

A person is wearing a VR headset. The front of the headset is a large, dark, rounded rectangle with a glowing white border. Inside this border, the title text is written in a bold, white, sans-serif font. The person's face is visible below the headset, showing their nose and mouth. The background is a solid light blue color.

EFFECTS OF VIRTUAL REALITY ON SPATIAL MEMORY ENCODING

Presented by Shreya,
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SPATIAL MEMORY

WHAT??

Spatial memory is the brain's capacity to encode, store, and retrieve spatial information.

WHERE??

Utilized in navigation, virtual spaces, sports, and fields like architecture and engineering.

WHY??

It's key for navigation, spatial reasoning, and understanding environments.

MOTIVATION

Spatial memory and retrieval are fascinating aspects of human cognition, enabling us to construct and navigate complex 3D representations in our minds.

DO VR EXPERIENCES ENGAGE OUR MEMORY IN THE SAME WAY AS REAL-WORLD ENVIRONMENTS, OR DO THEY REQUIRE DIFFERENT MENTAL STRATEGIES?

WHICH REGIONS OF THE BRAIN ARE INVOLVED IN SPATIAL ENCODING FOR REAL VERSUS VIRTUAL ENVIRONMENTS, AND DO THEY DIFFER?



RESEARCH ARTICLE

Where is the “where” in the brain? A meta-analysis of neuroimaging studies on spatial cognition

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Abstract

Spatial representations are processed in the service of several different functions. The present study capitalizes on the Activation Likelihood Estimation (ALE) meta-analysis to identify: (a) the shared neural activations among spatial functions; (b) the specific neural activations associated with different spatial functions. Following PRISMA guidelines, a total of 133 fMRI and PET studies were included in the meta-analysis. The overall analysis showed that the core network for spatial cognition comprises regions that are symmetrically distributed on both hemispheres, including the bilateral frontoparietal regions, presupplementary motor area, anterior insula, and the hippocampal region. The specific analyses revealed the brain regions that are selectively involved in different spatial functions, such as the right temporoparietal junction for shift of spatial attention, the hippocampal gyrus, and the retrosplenial cortex for navigation and spatial memory. The findings are integrated within a systematic review of the neurocognitive model of spatial cognition is proposed.

KEYWORDS

activation likelihood estimation, frontoparietal, long-term memory, meta-analysis, navigation, neuroimaging, spatial attention, spatial working memory

“D'où venons-nous? Que sommes-nous? Où allons-nous?”
Paul Gauguin.

1 | INTRODUCTION

“Where Do We Come From? What Are We? Where Are We Going?” is one of the most famous paintings by French artist Paul Gauguin. “Where?” became indeed the core question that Gauguin asked in his art. We decided to begin the present work citing this painting to highlight how the “where?” is an intrinsic question of the human being, and permeates our lives in its most mysterious and transcendent aspects as well as in its everyday, practical scopes, such as “Where

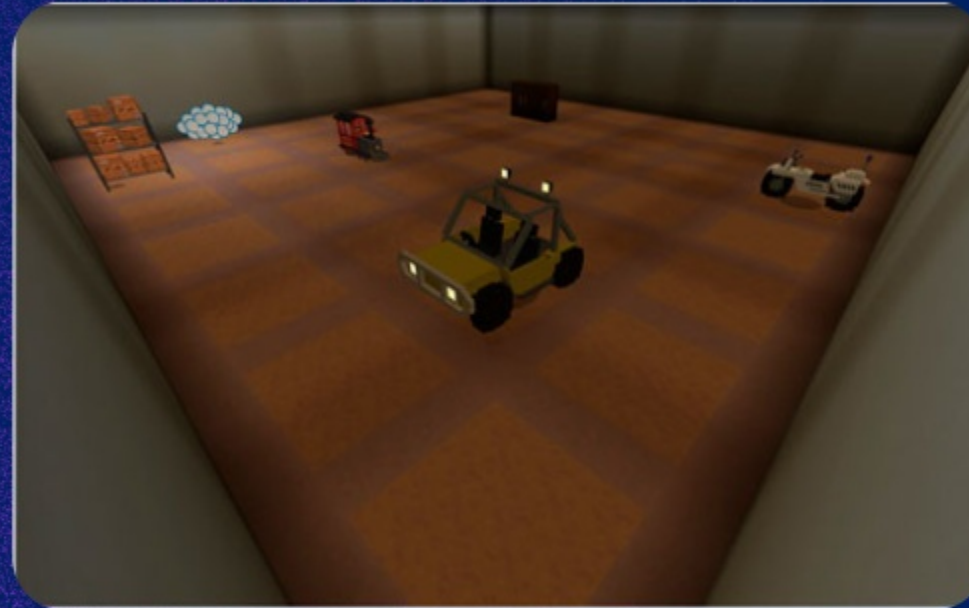
When speaking about the brain functions involved in spatial cognition, one of the first, most influential distinction between location-based “where” and content-based “what” information that has been proposed is the distinction between two regions (Ungerleider & Mishkin, 1982). Mishkin, Ungerleider, and Macko (1983) proposed that the visual system is divided into two separate pathways: the “what” stream, projecting from the occipital to the temporal lobe, and the “where” stream, projecting from the occipital to the parietal lobe. Pioneering research by Goldman-Rakic (1987) and others (see Levy & Goldman-Rakic, 2000) showed that such a dorsal-ventral distinction in the organization of information is carried through into the organization of spatial cognition.



RELATED WORK

COMPARATIVE ANALYSIS OF SPATIAL ABILITY IN IMMERSIVE AND NON-IMMERSIVE VIRTUAL REALITY

This study trained participants in both non-immersive (virtual monitor) and immersive (VR headset) settings. Tested their spatial recall by having them plot the locations of remembered objects in a 2D space.



[Comparative analysis of spatial ability in immersive and non-immersive virtual reality.](#)

USING VIRTUAL REALITY TO UNDERSTAND CONTEXT-DEPENDENT SPATIAL MEMORY

Testing in fully, partially, and non-replicated environments. Examined how familiar contexts impact retrieval. Participants trained in real-life and immersive VR settings recalled objects they had seen or not seen. Context significantly influences retrieval accuracy.

[Using virtual reality to understand context-dependent spatial memory.](#)

RESEARCH GAPS

Small sample
size (~30),
single age
group

No
standardization
of VR familiarity

No variation in
task complexity

3D training, but
2D testing—
raises memory
transfer concerns

Between-subject
design; within-
subject with
cross-testing
suggested

HYPOTHESIS

PARTICIPANTS TRAINED IN REAL-WORLD ENVIRONMENTS WILL SHOW BETTER SPATIAL MEMORY RECALL THAN THOSE TRAINED IN VR.

TASK COMPLEXITY AND CONTEXT MATCHING AFFECT RECALL PERFORMANCE.



EXPERIMENT

1. TASK SETUP

2. PARTICIPANT SELECTION

3. EVALUATION METRICS

4. METHODOLOGY

5. EXPECTED RESULTS

TASK SETUP

REAL-LIFE

VR

SCENARIO 1
OBJECT PLACEMENT
RECALL.



SCENARIO 2
ROUTE NAVIGATION.



SCENARIO 3
MAZE NAVIGATION.



PARTICIPANT SELECTION

INCLUSION CRITERIA

1. AGE RANGE: 18-40
2. BASIC TECHNOLOGICAL PROFICIENCY
3. NORMAL OR CORRECTED VISION
4. COGNITIVE HEALTH

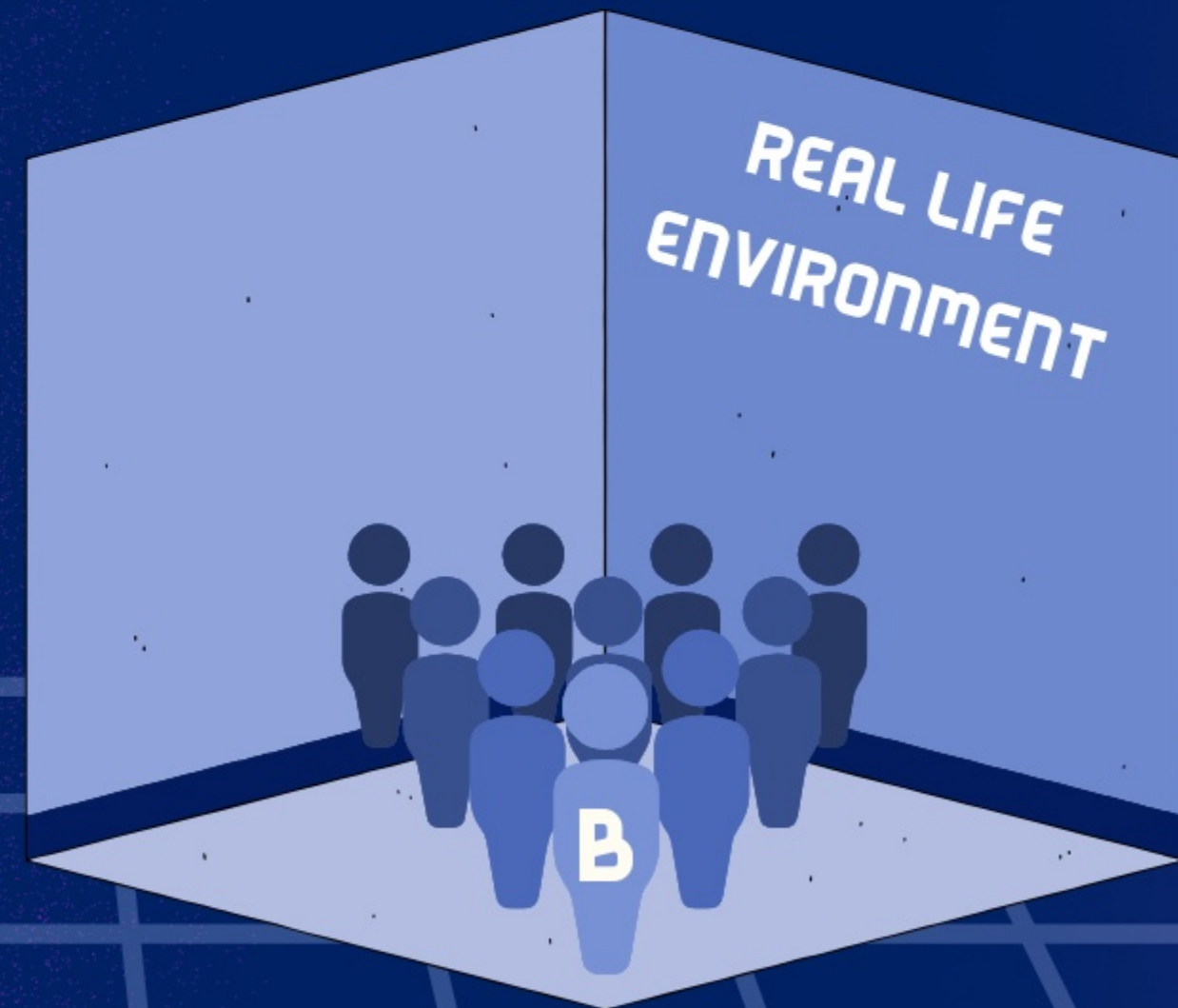
EXCLUSION CRITERIA

1. HISTORY OF MOTION SICKNESS
2. NEUROLOGICAL OR PSYCHIATRIC DISORDERS
3. USE OF PSYCHOACTIVE MEDICATIONS
4. HISTORY OF VR EXPOSURE



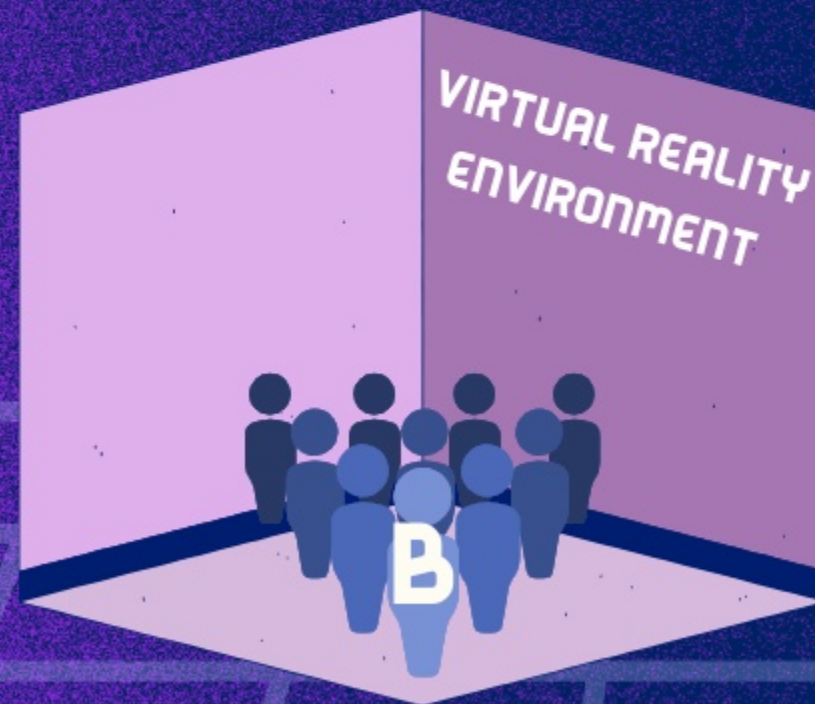
METHODOLOGY

ENCODING PHASE TRAINING

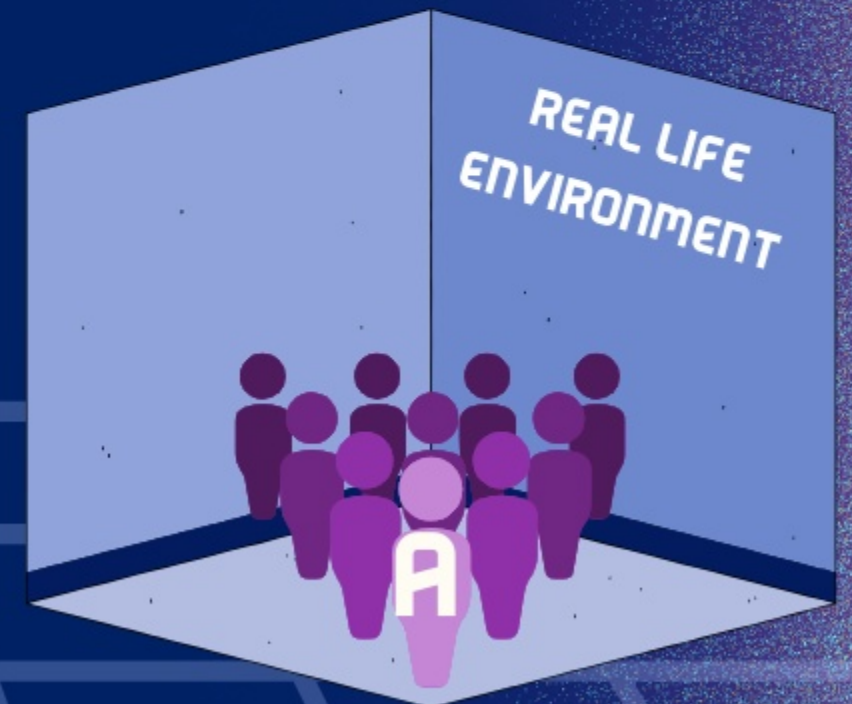
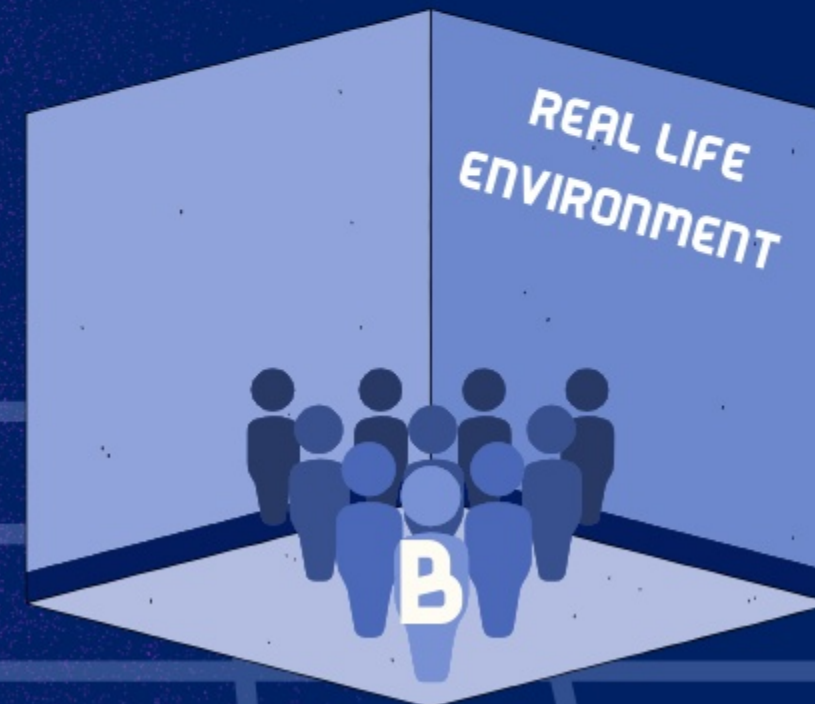


RETRIEVAL PHASE TESTING

IN VR ENVIRONMENT

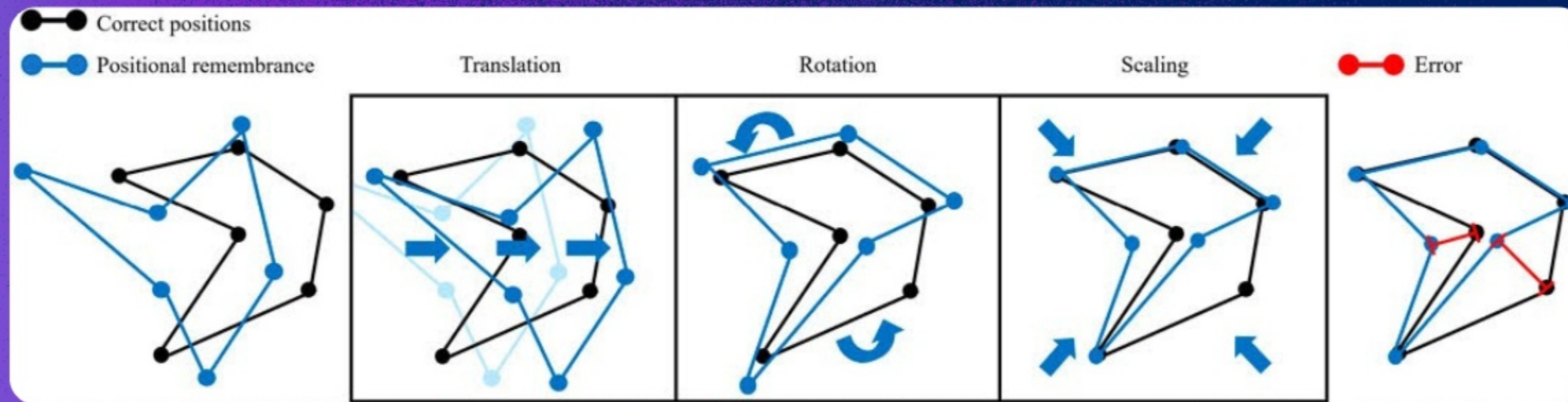


IN REAL-LIFE ENVIRONMENT



EVALUATION METRICS

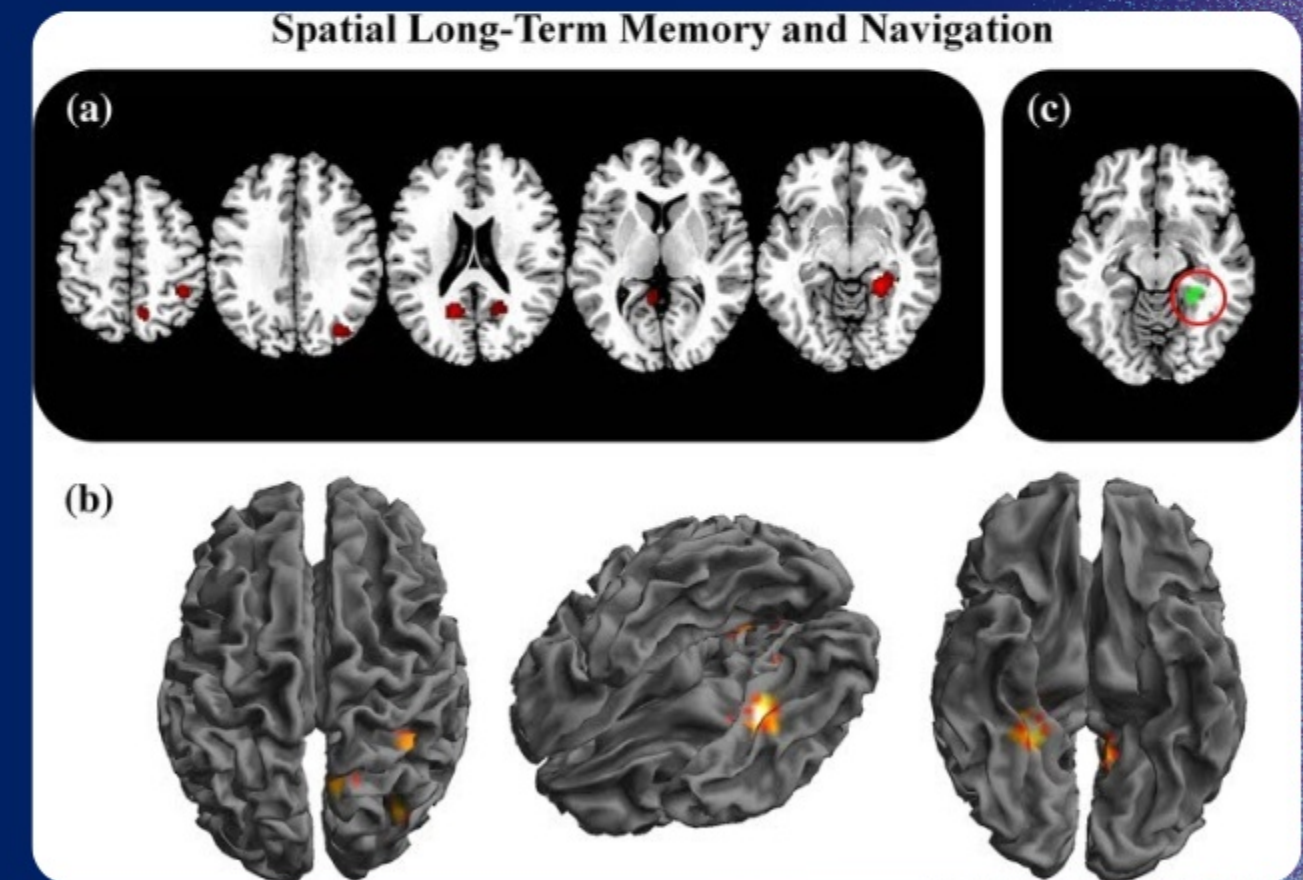
1. RECALL ALIGNMENT ERROR



3. RECALL TIME = TIME TAKEN TO FINISH THE RECALL TASK IN SECONDS



2. BRAIN REGIONS ACTIVATED



HIPPOCAMPUS AND MEDIAL
ENTORHINAL CORTEX (MEC)

ANALYSIS

VARIABLES BEING TESTED

PEARSON CORRELATION SCORE

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \sum (y - \bar{y})^2}}$$

INDEPENDENT

ENVIRONMENT

DEPENDENT

RETRIEVAL ALIGNMENT ERROR

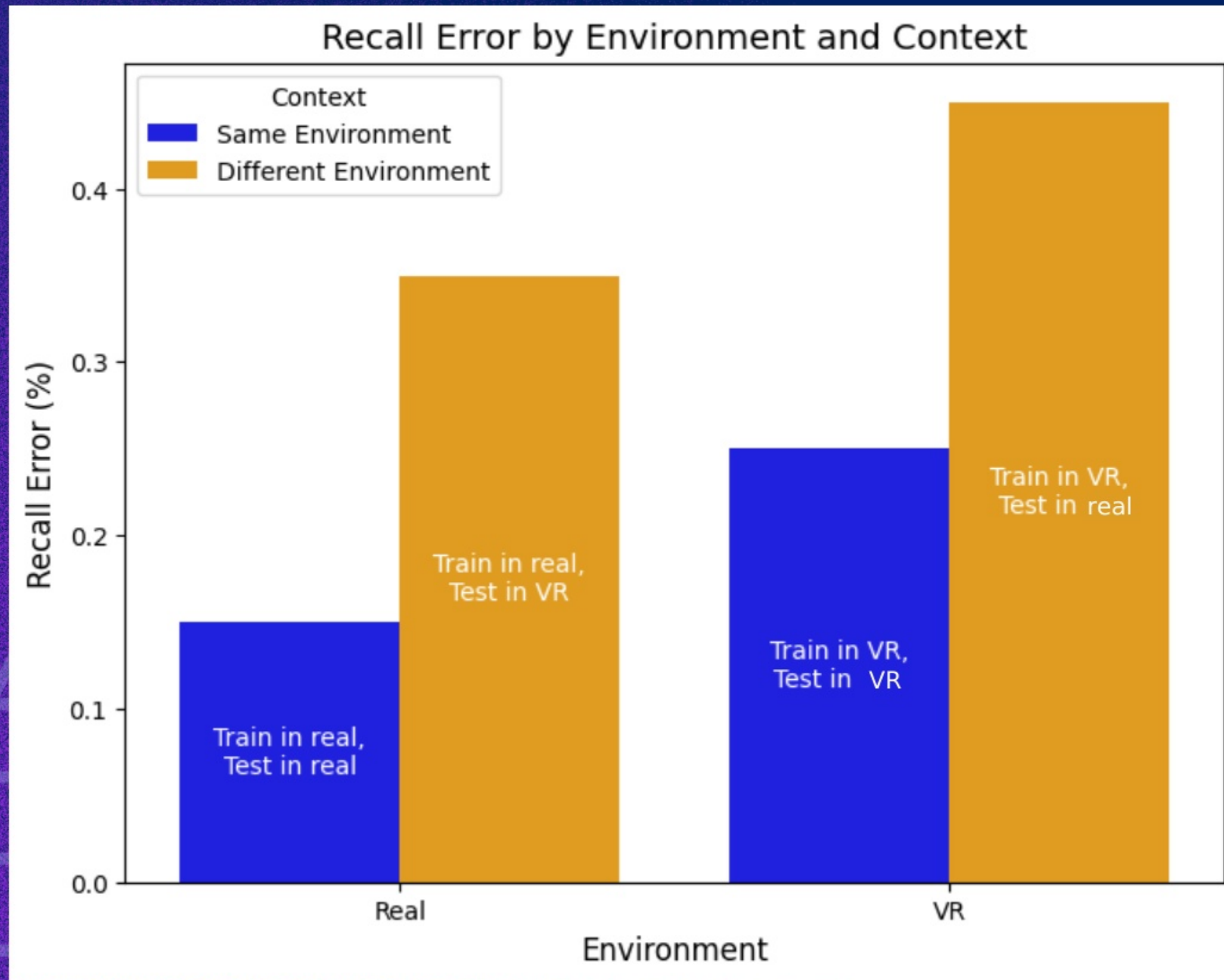
RECALL TIME

BRAIN REGIONS ACTIVATED

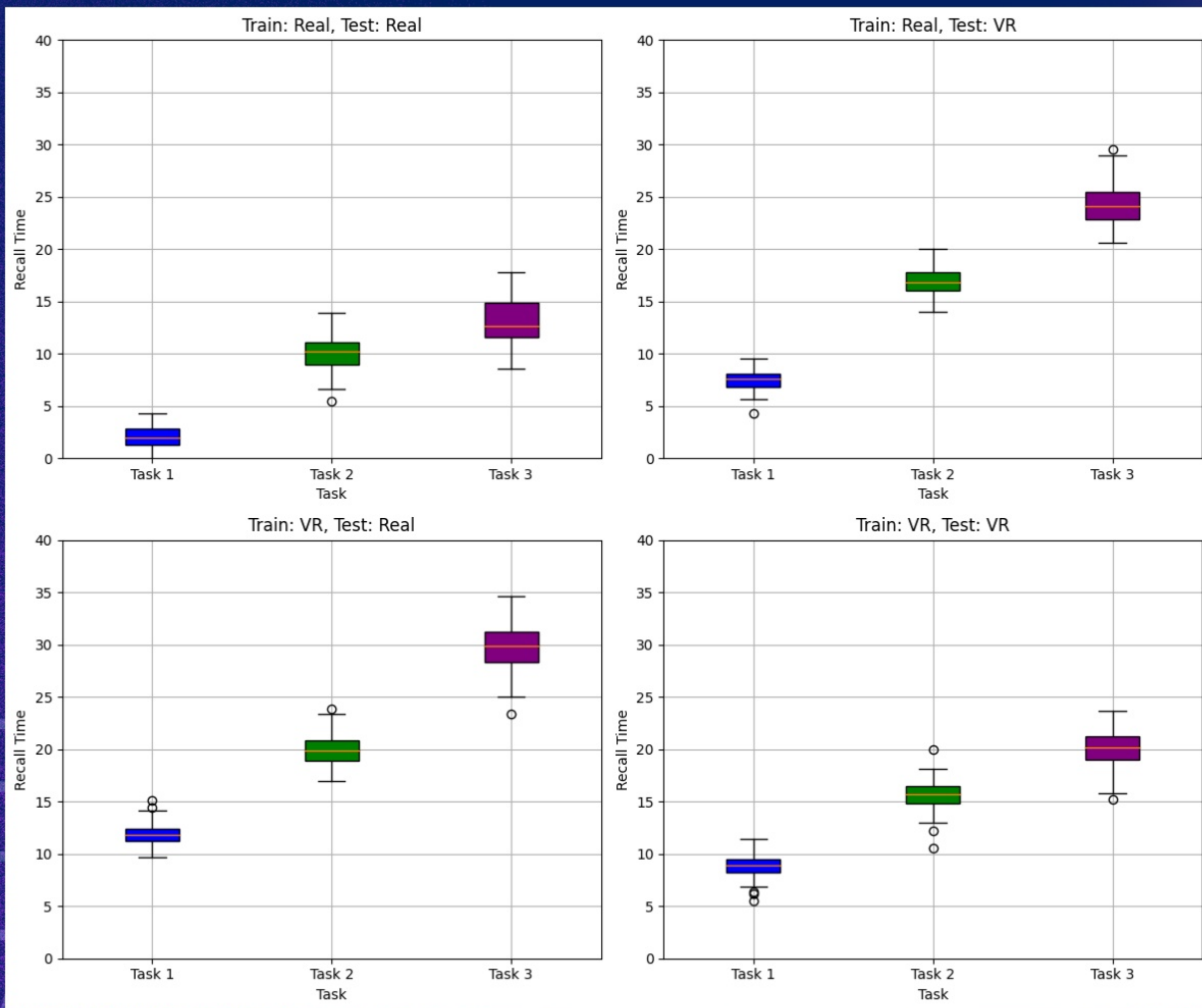


**EXPECTED
RESULTS**

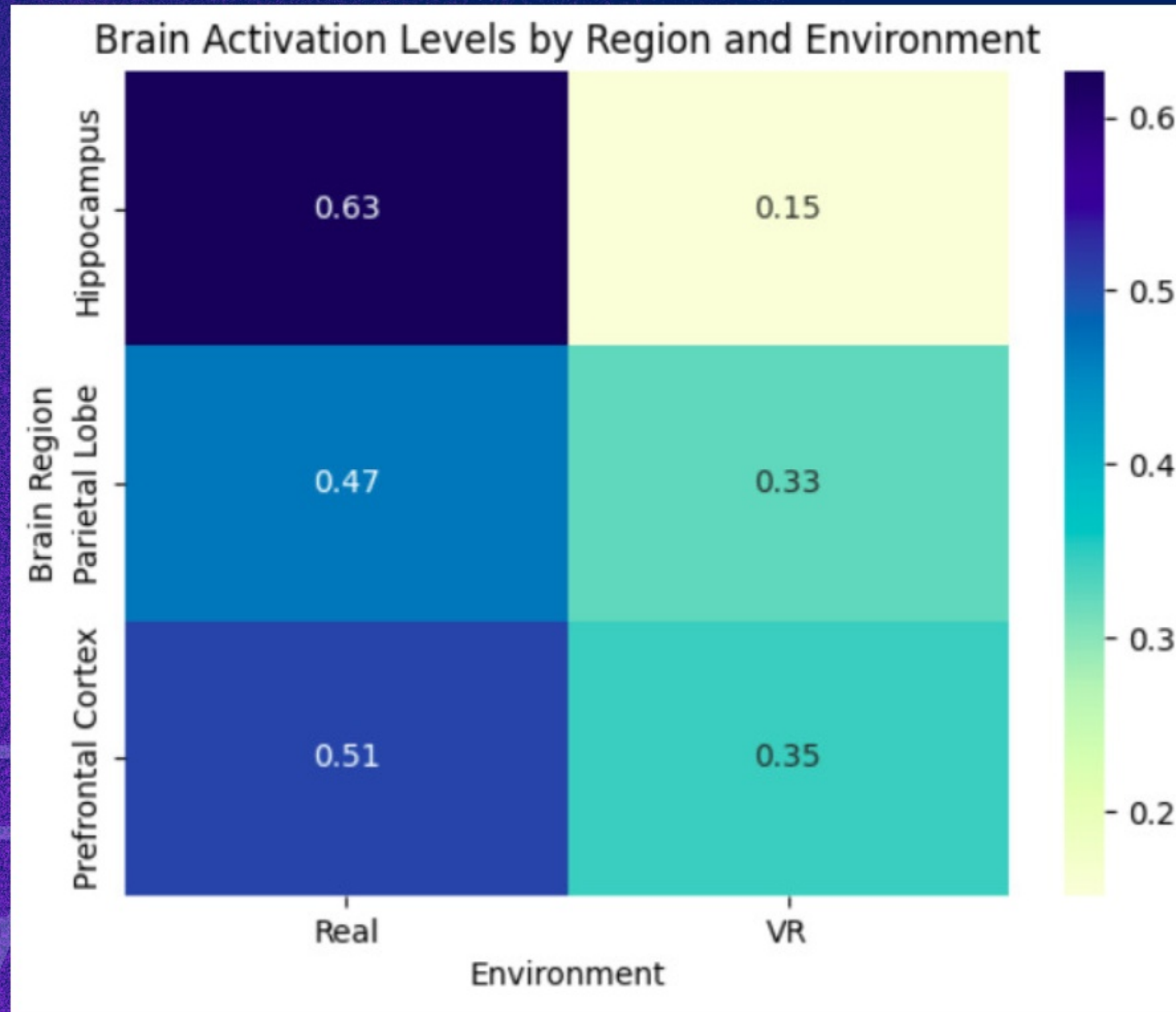
RECALL ERROR



EXPECTED RECALL TIME ACROSS TASKS AND ENVIRONMENTS

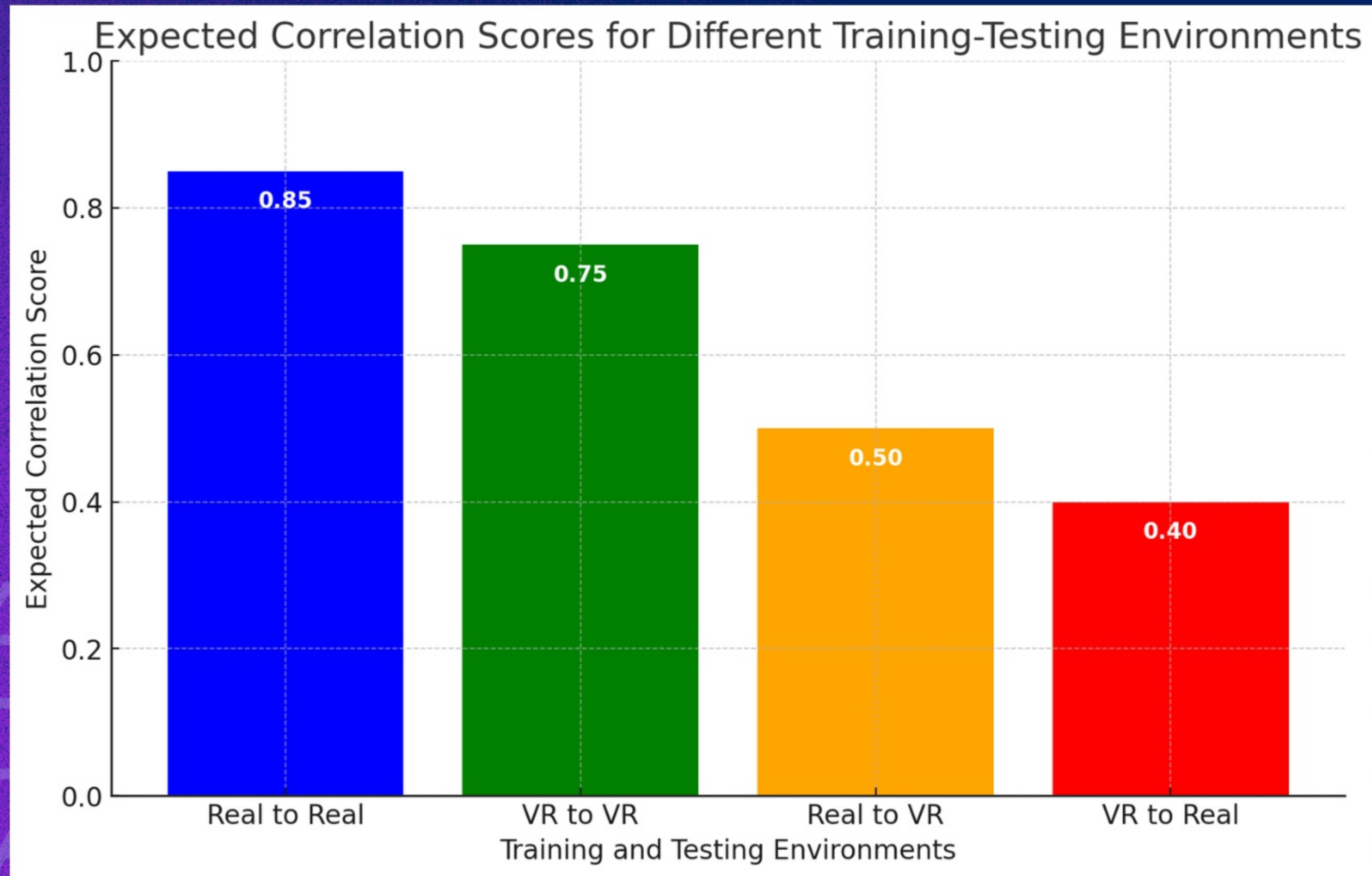


HIPPOCAMPUS IS MOST ACTIVATED DURING SPATIAL ENCODING



Where is the "where" in the brain?

EXPECTED CORRELATION SCORES IN DIFFERENT ENVIRONMENTS



CONCLUSION

- Sensorimotor engagement in real environments enhances spatial recall, reducing loss and response times.
- Complexity impacts recall differently in VR vs. real settings, with real environments outperforming VR in complex tasks.
- Consistent environment testing improves recall outcomes.

VR HOLDS PROMISE FOR SPATIAL LEARNING BUT REQUIRES OPTIMIZATION TO MATCH REAL-WORLD MEMORY ENCODING.

A close-up shot of a person wearing a VR headset. The headset is black with a glowing blue border around the lens area. The text 'THANK YOU!' is displayed in large, white, blocky letters across the center of the lens. The person's face is partially visible below the headset, showing their nose and mouth. The background is a soft, out-of-focus blue and purple gradient.

THANK YOU!

**Presented by Shreya,
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