Multi-Step Prediction and Integration in Naturalistic Environments

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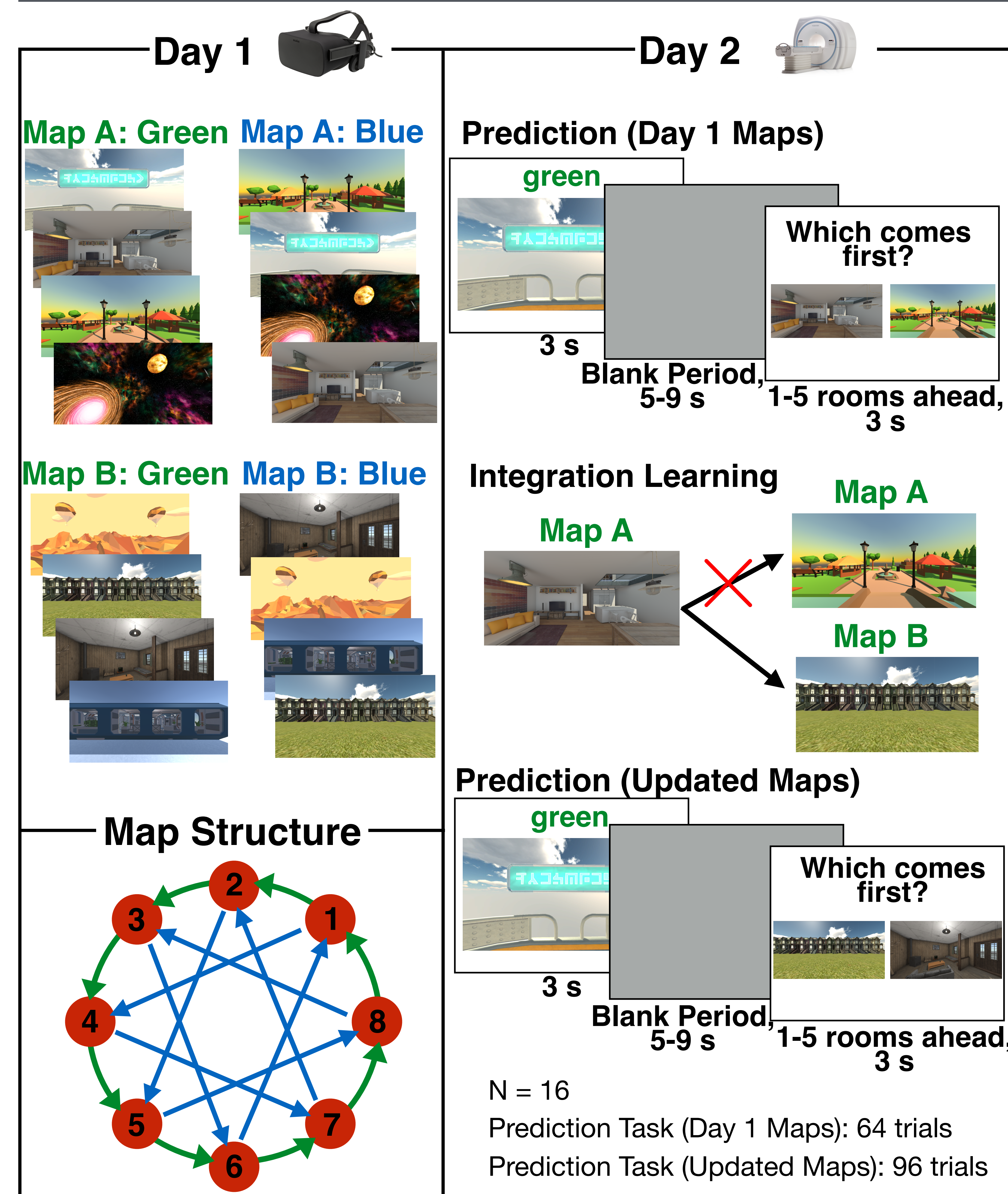
ALY LAB

DPML

Introduction

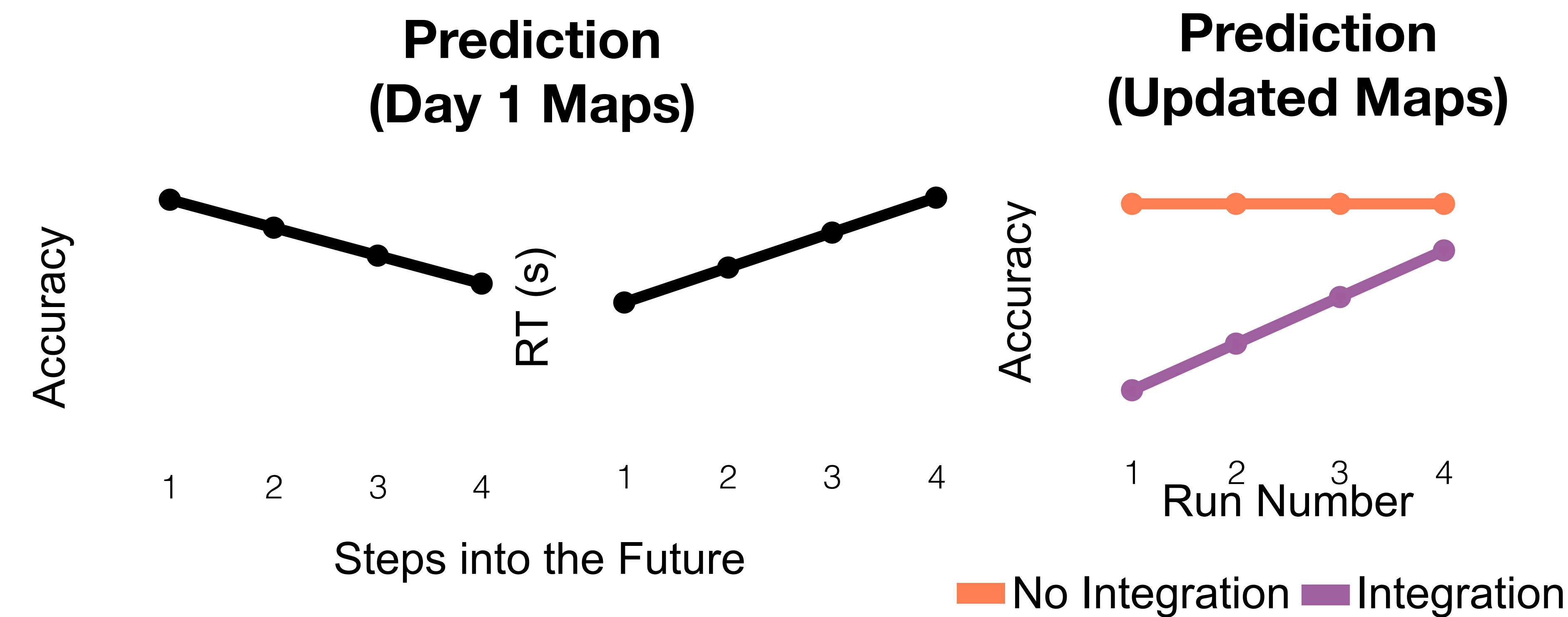Memory for the past serves a **prospective** function: to predict future events[1,2].

Question 1: How do we flexibly generate predictions at multiple timescales?

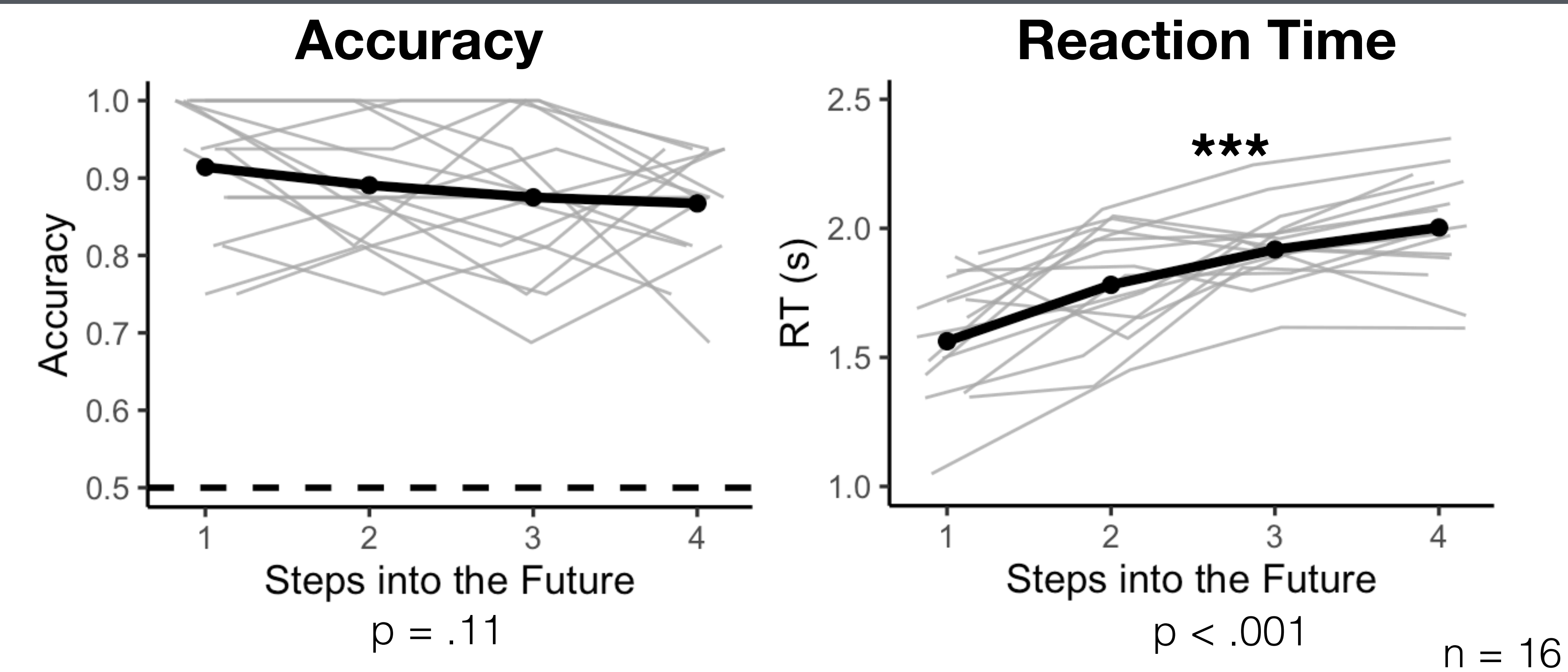## Question 2: How are predictions updated when our environments change?
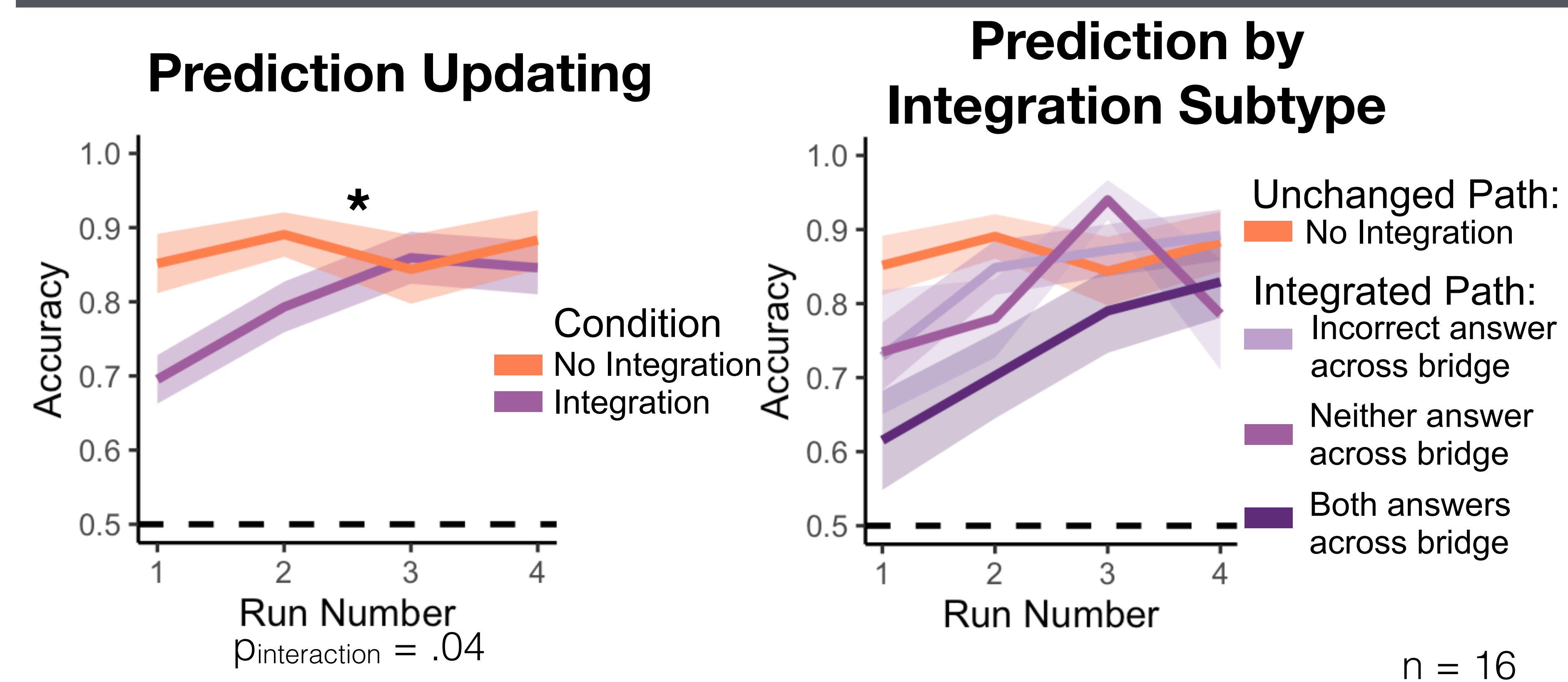
Experimental Design

Day 1

Map A: Green **Map A: Blue**

Map B: Green **Map B: Blue**

Day 2

Prediction (Day 1 Maps)

green

3 s

Blank Period, 5-9 s

Which comes first?

1-5 rooms ahead, 3 s

Integration Learning

Map A ✗ → Map A / Map B

Prediction (Updated Maps)

green

3 s

Blank Period 5-9 s

Which comes first?

1-5 rooms ahead, 3 s

N = 16
Prediction Task (Day 1 Maps): 64 trials
Prediction Task (Updated Maps): 96 trials

Map Structure

Hypotheses

Prediction (Day 1 Maps)
Accuracy / RT (s) vs Steps into the Future (1 2 3 4)

Prediction (Updated Maps)
Accuracy vs Run Number (1 2 3 4)

No Integration / Integration

Prediction at Multiple Timescales

Accuracy
Accuracy vs Steps into the Future
p = .11

Reaction Time
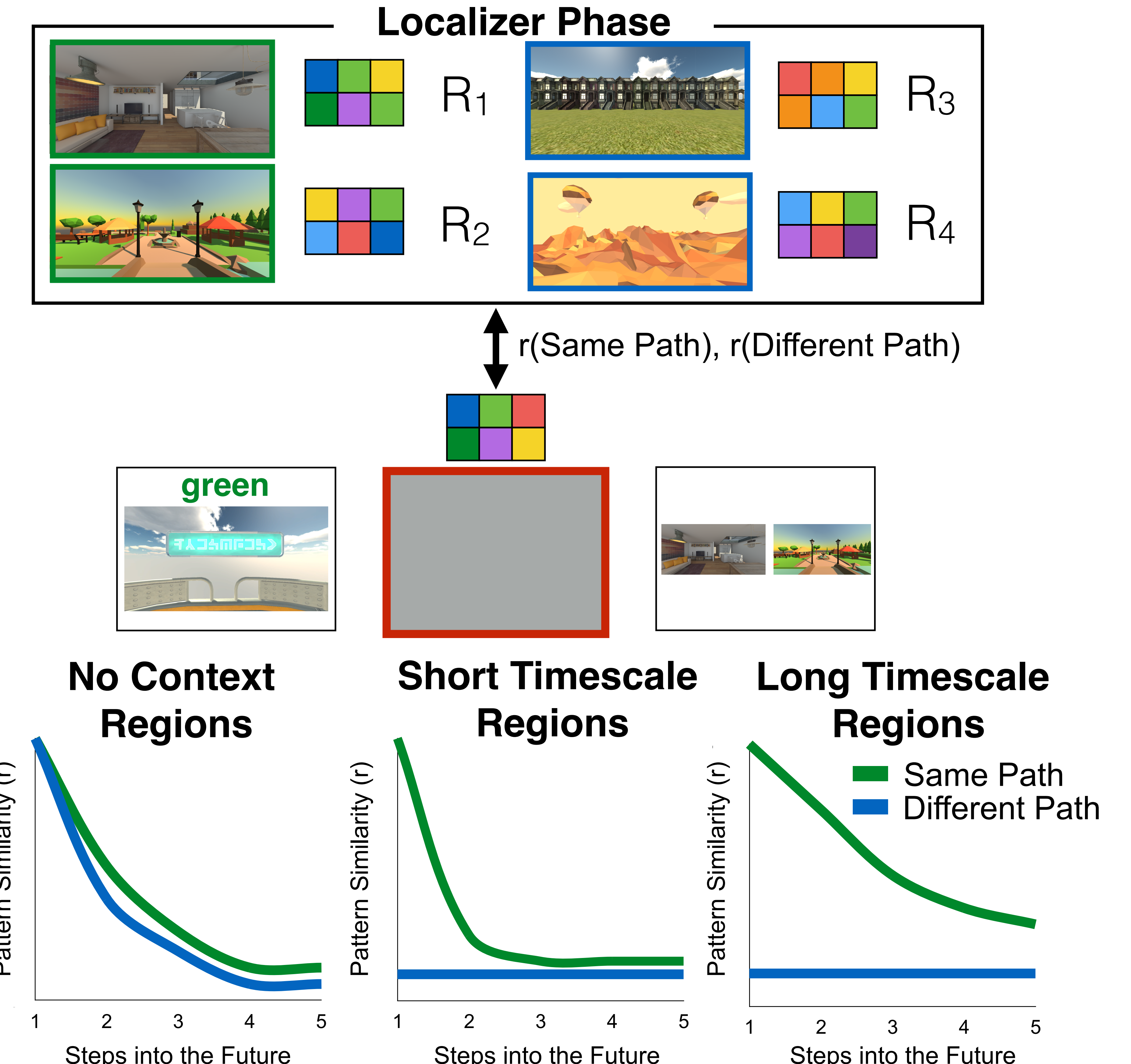RT (s) vs Steps into the Future
***
p < .001   n = 16

Participants predicted upcoming events from the day 1 maps along multiple timescales with comparable accuracy, but were slower for further rooms.

Predictions are Flexibly Updated after Integration

Prediction Updating
Accuracy vs Run Number
*
Condition: No Integration / Integration
p interaction = .04

Prediction by Integration Subtype
Accuracy vs Run Number
Unchanged Path: No Integration
Integrated Path:
  Incorrect answer across bridge
  Neither answer across bridge
  Both answers across bridge
n = 16

Prediction performance using the updated maps improved across runs, even without trial-by-trial feedback. Participants improved most for trials that required integration to reach the correct answer.

Planned Neuroimaging Analyses

Localizer Phase
R1 R2 R3 R4

r(Same Path), r(Different Path)

green

No Context Regions **Short Timescale Regions** **Long Timescale Regions**

Pattern Similarity (r) vs Steps into the Future
Same Path / Different Path

Activity patterns during the blank period should resemble those for upcoming rooms, though in some regions this prediction may not be context-specific. The timescale of prediction will be longer for progressively more anterior brain regions[3,4].

After integration, we hypothesize that patterns of activity will be updated to correlate with the templates for the integrated path, and these correlations will increase as a function of run number.

Summary

Individuals can accurately make predictions at a range of timescales. These predictions can be updated rapidly, but improve with practice. Ongoing fMRI studies will examine how multiple timescales of prediction are supported across perceptual and memory systems.

References

[1]Buckner, R.L. (2010). The role of the hippocampus in prediction and imagination. *Annual Review of Psychology, 61*, 27-48.
[2]Brown, T.I., Carr, V.A., LaRocque, K.F., Favila, S.E., Gordon, A.M., Bowles, B., Bailenson, J.M., Wagner, A.D. (2016). Prospective representation of navigational goals in the human hippocampus. *Science, 352(6291)*, 1323-1326.
[3]Hasson, U., Chen, J., Honey, C.J. (2015). Hierarchical process memory: memory as an integral component of information processing. *Trends in Cognitive Sciences, 19(6)*, 304-313.
[4] Brunec, I.K., Momennejad, I. (2019). Predictive Representations in Hippocampal and Prefrontal Hierarchies. *BioRxiv*, 786434