Novel analysis of response bias challenges representational accounts in attraction

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Agreement Attraction

(1) The **key** **was** rusty.

(Bock & Miller, 1991; Wagers et al., 2009)

Agreement Attraction

(1) The **key** **was** rusty.

(2) *The **key** **were** rusty.

(Bock & Miller, 1991; Wagers et al., 2009)

Agreement Attraction

(1) The **key** **was** rusty.

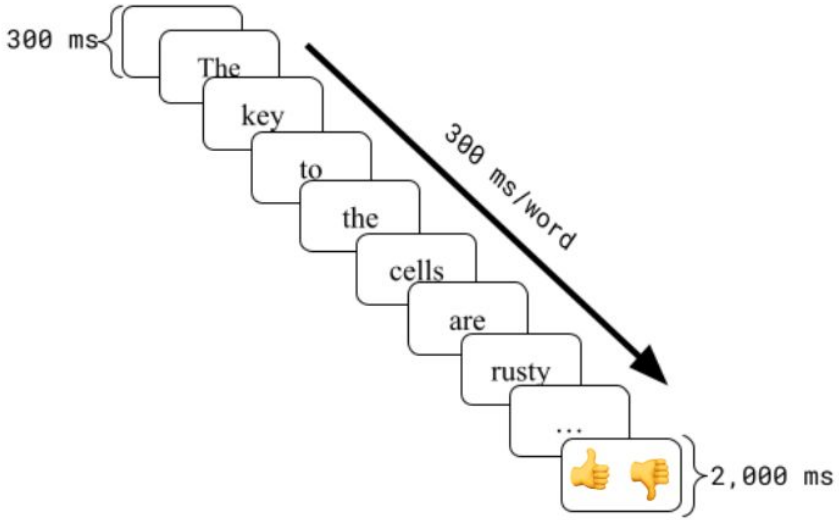
(2) *The **key** **were** rusty.

(3) *The **key** to the ***cells*** **were** rusty.

(Bock & Miller, 1991; Wagers et al., 2009)

Agreement Attraction: **Comprehension**

- Word-by-word, speeded acceptability judgment task



(Wagers et al., 2009)

Agreement Attraction: **Grammaticality Asymmetry**

- Attractor number mattered only in ungrammatical sentences

(Wagers et al., 2009)

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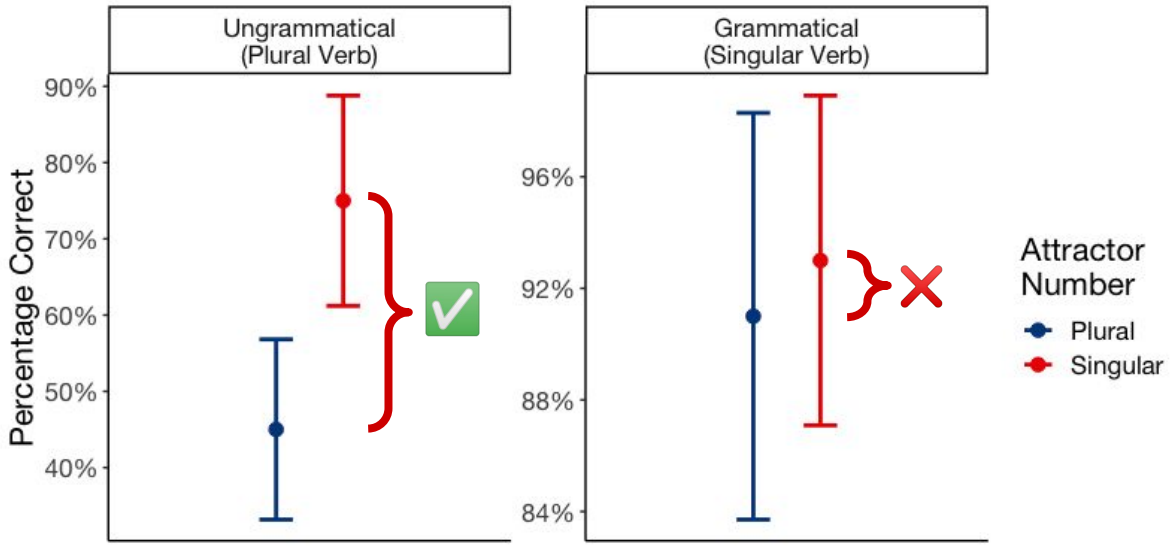
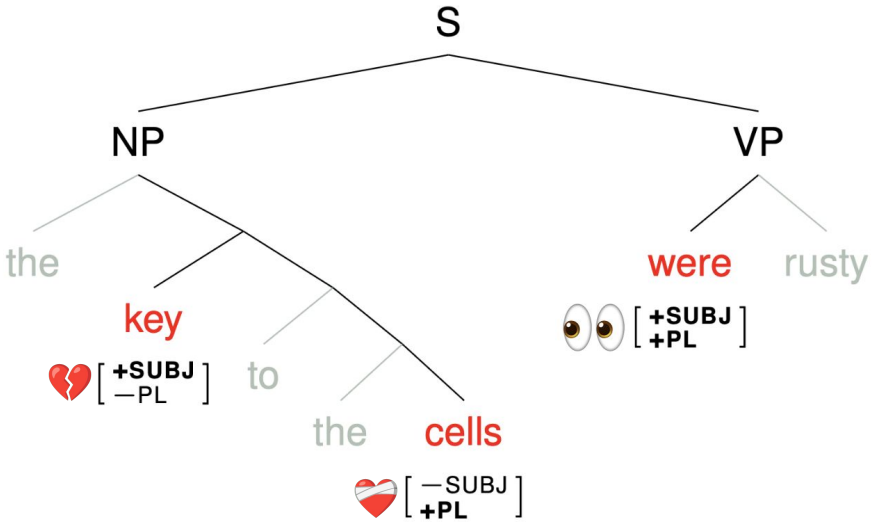
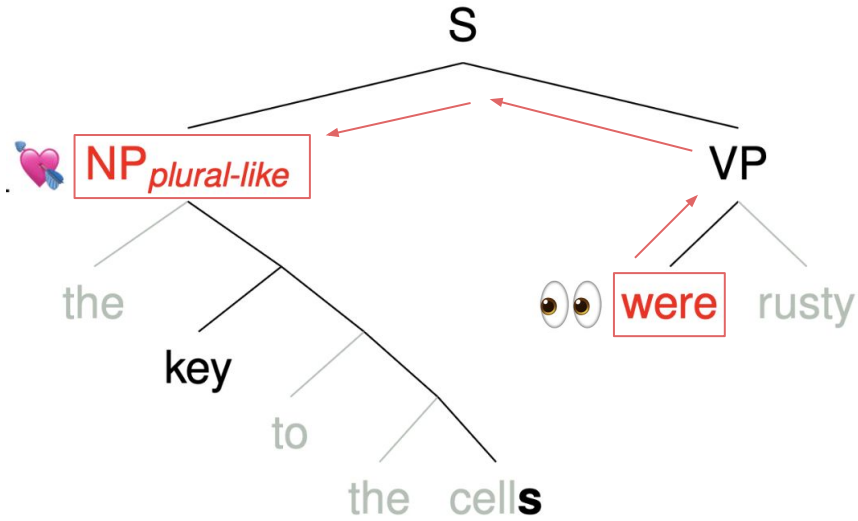


(Wagers et al., 2009)

Agreement Attraction: **Accounts**



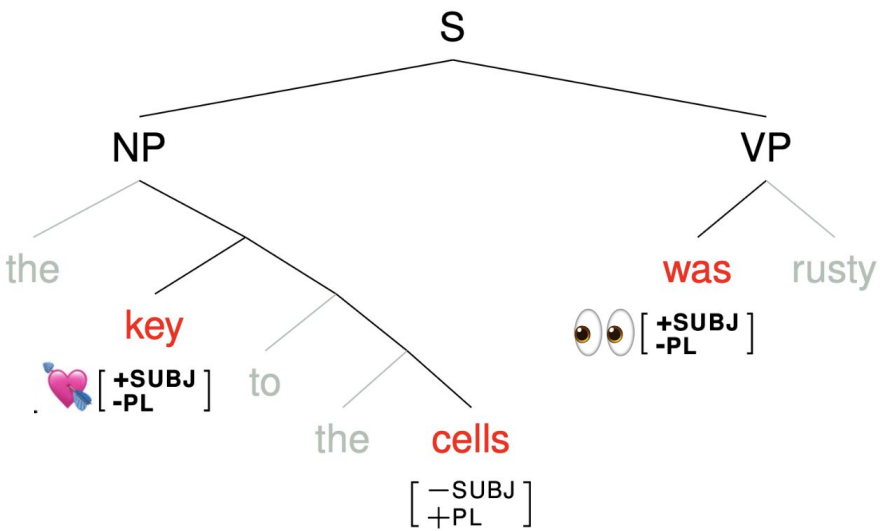
- **Retrieval:** Partial match may occasionally save the retrieval.



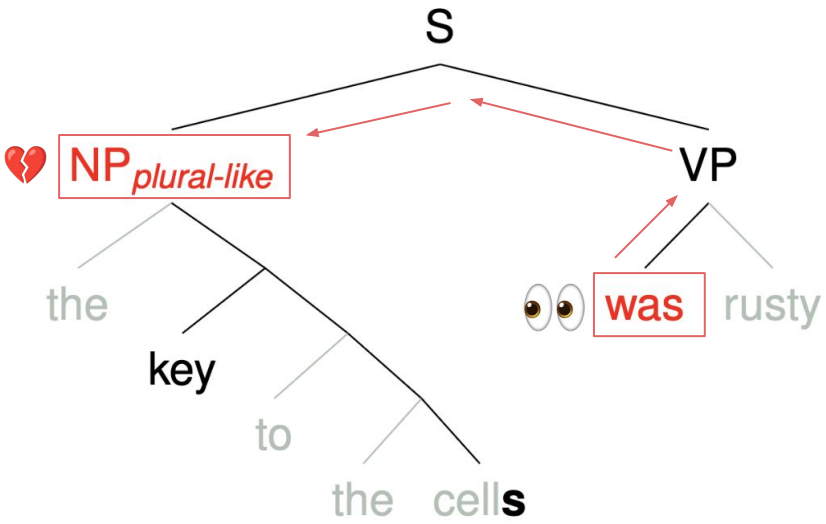
- **Representational:** probing acceptability in ungrammatical sentences

(Eberhard et al., 2005; Wagers et al., 2009; Engelmann et al., 2019; Yadav et al., 2023)

Agreement Attraction: **Accounts**



- **Retrieval:** Less interference when the true subject is a *perfect match*.



- **Representational:** probing *unacceptability* even in grammatical sentences

(Eberhard et al., 2005; Wagers et al., 2009; Engelmann et al., 2019; Yadav et al., 2023)

Roadmap

- ❏ 1. Hammerly et al. (2019) and Bias Calculation Problem
- ❏ 2. Turkish Experiment
- ❏ 3. Re-analysis of Hammerly et al. (2019)
- ❏ 4. Meta-analysis

Grammaticality Asymmetry: **Response Bias**

Hammerly et al. (2019)

- Grammaticality asymmetry does not have to favor Retrieval

(Hammerly et al., 2019)

Grammaticality Asymmetry: **Response Bias**

Hammerly et al. (2019)

- Grammaticality asymmetry does not have to favor Retrieval
- People have **a priori 'yes' bias**

(Ratcliff, 1978; Hammerly et al., 2019)

Grammaticality Asymmetry: **Response Bias**

Hammerly et al. (2019)

- Grammaticality asymmetry does not have to favor Retrieval
- People have **a priori 'yes' bias**
- When bias is reduced, both grammatical and ungrammatical sentences will show attraction effects

(Ratcliff, 1978; Hammerly et al., 2019)

Grammaticality Asymmetry: **Response Bias**

Hammerly et al. (2019)

- Manipulated bias through
  - instructions
  - ungrammatical to grammatical filler ratios

(Ratcliff, 1978; Hammerly et al., 2019)

Grammaticality Asymmetry: **Response Bias**

Hammerly et al. (2019)

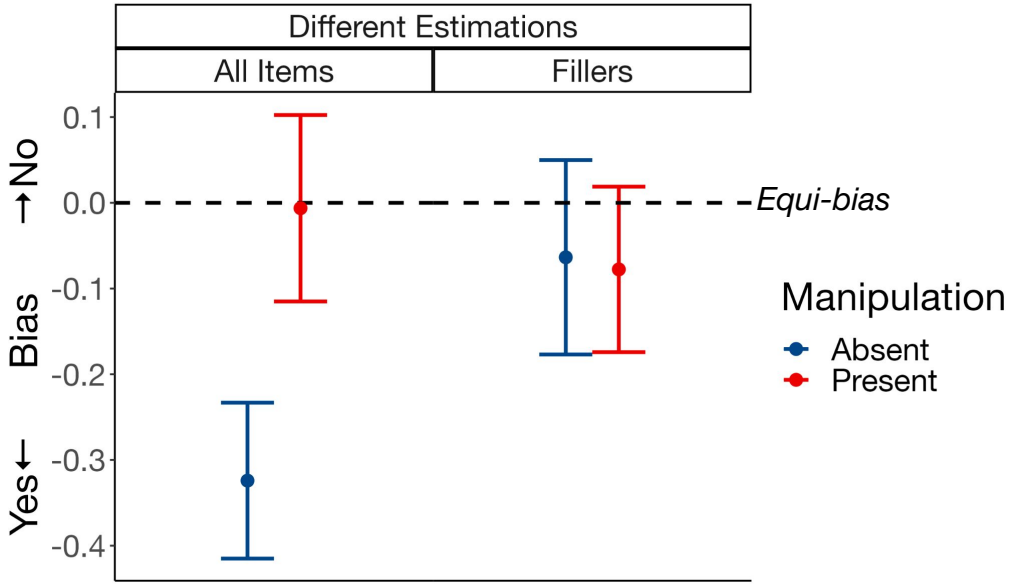
- Manipulated bias through
  - instructions
  - ungrammatical to grammatical filler ratios

- Results: Symmetrical effects independent of well-formedness.
  Thus, asymmetry is a residue of a response bias.

(Ratcliff, 1978; Hammerly et al., 2019)

Grammaticality Asymmetry: **Response Bias**

- **Problem:** They used all items in bias estimation.



(Macmillan & Creelman, 2005)

Grammaticality Asymmetry: **Why Fillers?**

- Experimental items can inflate the bias estimate

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Grammaticality Asymmetry: **Why Fillers?**

- Experimental items can inflate the bias estimate
- Bias in experimental items may tap into different mechanisms
- Indifferent to experimental manipulations
- Fillers are constant between participants
- More conservative test of the hypothesis

Roadmap

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Our Study ($N_{subject}$ = 114)

Goal: to test Hammerly et al. theoretical findings and verify bias results.

Our Study: **Experimental Items**

- Used Genitive modifier DPs as attractors (Lago et al., 2019; Turk & Logacev, 2022)

(4) [$_{DP}$ [$_{DP}$ *Milyoner-**ler**-in*] terzi-si]

millionaire-**PL**-GEN tailor-POSS

"the tailor of *the millionaires*"

Our Study: **Experimental Items**

- Ungrammaticality due to singular head and plural verb.

(5) * [$_{DP}$ [$_{DP}$ *Milyoner-**ler**-in*] terzi-si] kov-ul-du-**lar.**

millionaire-**PL**-GEN tailor-POSS fire-PASS-PST-**PL**

"the tailor of *the millionaires* were fired."

Our Study: **Experimental Items**

- Within-subject factors: *Verb x Attractor number*

(6) a. * [$_{DP}$ [$_{DP}$ *Milyoner-**ler**-in* terzi-si] tamamen gereksizce kov-ul-du-**lar**.
millionaire-PL-GEN tailor-POSS completely without_reason fire-PASS-PST-PL
"The tailor of *the millionaires* were fired for no reason at all."

b. * *Milyonerin* terzisi tamamen gereksizce kovuldu**lar**.

c. *Milyoner**ler**in* terzisi tamamen gereksizce kovuldu.

d. *Milyonerin* terzisi tamamen gereksizce kovuldu.

(Lago et al., 2019)

Our Study: **Bias**

- Between subjects factor: Bias.

- Manipulated bias through
  - instructions
  - ungrammatical to grammatical filler ratios

(Hammerly et al., 2019)

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- No bias difference between groups

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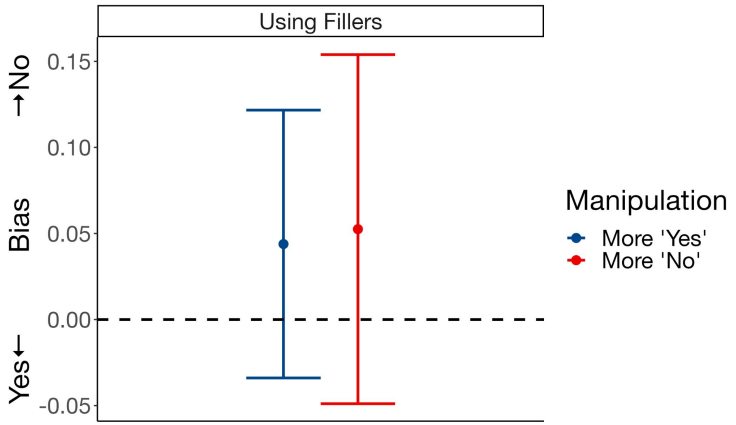
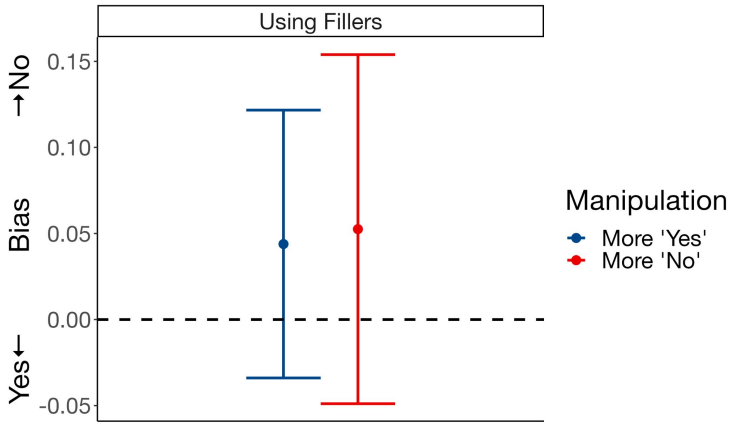


(Macmillan & Creelman, 2005; Hammerly et al., 2019)

Our Study: **Bias**

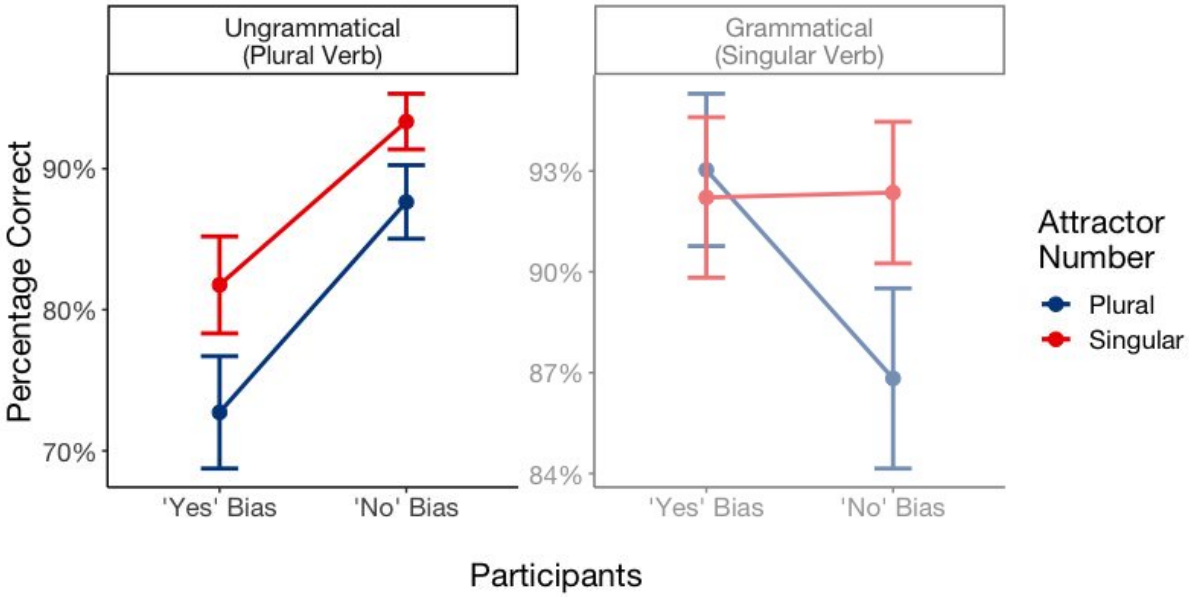
- Between subjects factor: Bias.
- Manipulated bias through
  - instructions
  - ungrammatical to grammatical filler ratios
- No bias difference between groups
- Exploited the individual bias differences



(Macmillan & Creelman, 2005; Hammerly et al., 2019)

Our Study: **Results**

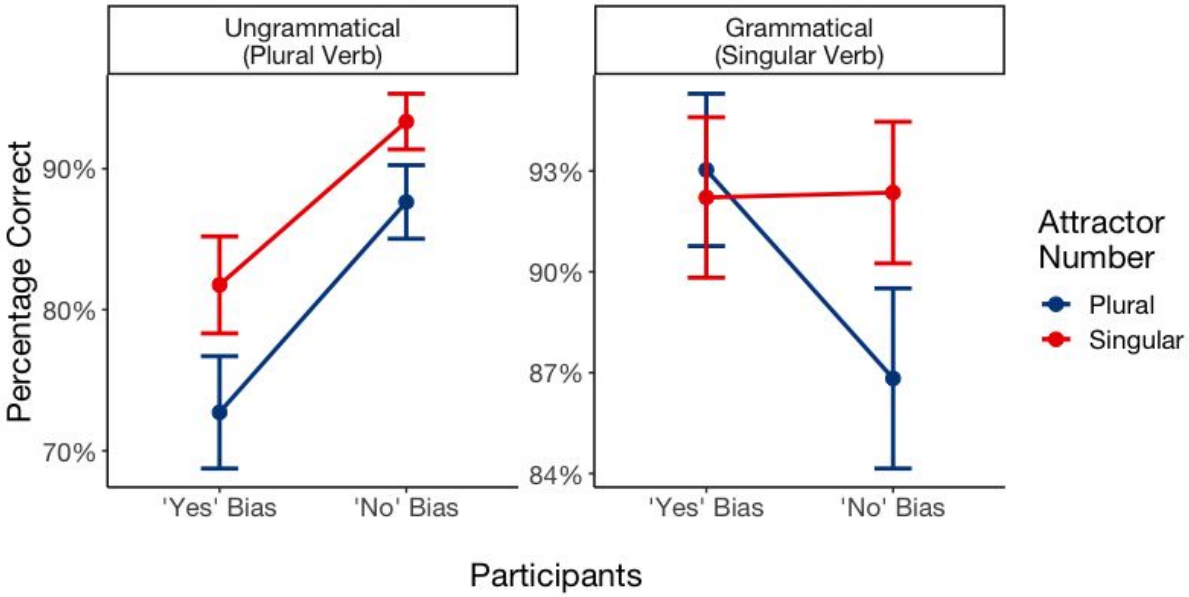
- Attraction in ungrammatical sentences independent of response bias



(Cousineau, 2005; Morey, 2008)

Our Study: **Results**

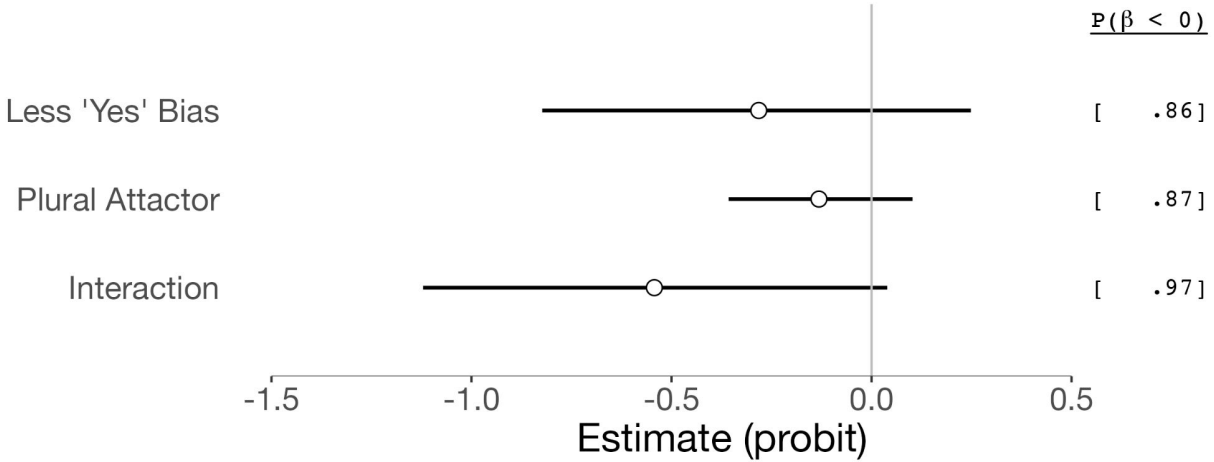
- Attraction in **grammatical** sentences as a function of bias



(Cousineau, 2005; Morey, 2008)

Our Study: **Bayesian Model**

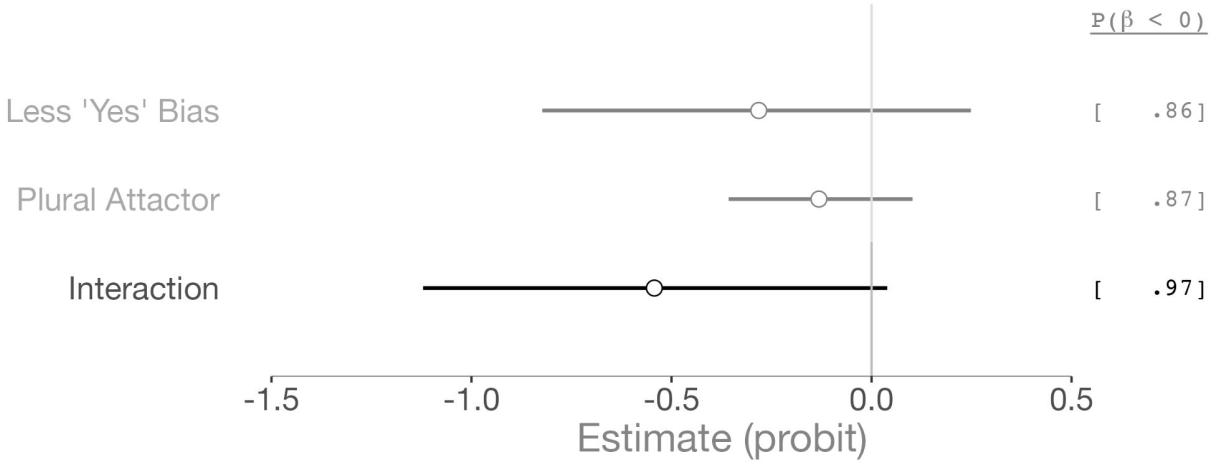
- Verified our results with a maximal Bayesian GLM.
  - Fitted to **grammatical** sentences
  - No main effect of PLURAL ATTRACTOR
  - P(INTERACTION < 0) = 0.97



(Gelman & Hill, 2007; Barr et al., 2013; Nicenboim & Vasishth, 2016; Kruschke, 2018)

Our Study: **Bayesian Model**

➔ The effect of plural attractor is more pronounced in people with less “yes” bias in grammatical sentences



(Gelman & Hill, 2007; Barr et al., 2013; Nicenboim & Vasishth, 2016; Kruschke, 2018)

Our Study: **Findings**

- Replicated theoretically significant findings of Hammerly et al.

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- Grammaticality asymmetry can be explained via response bias

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- Replicated theoretically significant findings of Hammerly et al.
- Grammaticality asymmetry can be explained via response bias
- No need for a strong preference of retrieval accounts

Roadmap

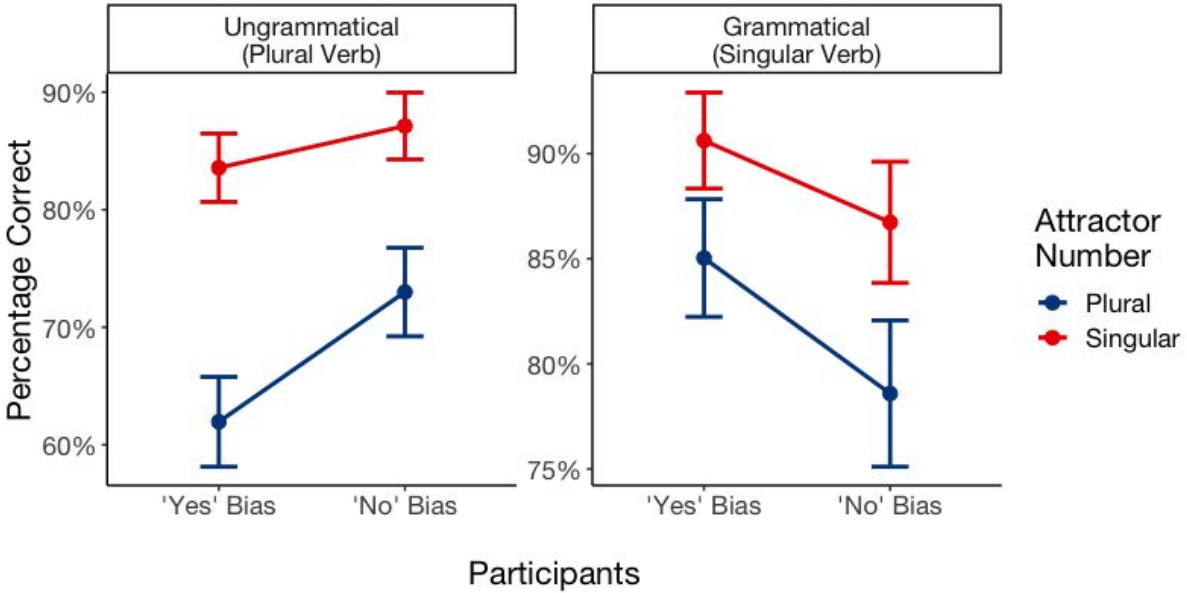
- ✔ 1. Hammerly et al. (2019) and Bias Calculation Problem
- ✔ 2. Turkish Experiment
- ❑ 3. Re-analysis of Hammerly et al. (2019)
- ❑ 4. Meta-analysis

Reanalysis of Hammerly et al. (2019)

- Grouped participants according to their bias in fillers

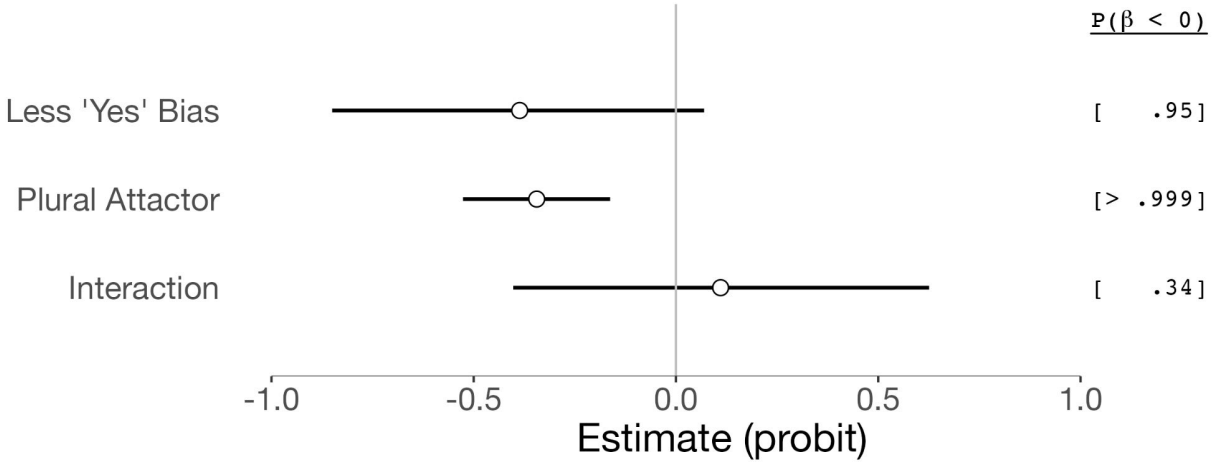
Reanalysis of Hammerly et al. (2019): **Results**

- Grouped participants according to their bias in fillers
- Attraction in both grammatical and ungrammatical sentences **independent of response bias**



Reanalysis of Hammerly et al. (2019): **Bayesian Model**

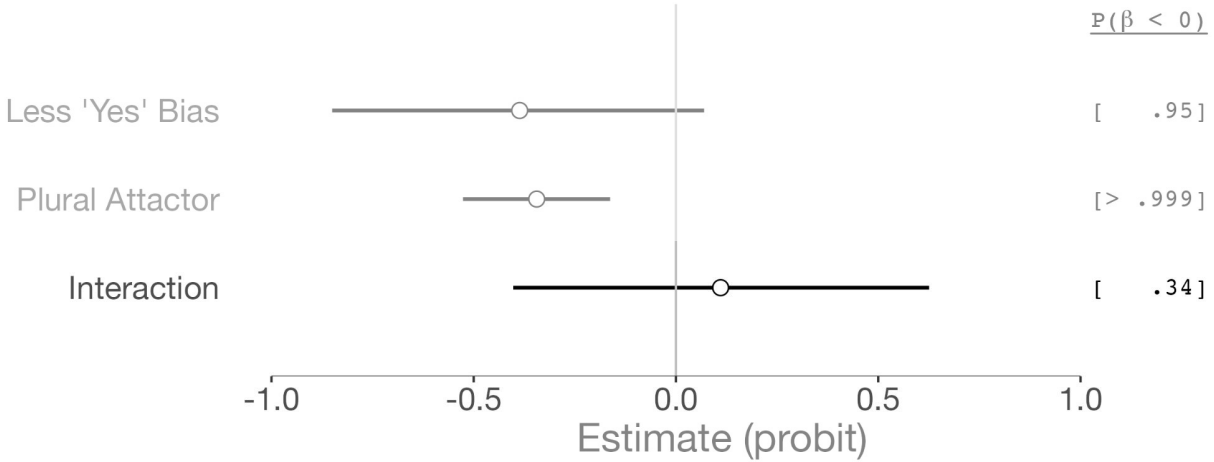
- Verified lack of bias effect with a maximal Bayesian GLM.
  - Fitted to **grammatical** sentences
  - Clear main effect of PLURAL ATTRACTOR, $P(\beta < 0) > 0.999$
  - No interaction, $P(\text{INTERACTION} < 0) = 0.34$



(Gelman & Hill, 2007; Barr et al., 2013; Nicenboim & Vasishth, 2016; Kruschke, 2018)

Reanalysis of Hammerly et al. (2019): **Bayesian Model**

➔ Having weaker “yes” bias did not affect the contribution of the plural attractor



(Gelman & Hill, 2007; Barr et al., 2013; Nicenboim & Vasishth, 2016; Kruschke, 2018)

Reanalysis of Hammerly et al. (2019): **Findings**

- Attraction in grammatical sentences surfaces even with “yes” bias
- Different reflex of bias according to the manipulation
- Original findings may not reflect participants’ a priori bias

Roadmap

✔ 1. Hammerly et al. (2019) and Bias Calculation Problem

✔ 2. Turkish Experiment

✔ 3. Re-analysis of Hammerly et al. (2019)

❑ 4. Meta-analysis

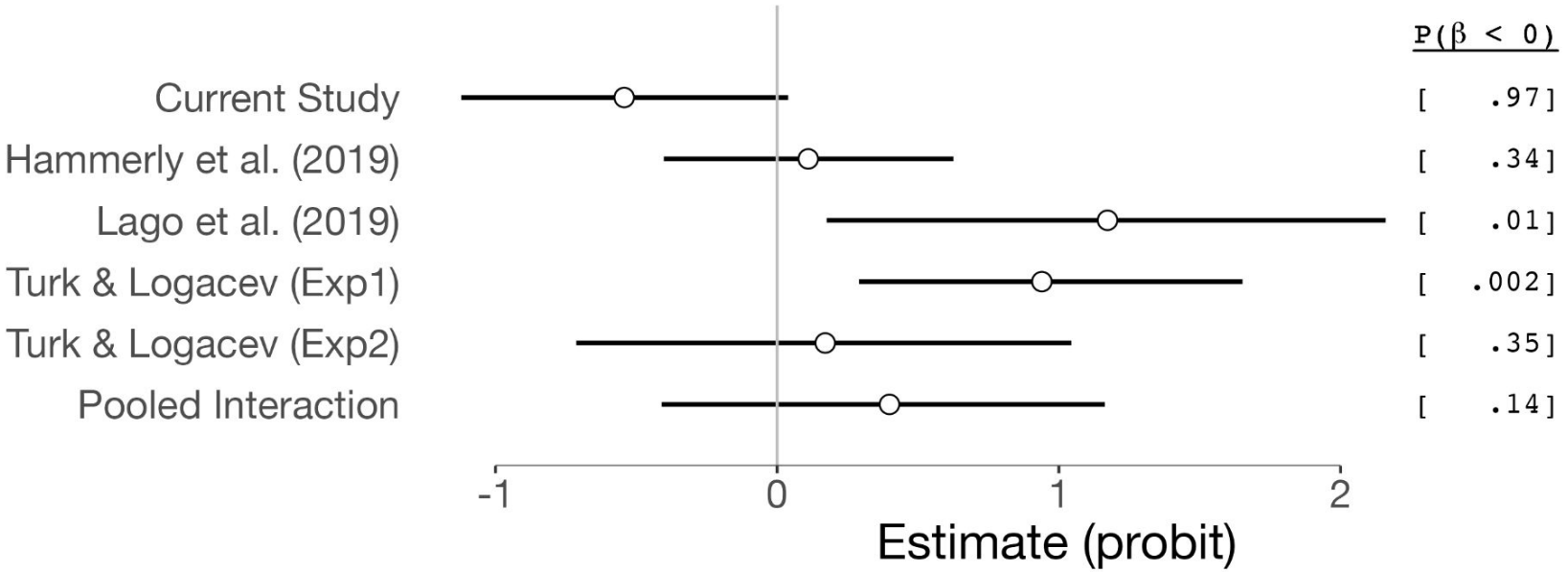
Meta-analysis: **Bayesian Model Details**

- What about other experiments without bias manipulation?

  - Conducted a multilevel Bayesian meta-analysis
  - Fitted to correct responses to **grammatical** sentences
  - Predictors:
    - Experiments, subjects, and items as random effects
    - Bias Value (calculated using fillers)
    - Attractor Number
    - The interaction
    - Trial number

(Berkey et al., 1998; Gelman & Hill, 2007; Gleser & Olkin, 2009; Konstantopoulos, 2011)

Meta-analysis: **By-experiment Interaction Posteriors**



➔ Cannot say grammaticality asymmetry reflects response bias, it sometimes does.

(Gelman & Hill, 2007; Barr et al., 2013; Nicenboim & Vasishth, 2016; Kruschke, 2018)

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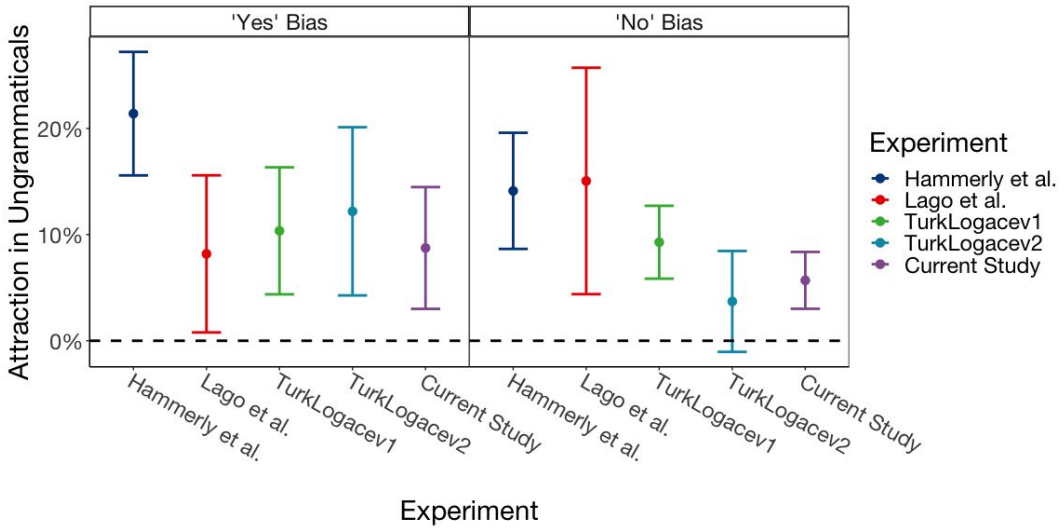
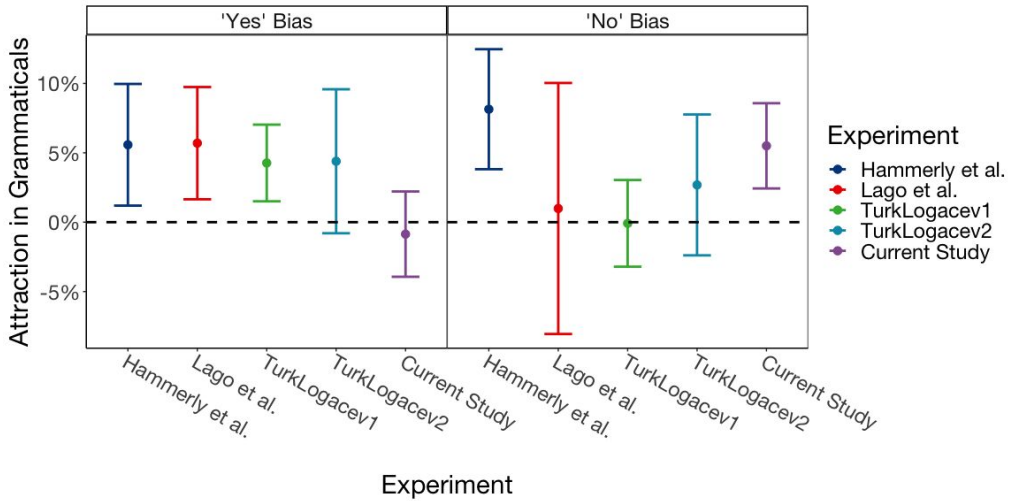
Findings

- The effect in ungrammatical sentences: **Persistent**



Findings

- The effect in ungrammatical sentences: **Persistent**
- The effect in grammatical sentences? **Finicky**



Take-Home Messages

- Asymmetry is still important.

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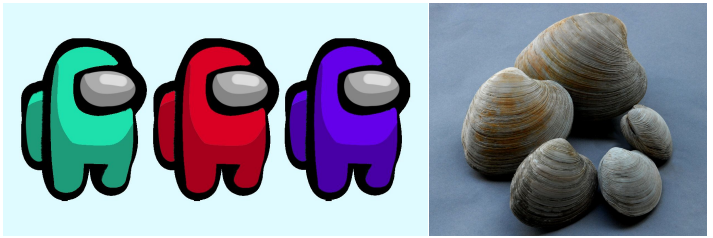
- Asymmetry is still important.
- Retrieval accounts handle our findings more graciously.

Special Thanks


Colin Phillips


Ellen Lau


Brian Dillon


my UMD cohort *SUS CLAMS*

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Language at Maryland

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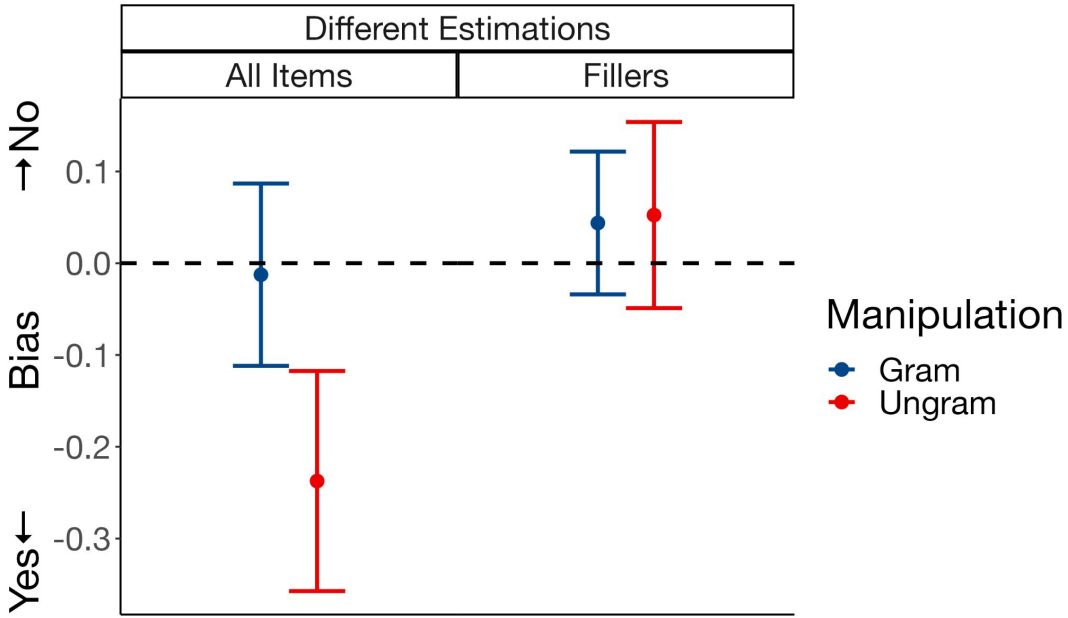
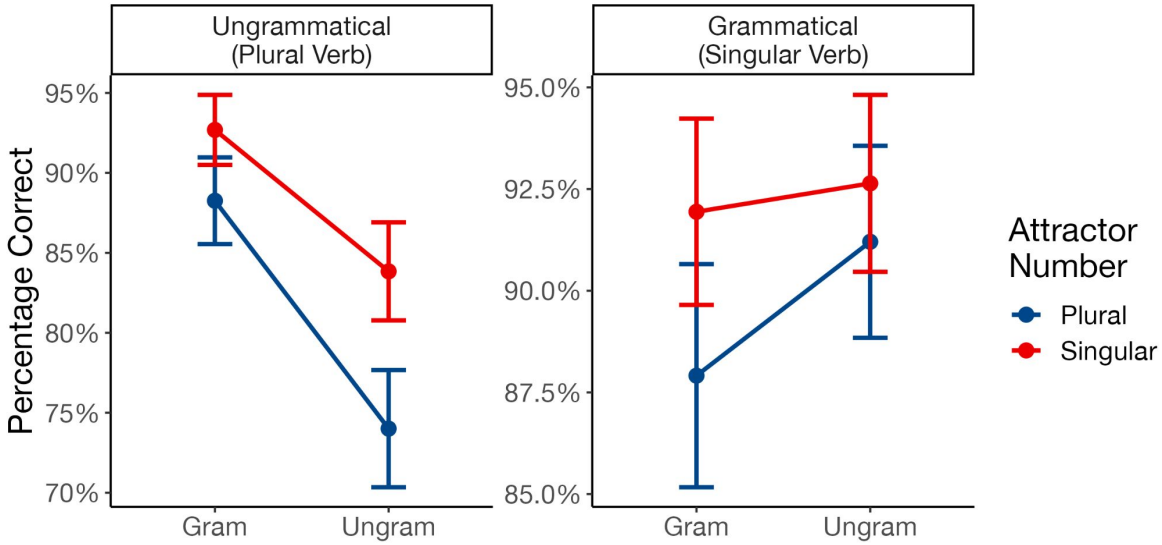
Appendix A: Our Exp with Different Bias Estimations

- In “Towards Ungrammatical” Bias, we had more ‘yes’ bias.



Appendix B: Our Exp with Original Manipulation Grouping

- Even when we look at “Ungram” as more ‘yes’ bias,
  and “Gram” as equi-bias, our results do not follow from bias-informed theories



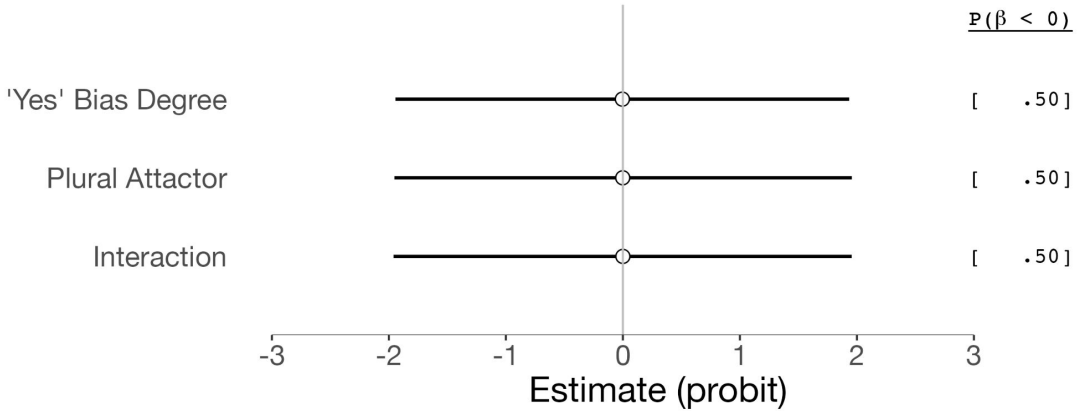
Appendix C: Model Specifications

- Packages: `cmdstanr` and `brms`
- Priors: Agnostic Priors

$$\text{Intercept} \sim Normal(0,1)$$
$$\beta \sim Normal(0,1)$$
$$\sigma \sim Normal(0,1)$$
$$\rho \sim LKJ(2)$$

- Sum contrast coding

Bias is continuous, no coding.
+0.5 for Plural Attractor
-0.5 for Singular Attractor
(+0.5 for Ungrammatical)
(-0.5 for Grammatical)



Appendix C: Model Specifications

- Formula & Predictors:
  - Continuous Response Bias Value
  - Attractor Number
  - The interaction
  - Trial Number (log)

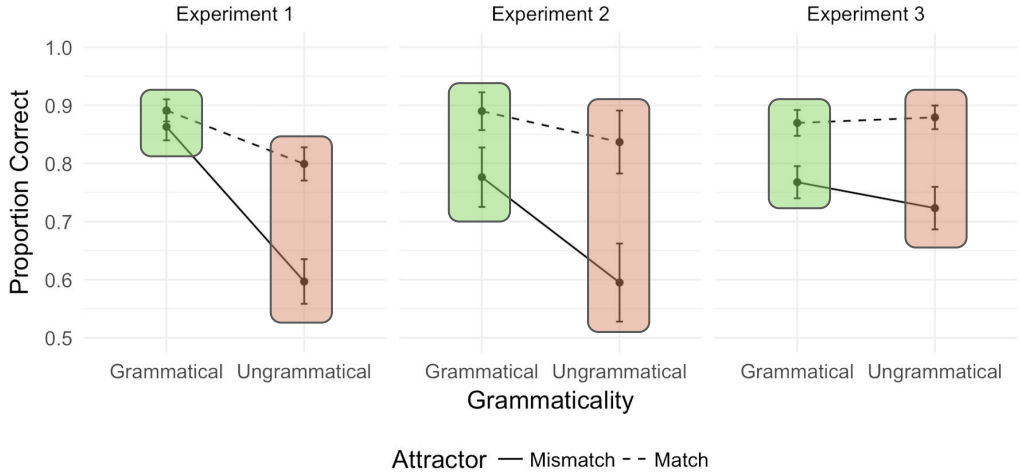
```
response_yes ~ bias * attractor_number + log_trial +
                    (bias * attractor_number + 1 | subject) +
                    (attractor_number + log_trial + 1 | item)
```

Appendix D: Bias Estimations

- How to calculate bias?

$$-\frac{Z(\text{Hit Rate}) + Z(\text{False Alarms})}{2}$$

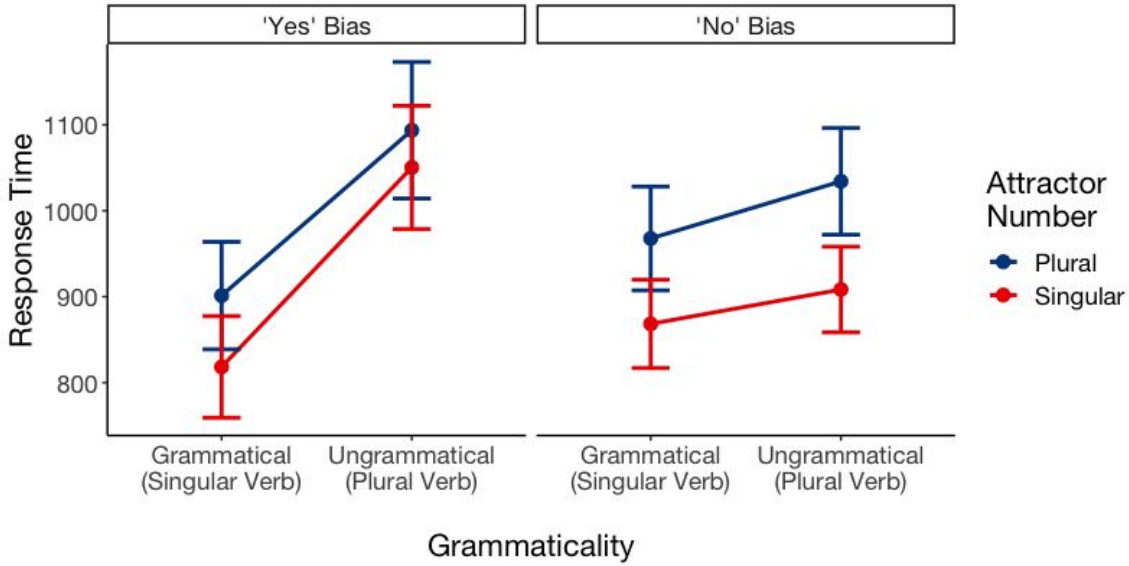
- What happens when we use ALL Items?



(Macmillan & Creelman, 2005)

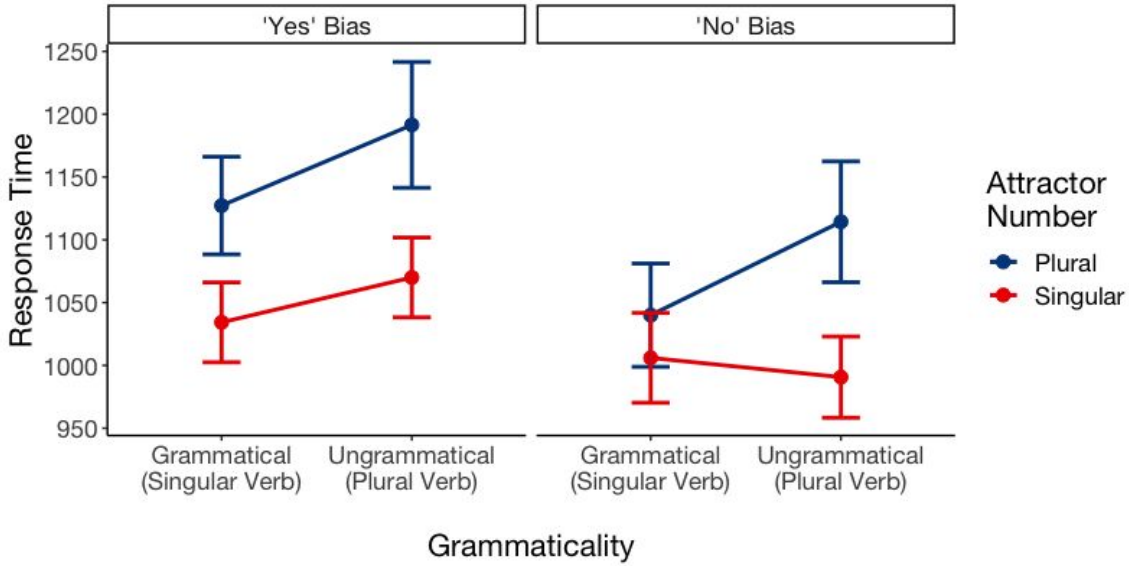
Appendix E: RTs?

- What do we see in vanilla attraction experiments?
  - Overall slowdown for ungrammaticals
  - Additional slowdown for plurals in ungrammaticals
- What does bias-informed analysis expect?
  - No slowdown for ungrammaticals
  - Same contribution from plurals in both grammatical and ungrammatical



Appendix E: RTs?

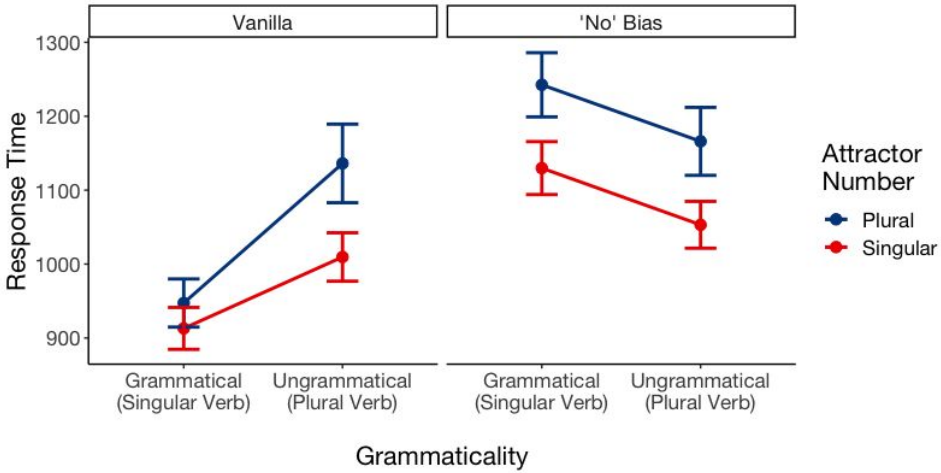
- Our experiment RTs close to prediction, but not quite.
- Hammerly et al's? RTs look close to the prediction as well.



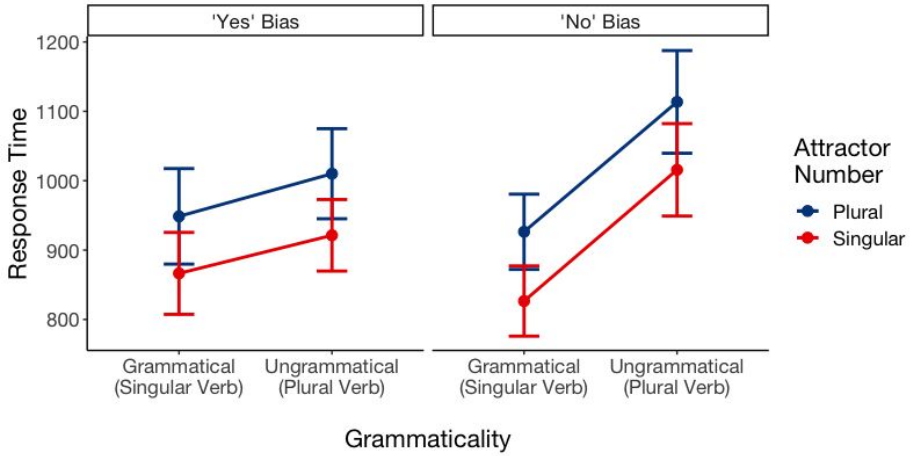
Appendix E: RTs?

- Maybe our bias estimation is actually not good?
  - Hammerly bias(all) predictions ✅
  - Our bias(all) predictions ❌
- Their bias estimation: Their Acceptability & RT ✅, Our Acceptability & RT ❌
- Our bias estimation: Their Acceptability & RT ❌, Our Acceptability & RT ✅

Hammerly et al.

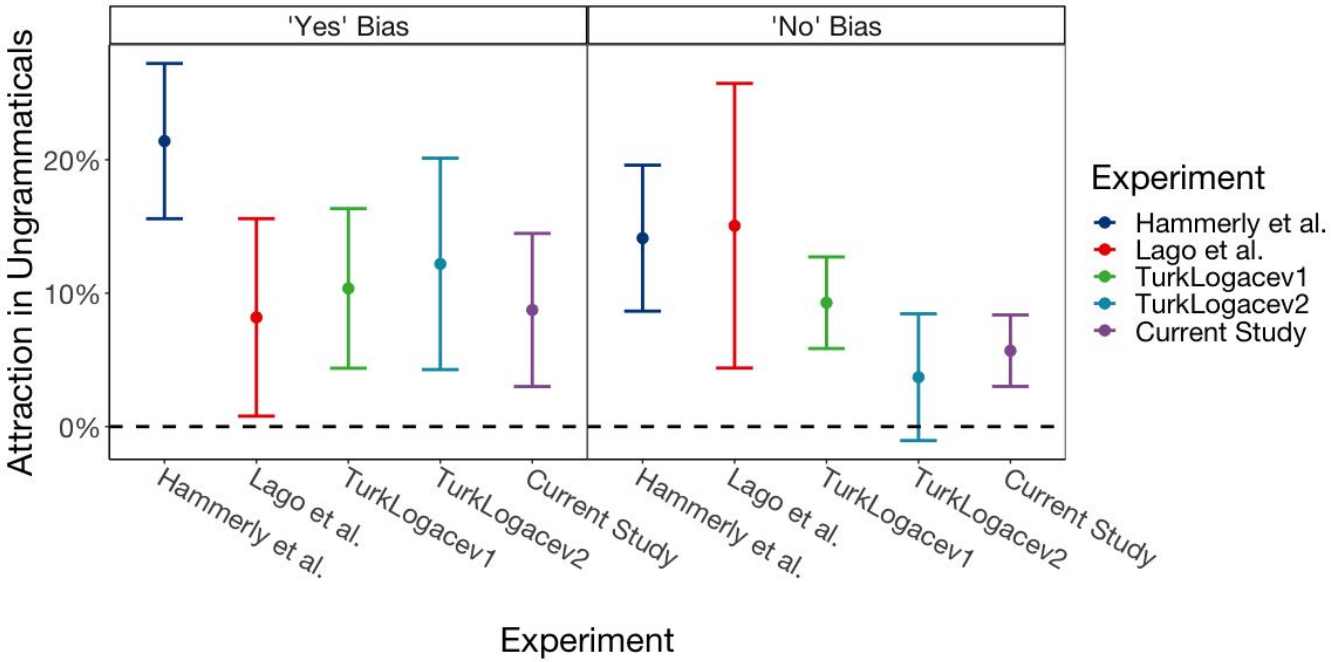


Our Experiment



Appendix F: Stable Attraction in Ungrammaticals

- Attraction effects are persistent in ungrammatical sentences.
  - independent of response bias and experiment.



Appendix G: Finicky Attraction in Grammaticals

- Attraction effects vary in grammatical sentences.