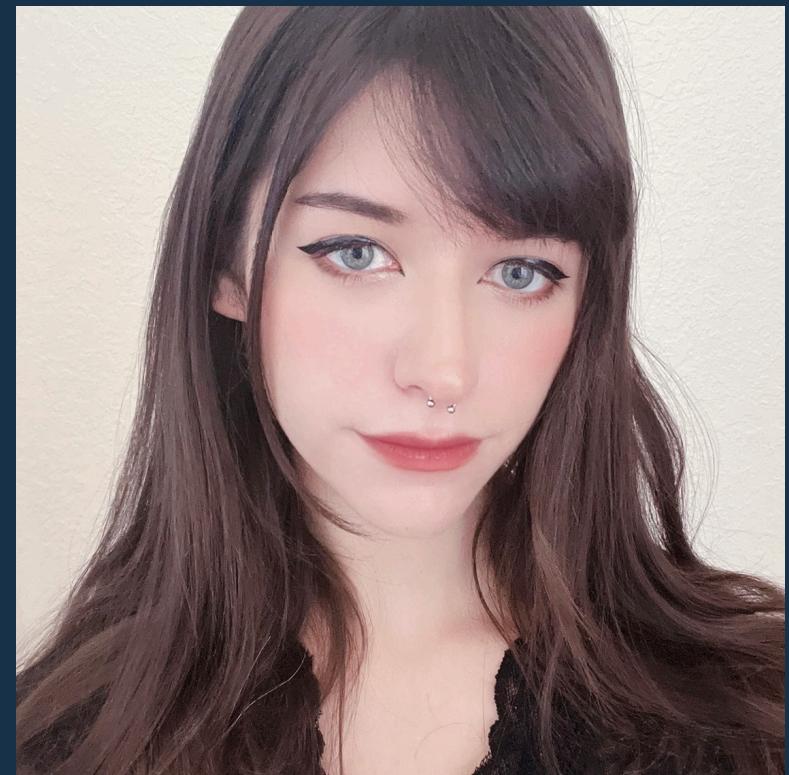
$P(\text{SRC} \mid \text{animate}) \approx P(\text{ORC} \mid \text{animate})$?

In sum:

Zapotec comprehenders did not demonstrate SRC expectations at RC heads, regardless of head animacy.

This may be a consequence of differences in grammar producing differences in the processing burdens for RCs.

Cross-linguistic variation in processing can shine a light on the source of processing behavior.

Delaney Gomez-Jackson   Fe Silva Robles   Maziar Toosarvandani   Matt Wagers
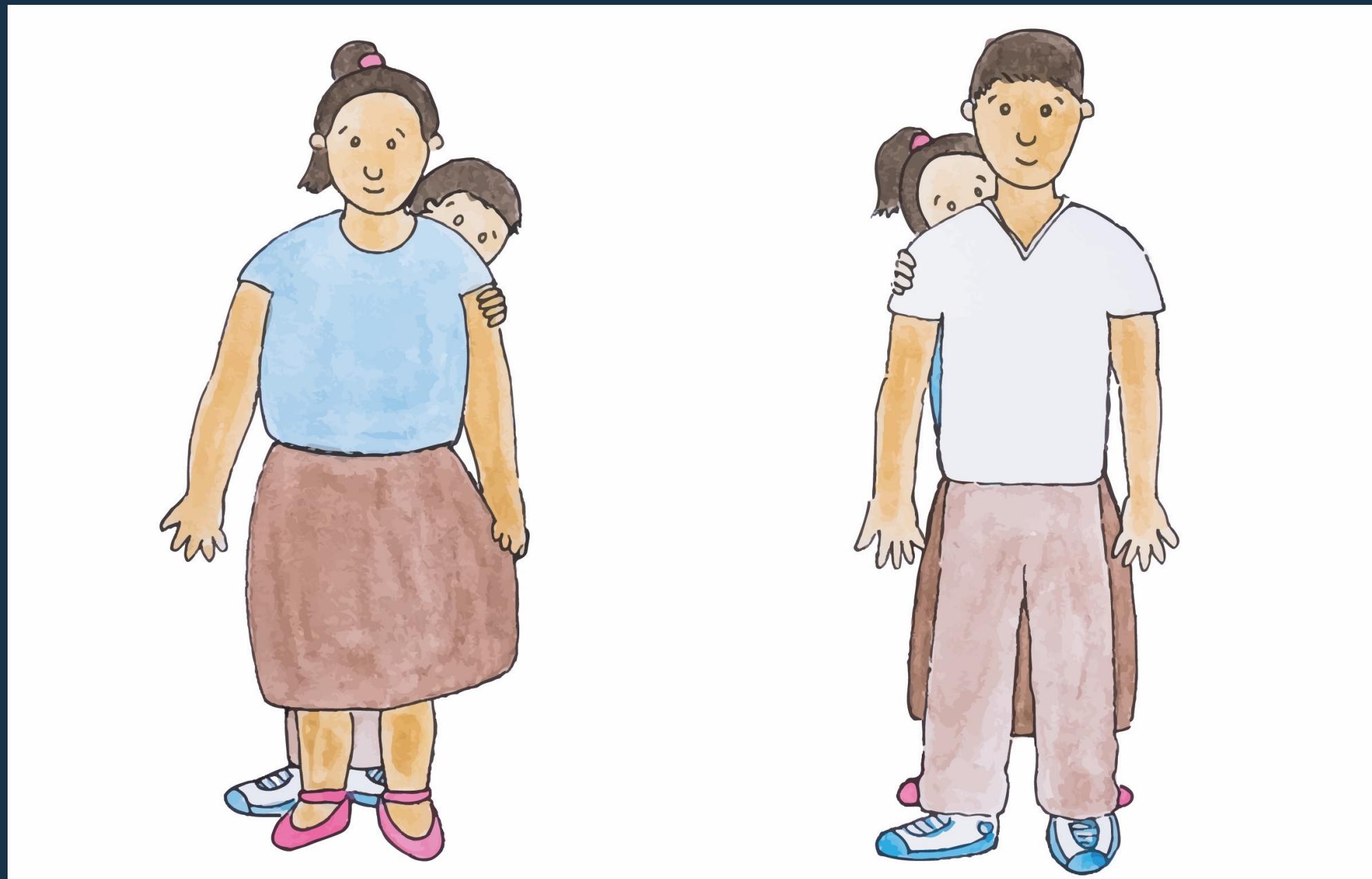
Thanks! (Duxklhenhu'!)

Thanks to the residents of Santiago Laxopa, and the Oaxacan community of the Monterey Bay for their support and generosity, thanks to Roque Reyes for our illustrations, and thanks to other members of the Zapotec Language Project, as well as Raul Diaz Robles, Mandy Cartner, Samar Husain, and Ivy Sichel for helpful insight and discussion.
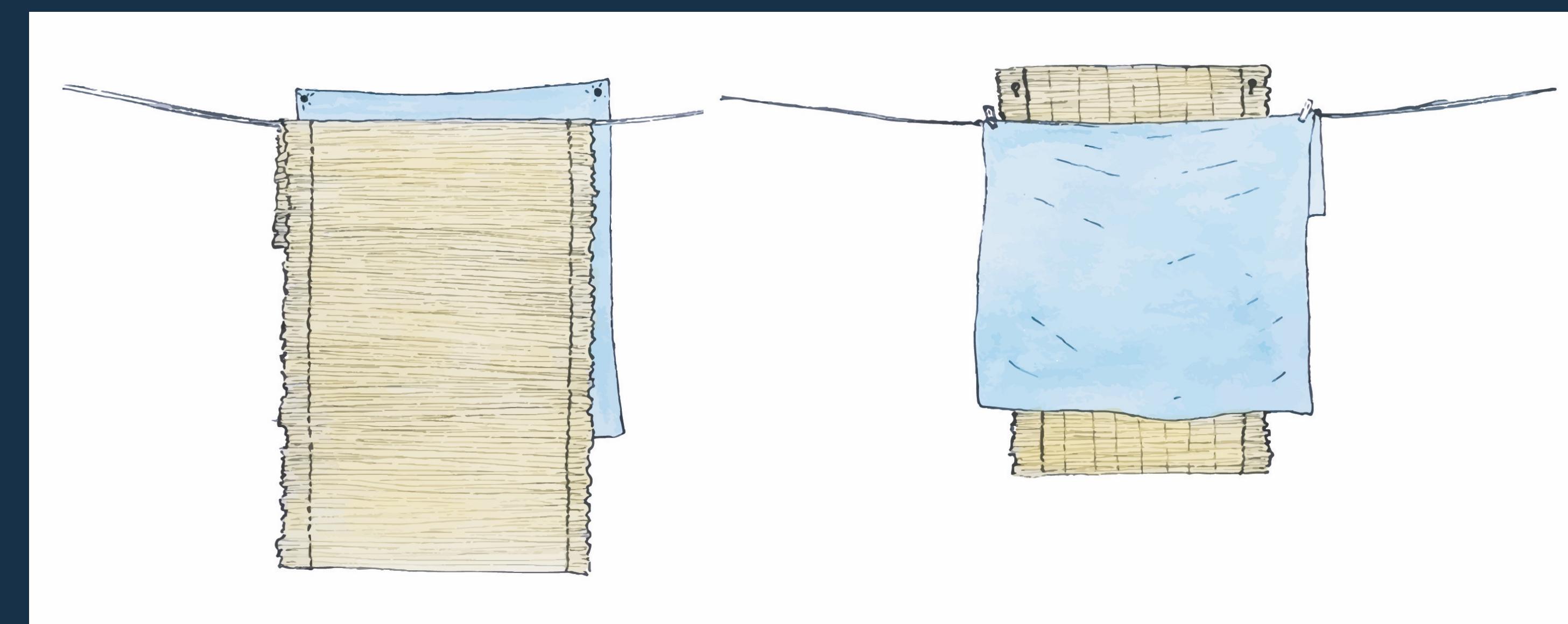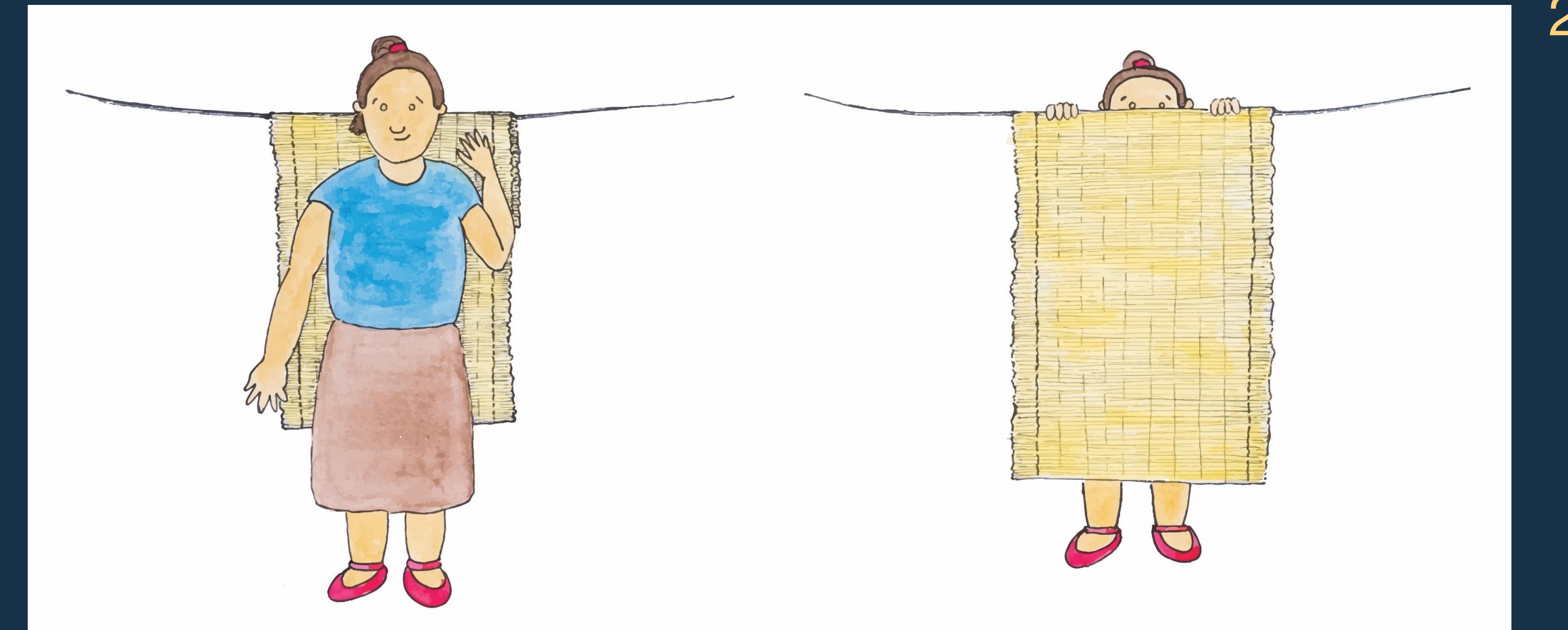
Ask us about:

- More example items
- Gaze data for Subject RP fillers
- Exclusions and by-participant variation
- Prosodic anticipation of RPs
- More details on the grammar of Santiago Laxopa Zapotec

UC SANTA CRUZ

UNIVERSITÄT DES SAARLANDES

SENDEROS
CREATING PATHWAYS

Other items

girl/boy

hide   girl/capisallo

blanket/capisallo
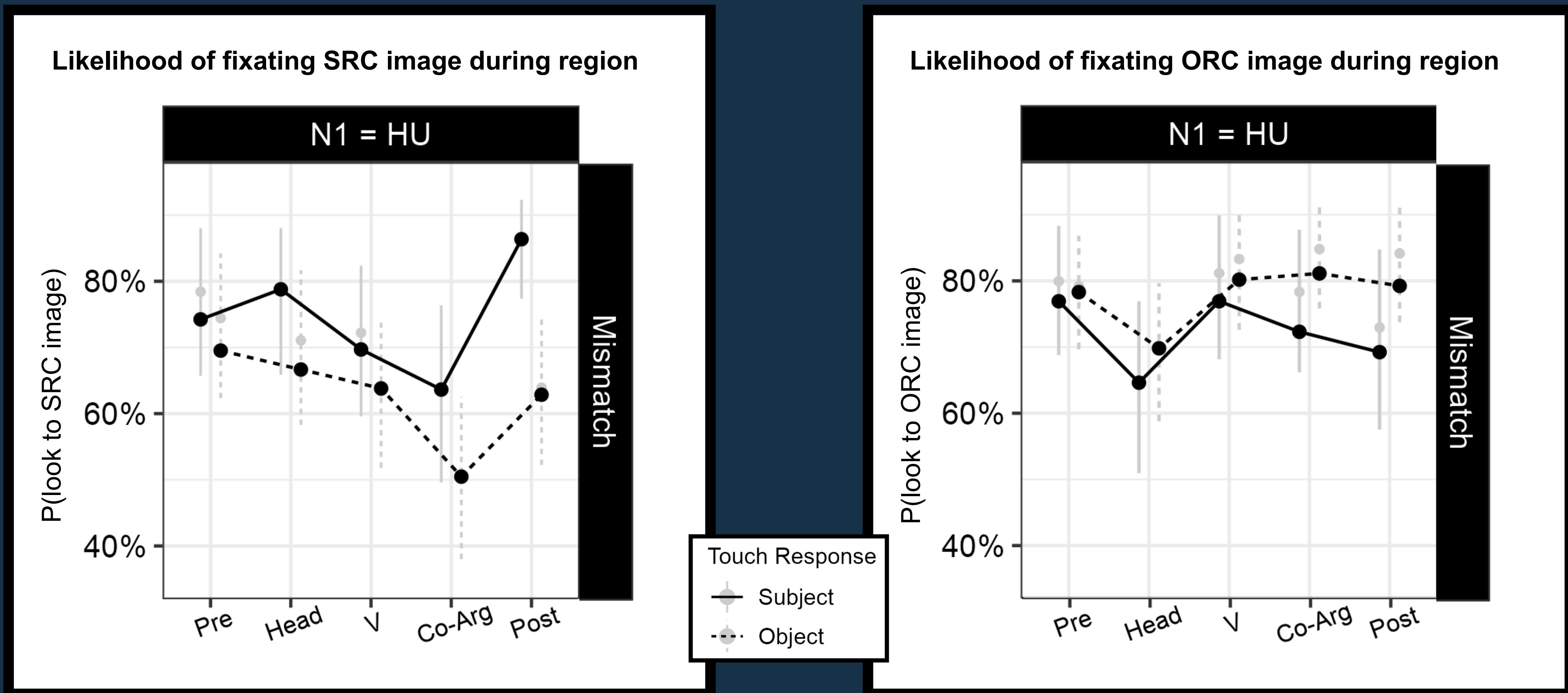
Other items
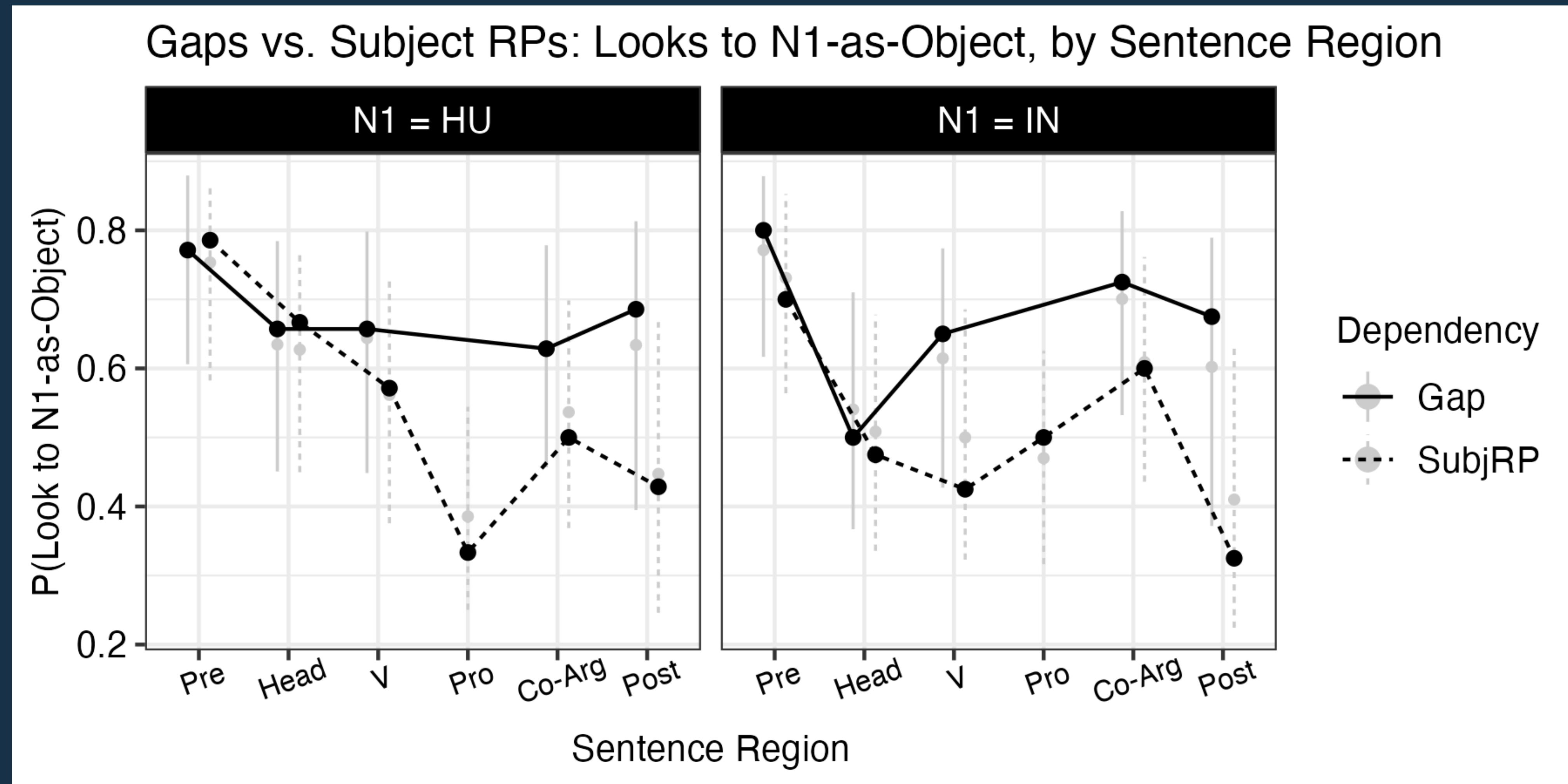
girl/boy

cause.wet   girl/pot

hose/pot

SRC Gazes vs. ORC Gazes
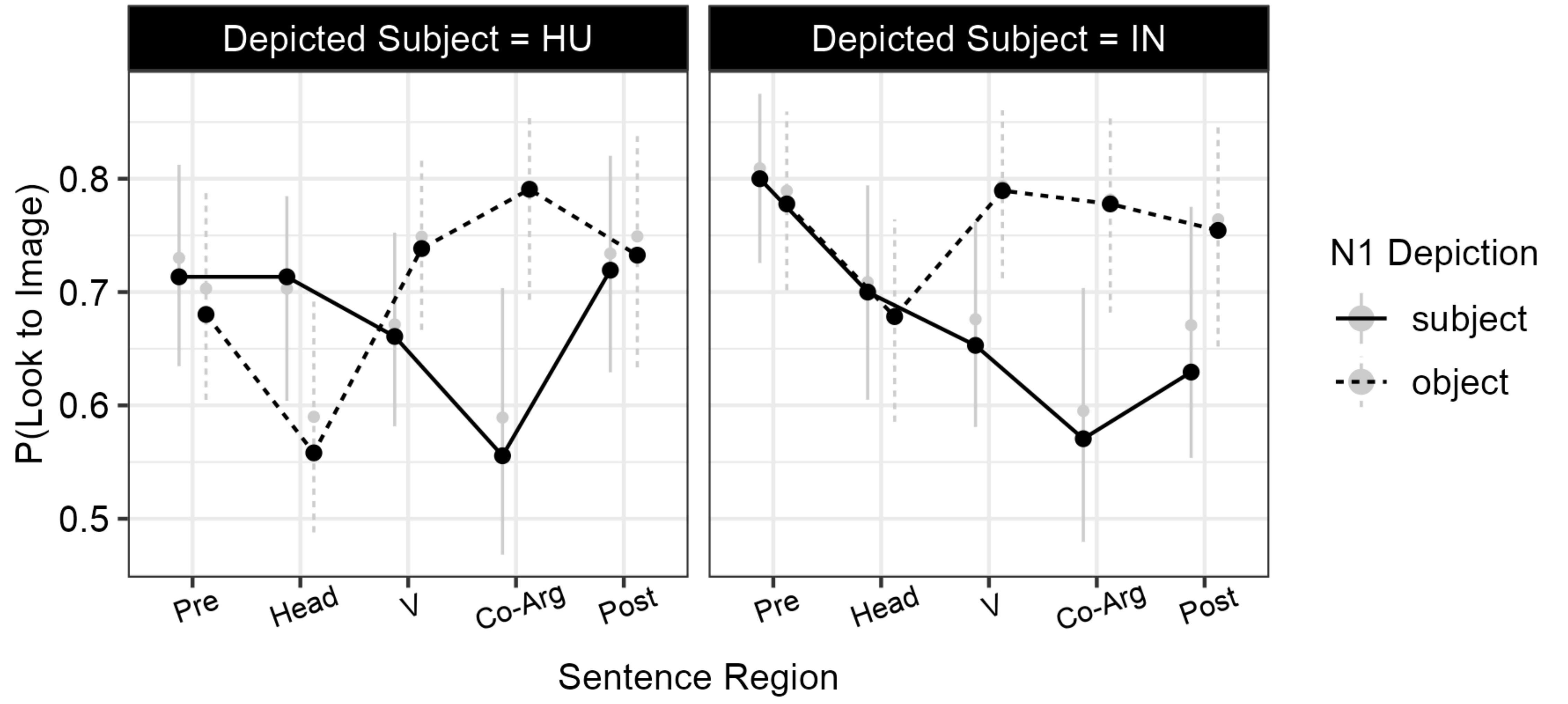
Gaze during SubjRP items

Gaps vs. Subject RPs: Looks to N1-as-Object, by Sentence Region

Picture-matched gaze patterns for Gaps

Looks to Image by Image Properties in Gap Mismatch Conditions

Participant exclusion criteria

102 volunteers participated

Were eye movements recorded with separable L/R/C gaze bins?

of 102:   Yes: 78   No: 24

Was their participation free from persistent visual distractions?

of 78:   Yes: 68   No: 10

Did they demonstrate accuracy of > 50% on unambiguous trials?

of 68:   Yes: 62   No: 6

Data from **62 participants** was analyzed
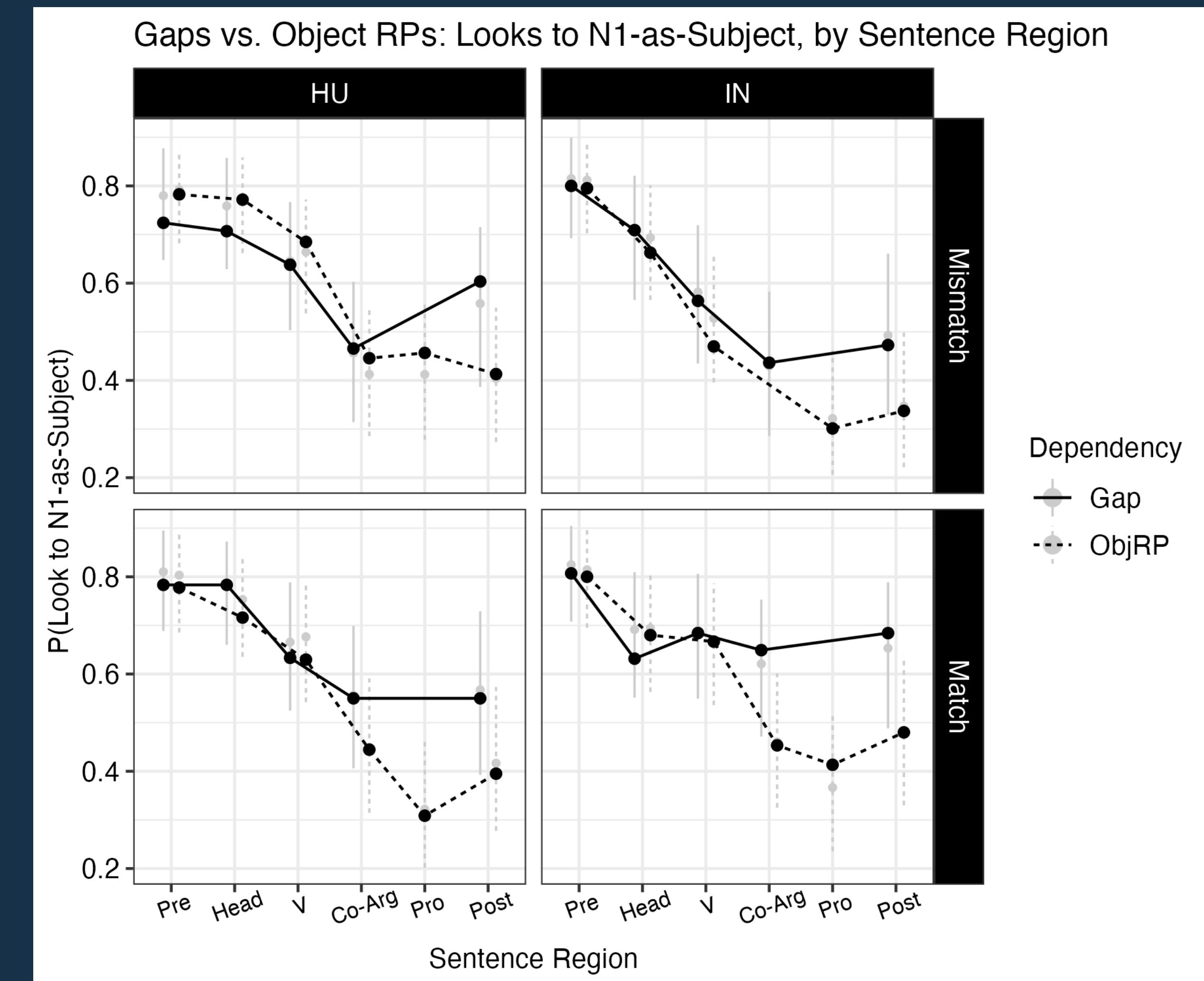
Results with exclusions based on language history questionnaire

Criteria for highly SLZ-dominant participants:
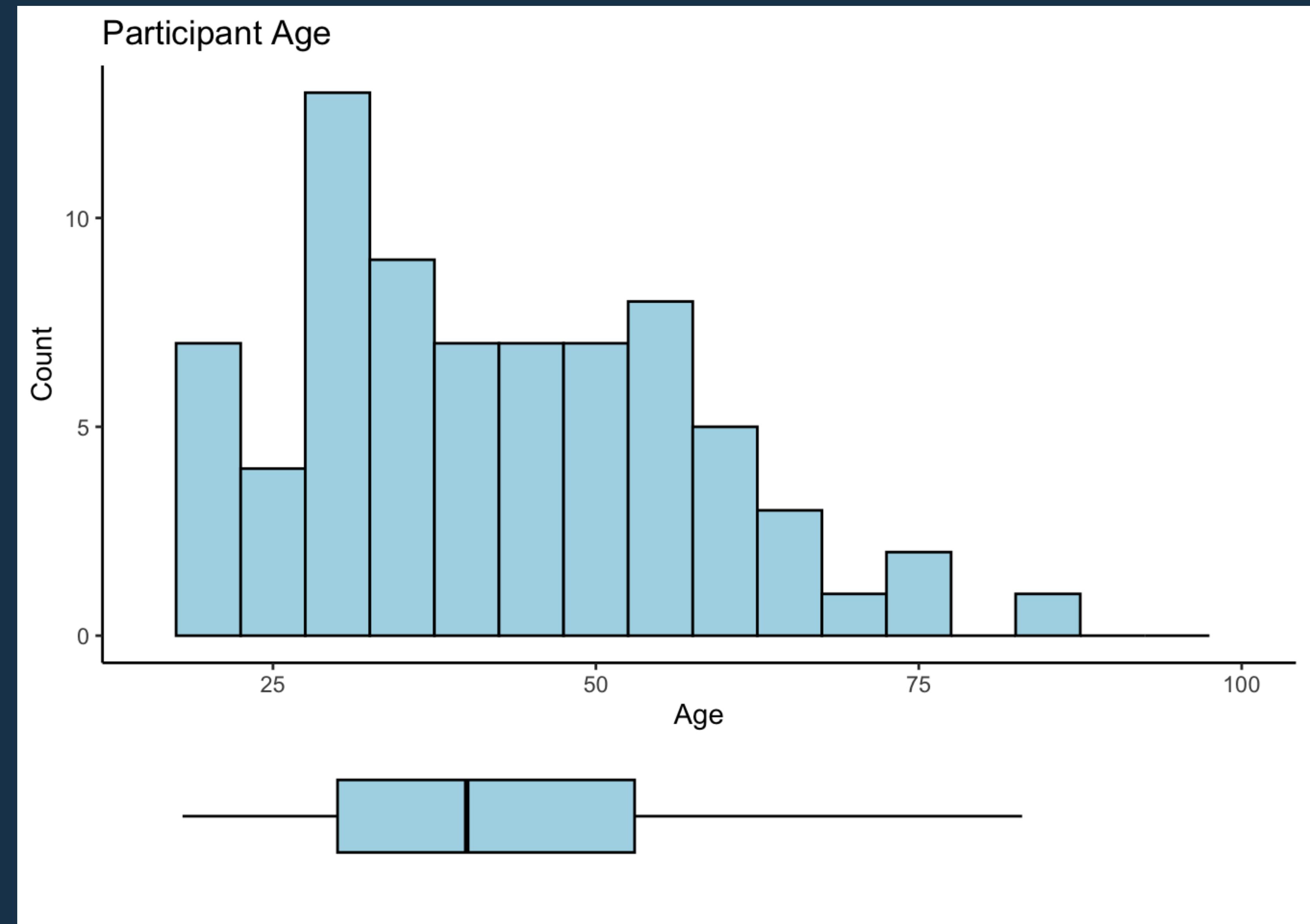
- Acquired SLZ before age 10

- Only use Spanish more than Zapotec in at most one aspect of daily life (family, friends, work)

35 of the 62 participants in our full sample met these criteria.

Analysis of just these participants revealed no changes in our critical effects, only a small apparent decrease in precision of posteriors.


Gaps vs. Object RPs: Looks to N1-as-Subject, by Sentence Region
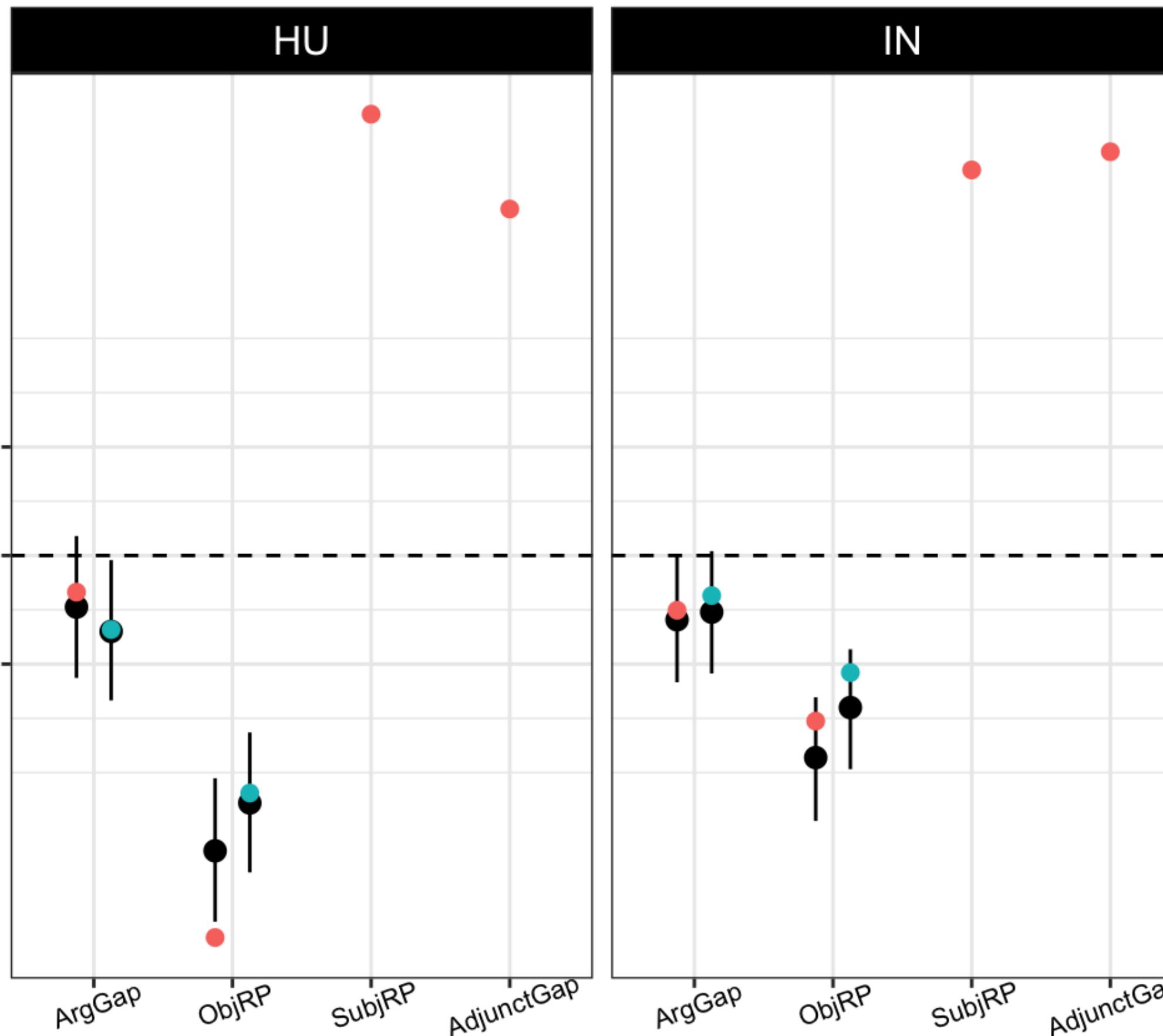
Participant age distribution
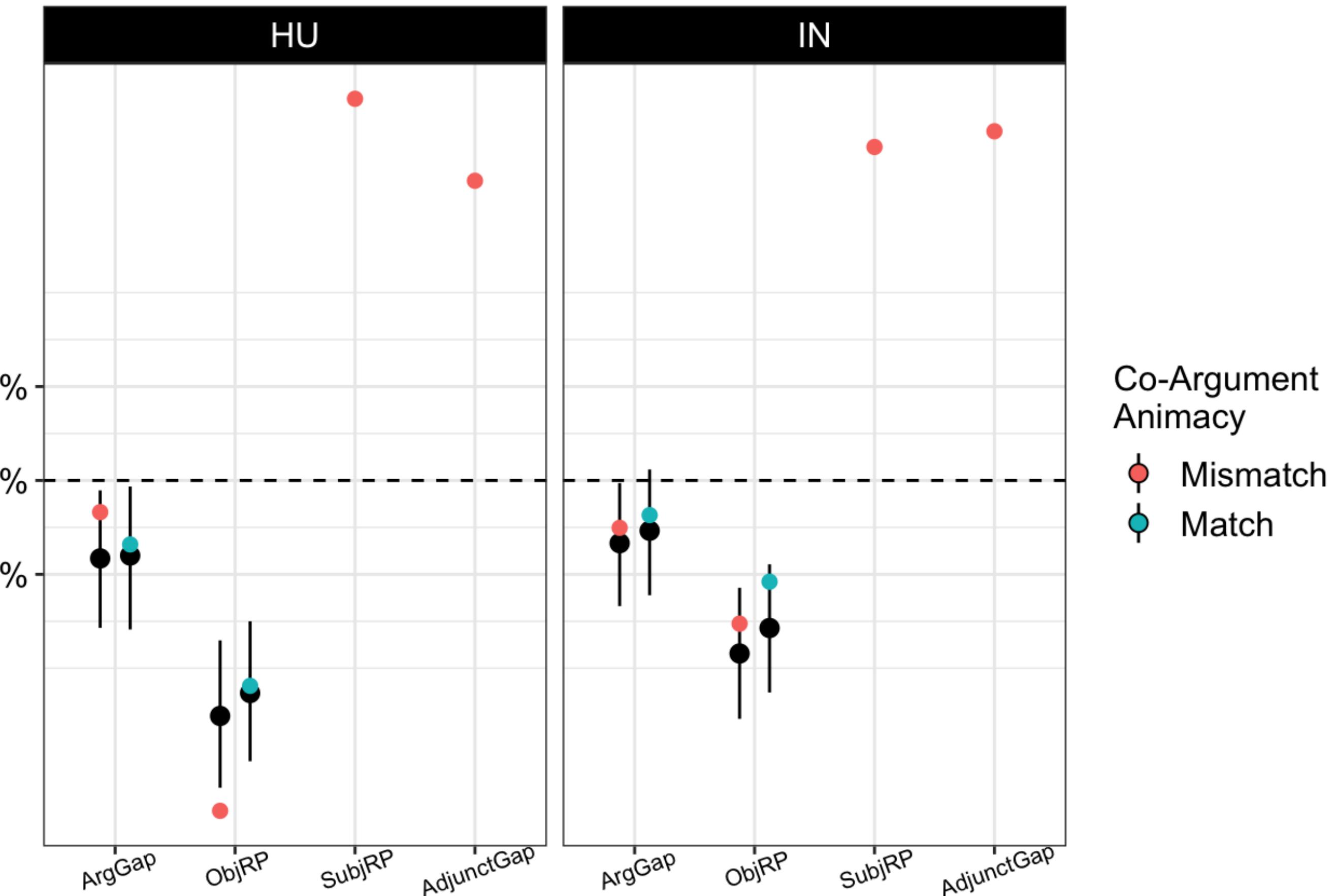
Offline results for full sample vs. ≤40yo

% 'N1 as Subject' Responses: All Participants
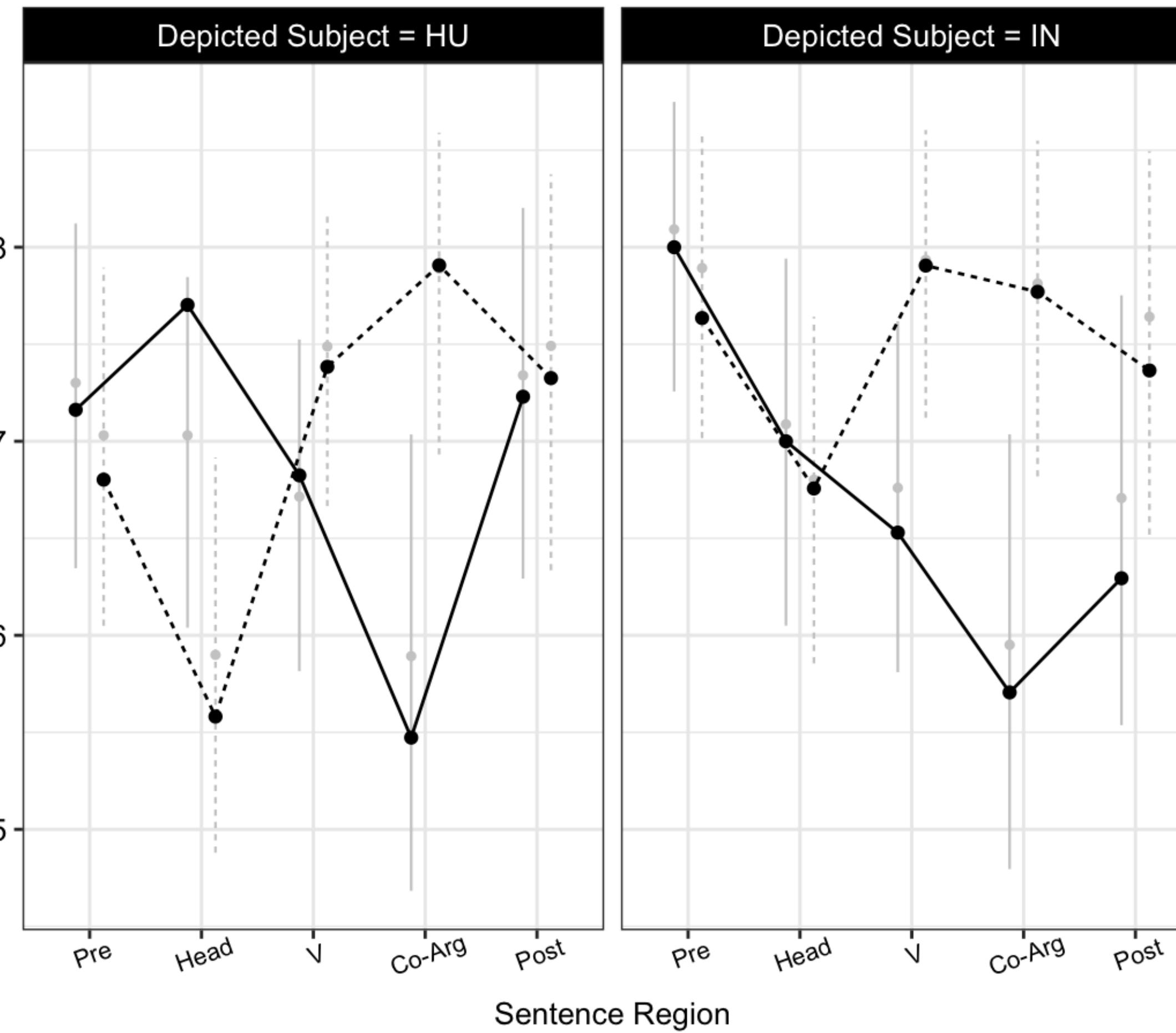
% 'N1 as Subject' Responses: Younger Participants

Co-Argument Animacy
● Mismatch
● Match
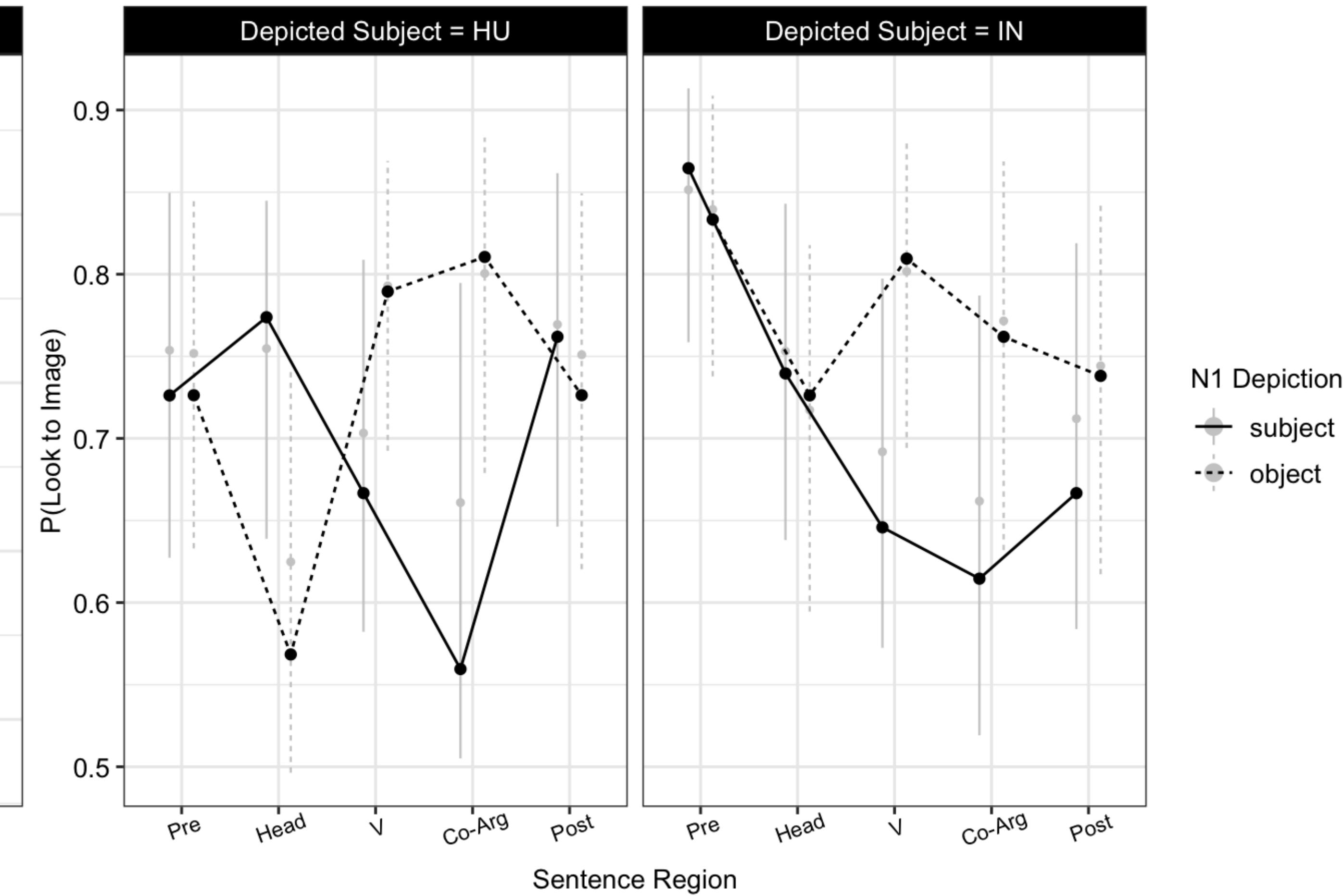
Online results for full sample vs. ≤40yo

Looks to Images in Gap Mismatch Conditions: All Participants

Looks to Images in Gap Mismatch Conditions: Young Participants

N1 = ANIMAL (the deer)

N1 = INANIMATE (the tractor)

R. Macdonald et al. (2020): English VW data

Limited to animals and locomotive inanimates.

Robust incremental SRC bias only turned out for inanimates with mismatching co-args.

COARG MISMATCH

COARG MATCH
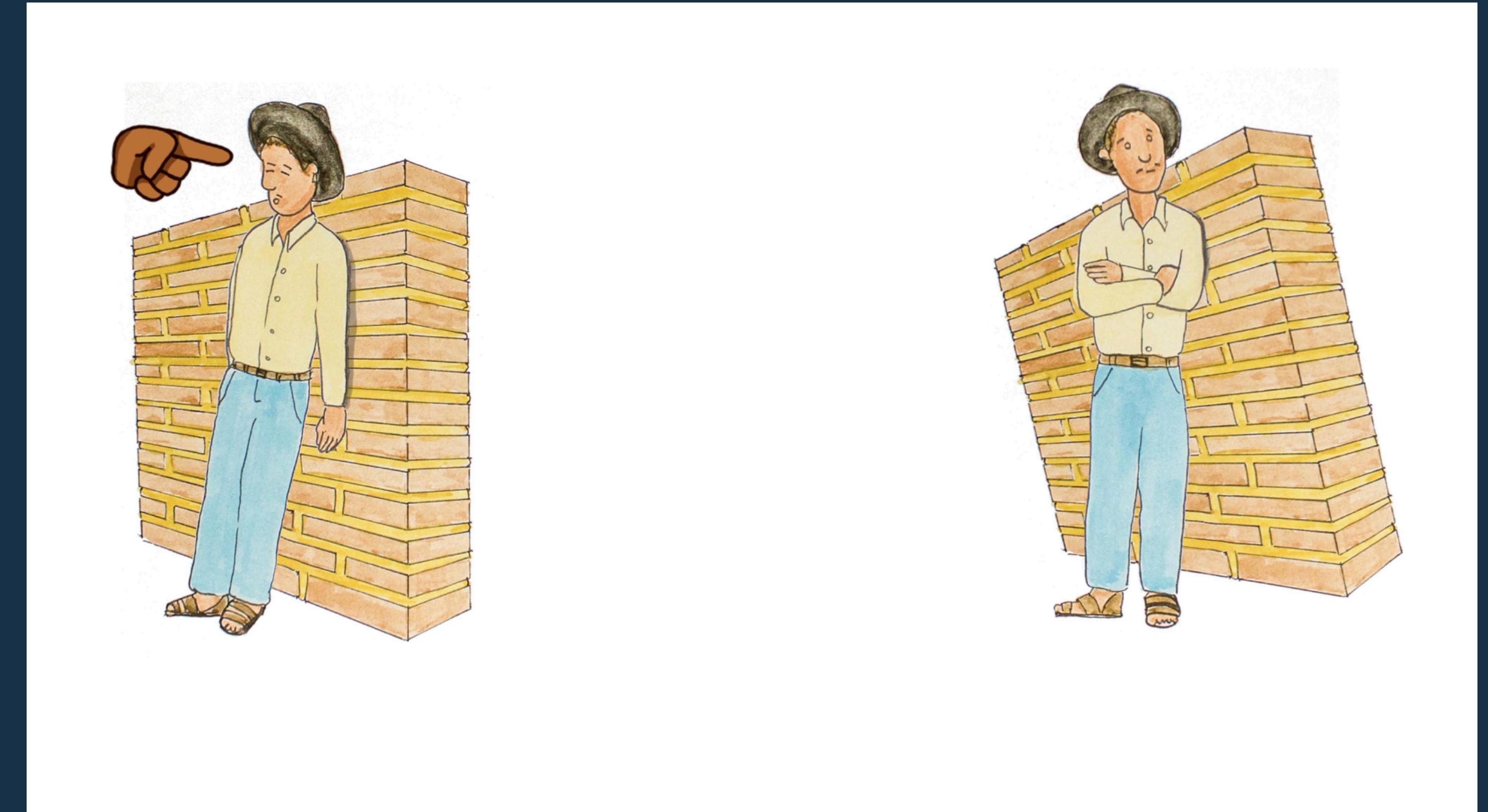
Production study
(transcription and analysis ongoing)

"Who am I pointing to?"

Instructed to respond with relative clauses, e.g. "The man who is leaning on the wall."

So far:

- Frequent RC use

- RCs often include RPs

We hope to have evidence about the likelihood of SRCs vs. ORCs and the likelihood of RPs in production to test our conjectures about experience!