Enhancing Navigation Skills:
Immersive Virtual Reality Training for Alzheimer's Disease Patients

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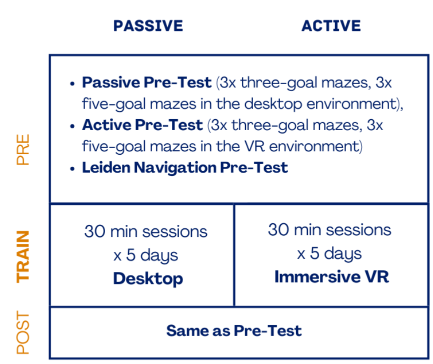
Background and Objective: Spatial navigation skills are crucial for daily living. Allocentric navigation is one of two main strategies used by people while navigating an environment; it involves relying on spatial memory of how key landmarks in an environment relate to each other [1]. Allocentric navigation is negatively impacted when hippocampus function is impaired, which occurs in Alzheimer's disease [2]. Training allocentric navigation abilities thus could potentially improve everyday function and quality of life for people with Alzheimer's disease.

Previous navigation training paradigms have often utilized desktop environments (where participants navigate based solely on visual input from a computer, also known as passive navigation) [3][5-6] or physical environments [4], but the former results in decreased efficacy and accuracy while navigating [7] and the latter cannot adapt to the user. Immersive virtual reality could be a preferable training medium since it promotes active navigation (based on visual, motor, and vestibular input), can adapt to user performance, and results in superior navigation performance [7]. Consequently, we sought to explore how we could assess the efficacy of an immersive virtual reality training geared toward developing allocentric navigation skills.

Hypothesis: We hypothesize that an active version of the allocentric navigation training (using immersive VR) will be more effective than a passive version (using a desktop computer).

Methods and Outcome Measures:
A passive (displayed on a desktop computer, navigated with arrow keys) and active version (displayed on a head-mounted VR headset, navigated by physically walking and turning) of a maze task were developed in Unity. The maze task involves subjects navigating a maze freely with the objective of finding all goals (game tokens like crystals, coins, and stars), followed by an assessment asking the subject to recall and navigate to the position of each goal in a specific order. A similar setup has been used to assess allocentric navigation abilities in the past [2]. A training session involves performing this maze task on as many novel mazes as possible for 30 minutes, with assessment results shown between mazes to provide feedback.

Subjects would be asked to complete a pre-test, five training sessions, and a post-test using the procedure shown below depending on their condition (passive or active):



Initial procedure for assessing efficacy of the active training

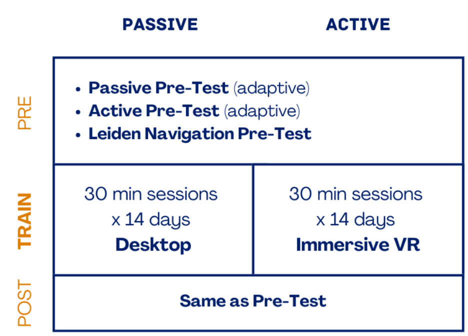
During training sessions, gait data would be collected with sensors on both feet and the pelvis (for the active training). Assessment accuracy, time taken, and position would be collected for each maze.

If the training method was effective overall, accuracy would increase, time taken would decrease, and the number of incorrect turns/prolonged pauses while navigating would decrease for both the passive and active conditions. Performance on the Leiden Navigation Test [8] would also increase for both conditions, indicating the navigation abilities developed in the mazes are transferable. 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 and 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, the following insights were derived from the process:

1) Mazes should either be made smaller or the minimum number of goals should be increased to prevent subjects from learning routes instead of building a cognitive map.
2) The baseline number of goals in the mazes that subjects start their training with should be dependent on the subject so that the training is sufficiently challenging and effective for the subject. This requires a pre-test and post-test that adapts to the subject.
3) 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.
4) Goals should be placed completely 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: The randomization of goal placement and assessment order have already been implemented; the adaptive pre-test/post-test and resized mazes are still left to be developed. Upon finishing VR development, the next step will be to run an experiment with approximately 10 healthy participants each for the passive and active conditions using the procedure below:



Revised procedure after evaluation with pilot participant

The main changes to the procedure include the use of an adaptive pre-test/post-test and an increase in the duration of the experiment (14 days instead of five, as it is more valuable and precedented to examine improvements over the long term). The study would then be repeated with Alzheimer's disease 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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