When do we plan agreement?

Evidence from agreement attraction and unaccusatives

888 Defense, April 15, 2025

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why should you even care?

- our syntactic knowledge guides what we say and how we speak

- what do humans compute vs. how do humans compute
  - ➢ when do humans compute

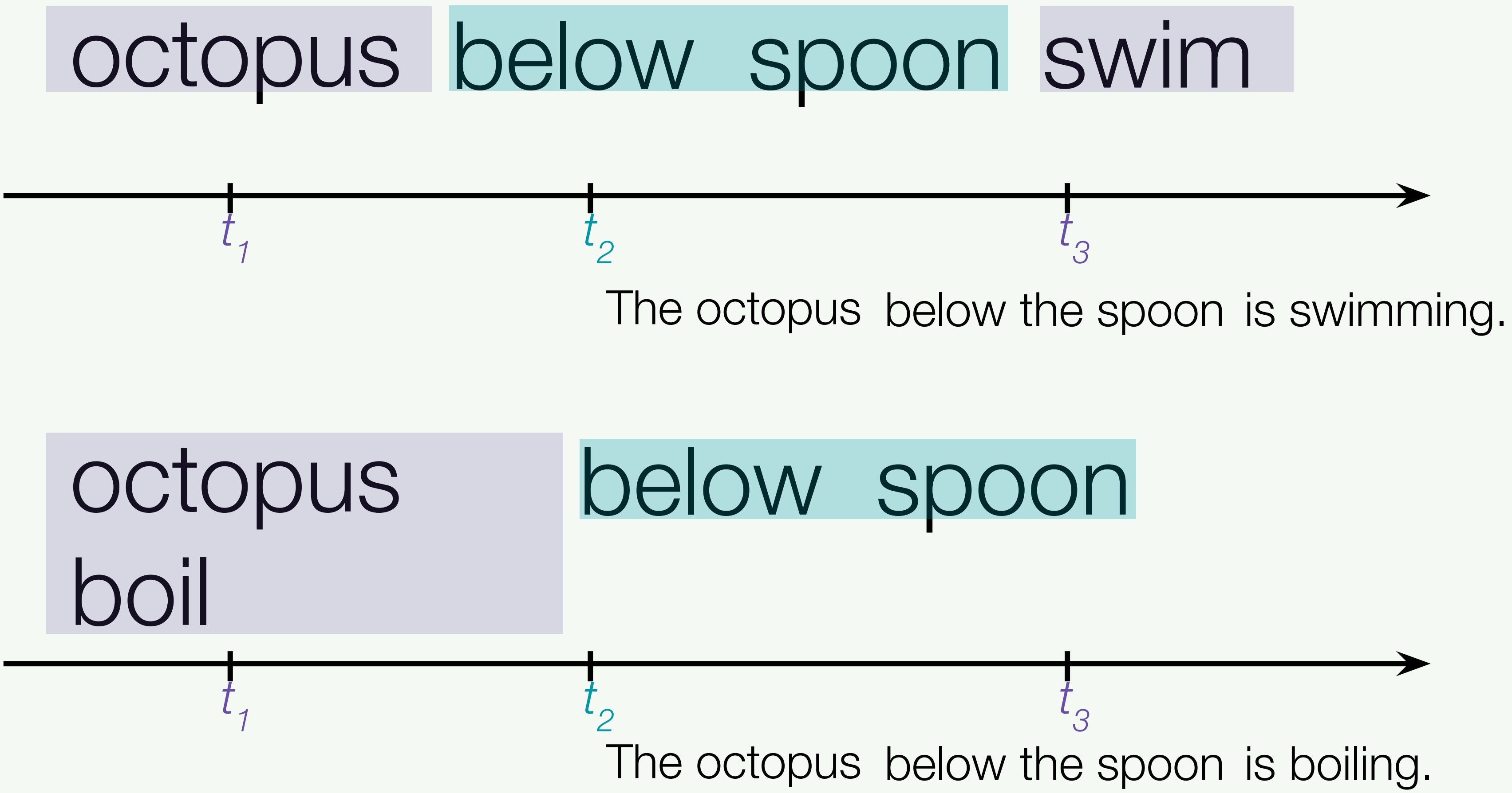
- we are in a place to streamline the question of when

Planning

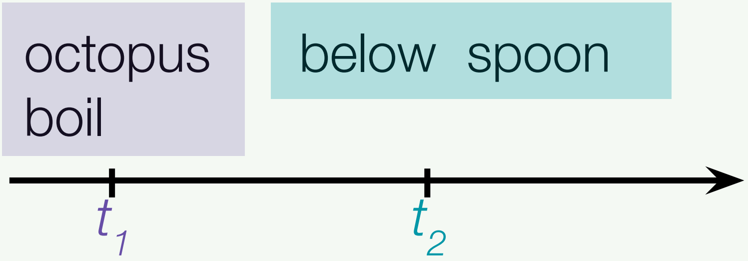
octopus below spoon swim

The octopus below the spoon is swimming.

Kempen & Hoenkamp 1987, Bock 1989, Ferreira 2003, Momma et al. 2016, Momma & Ferreira 2019



Kempen & Hoenkamp 1987, Bock 1989, Ferreira 2003, Momma et al. 2016, Momma & Ferreira 2019



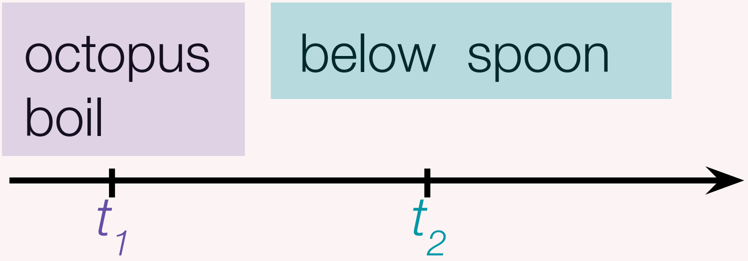
The octopus below the spoon is boiling.

syntax can license advance planning of the verb
prior to the other intervening elements

Kempen & Hoenkamp 1987, Bock 1989, Ferreira 2003, Momma et al. 2016, Momma & Ferreira 2019

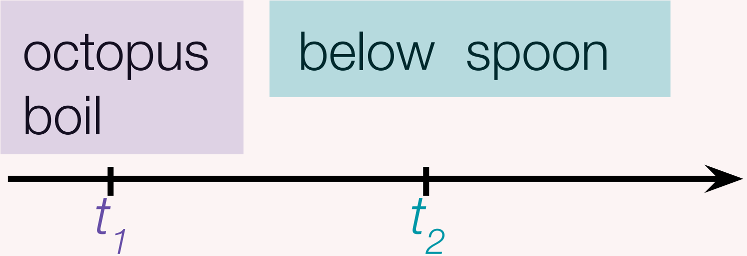
Planning

Features



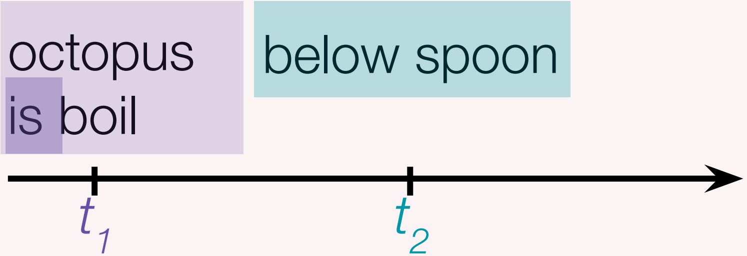
The octopus below the spoon is boiling.

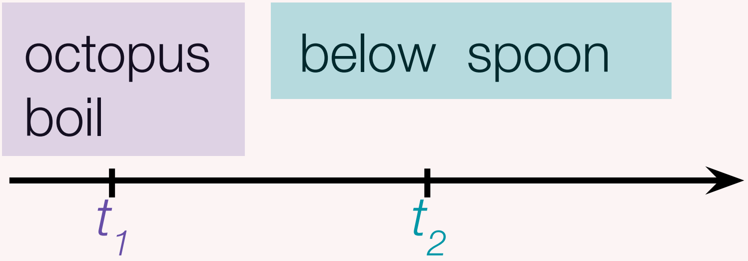
Levelt 1989, Levelt et al. 1999, Schriefers et al. 2002, Faroqi-Shah 2023, Slevc 2023



The octopus below the spoon is boiling.

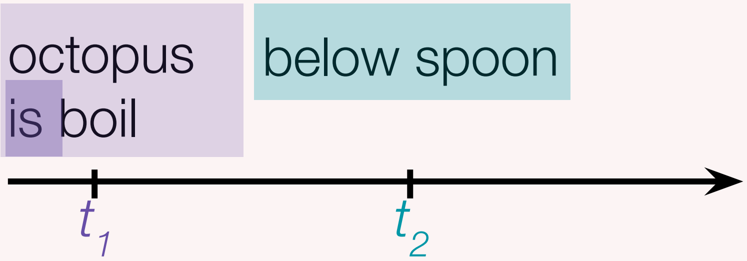
eager agreement



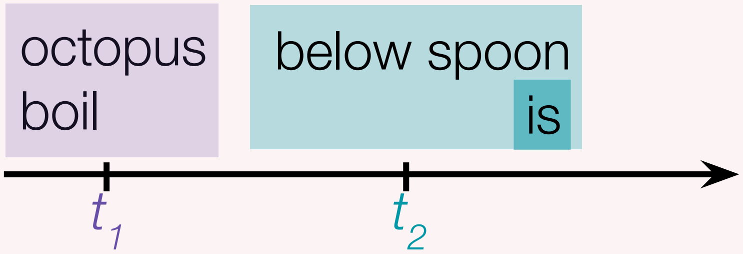


The octopus below the spoon is boiling.

eager agreement



lazy agreement



Planning | Features | Attraction

+SG +SG

The key to the cell was rusty.

Bock & Miller 1991, Wagers et al. 2009, Kandel & Phillips 2022

+SG +SG

The key to the cell were rusty.

+SG +*PL* +PL

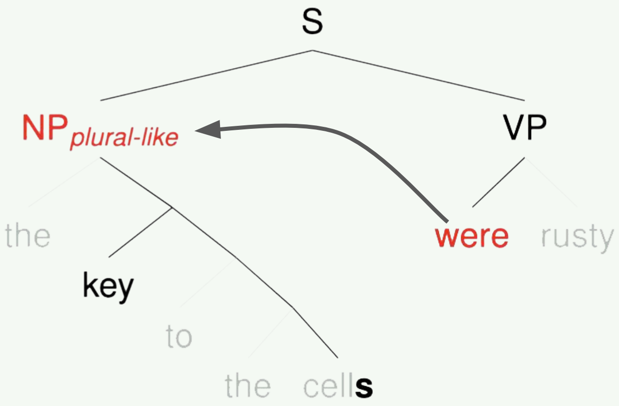
The key to the *cells* were rusty.

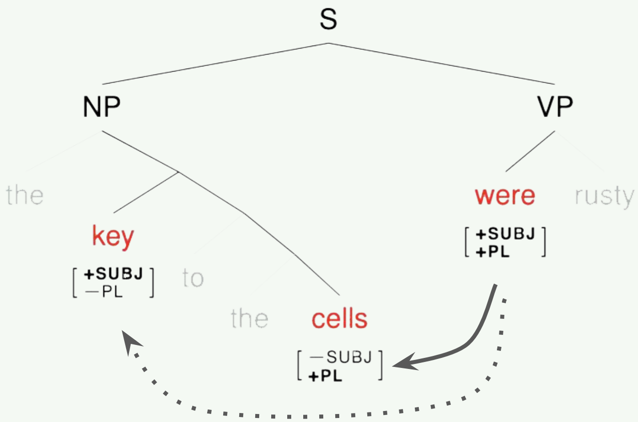
speakers systematically produce erroneous agreement
especially with nearby number-mismatching noun

Bock & Miller 1991, Wagers et al. 2009, Kandel & Phillips 2022

+SG +PL +PL

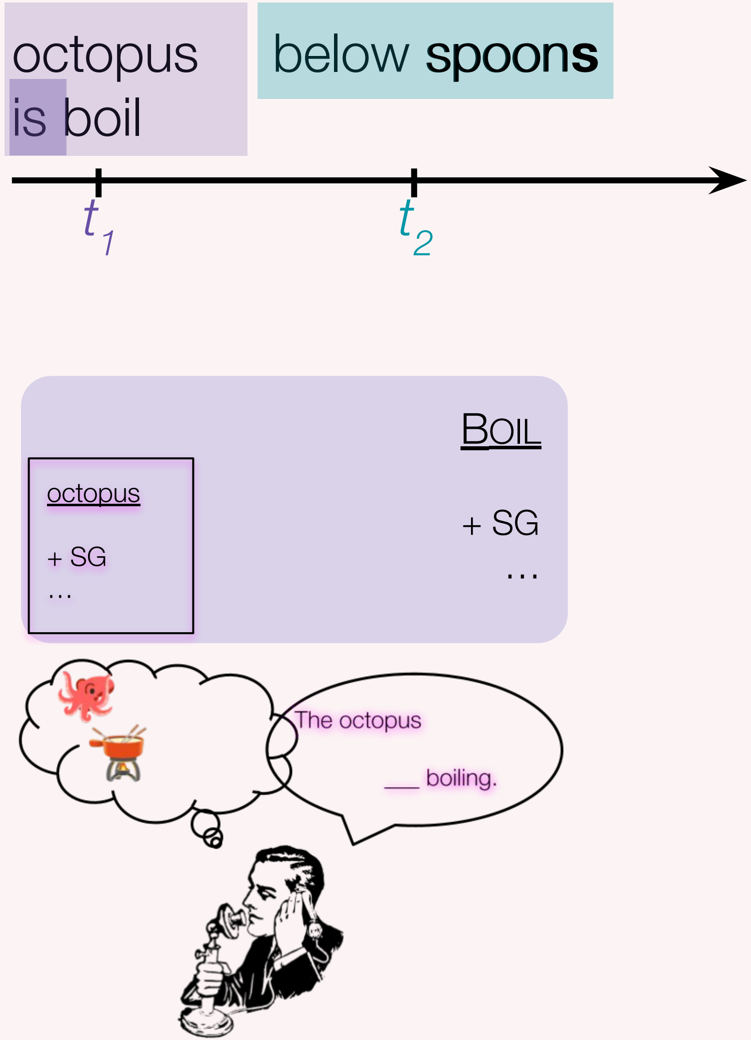
The key to the *cells* were rusty.

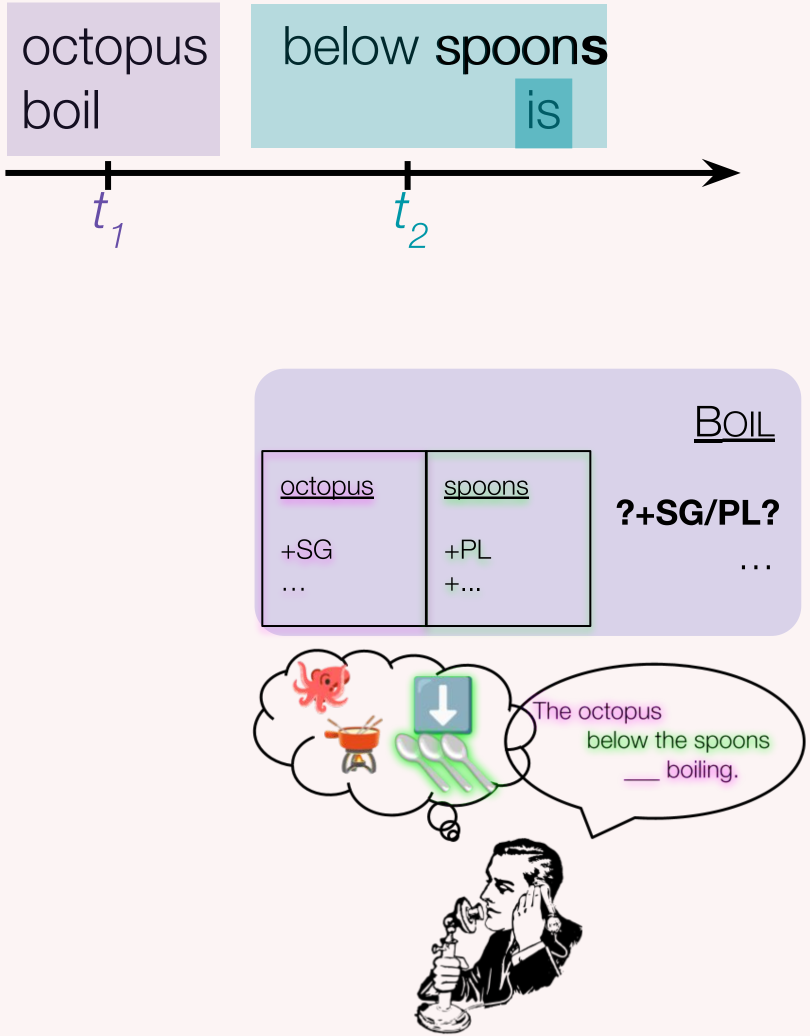


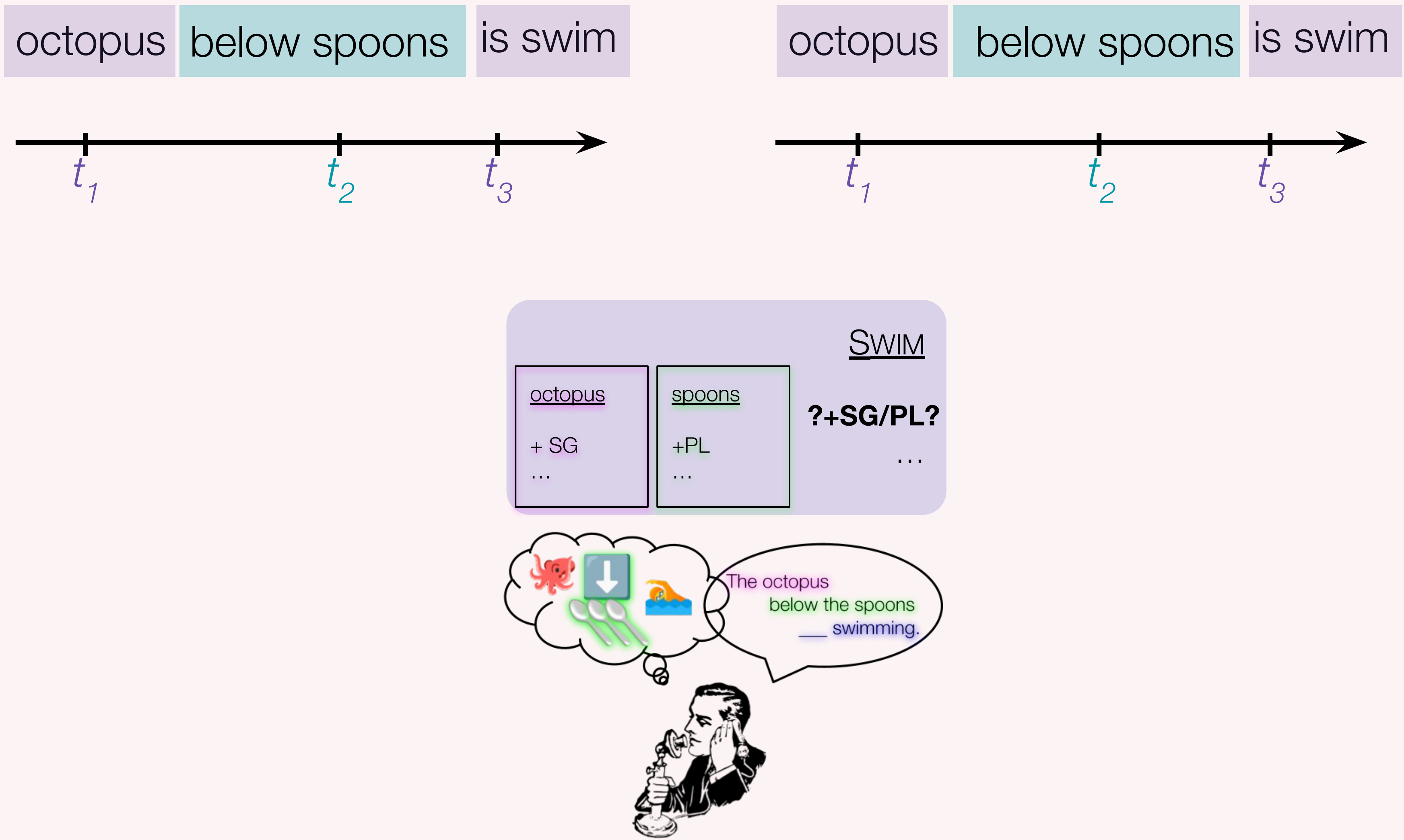


speakers systematically produce erroneous agreement

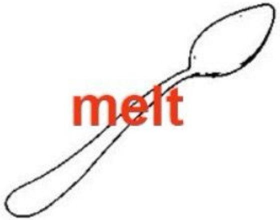
Bock & Miller 1991, Wagers et al. 2009, Kandel & Phillips 2022

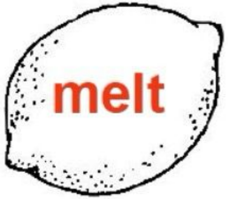

octopus
is boil
below spoons
t_1
t_2
BOIL
octopus
+ SG
…
+ SG
…
The octopus
___ boiling.


octopus
boil
below spoons
is
t_1
t_2
BOIL
octopus
+SG
…
spoons
+PL
+…
?+SG/PL?
…
The octopus
below the spoons
___ boiling.



octopus
below spoons
is swim
t_1
t_2
t_3
octopus
below spoons
is swim
t_1
t_2
t_3
SWIM
octopus
+ SG
…
spoons
+PL
…
?+SG/PL?
…
The octopus
below the spoons
___ swimming.


melt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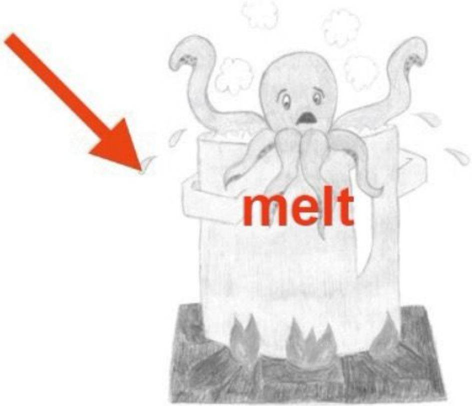
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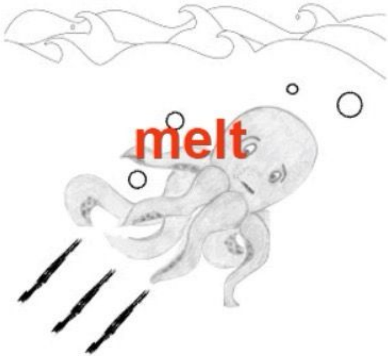
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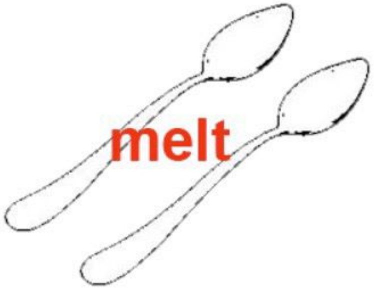
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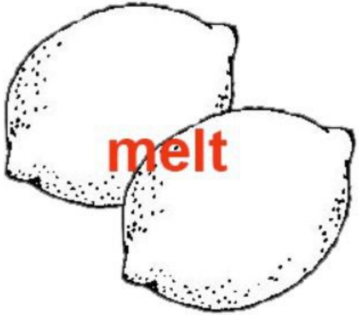
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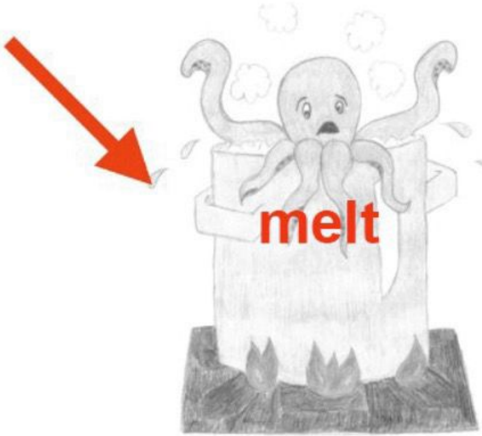
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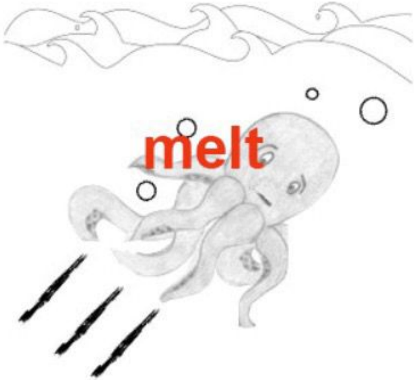
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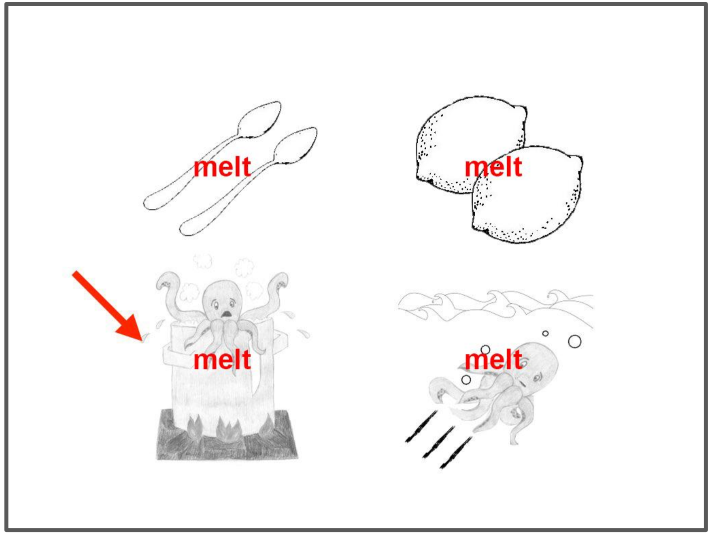
Exp1: ePWI experiment (N=74)

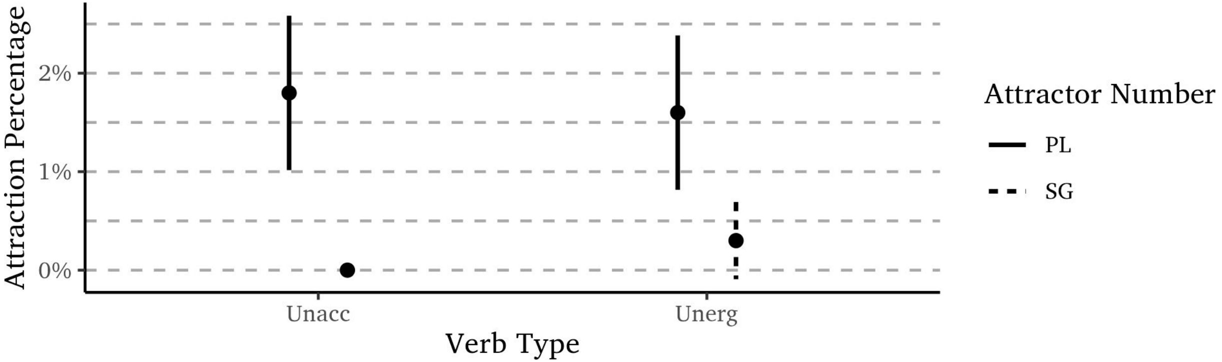
- Similar to Momma & Ferreira (2019)
  - 12 entities and 24 objects
  - 12 unergative and 12 unaccusative scenes
  - Relatedness (2: related x unrelated)

- Unlike Momma & Ferreira (2019)
  - Attractor number (2: PL x SG)
  - 6 more entities
  - 12 additional objects
  - 12 additional control scenes

- 144 trials, repeated measures, PCIbex+Prolific



People are good at agreement

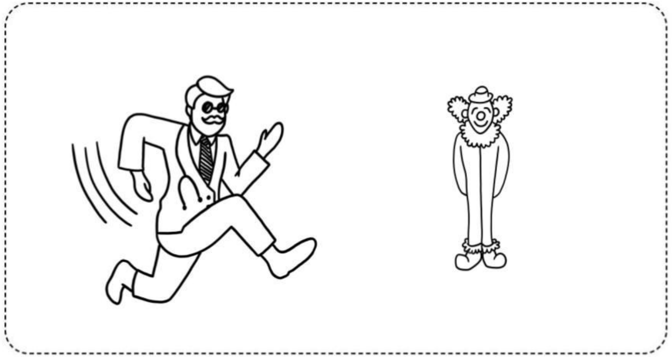


- Why are they suddenly good at agreement?
    - Attractors are not in the “controller” response set
    - Visual cue makes the head more salient
    - Non-restrictive attractors
    - Uncertainty associated with verb retrieval

Roelofs 2001, Nozari & Omaki 2022, Kim & Xiang 2024

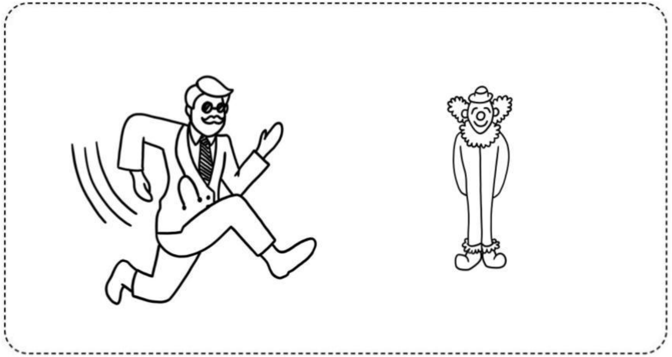
Exp2: picture description experiment materials (N=54+40)

- What changed?
  - Only 6 entities, used as head and the attractor
  - No visual cue directly on the head
  - Attractors have communicative intent
  - No controls: less verbs to remember

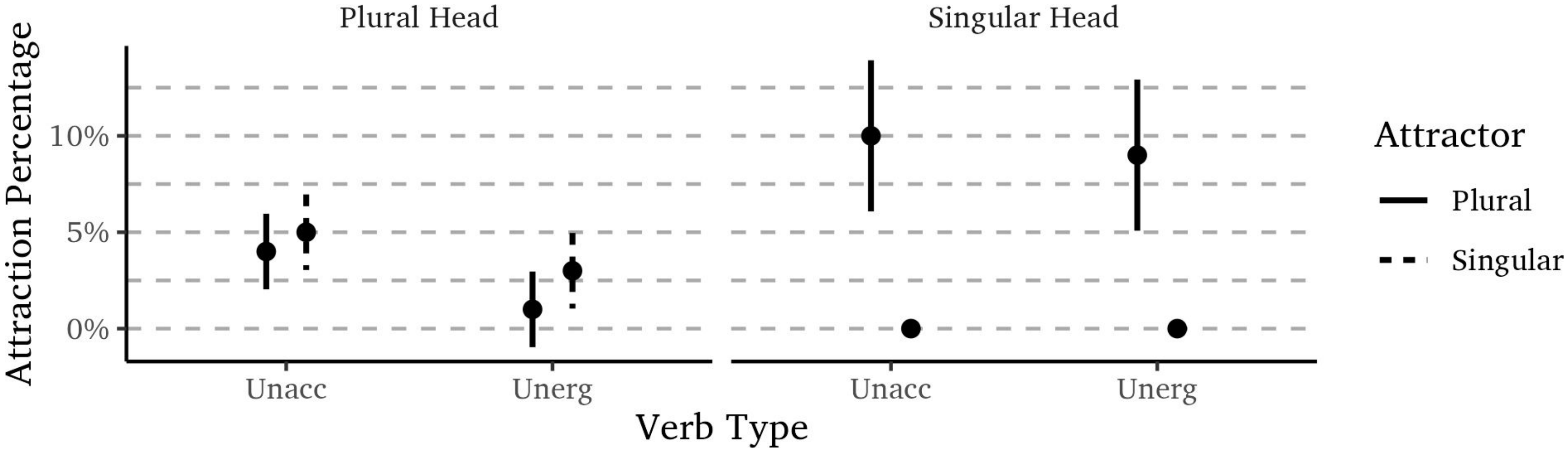


Materials

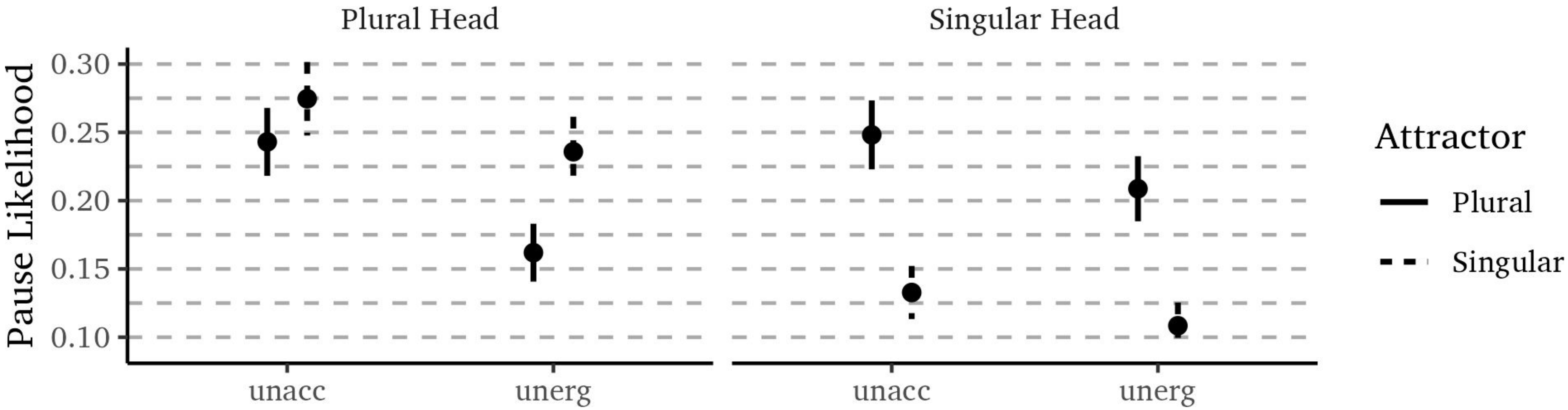
- 6 Entities
- 12 unergative & 12 unaccusative scenes
- 4 Conditions
  - Attractor number (2: PL x SG)
  - Head number (2: PL x SG)
- Latin square design
- 144 (scene-entity pairs) in 4 conditions put in 2 lists
- 18 scenes per number condition per participant
- PCIbex + SONA



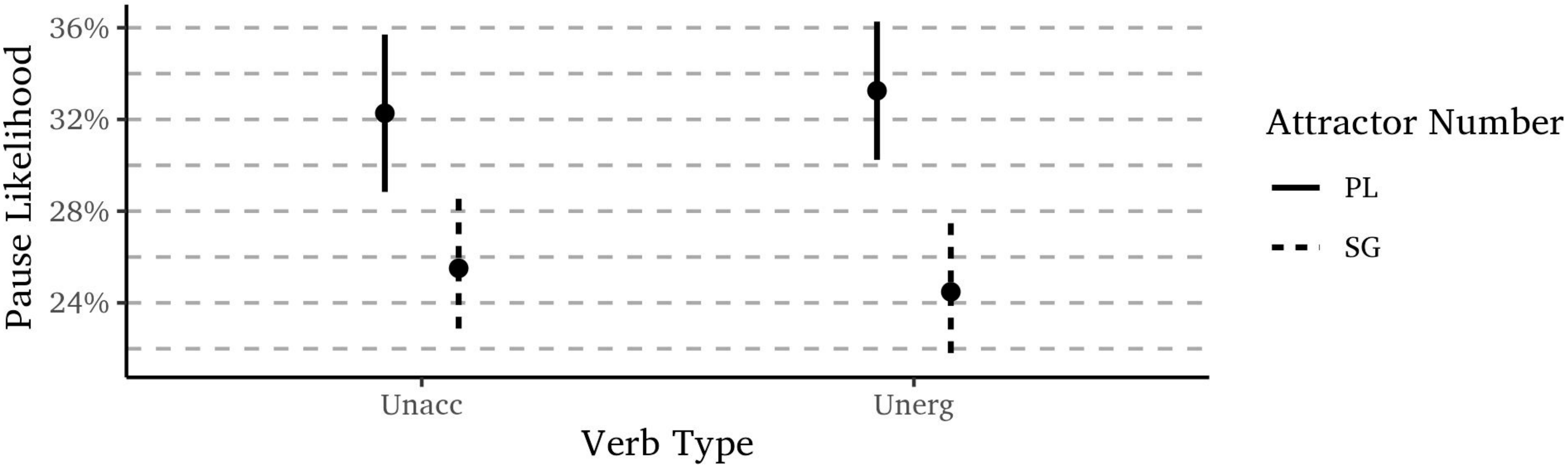
Comparable attraction across verb types



Pause likelihood as a timing index



Pause likelihood as a timing index (even in Exp1)



Take home messages

✔ Attraction “outputs” are comparable in both verb types

→ Attraction is late

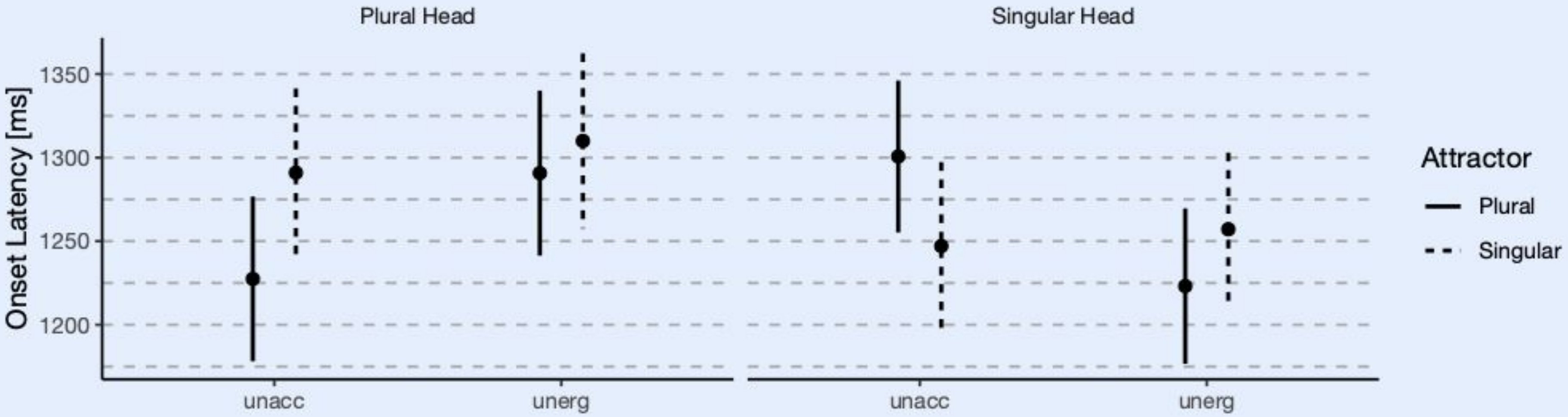
✔ Pause likelihood reflects the agreement computation

✔ Subjecthood and modifier status matter for attraction

Planning | Features | Attraction | Experiments | Onset t

What about real time measures?

What about real time measures in Exp2?

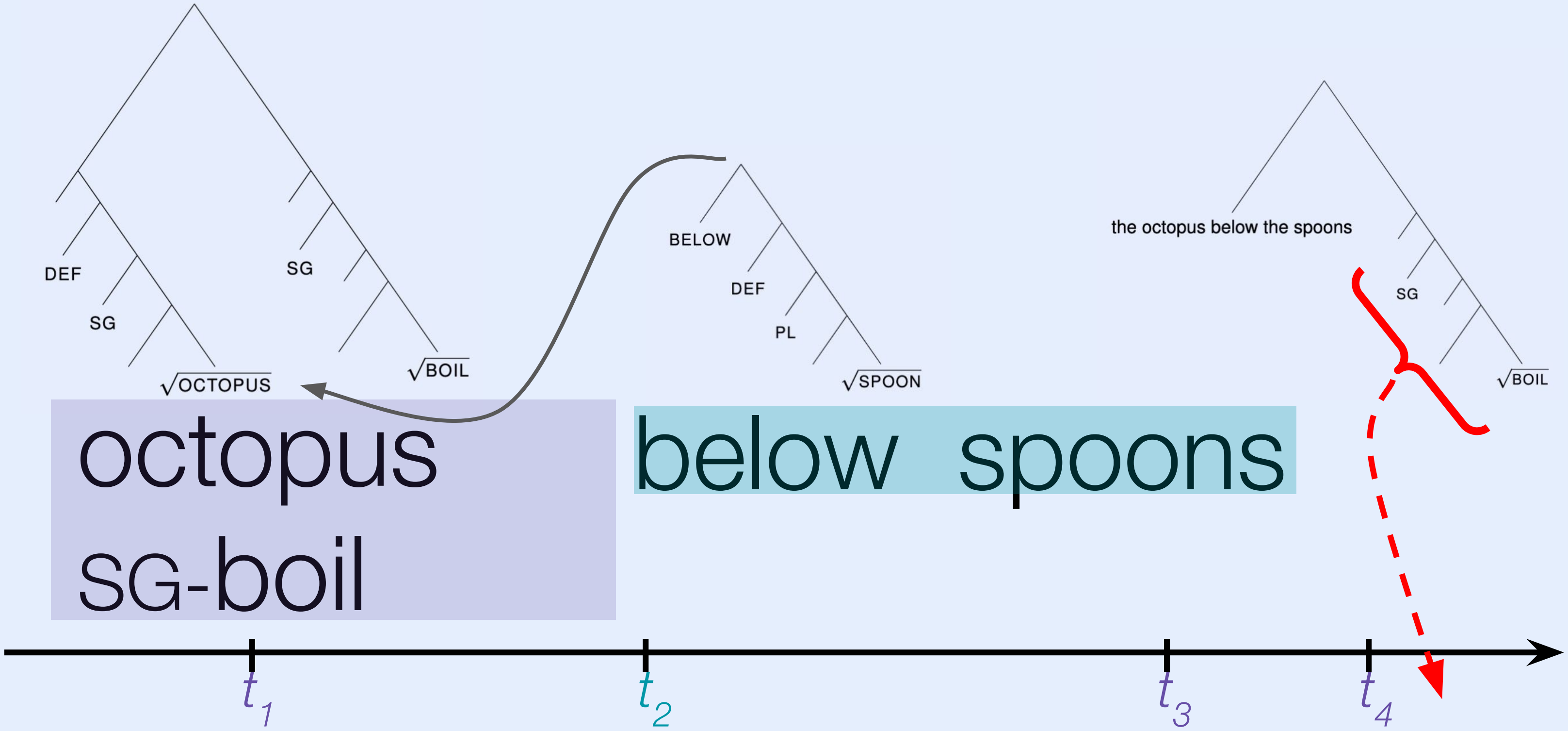


✔ People are slower to start uttering plural heads

🤯 Number of the attractor only matters for unaccusatives

🤔 How do we reconcile “Late Attraction”, but “Early Agreement”?

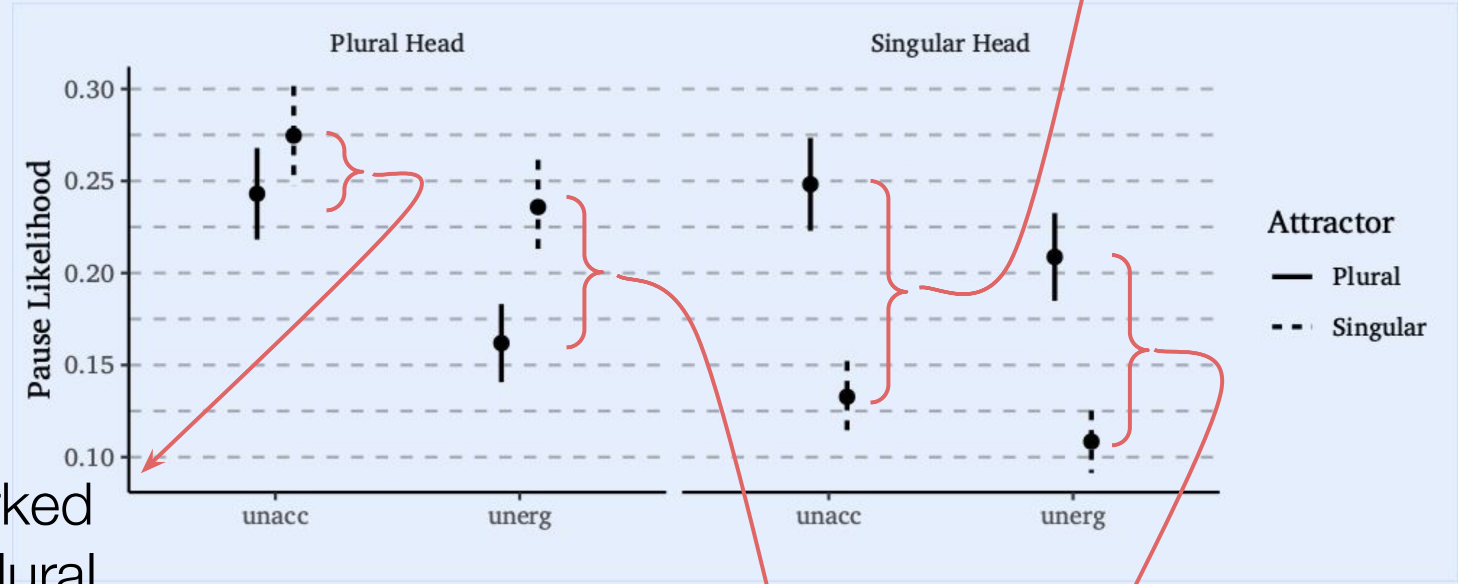
Attraction as a linearization problem



The octopus below the spoons are boiling.

Evidence from pause likelihood

Self-monitoring + accessing the word form



More marked existing plural head disallows self-monitoring

Handling agreement + accessing the word form

What did we find?

- ✔ Unaccusative specific number effect on the onset timing
- ✔ Verb-insensitive number effect on pause likelihood
- ✔ Verb-insensitive attraction effects

What can we speculate?

- ➢ Morpho-syntactic diacritic specification (agreement) is early
- ➢ Access to morpho-phonological form is late
- ➢ Attraction effects are due to linearization mistakes in production

Where to go from here?

- Exp to verify early planning without semantic interference

- Testing attraction in a language where number is more mechanistic than English

- Exp to check different agreements
  - Inherent features and agreement, i.e. gender in Dutch/Czech
  - Fusional unacc-unerg and number marking in Spanish/Laz

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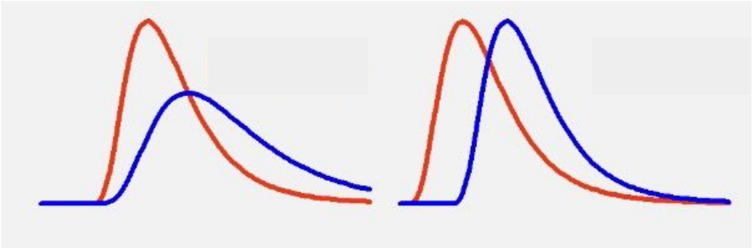
Model Specifications: Pause + disfluency + attraction

Parameter	Specification
Family	`bernoulli("probit")`
Formula	error ~ 1 + verb_type * sem_type * dist_num + (1 + verb_type * sem_type * dist_num | subject) + (1 + verb_type * sem_type * dist_num | head)
Intercept Prior	Student's t(3, 0, 2.5)
Coefficient Prior	Normal(0,1)
σ **Prior** (Random Effects)	$Cauchy^{+}(0,1)$
ρ **Prior**(Correlations)	LKJ(2)
Chains	12000 (2000 warmup)

Model Specifications: onset + preverbal

Parameter	Specification
Family	`exgaussian()`
Formula	`duration ~ 1 + verb_type * dist_num * sem_type + l_pres + (1 + verb_type * dist_num * sem_type | subject_id) + (1 | head)`
Intercept Prior	Normal(1000, 50) / Normal(800,20) for preverbal
Coefficient Prior	Normal(50, 10)
σ **Prior (Random Effects)**	$\text{Cauchy}^+(50, 10)$
σ **Prior (Residual)**	$\text{Cauchy}^+(50, 10)$
Chains	12000 (2000 warmup)
Backend	cmdstanr
Cores	8

Why exGaussian, but no tail parametrization?



- Momma & Ferreira (2019): inverse Gaussian, only mean is parametrized, tail difference is due to mean variance

- Roeser et al. (2024): mixture (two gaussians) distribution, only variance parameterization, mean is thought as “decision time” and was not shifted

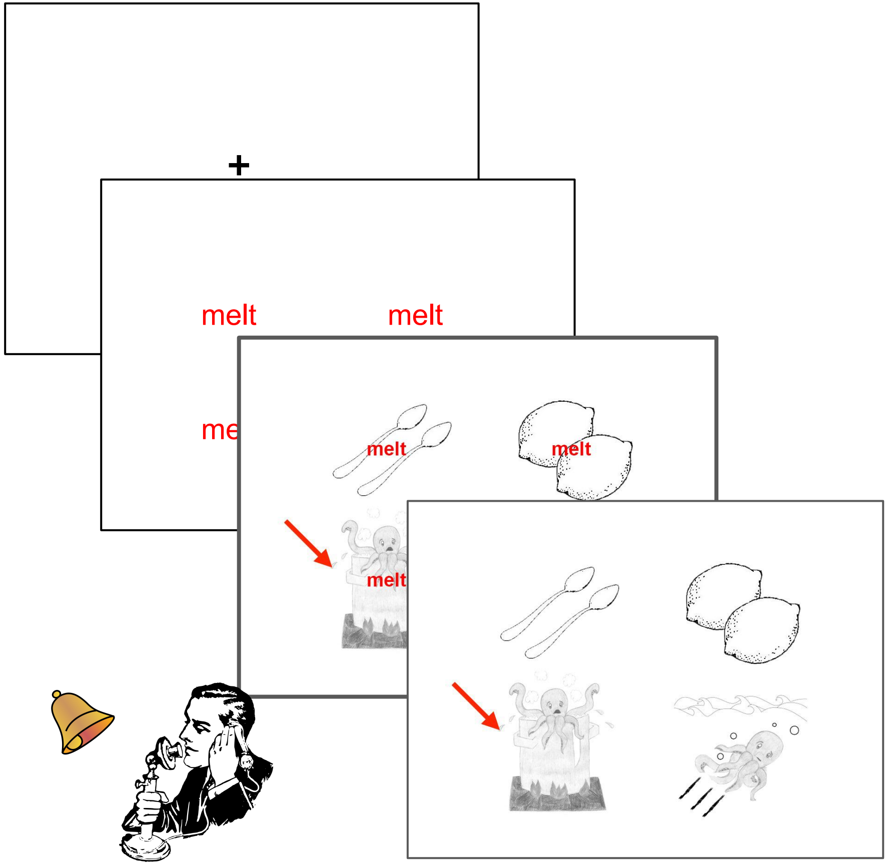
My assumption:
- it is about the trials that starts late: so definitely mean parameterization
- The distribution in a mixture though, so definitely mean variance should not derive tail, tail should be independent

Model Specifications: contrasts

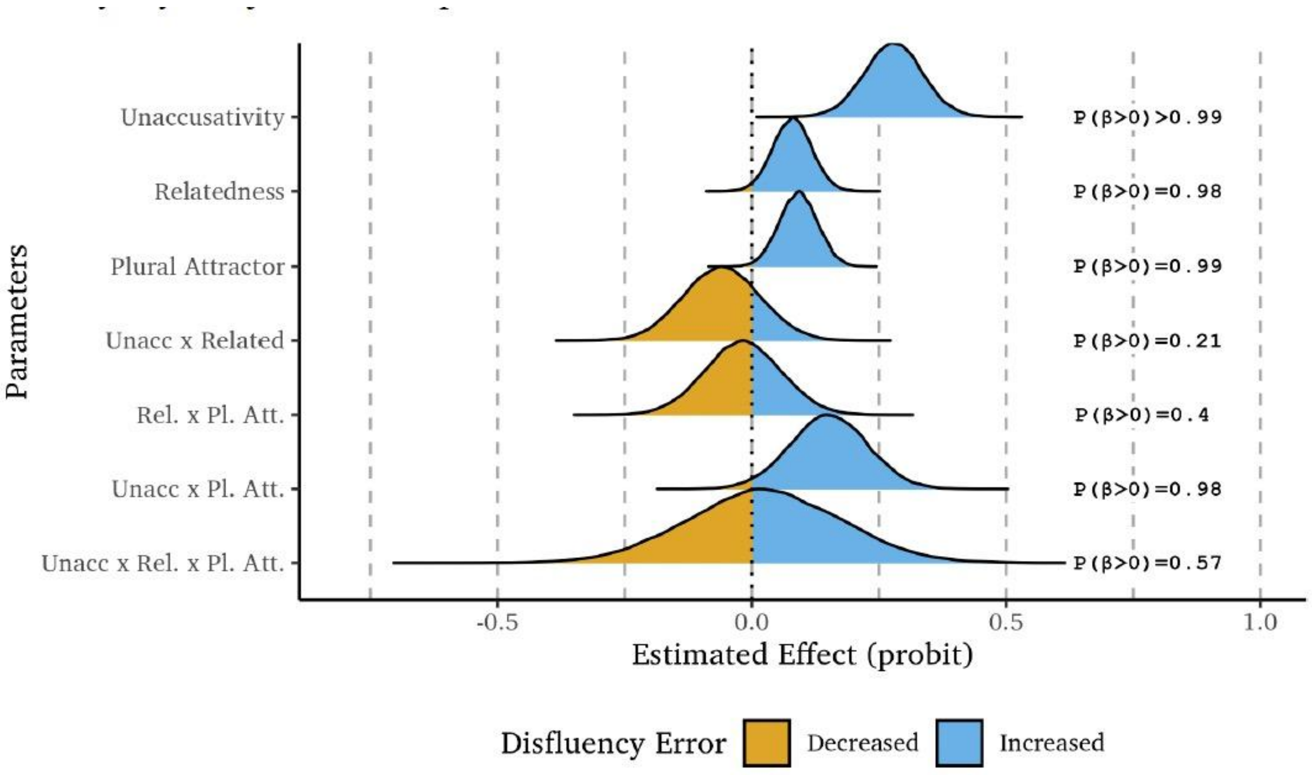
Predictors	+0.5	-0.5
Verb-Type	Unaccusative	Unergative
Semantic Relatedness	Related	Unrelated
Attractor Number	Plural	Singular

Procedure: Exp1

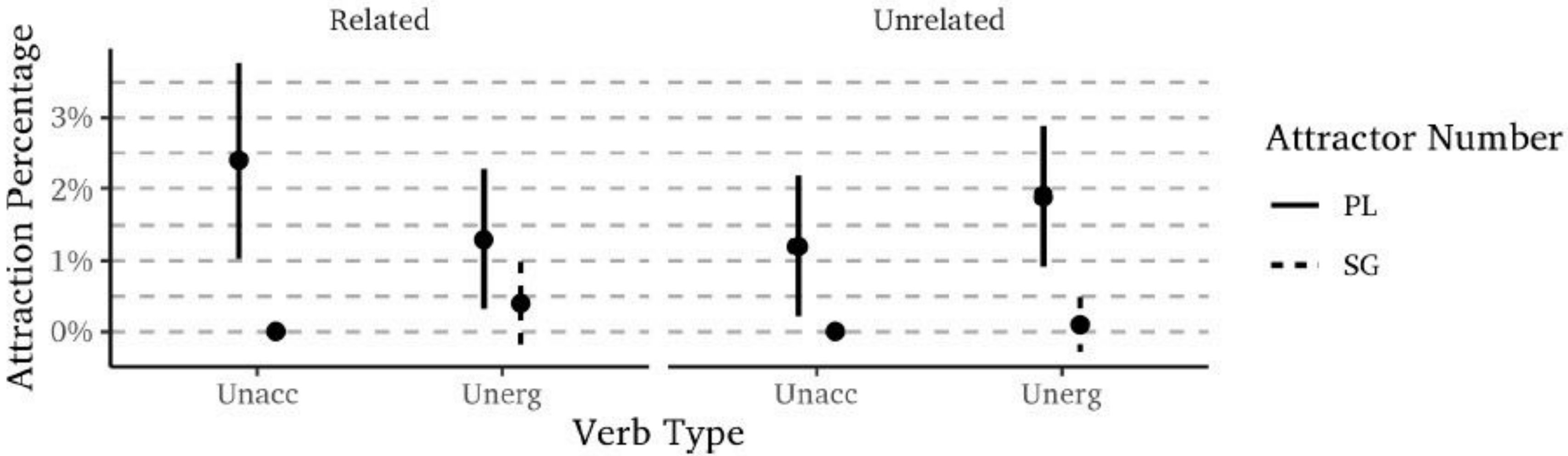
- Distractors come 150ms before
- Prompted to utter sentence with pictures
- 5 seconds to utter sentence
- Repeated measures
    - Participants saw all conditions (144 trials)
- PCIbex (unlike Momma & Ferreira 2019)
- ~38% excluded



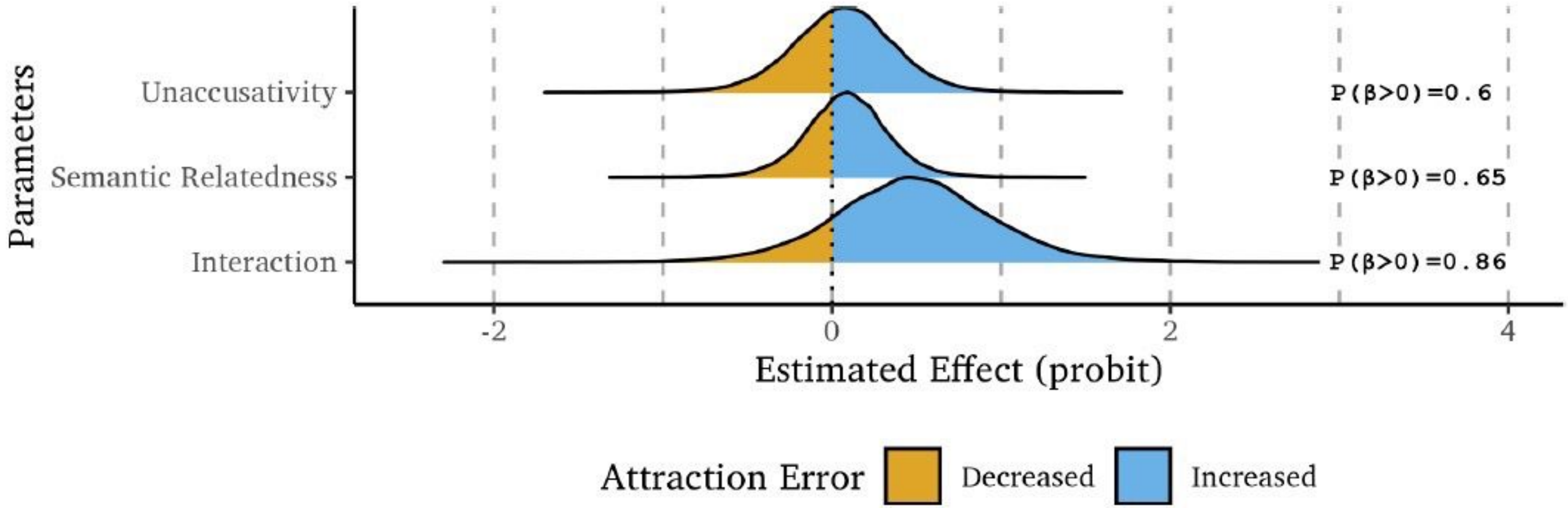
Exclusions in Exp1



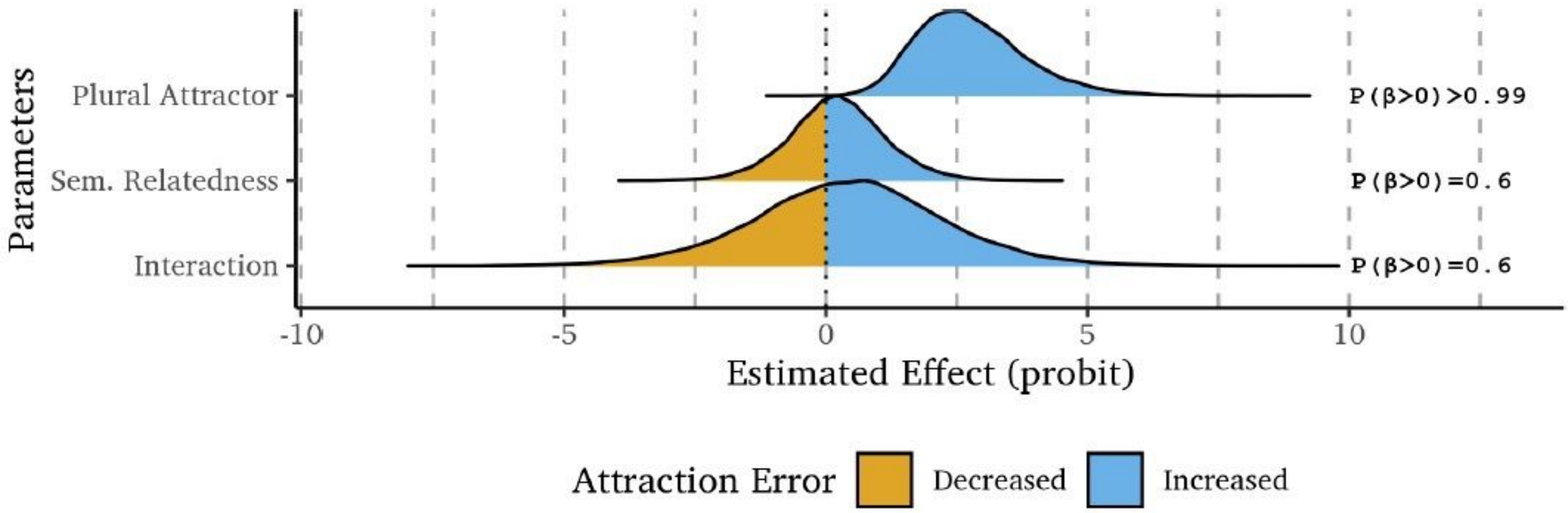
Full Picture of Attraction in Exp1



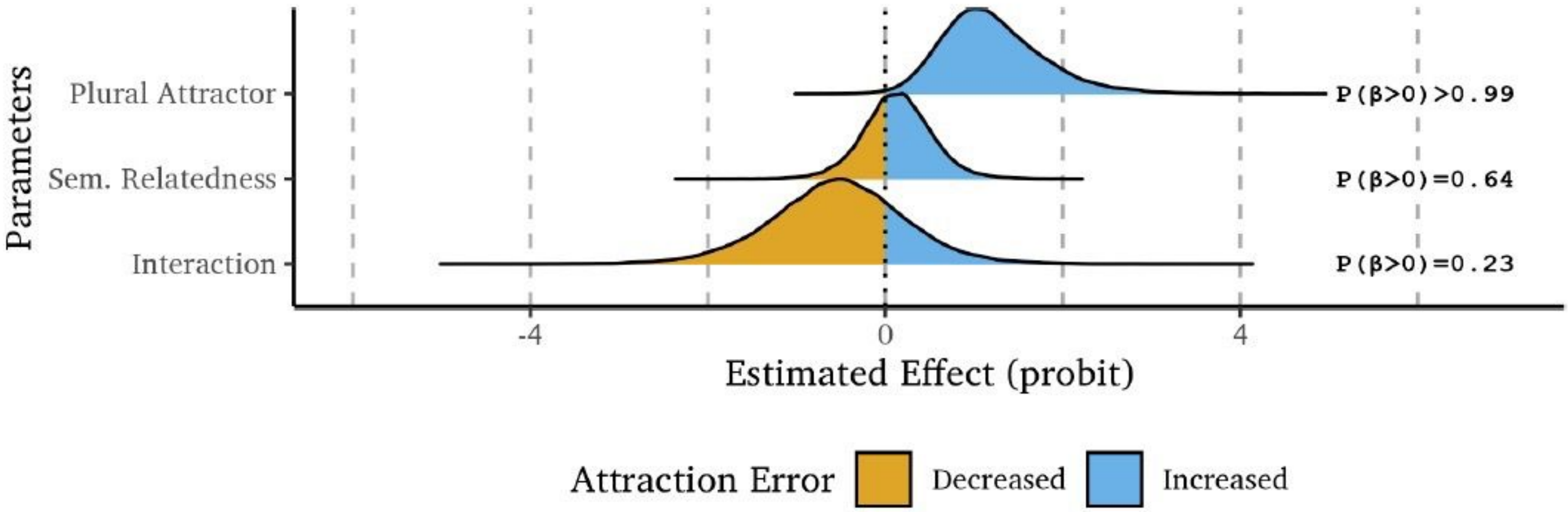
Attraction Model in Exp1 when the attractor is plural



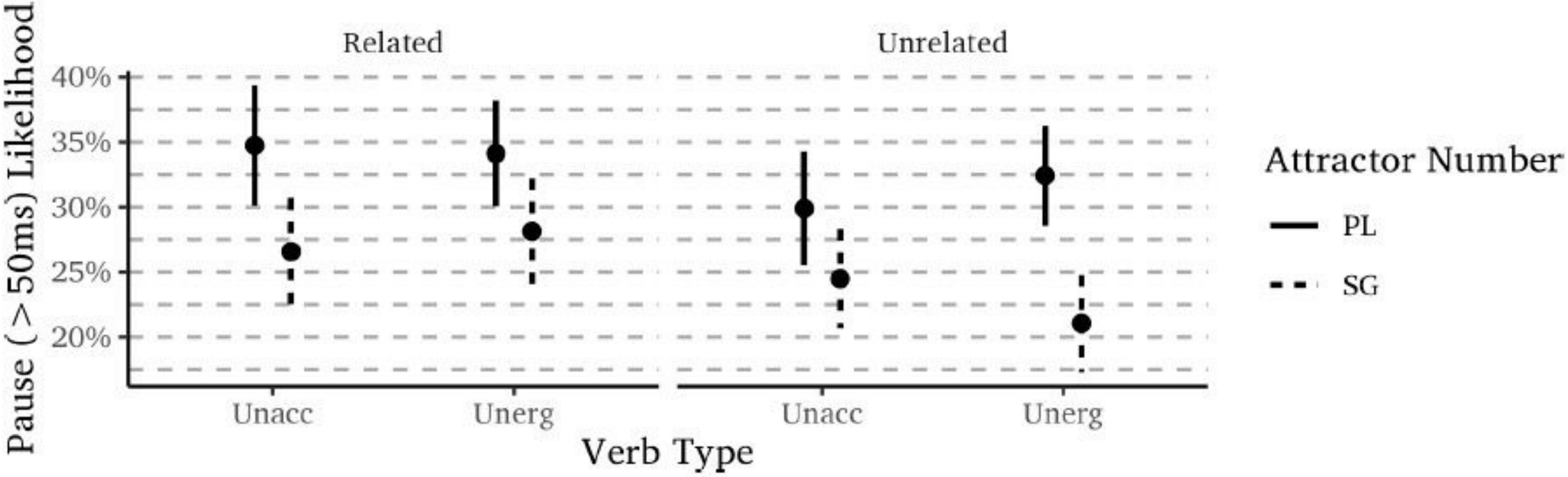
Attraction Model in Exp1 with unaccusatives



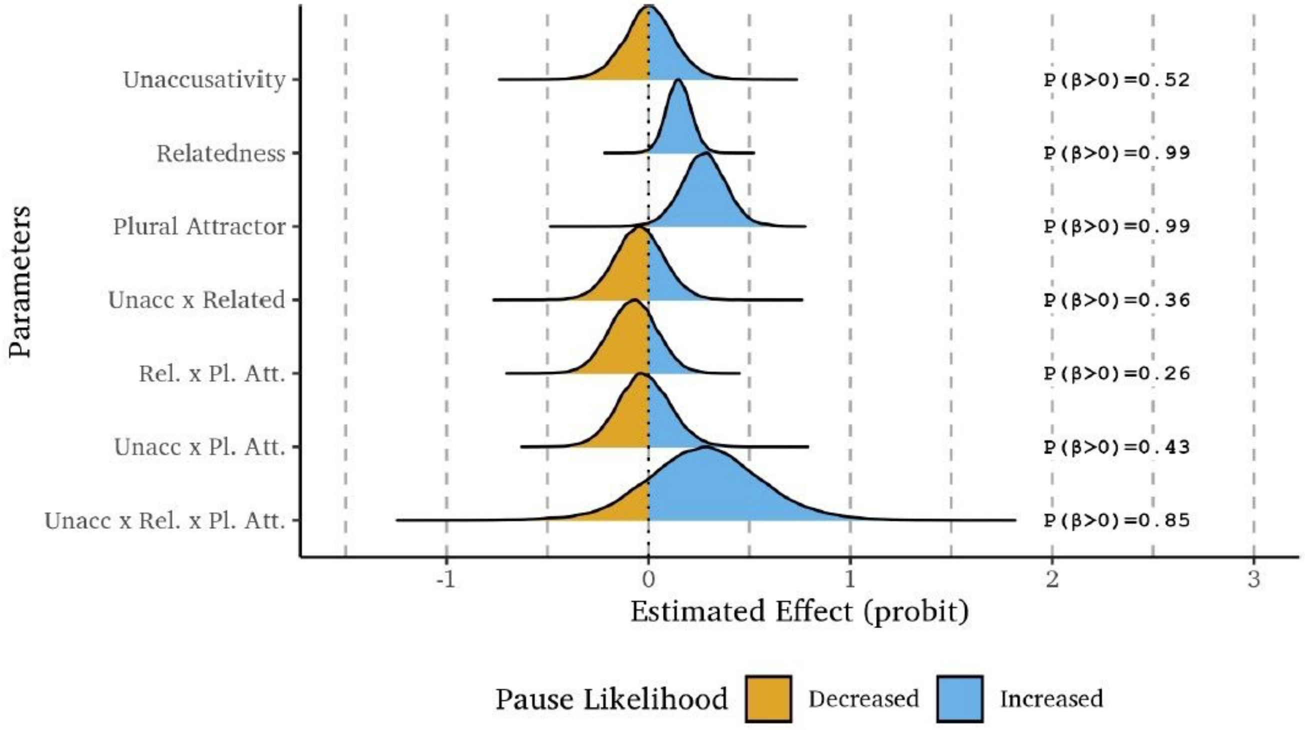
Attraction Model in Exp1 with unergatives



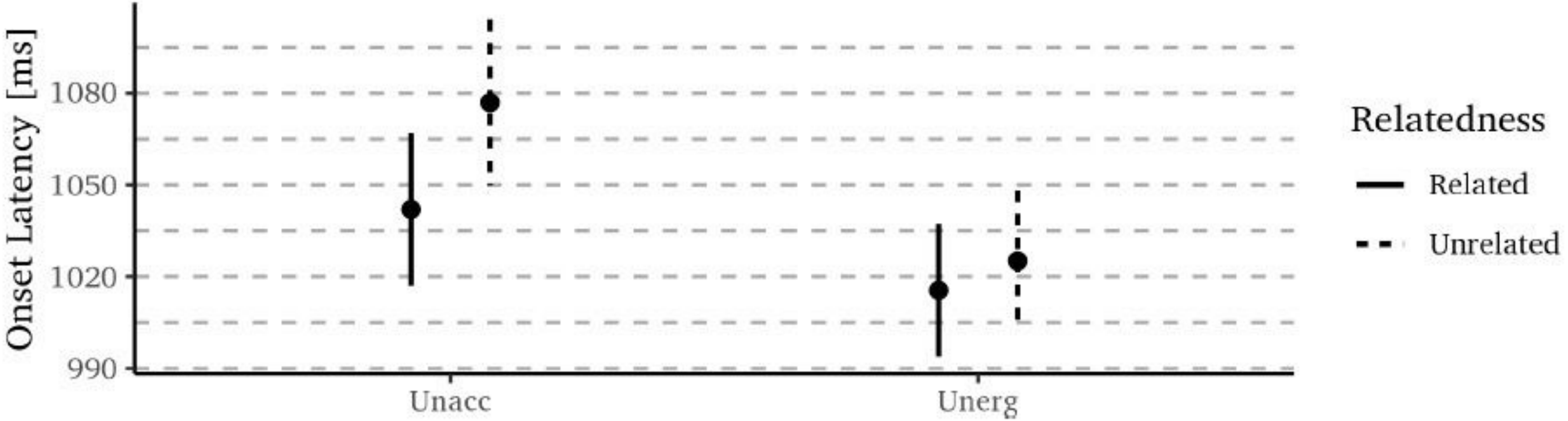
Pause Likelihood results in Exp1



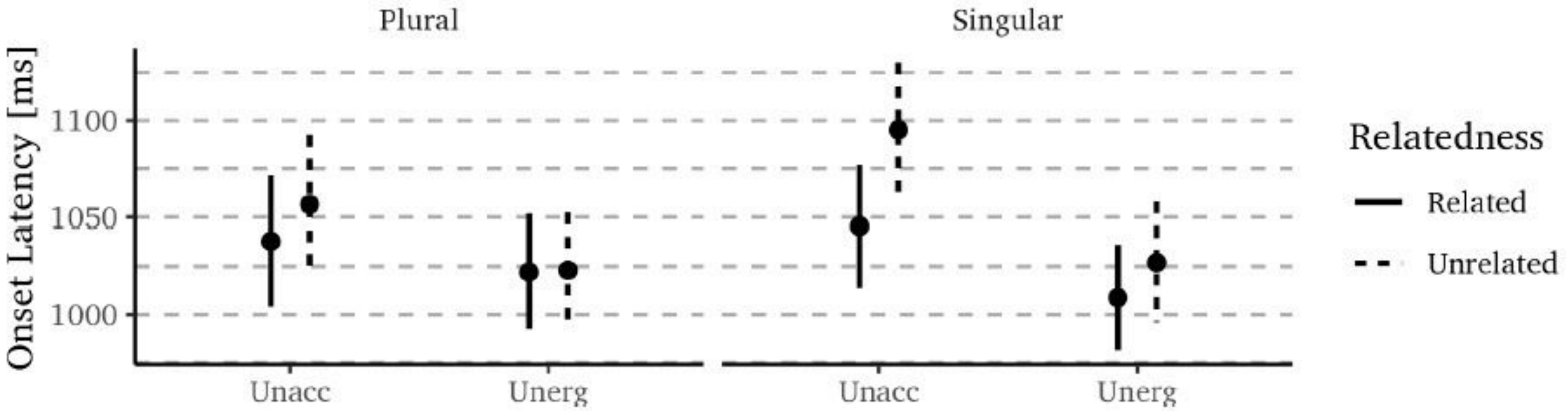
Pause Likelihood model in Exp1



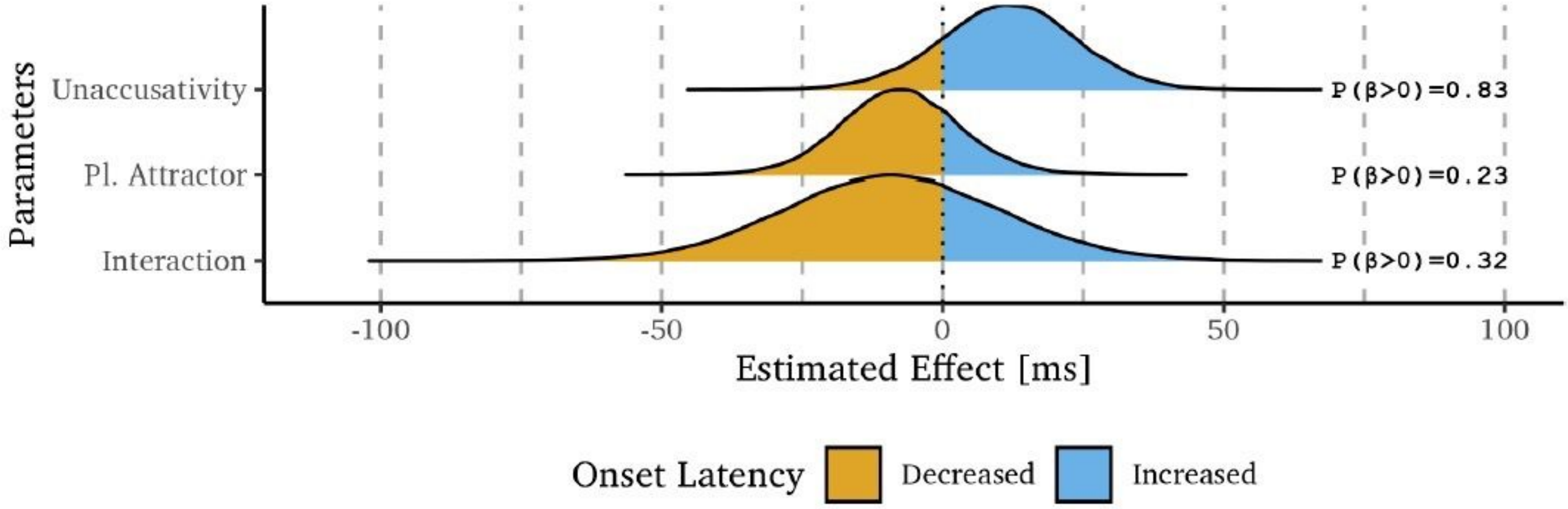
Onset Results in Exp1(nested)



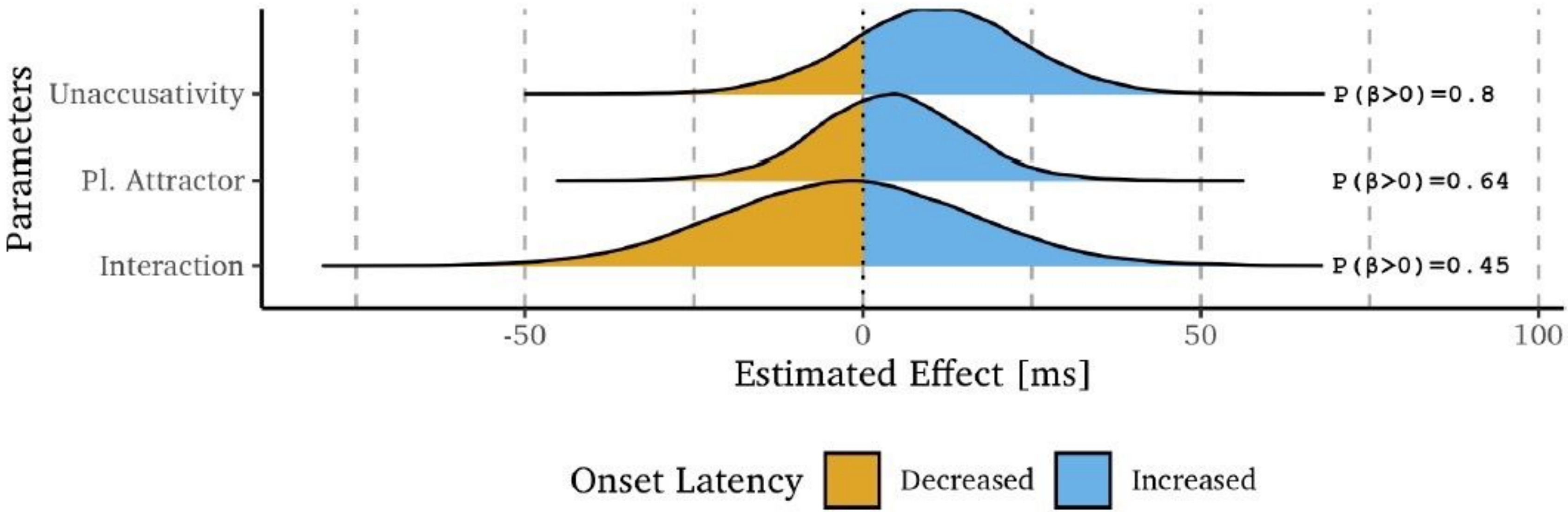
Onset Results in Exp1



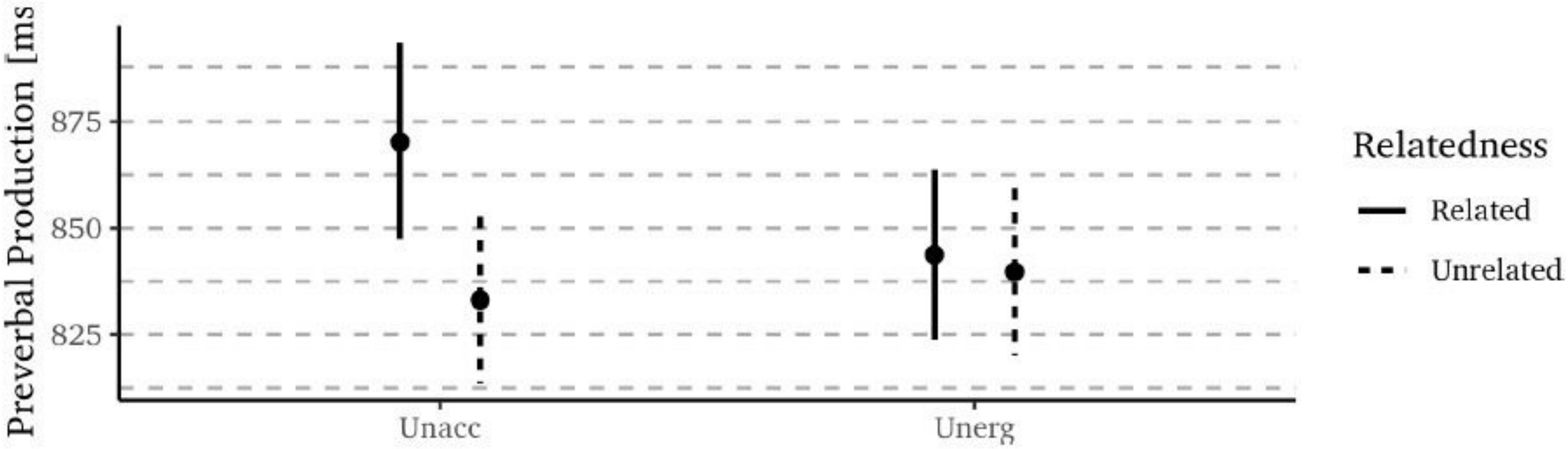
Onset Latency model in Exp1 with semantically related distractors



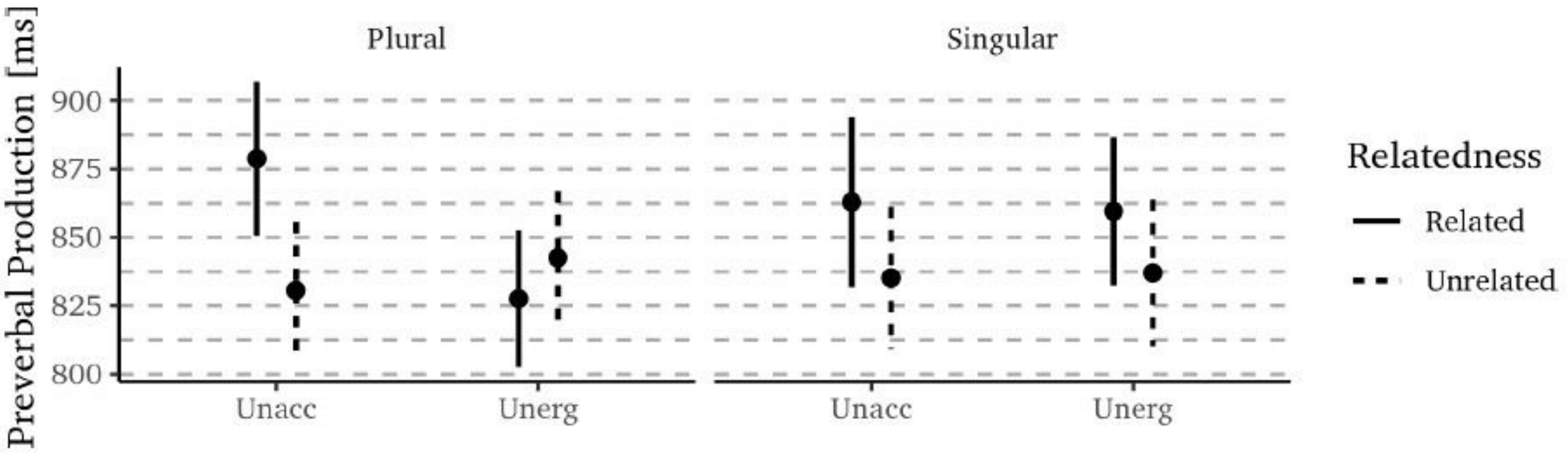
Onset Latency model in Exp1 with semantically unrelated distractors



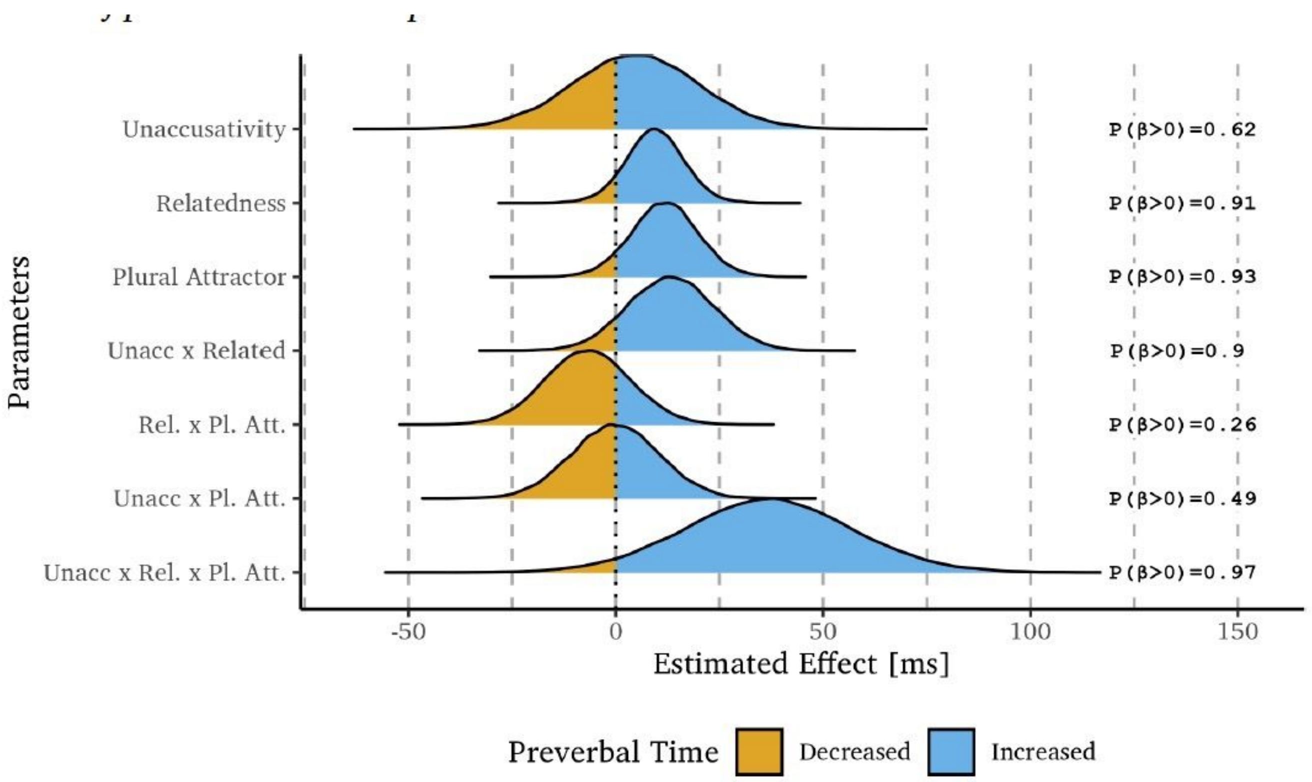
Preverbal results in Exp 1(nested)



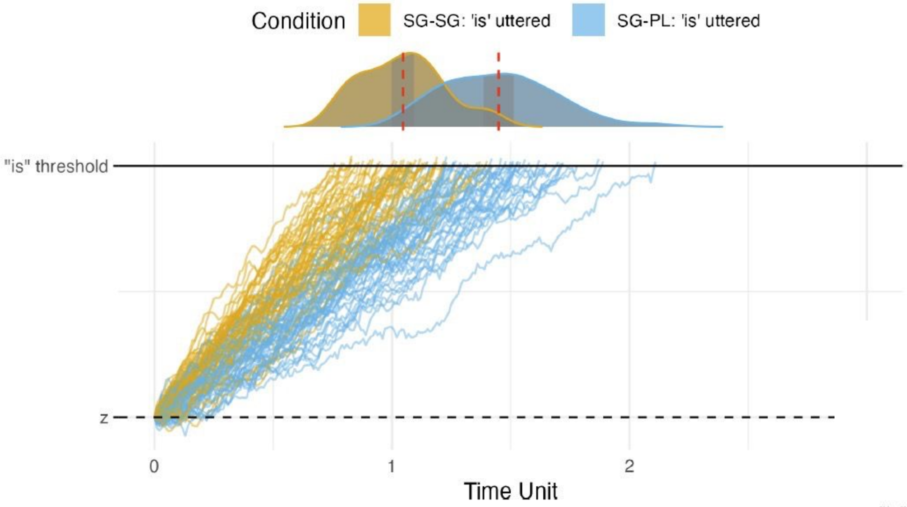
Preverbal results in Exp 1

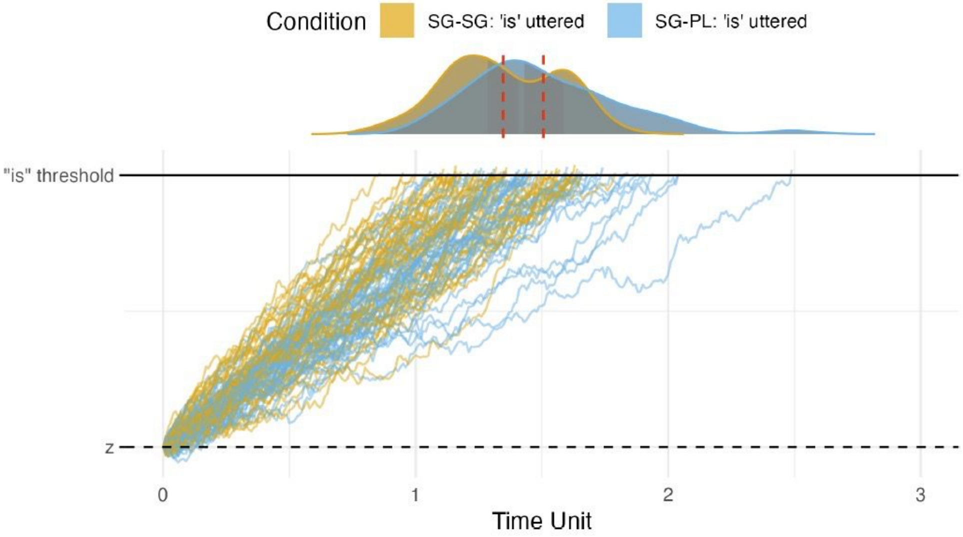


Preverbal model in Exp 1

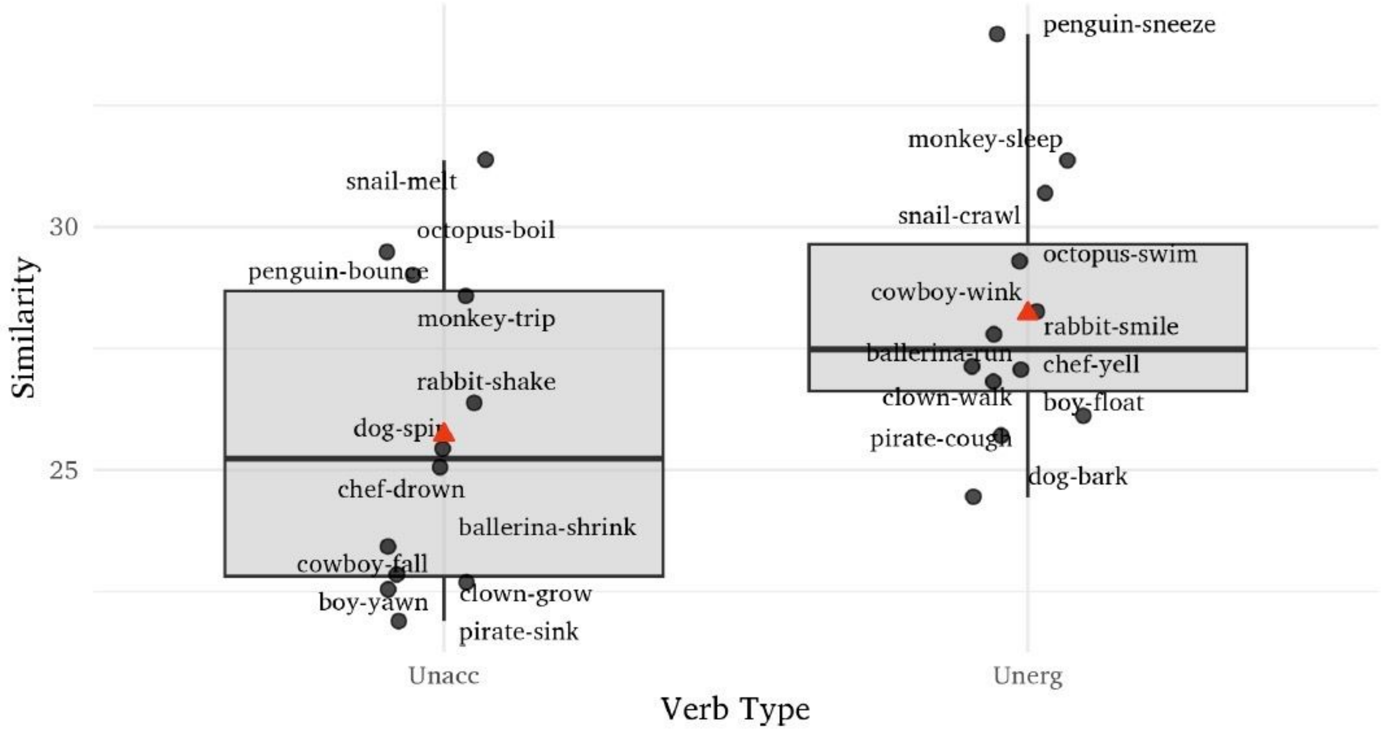


Why we needed Exp2? DDM Answer



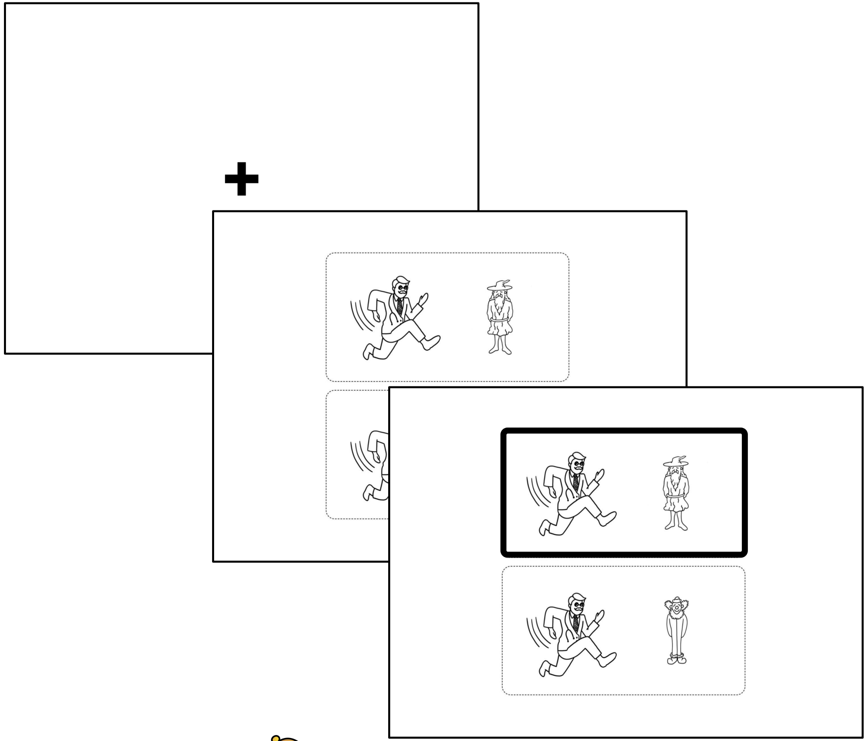


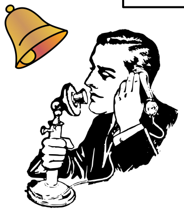
Why Unaccusatives were slower? Not due to “identifiability”



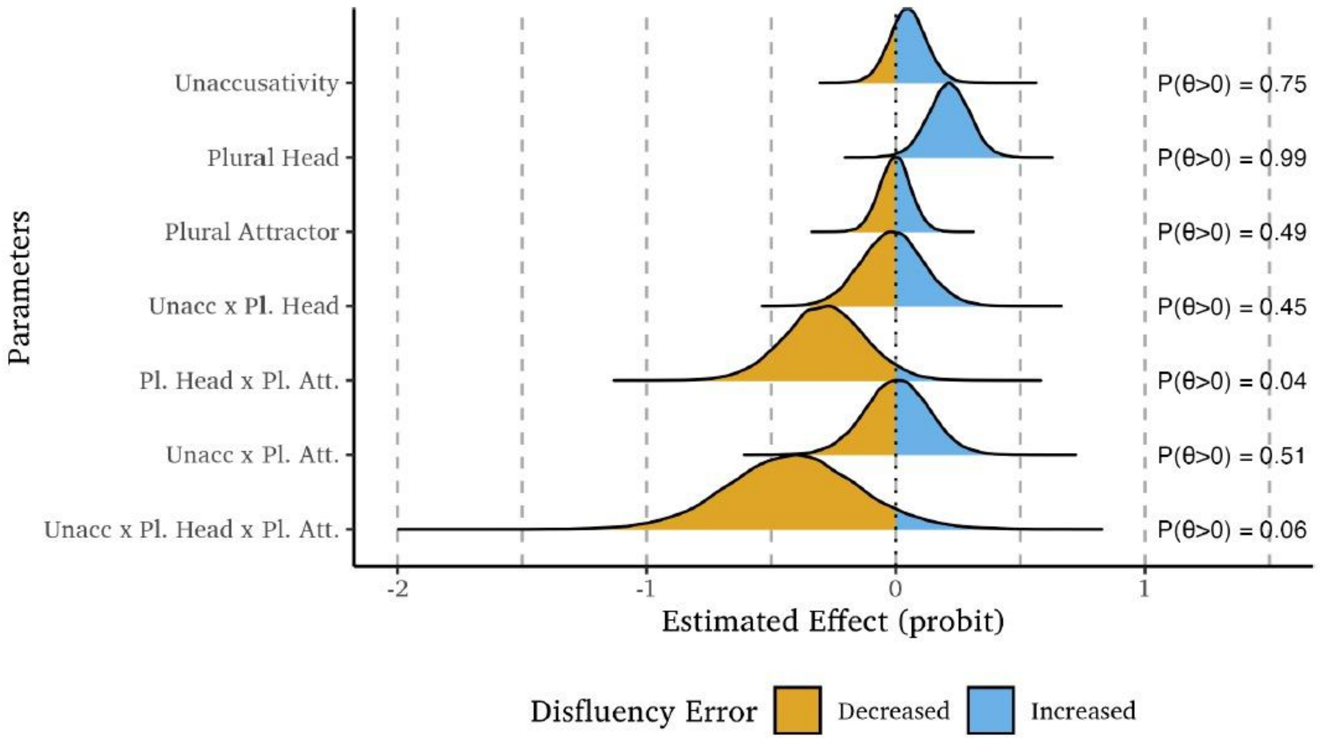
Procedure: Exp2

- 500ms cross
- 1500 ms picture explorations
- 4000 milliseconds of “square” = recording
- ~28% exclusion for attraction
- ~39% exclusion for timing

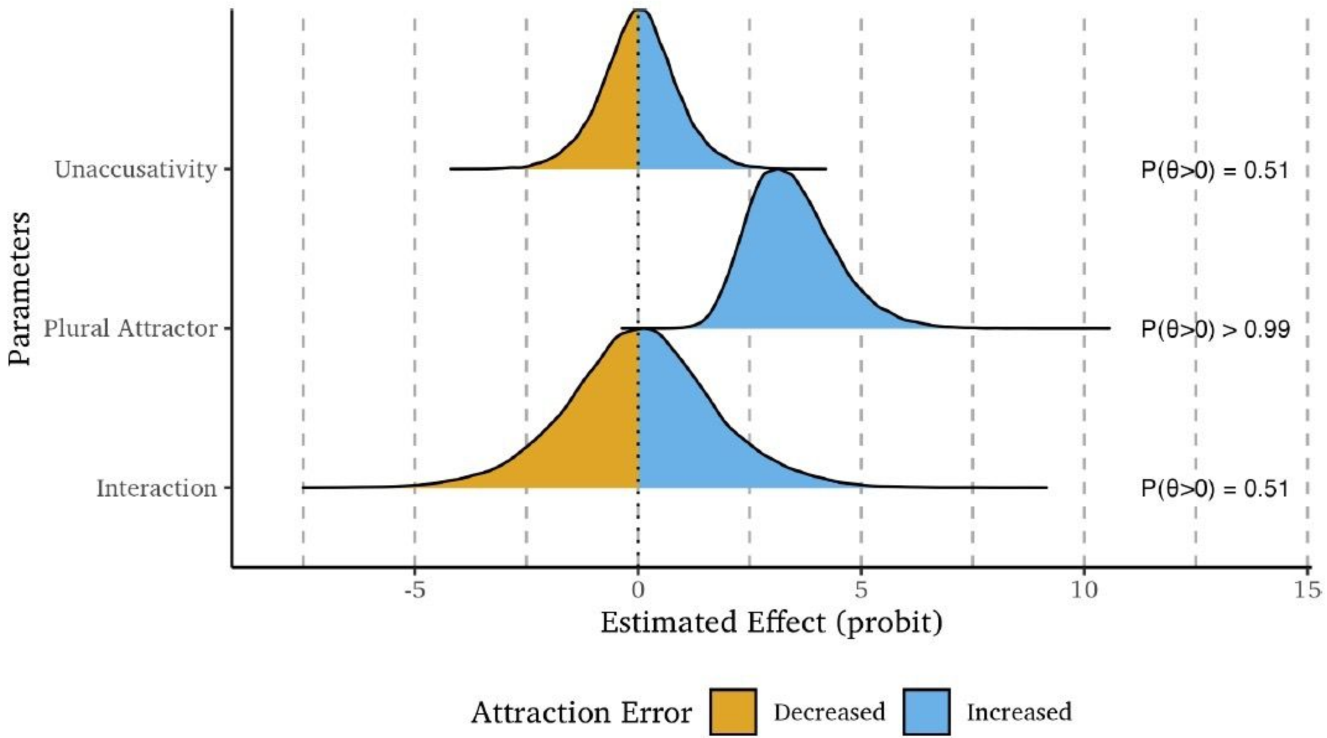




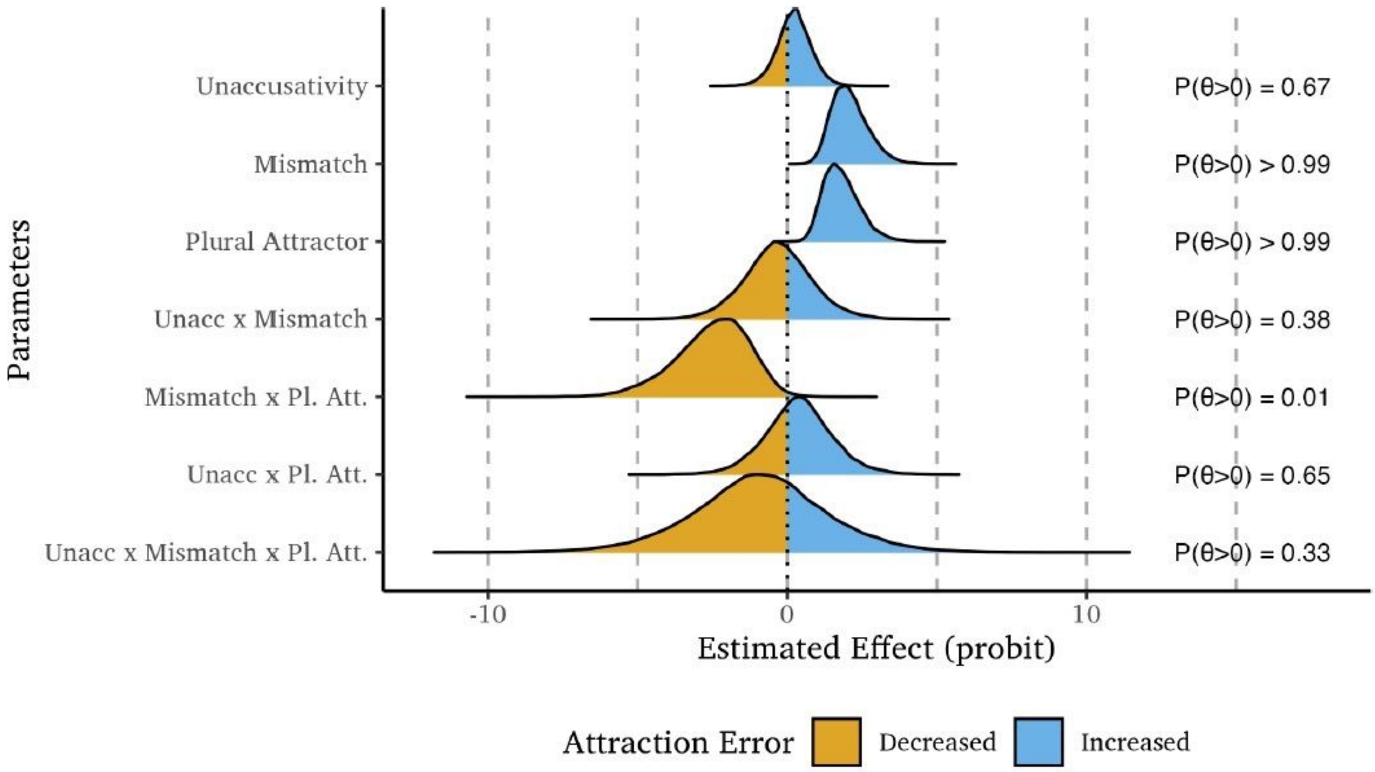
Exclusions in Exp2



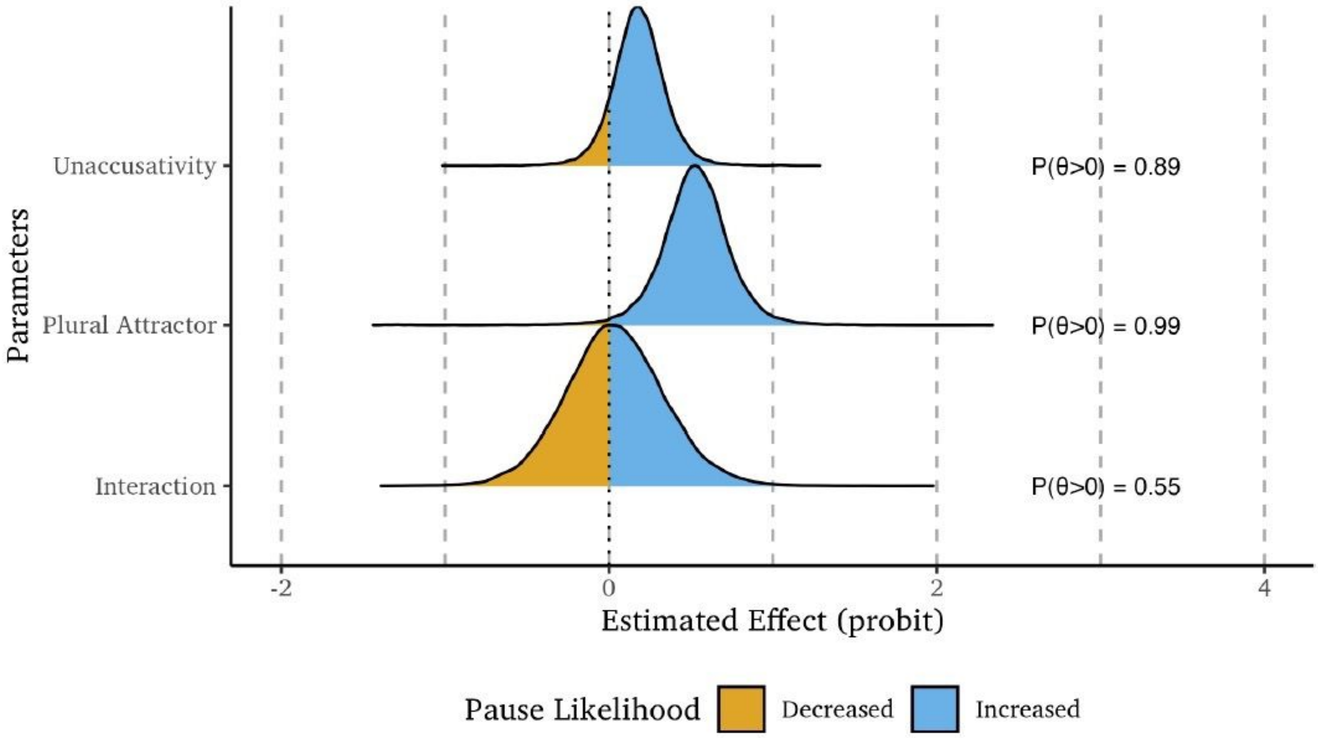
Attraction model in Exp2 with singular heads



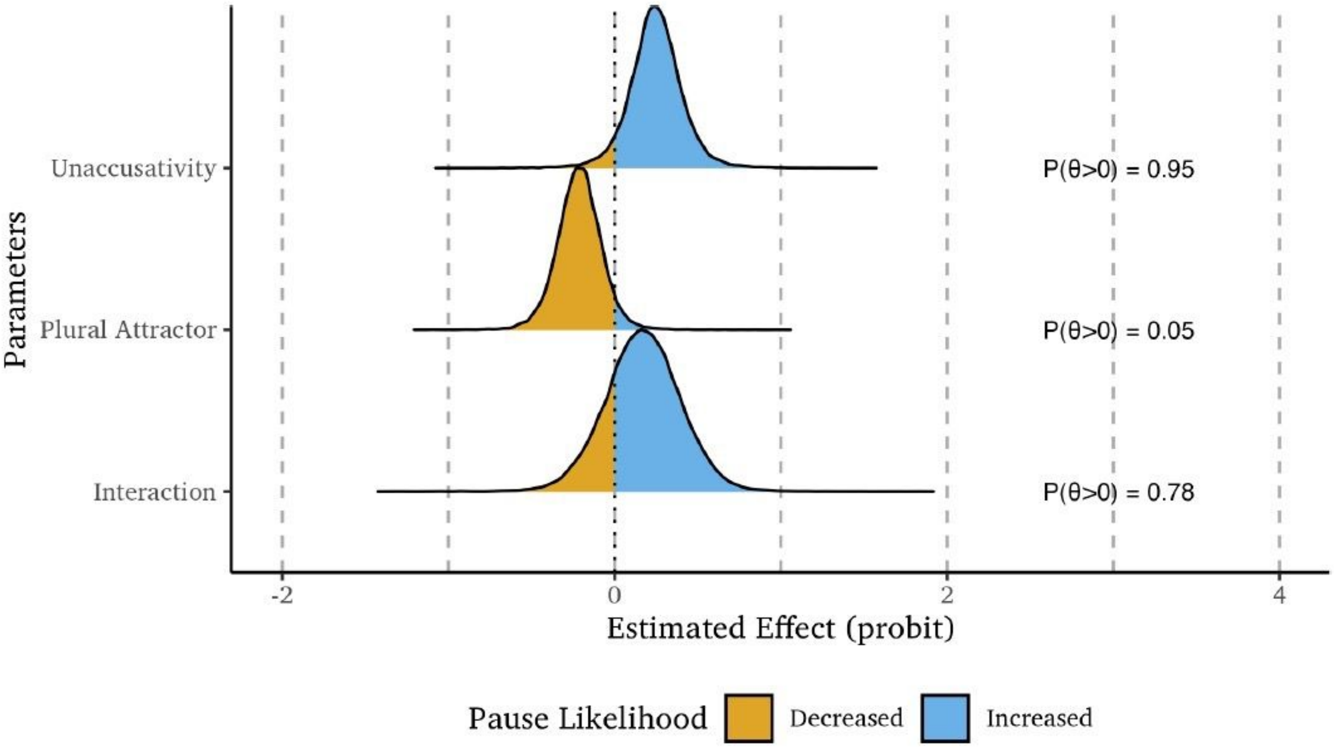
Attraction model in Exp2



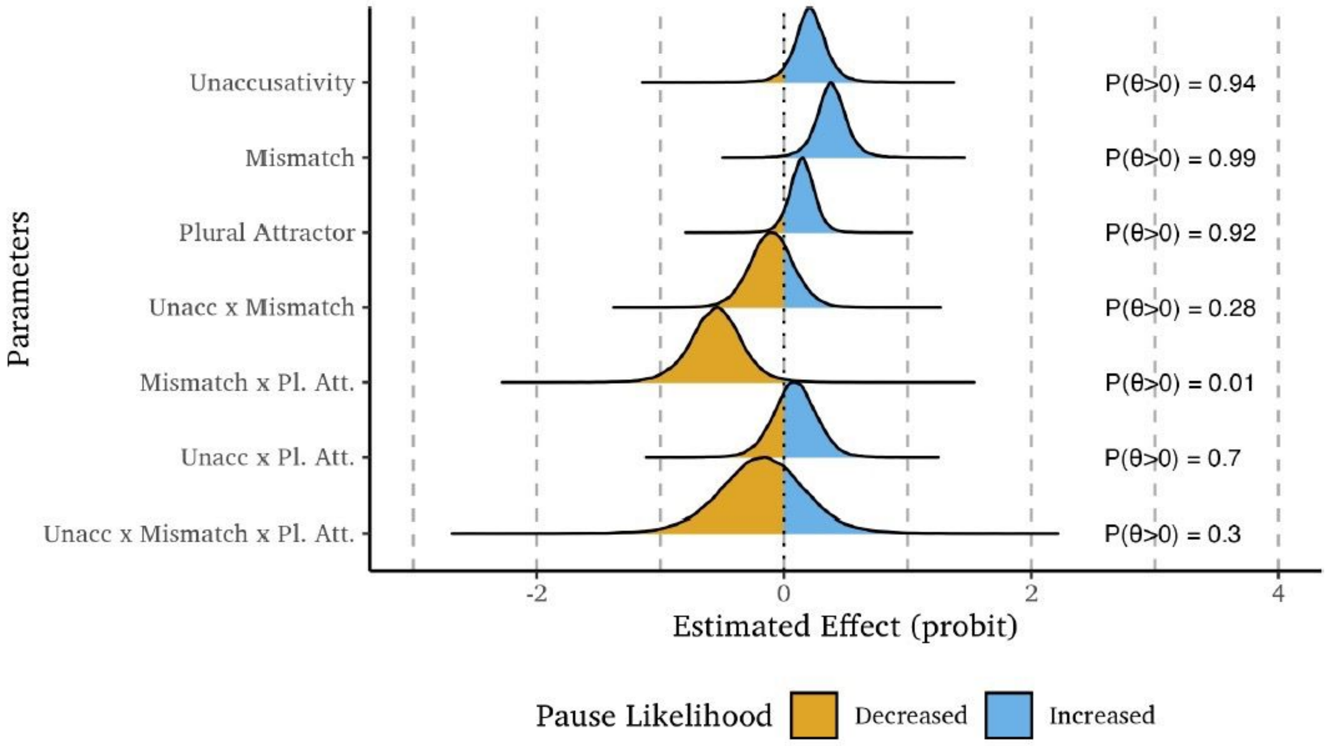
Pause likelihood model in Exp2 with singular heads



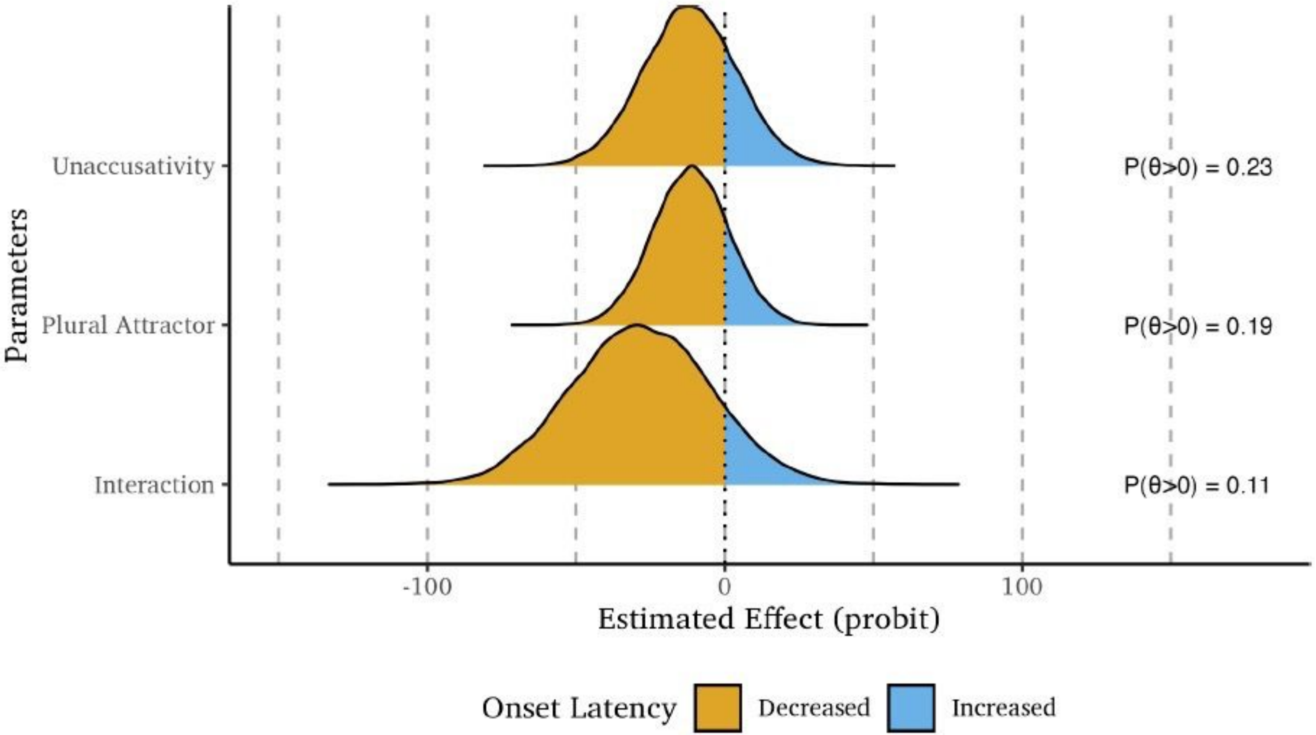
Pause likelihood model in Exp2 with plural heads



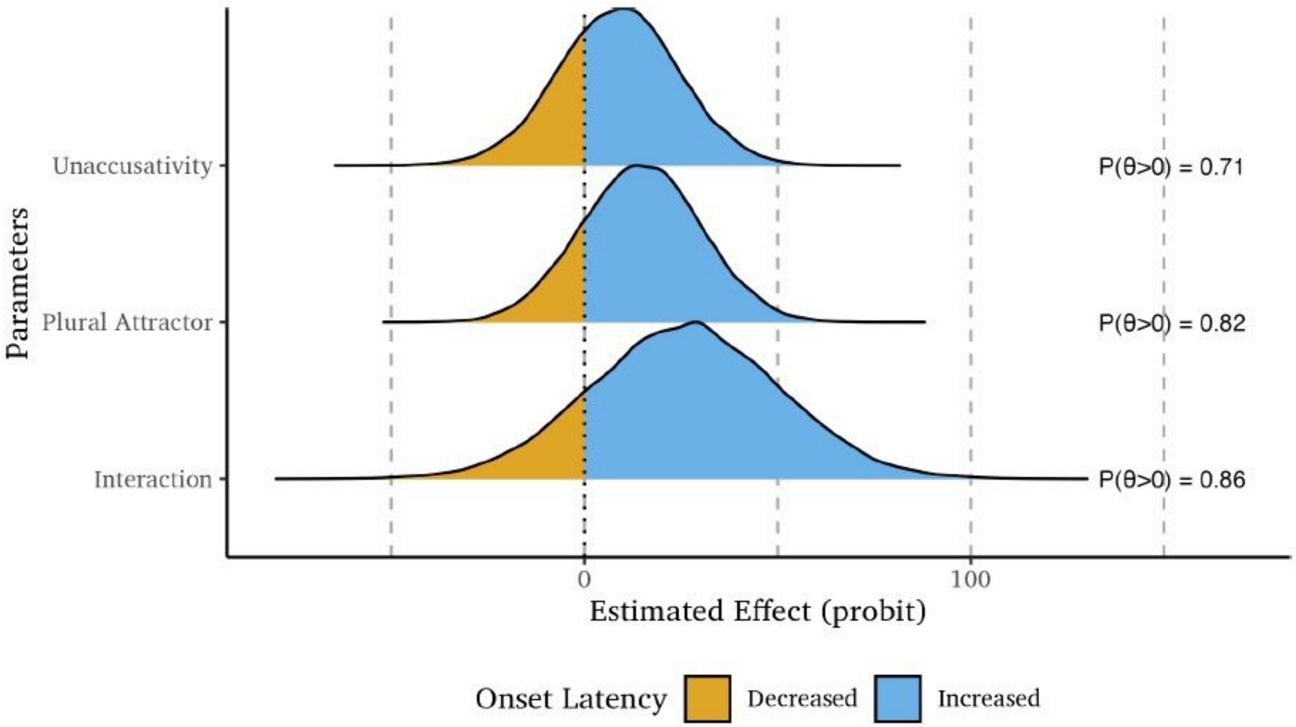
Pause likelihood model in Exp2



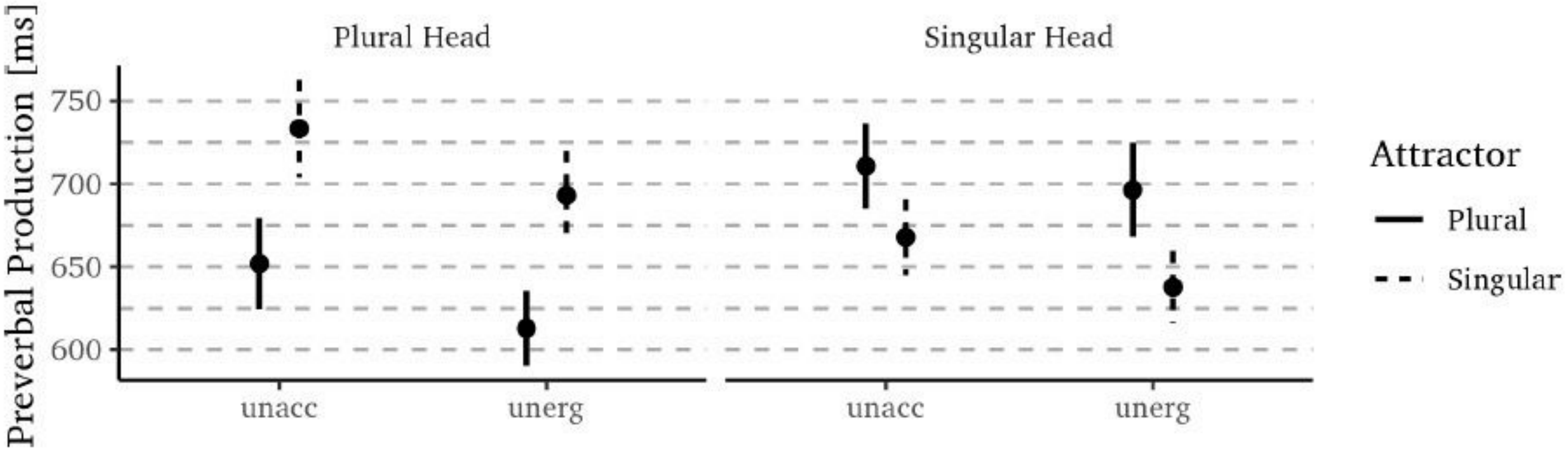
Onset model in Exp2 with plural heads



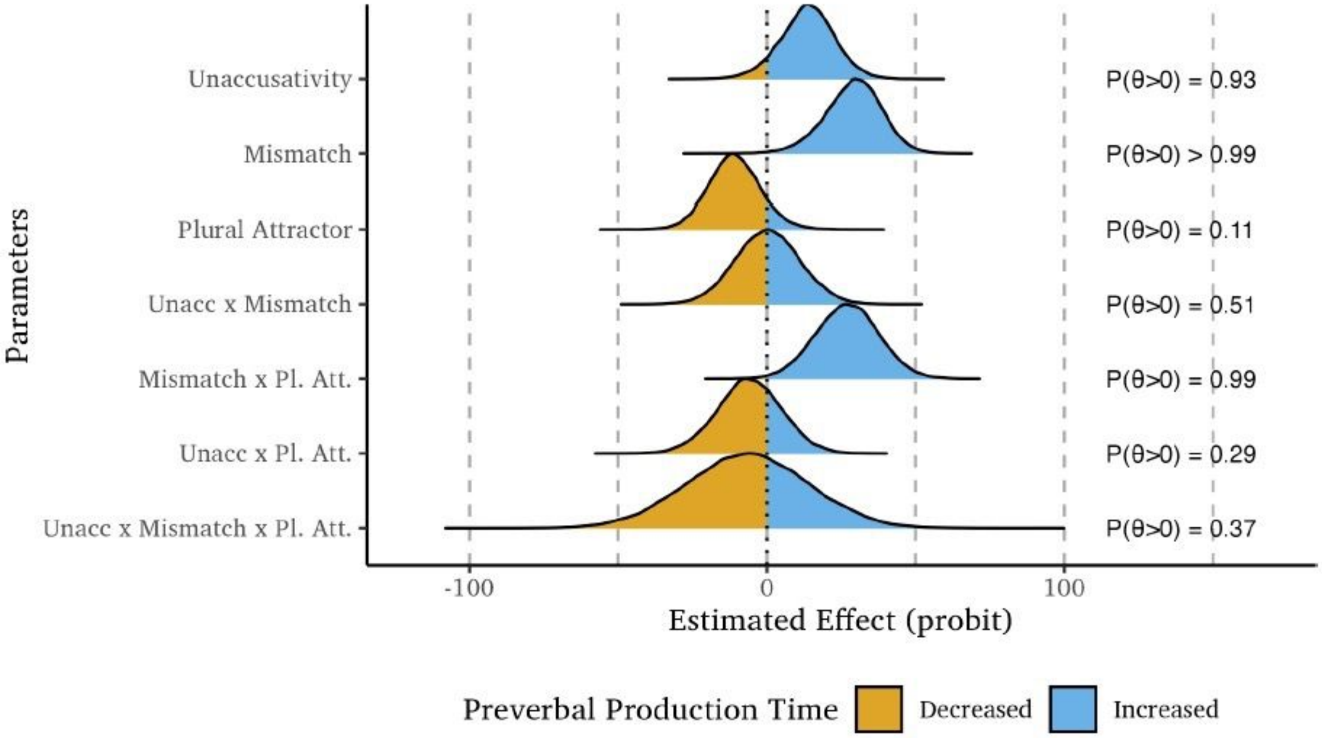
Onset model in Exp2 with singular heads



Preverbal results in Exp2



Preverbal model in Exp2



Codability and early planning in Exp2

We fit a preliminary model to our onset latency data using this entropy-based codability measure as a predictor, including an interaction term with verb type. While the model revealed strong evidence for a main positive effect of codability ($\hat{\beta} = 31.44$; $CI = [-3.98; 67.06]$; $P(\beta > 0) = .96$), we did not find strong evidence for its interaction with verb type ($\hat{\beta} = 28.52$; $CI = [-39.93; 97.46]$; $P(\beta > 0) = .79$). However, in more complex models, we observed a weak effect of a three-way interaction between

codability, verb type, and attractor number ($\hat{\beta} = 98.19$; $CI = [-86.92; 282.38]$; $P(\beta > 0) = .85$).