Long-term memory guides resource allocation in working memory

Allison Bruning and Jarrod A. Lewis-Peacock

Department of Psychology, Center for Learning and Memory, University of Texas at Austin

Lewis-Peacock Lab

1 INTRODUCTION

Background

Working memory resources are flexible but limited

- We are capable of giving unequal attention to items during both encoding and maintenance[1,2,3].

- This flexibly allows for more optimal use of the limited resources of working memory by minimizing errors[4,5].

Variable precision
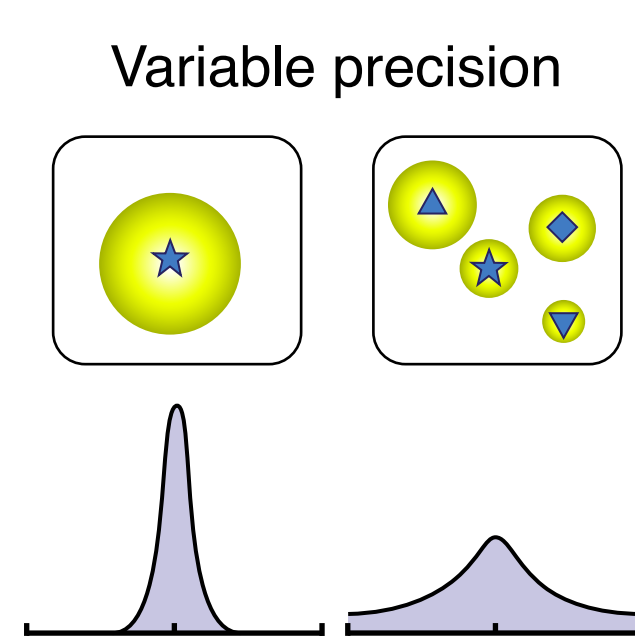
Working memory is influenced by multiple sources of information

- Behavioral relevance[5]
- Uncertainty[6]
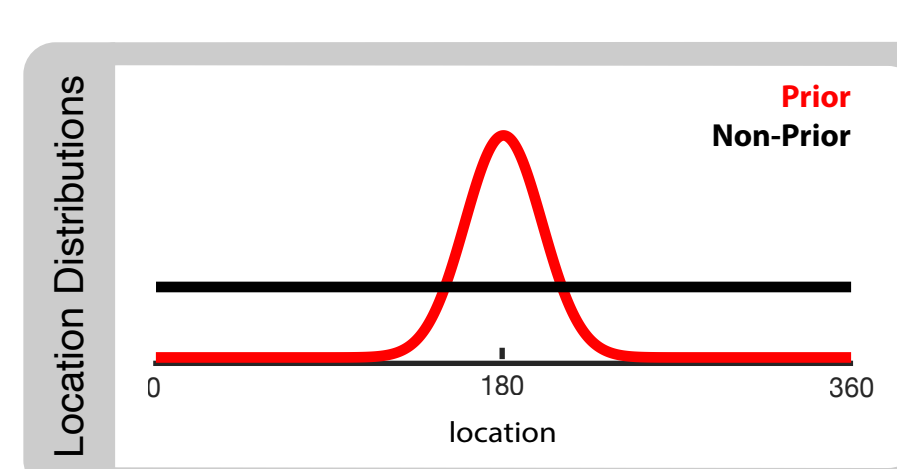- Long-term memory
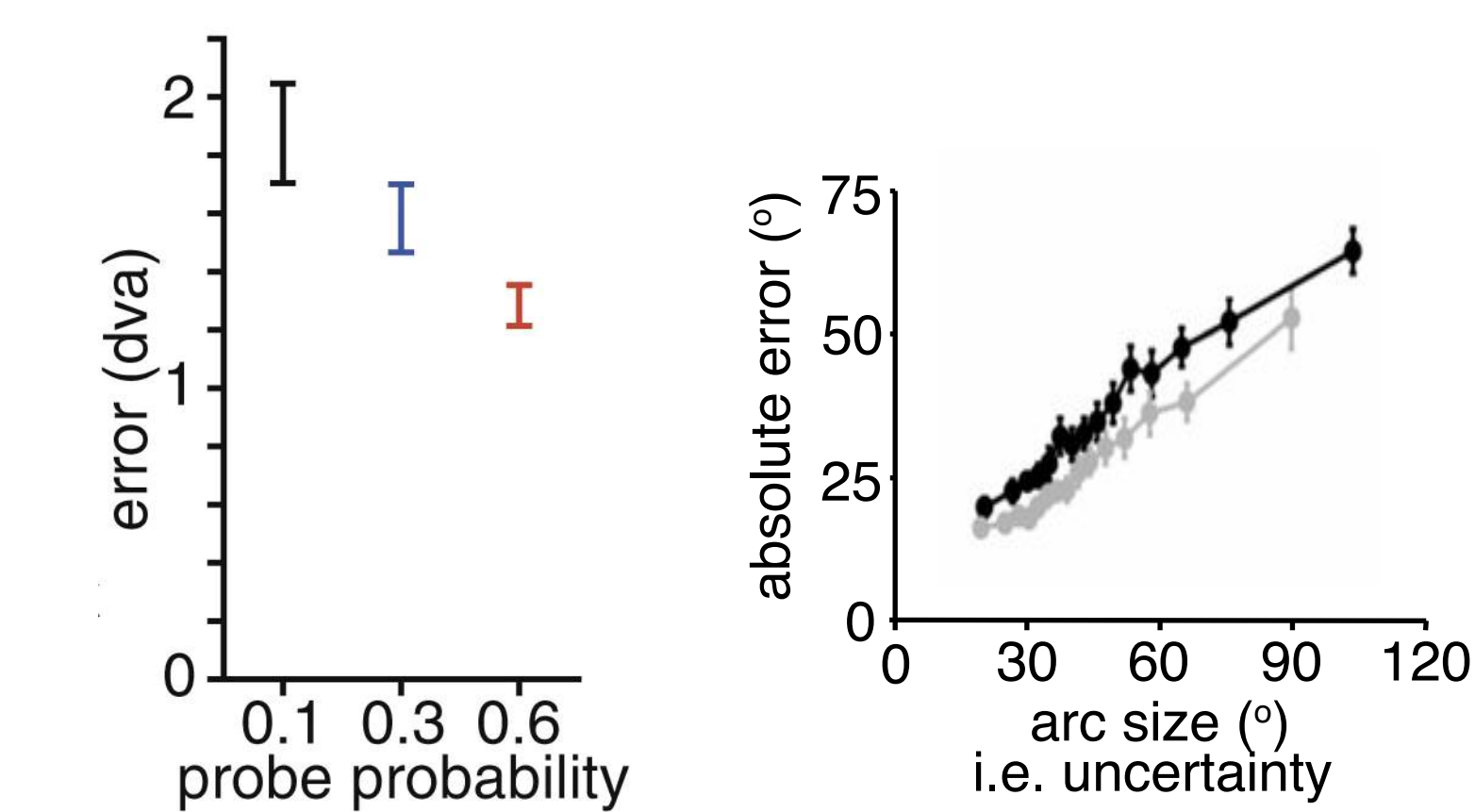
RESEARCH QUESTION

— Do participants use goal relevant long-term memory information and how does it influence allocation of working memory resources?
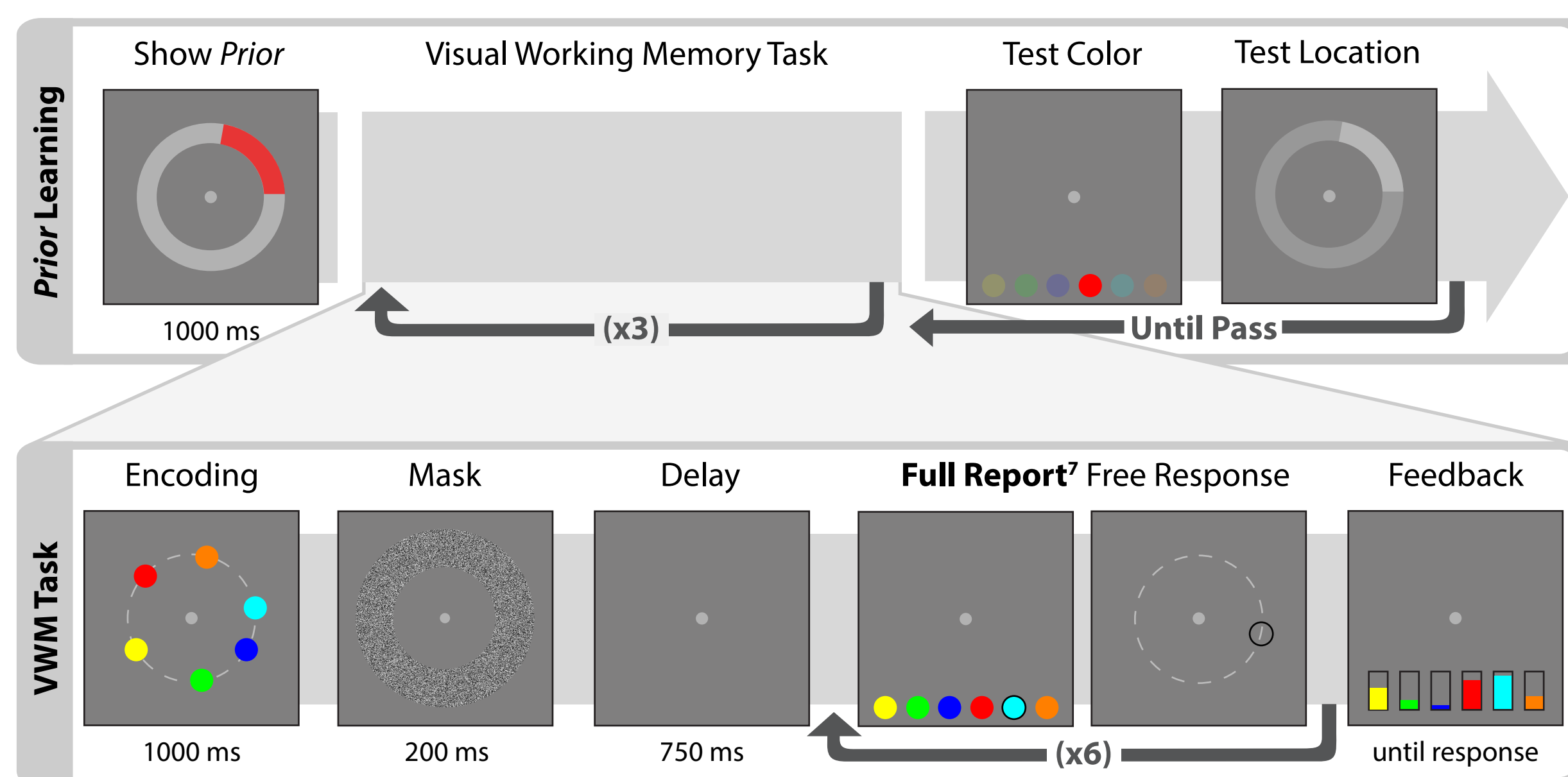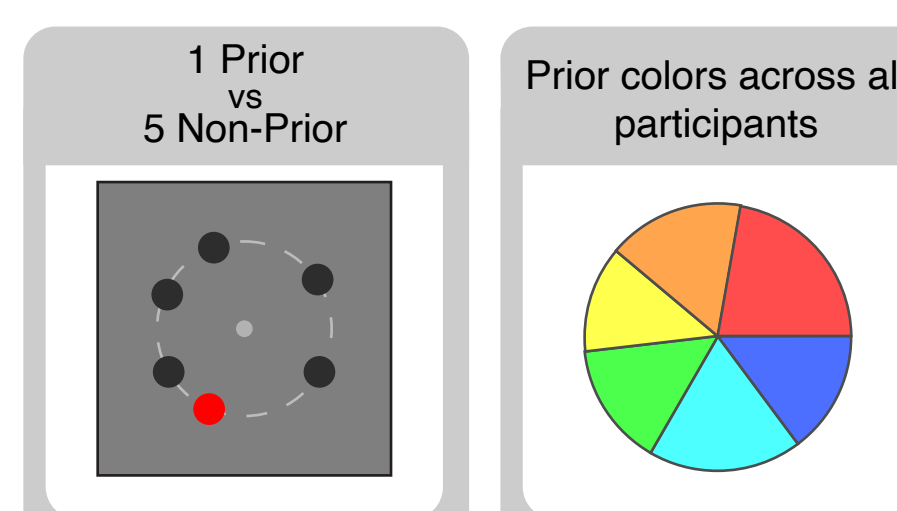
Hypothesis

In order to reduce errors, participants will prioritize encoding items with no LTM information and rely on prior knowledge to make educated guesses

2 EXPERIMENTAL DESIGN

Prior vs Non-Prior


*Color and location randomized across participants

1 Prior vs 5 Non-Prior | Prior colors across all participants

Prior Learning — Show *Prior* | Visual Working Memory Task | Test Color | Test Location | 1000 ms | (x3) | Until Pass

VWM Task — Encoding | Mask | Delay | Full Report[7] Free Response | Feedback | 1000 ms | 200 ms | 750 ms | (x6) | until response

*Prior was shown once during training and remained constant throughout the experiment
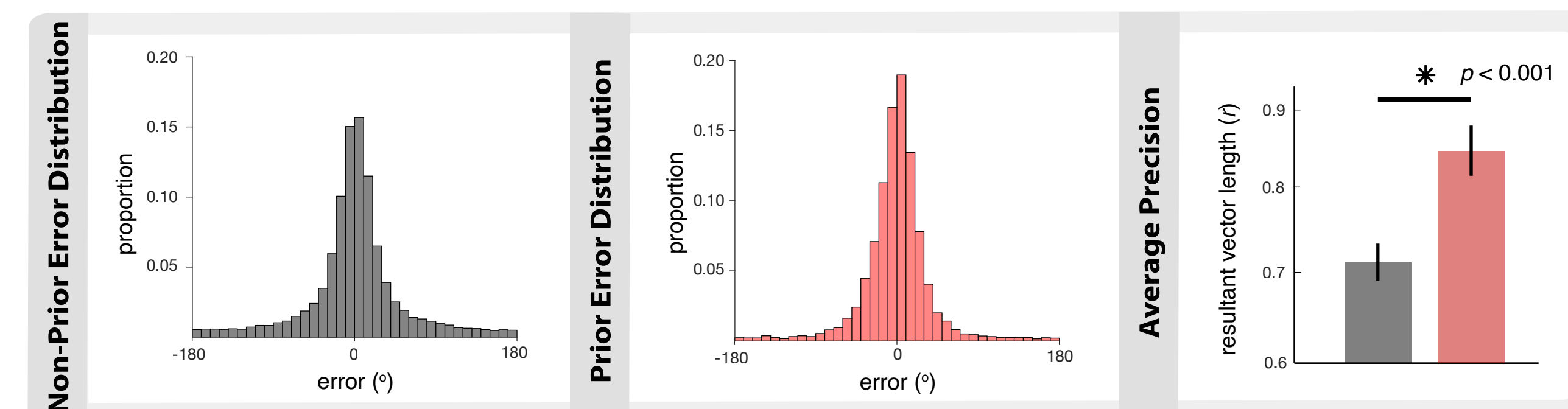
Knowledge of the prior

Location checks of Prior

- Participants were asked to report the center of the prior distribution at the end of each block of trials

*aggregate across all participants
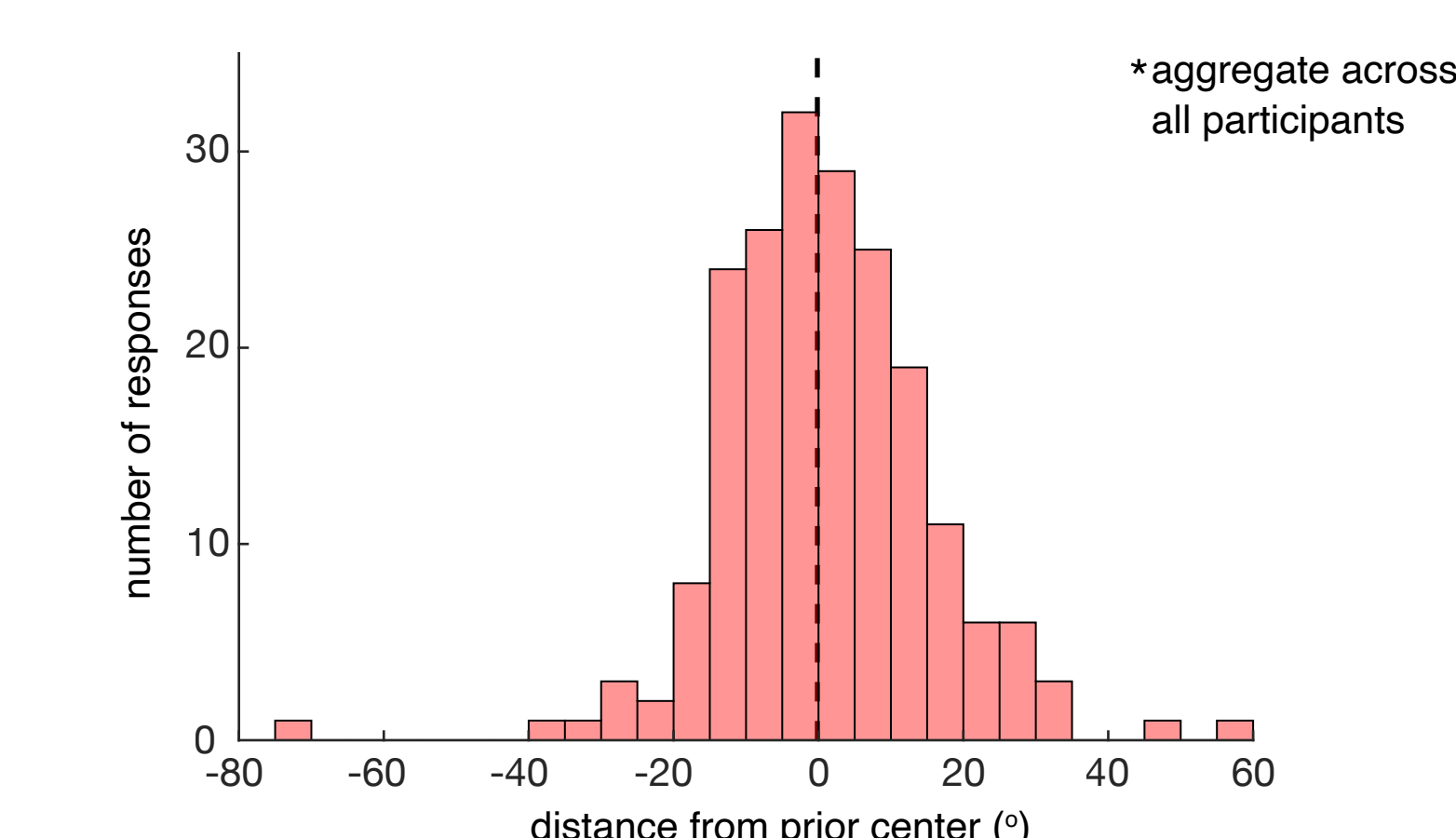

3 BEHAVIORAL RESULTS | *N* = 54

Participants use prior information

Non-Prior responses have greater error

$p < 0.001$

**Difference in error only present in the late responses**

— Following previous work, participants report items in order of highest precision to lowest[7]

— Prior items have greater resistance to degrading due to the prior information allowing for educated guesses

Response 1 | Response 2 | Response 3 | Response 4 | Response 5 | Response 6

Prior | Non-Prior | * $p < 0.001$
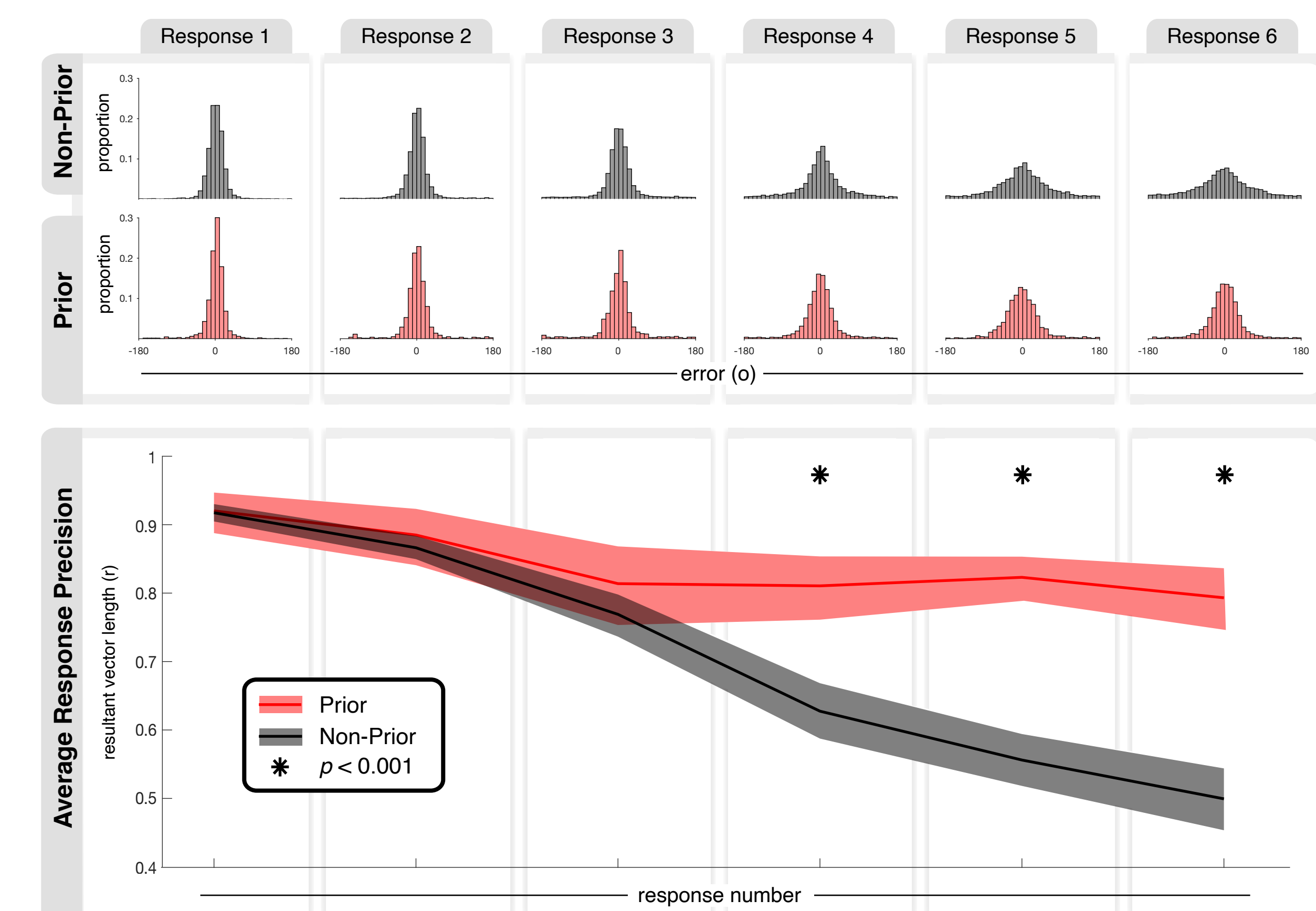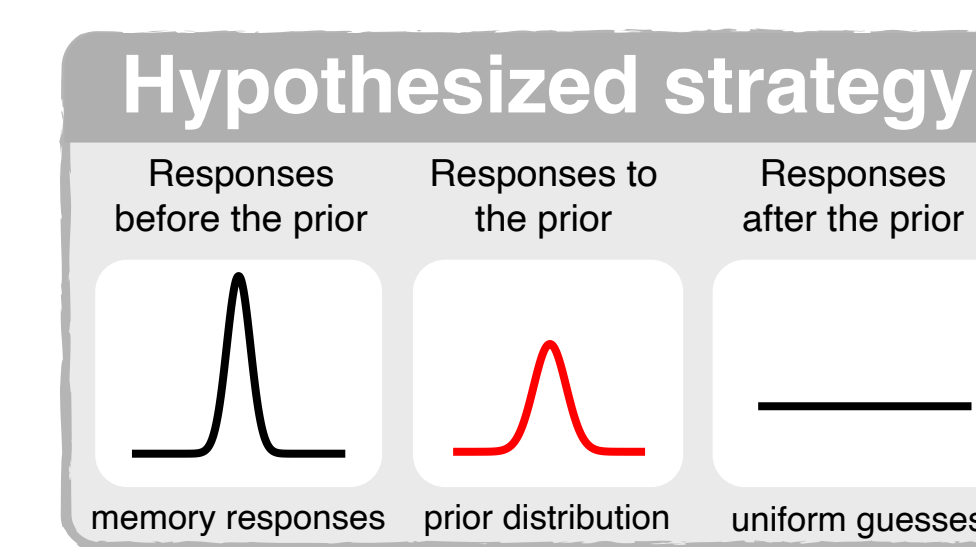
Participants report items in strategic order

Prior item response order is non-uniform

— Reporting prior items later indicates participants are prioritizing resources for non-prior items


Chance | $\chi = 319.55$; $p < 0.001$
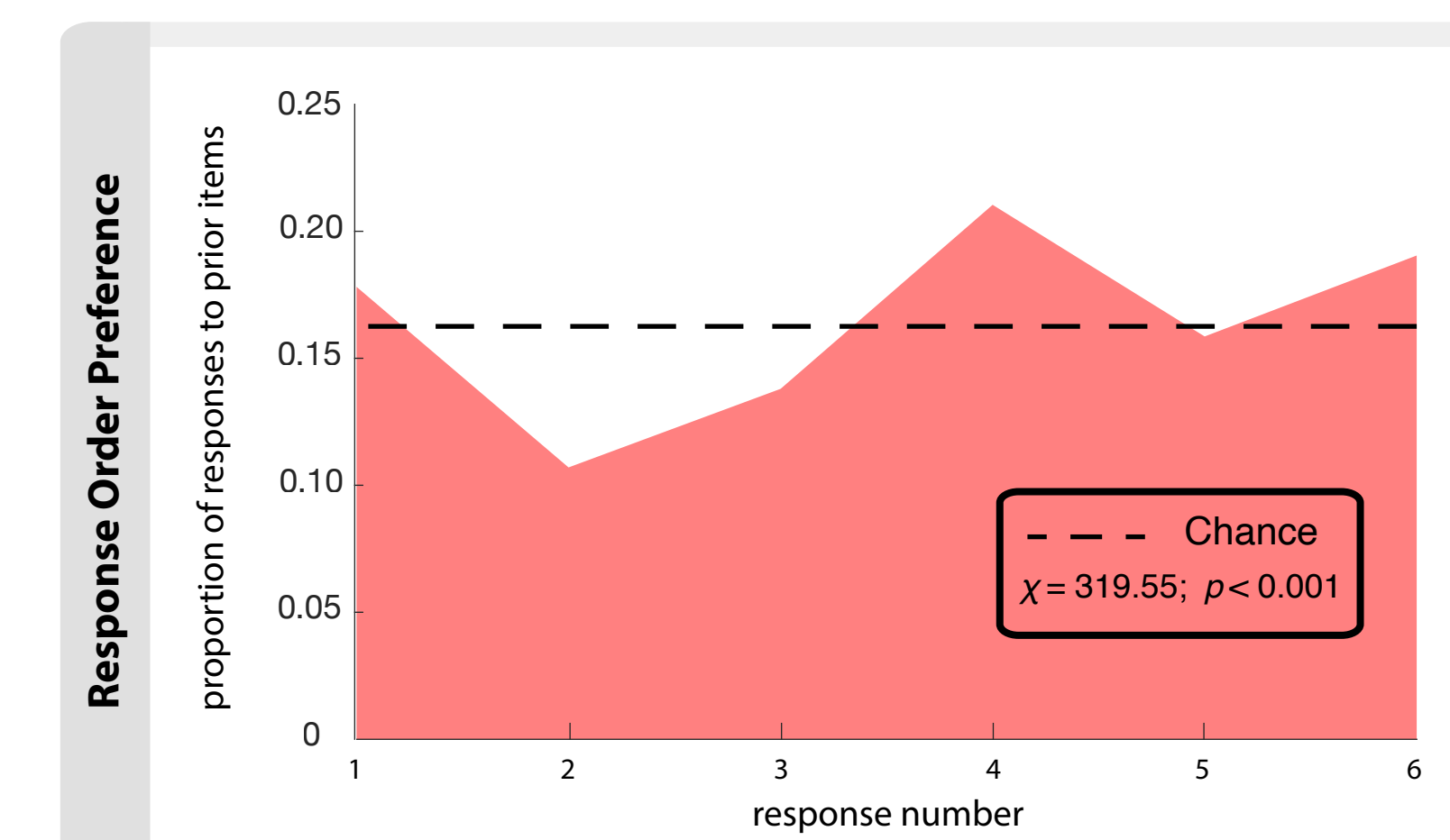
Non-prior responses have greater precision when reported before the prior item

— We propose this is due to the prior item marking a boundary between reporting items in memory and guessing

Hypothesized strategy

Responses before the prior | Responses to the prior | Responses after the prior
memory responses | prior distribution | uniform guesses

— This would indicate that rather than encoding the prior item, participants are relying on the prior information and instead encoding non-prior items

Before Prior | After Prior | * $p < 0.01$ | ~ uncorrected
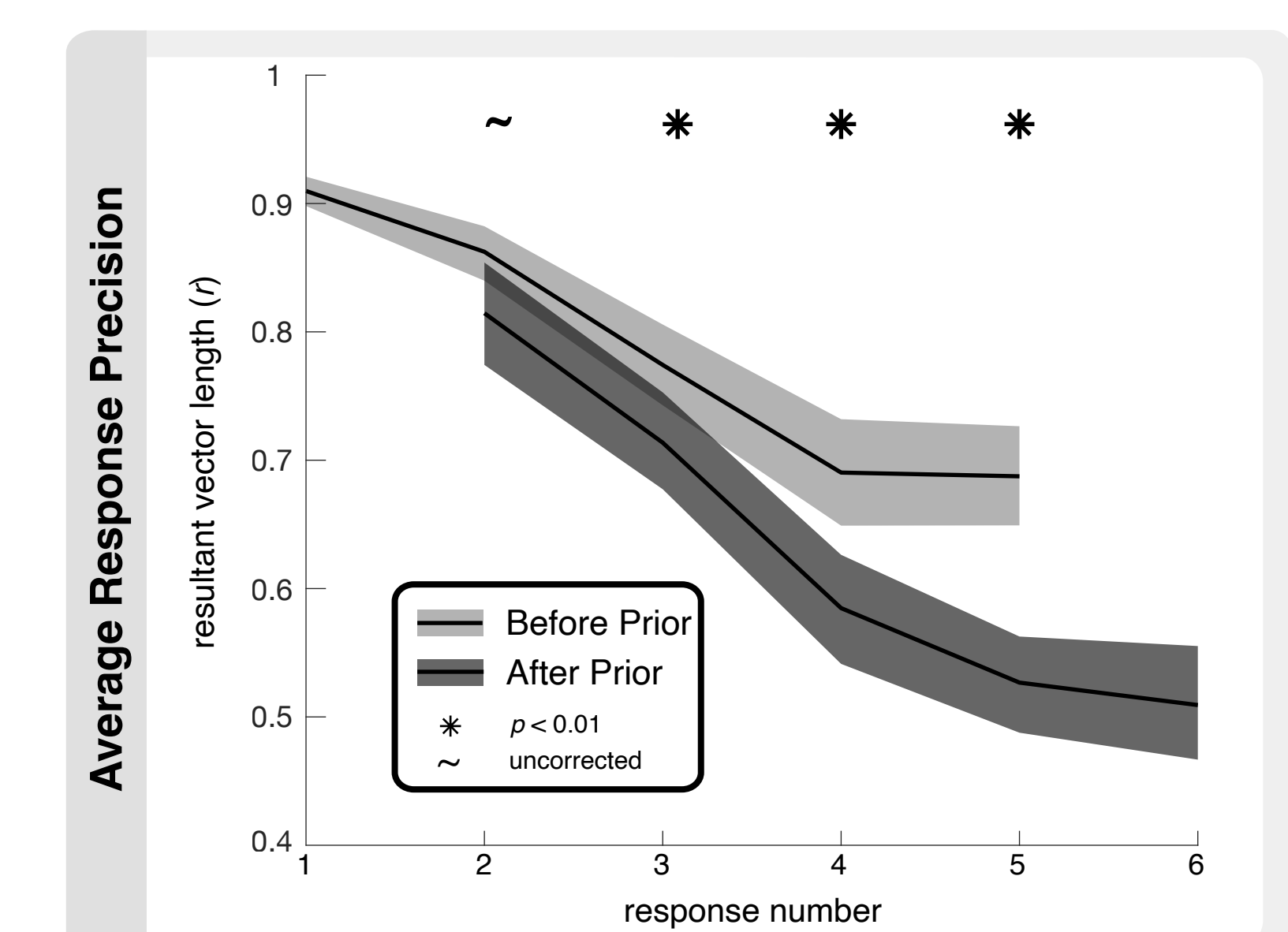
Participants attend away from the location of the prior

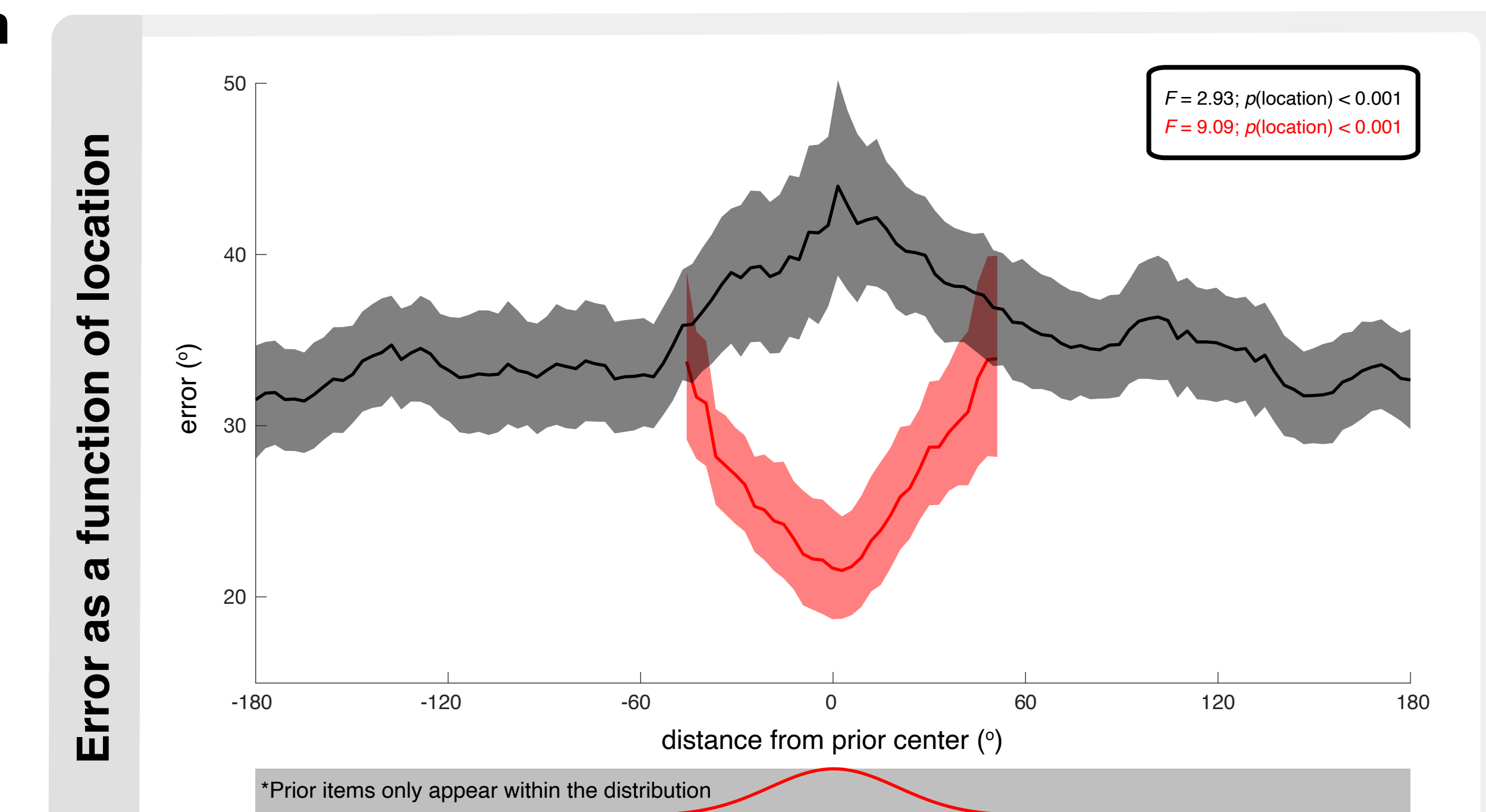**Error for the prior and non-prior items show an inverse relation as a function of location**

Non-Prior
- Responses to **non-prior** items **increase** in error as the item's true location approaches the center of the prior distribution
- The increase in error for non-prior items indicates participants are allocating fewer resources to this area

Prior
- Responses to **prior** items **decrease** in error as the item's true location approaches the center of the prior distribution
- The decrease in error for prior items indicates participants are using the prior to guess, i.e. if the participant always reports the mean of the prior distribution, error would increase the farther the item is from the center

- By choosing to constrain where they attended, participants benefited from decreased error for prior items, however at a cost of increased error for non-prior items that appeared in that same area

$F = 2.93$; $p(\text{location}) < 0.001$
$F = 9.09$; $p(\text{location}) < 0.001$

*Prior items only appear within the distribution

4 DISCUSSION

- These results indicate that participants can and do make use of long-term memory infromation in order to minimize error

- Specifically, we have demonstrated that participants priroritized non-prior items in working memory by attending away from the location of the prior

- Critically, this came at the cost of increased error for non-prior items in that location, indicating that incorporation of long-term memory optimizes allocation but does not increase capacity

References

1. Bays & Husain, 2008. *Science*
2. Ma et al., 2014. *Nat. Neurosci*
3. Emerich et al., 2017. *J Exp Psych*
4. Sims, 2015. *J. Vis*
5. Yoo et al., 2018. *Sci Rep*
6. Honig et al., 2020. *PNAS*
7. Adam et al., 2017. *Cog Psych*