REFERENCES

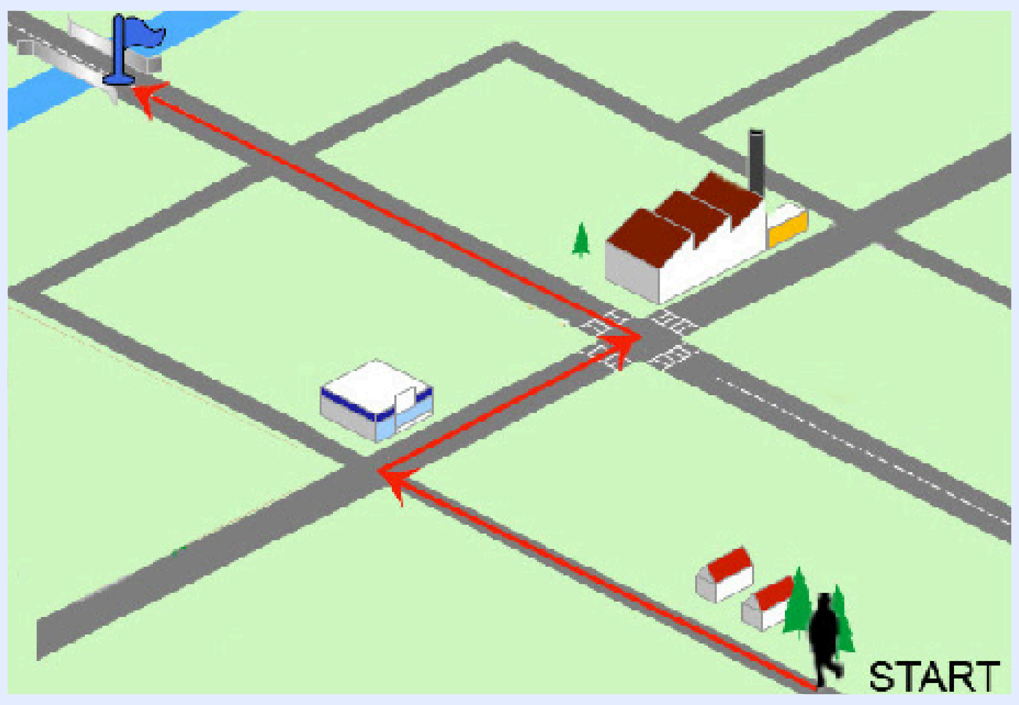
Columbia University Medical Center | Columbia Engineering — The Fu Foundation School of Engineering and Applied Science | ROAR: RObotics And Rehabilitation Laboratory

ENHANCING NAVIGATION SKILLS:

IMMERSIVE VIRTUAL REALITY TRAINING FOR ALZHEIMER'S DISEASE PATIENTS

BACKGROUND

- **Allocentric navigation** = based on spatial memory of how key goals in an environment relate *to each other* [1]
- Allocentric navigation is negatively impacted by Alzheimer's disease [2], so training allocentric navigation abilities could improve their quality of life since navigation is necessary for daily living
- Previous navigation training paradigms have:
  - Used desktop environments (**passive navigation** = based only on visual input) [3][5-6], which results in inaccurate and inefficient navigation compared to immersive virtual reality [7]
  - Focused on a different navigation strategy [4]
- Immersive virtual reality *could* be a preferable medium since it relies on **active navigation** (based on visual, motor, and vestibular input) and promotes superior navigation performance [7]

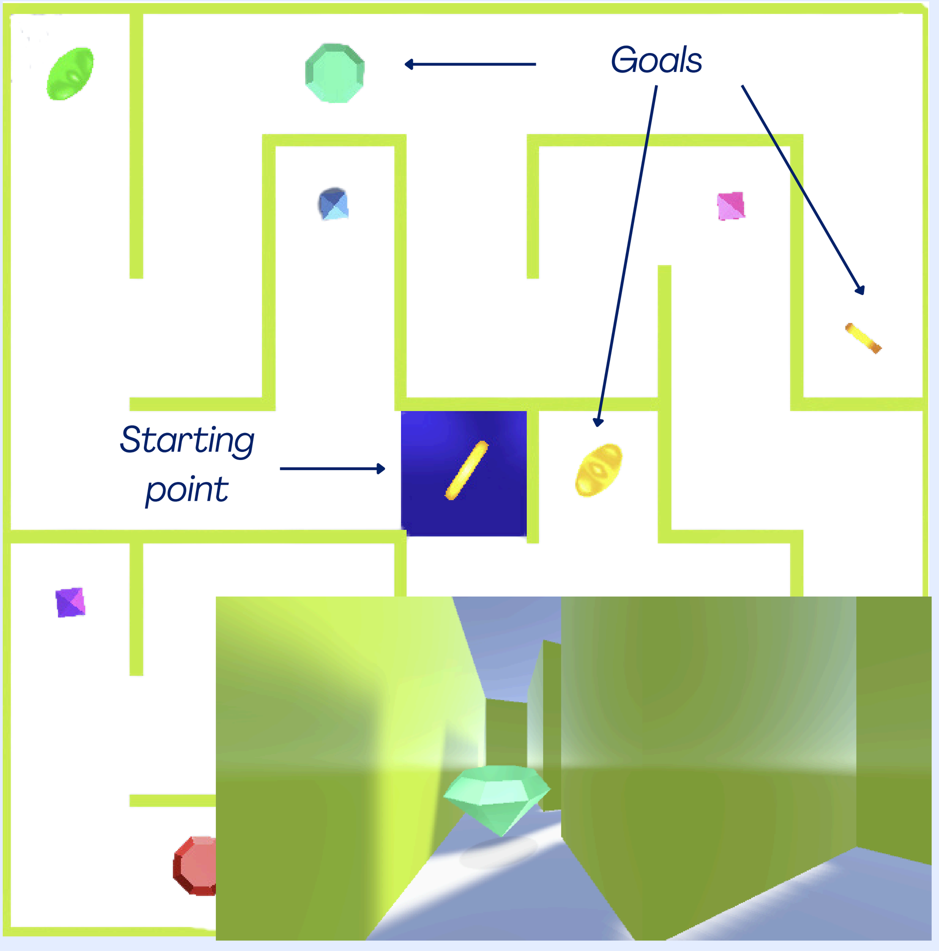


An example of allocentric navigation [x]

RESEARCH QUESTION

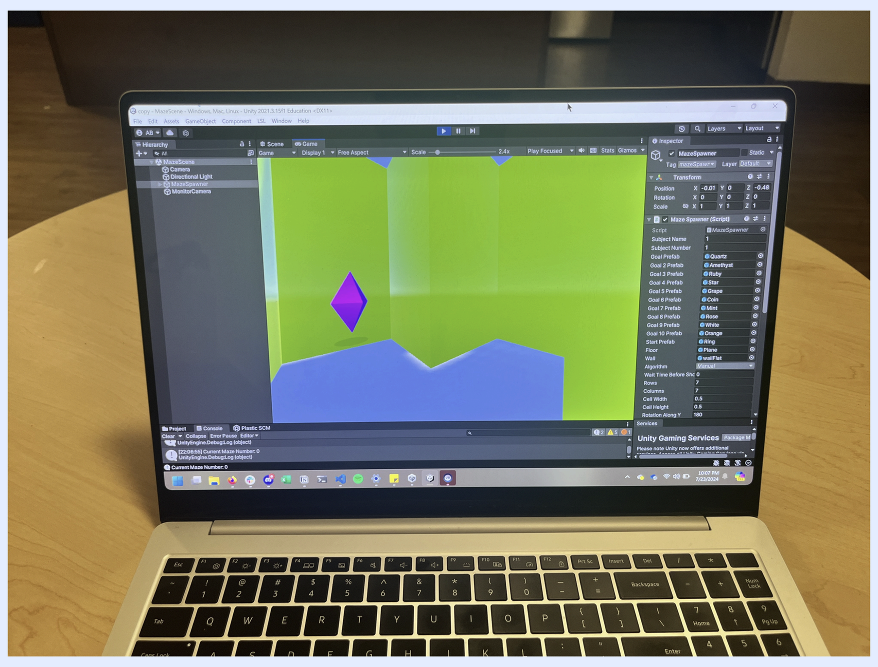
How can we assess the efficacy of an immersive virtual reality training geared toward developing allocentric navigation skills?

In this study, we want to evaluate an active and passive virtual reality training paradigm, and we hypothesize that the **active** version will be **more effective** than the **passive** version.



Overhead view and first-person view of the training mazes

A person in a VR headset



The passive training on a laptop

	PASSIVE	ACTIVE
PRE	• **Passive Pre-Test** (3x three-goal mazes, 3x five-goal mazes in the desktop environment), • **Active Pre-Test** (3x three-goal mazes, 3x five-goal mazes in the VR environment) • **Leiden Navigation Pre-Test**	
TRAIN	30 min sessions x 5 days **Desktop**	30 min sessions x 5 days **Immersive VR**
POST	**Same as Pre-Test**	

Initial procedure for assessing efficacy of the active training

	PASSIVE	ACTIVE
PRE	• **Passive Pre-Test** (adaptive) • **Active Pre-Test** (adaptive) • **Leiden Navigation Pre-Test**	
TRAIN	30 min sessions x 14 days **Desktop**	30 min sessions x 14 days **Immersive VR**
POST	**Same as Pre-Test**	

Revised procedure after evaluation with pilot participant

METHODS + OUTCOME MEASURES

- A passive (desktop computer, navigated with arrow keys) and active version (head-mounted VR headset, navigated physically) of a maze task were developed in Unity
- The maze task involves a subject navigating a maze freely and finding all goals, followed by an assessment asking the subject to recall and navigate to the position of each goal in a specific order
  - Gait data, assessment accuracy, time taken, and position would be collected for each maze
- Subjects would undergo a pre-test, five training sessions, and a post-test.
  - Procedure is as shown on the right
  - A training session involves performing the maze task on as many novel mazes as possible
  - Subjects would be shown their assessment results between mazes as feedback
- If the training method was effective overall:
  - Accuracy would increase, time taken would decrease, the # of incorrect turns/prolonged pauses while navigating would decrease, and performance on the Leiden Navigation Test [8] would also increase
  - If the active training was *more effective* than the passive training, these changes would either be greater in magnitude or occur more quickly

INITIAL EVALUATION + INSIGHTS

The proposed procedure for the active training was evaluated on a pilot participant. Though the training sessions and post-test could not be completed, we still derived the following insights:

- **Mazes** should either be made **smaller** or the minimum number of goals should be increased
- The baseline number of goals in the mazes that subjects start their training with should be dependent on the subject; this requires **a pre-test and post-test that adapts to the subject**
- The subject's **recall** of goal positions should be **assessed in a randomized order** to prevent subjects from memorizing a route connecting the goals in the assessment order
- **Goals should be placed randomly**, not just at dead ends; this ensures subjects must recall the actual physical location of the goals instead of vague notions of their positions (e.g., "upper right corner")

FUTURE WORK

- All randomization has been implemented; adaptive pre-test/post-test and maze rescaling must be developed
- The next step will be to run an experiment with ~10 healthy subjects each for the passive and active conditions using the procedure above
- The study would then be repeated with Alzheimer's patients
- If the active training yields performance improvements and is more effective than the passive training, it could be used to help improve allocentric navigation abilities of Alzheimer's patients, improving their everyday ability to function

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