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Understanding Changes in Garden-Paths as Expectation Expectation

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Background

More than processing: there is suggestive evidence that comprehenders implicitly learn during comprehension [1,2], sometimes within the course of a single experiment [3]

However, explicit computational models of adaptation have been lacking (but see [4])

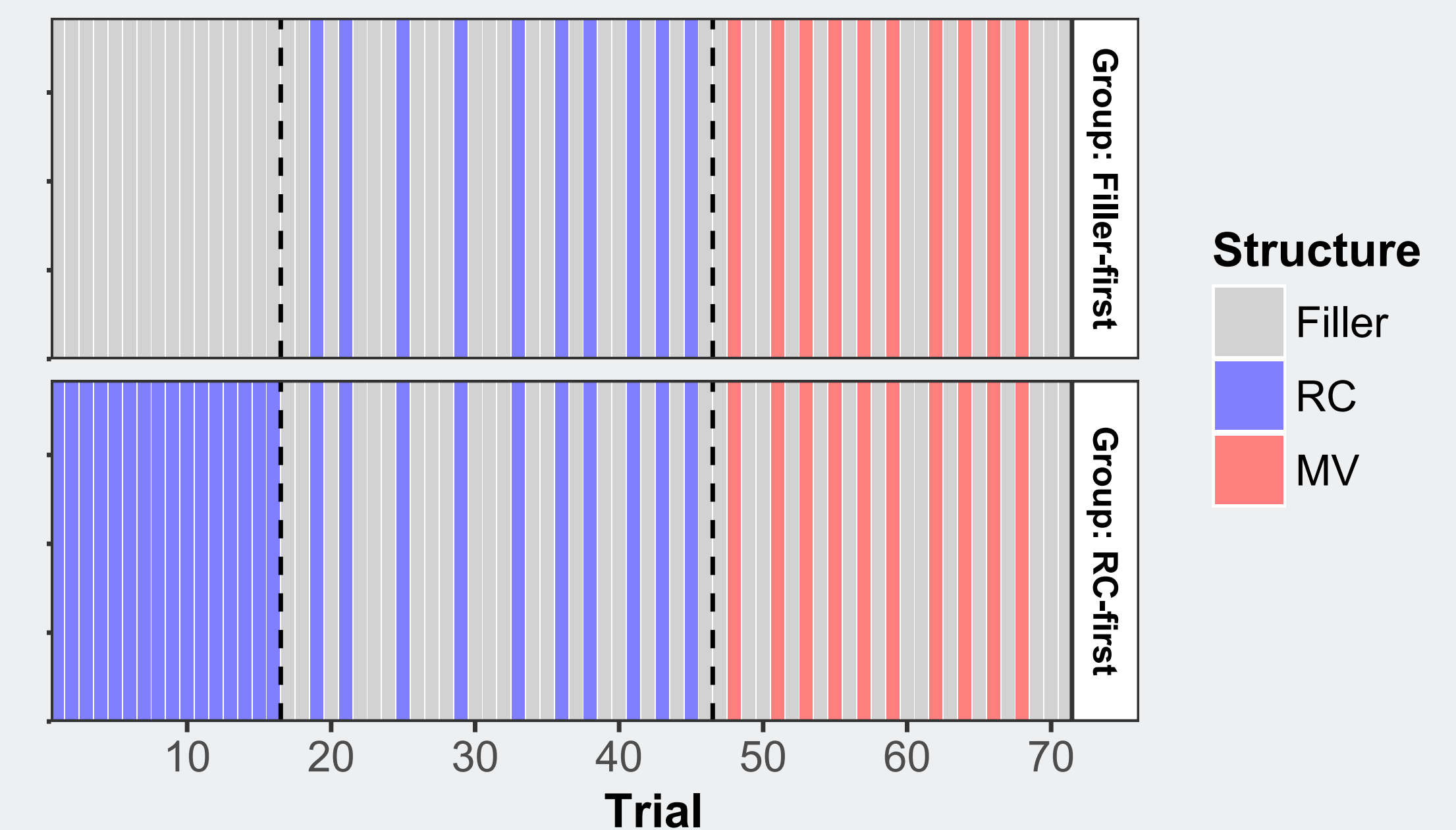
Our contributions: (1) Develop & test a Bayesian belief-updating model that captures the theoretical predictions of expectation adaptation; (2) infer comprehender's probabilistic beliefs
→ prior beliefs inferred match production statistics

Datasets

Two experiments on the **Relative Clause (RC)/Main Verb (MV)** ambiguity
→ Fine et al. (2013)
→ Harrington Stack et al. (2018)

Both used between-subjects designs with more or less exposure to **RCs**
→ Harrington-Stack et al. doubled number of items in each block

Design of Fine et al. (2013)



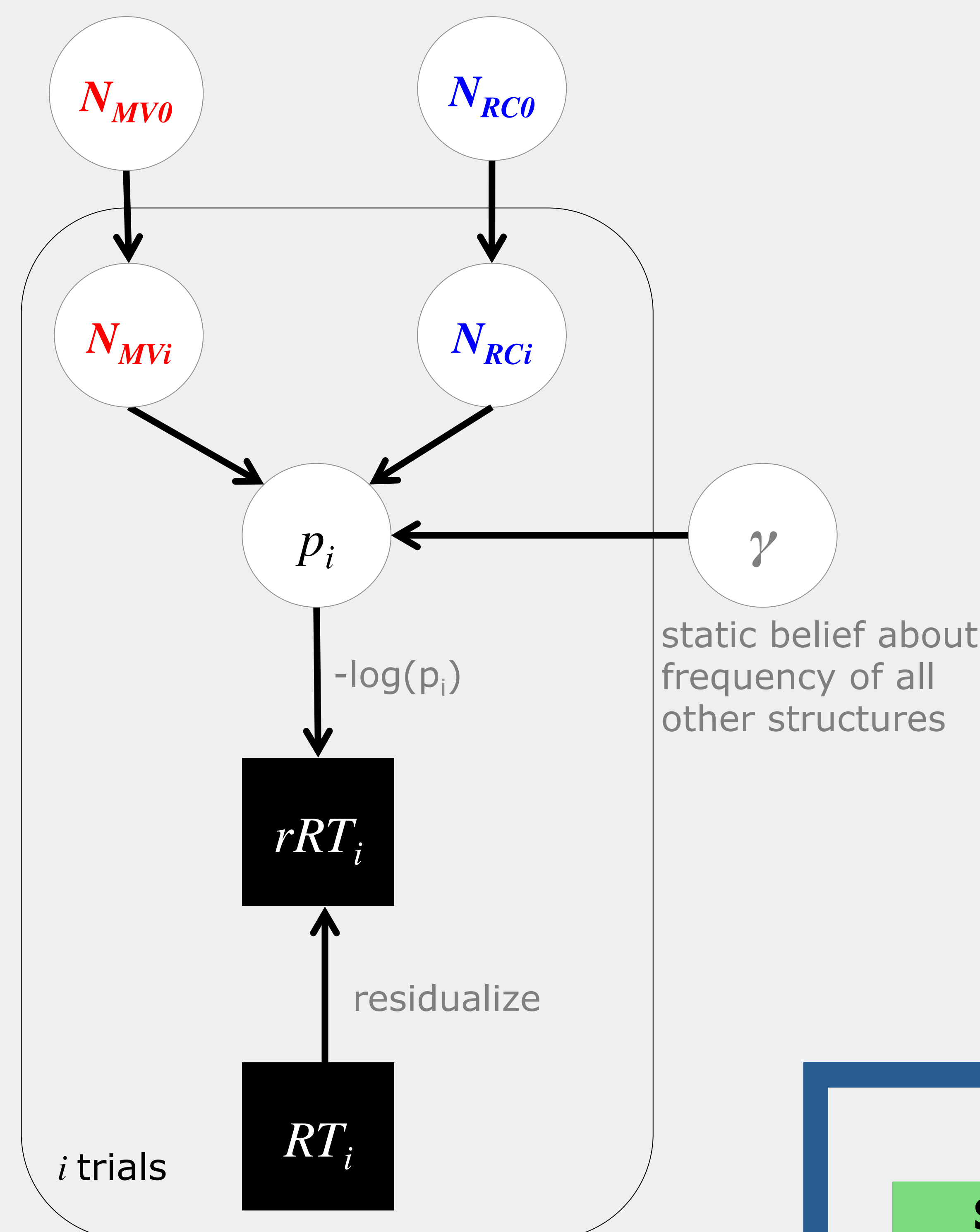
A Simple Beta-Binomial Belief Updating Model

prior belief about the frequency of structural alternatives

current belief about frequency

current belief about relative probability of each structure

link to residualized reading time of current sentence



Residualization Model

$$\log(RT_{\text{Fillers}}) \sim s(\text{Trial}) + s(\text{Word Length}) + (s(\text{Word Length}) + s(\text{Trial}) \mid \text{Subject})$$

fit to only filler trials to avoid overfitting

non-linear smooth over trial controls for theoretically irrelevant task adaptation

Conclusions & Future Work

Surprisal from beta-binomial model fits the data fairly well
→ But many of the other factors still matter, namely main effects of trial, structure, group, etc

Inferred prior strength relatively low
→ suggests listeners come into an experiment with looser prior expectations

Future work

Test with different structures
→ clearest evidence would come from enough adaptation to elicit a garden path in the a priori more frequent structure
→ suggestive evidence here that that's unlikely to happen within a single experiment, at least for MV/RC ambiguity

References & Acknowledgments

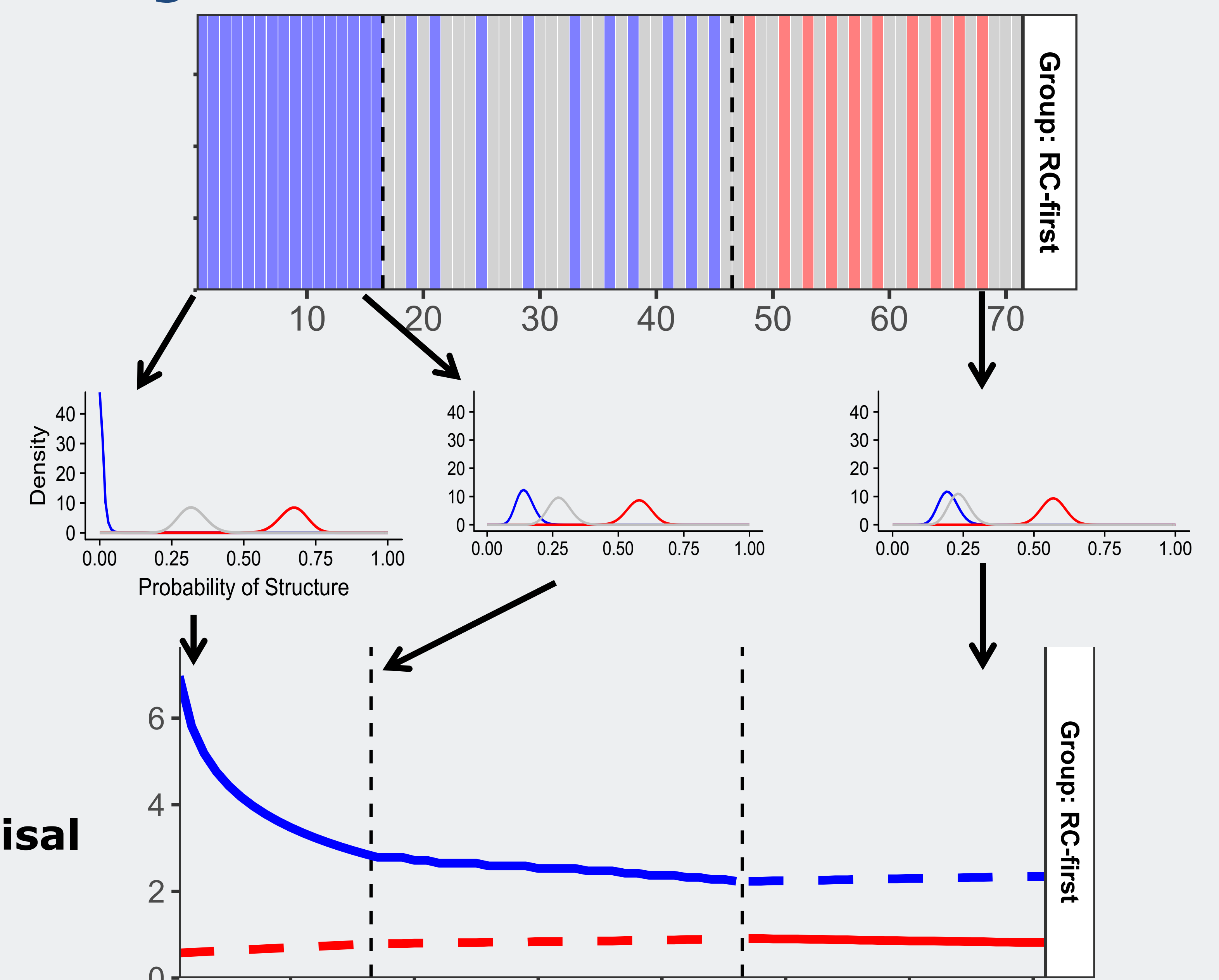
[1] Chang, Dell, & Bock (2006) Psych Review; [2] Wells et al 2009 Cog Psych; [3] Fine et al 2013 Plos One; [4] Fine et al 2010 CogSci Proceedings; [5] Harrington Stack et al 2018 Mem & Cognition [6] Roland et al 2007 JML

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Observations

Belief Updating

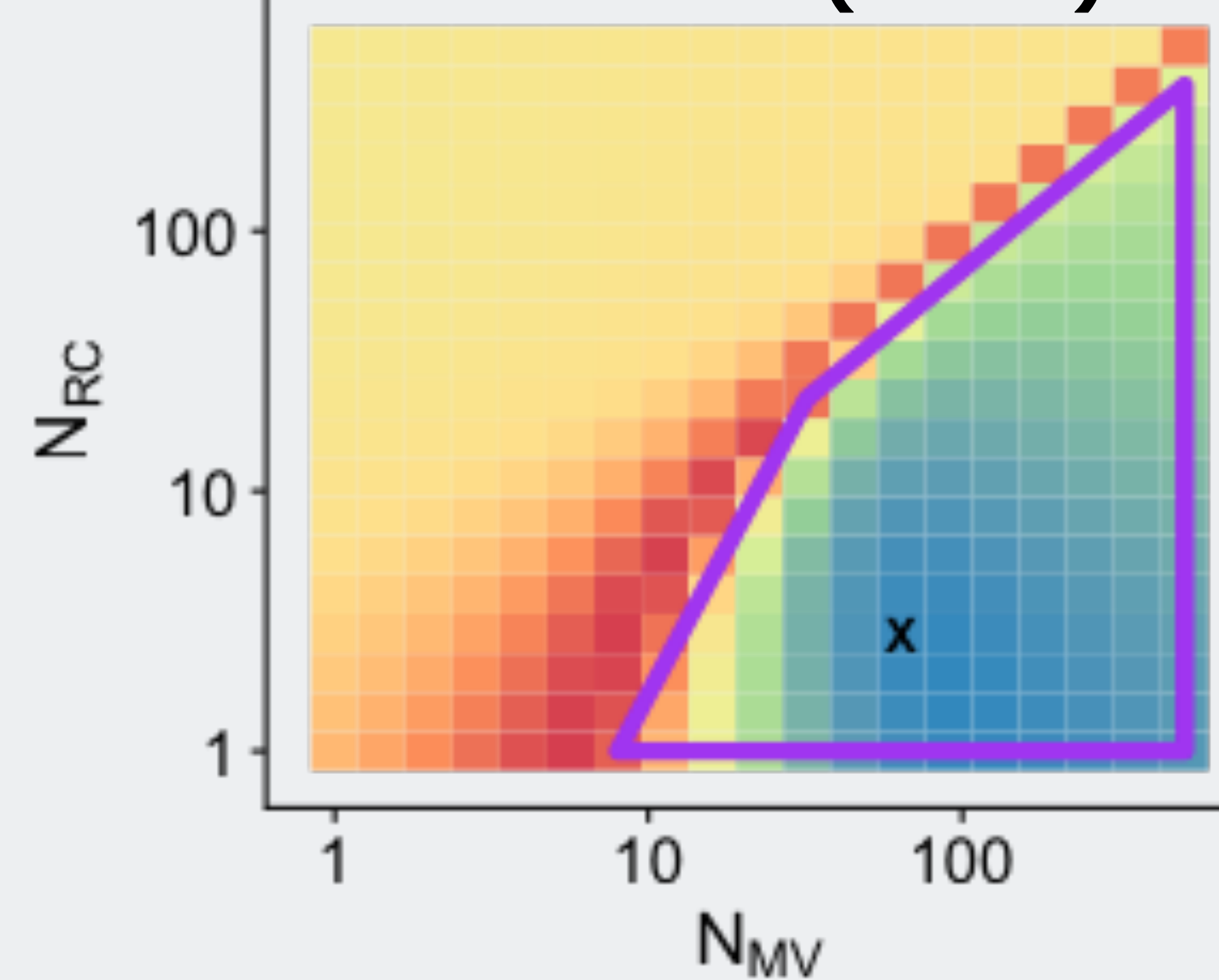
Resulting Surprisal



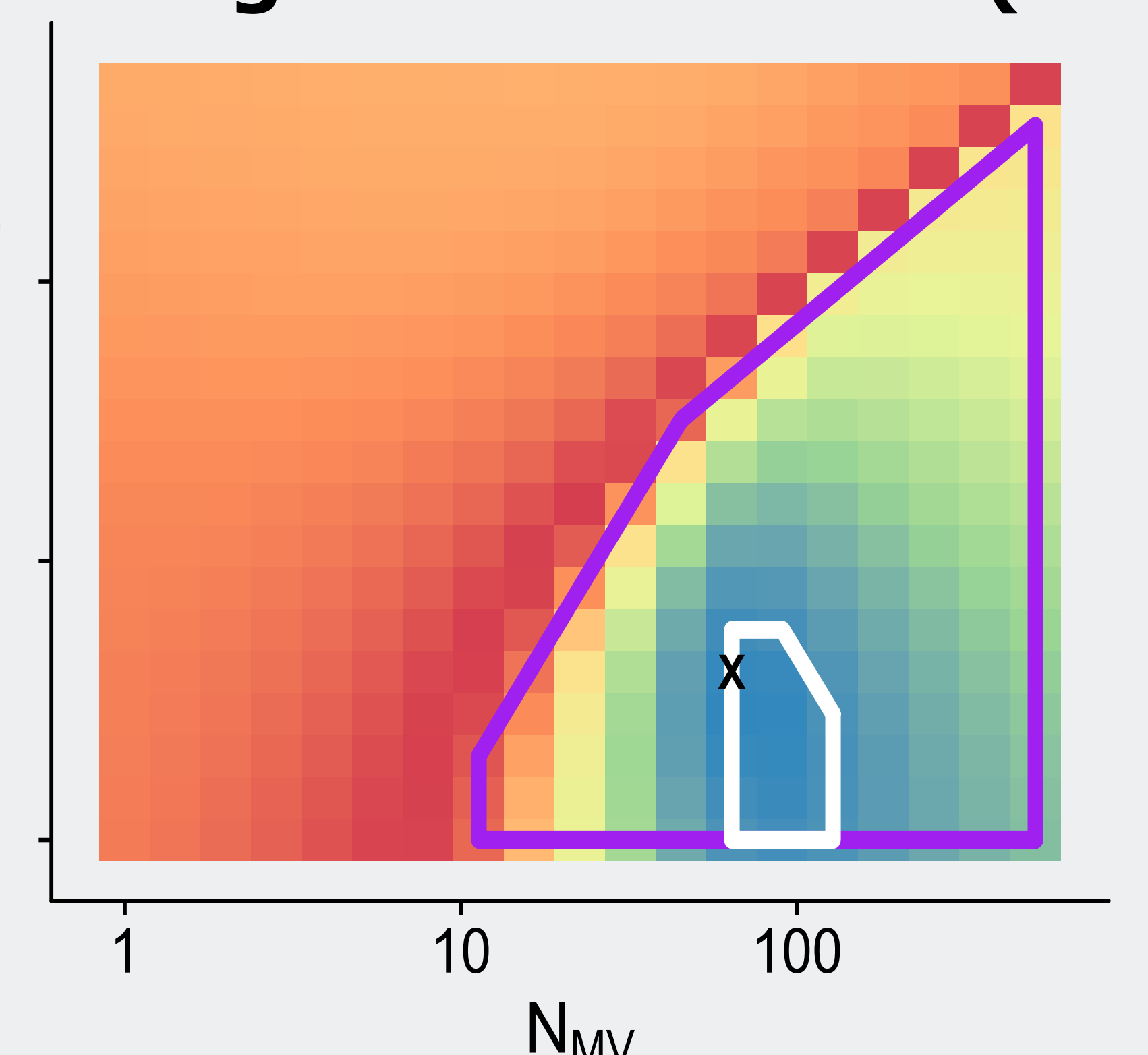
Results

Surprisal and surprisal x ambiguity both contribute over and above control factors for a wide range of prior beliefs
Best-fitting priors close to what we would expect from production probabilities [6]

Fine et al. (2013)



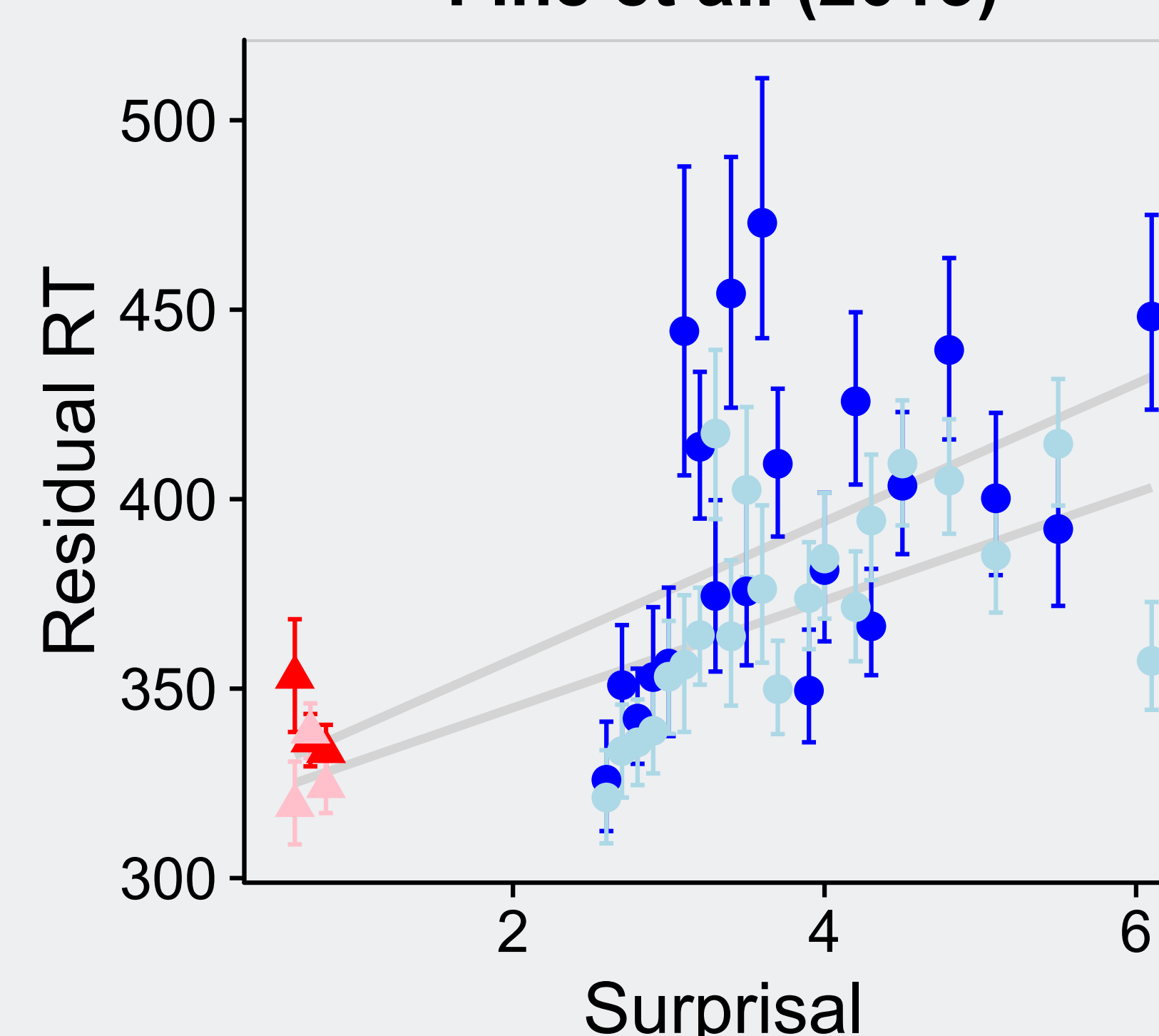
Harrington Stack et al. (2018)



— surprisal and surprisal x ambiguity significant in the correct direction — beta-binomial model performs better than non-linear control model X best fit

Data broadly follows theoretical predictions

Fine et al. (2013)



Harrington Stack et al. (2018)

