RObotics And Rehabilitation Laboratory

Virtual Reality Maze Navigation as a Cognitive Training Tool for Gait and Balance Rehabilitation

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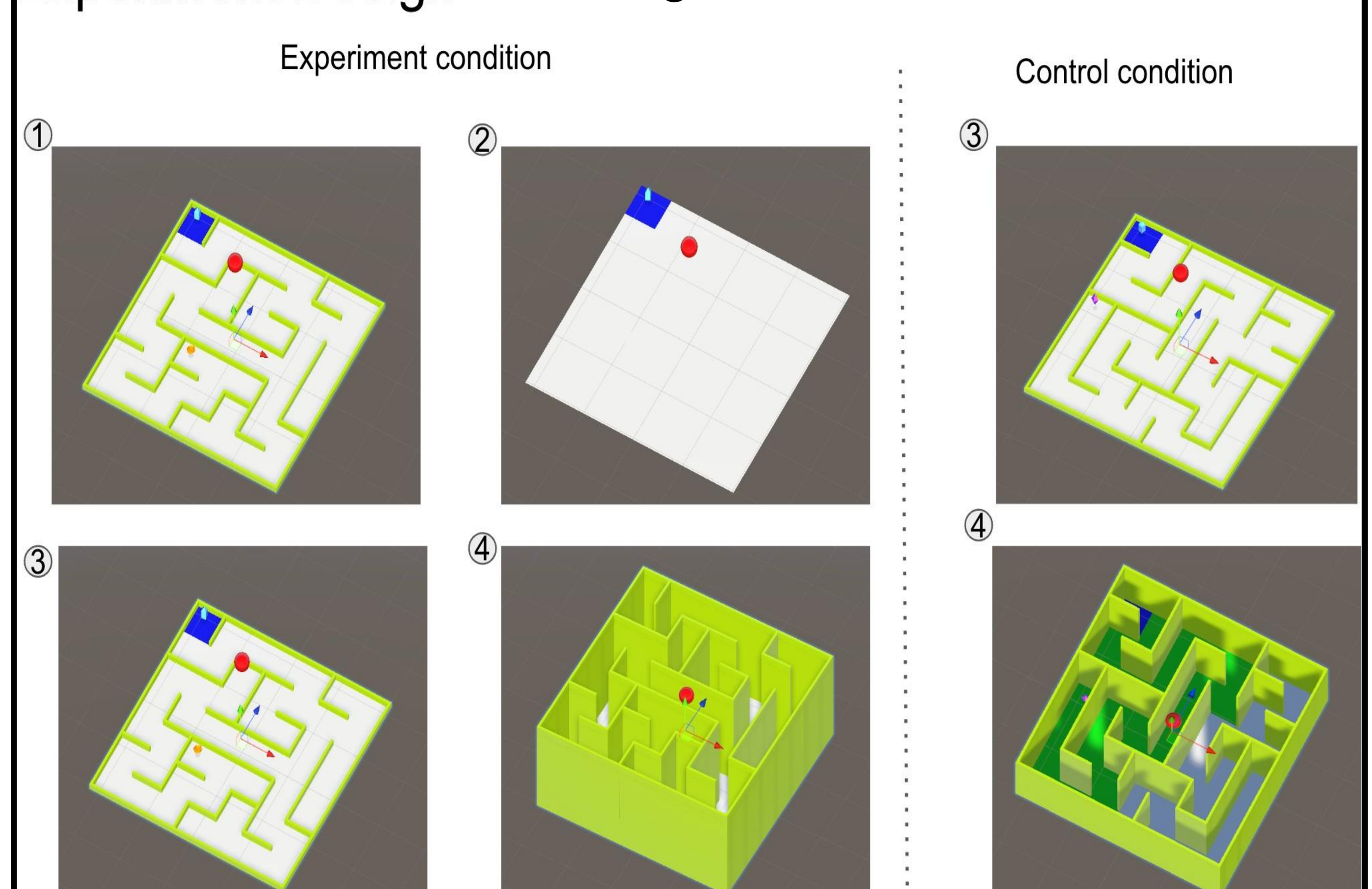
Introduction-Motivation

- Based on research by (Tangen et al., 2015) showing the original **Floor Maze Test** distinguishes between patients with mild **cognitive impairment** and mild Alzheimer's disease, efforts are being made to develop an advanced version of the **FMT** to better assess early **spatial navigation deficits**.
- The goal is to develop a virtual reality maze navigation system that can be used for cognitive rehabilitation and gait and balance improvement.
- This larger, more realistic 3D maze may provide a more **precise measure** of the types of navigation difficulties relevant to identifying **early cognitive impairment** compared to the original 2D Floor Maze Test, working towards **improving spatial navigation assessments.**

Experiment Design **Figure 1**



- Tangen, G. G., Engedal, K., Bergland, A., Moger, T. A., Hansson, O., & Mengshoel, A. M. (2015a, February 3). *Spatial navigation measured by the floor maze test in patients with subjective cognitive impairment, mild cognitive impairment, and mild alzheimer's disease: International psychogeriatrics*. Cambridge Core.

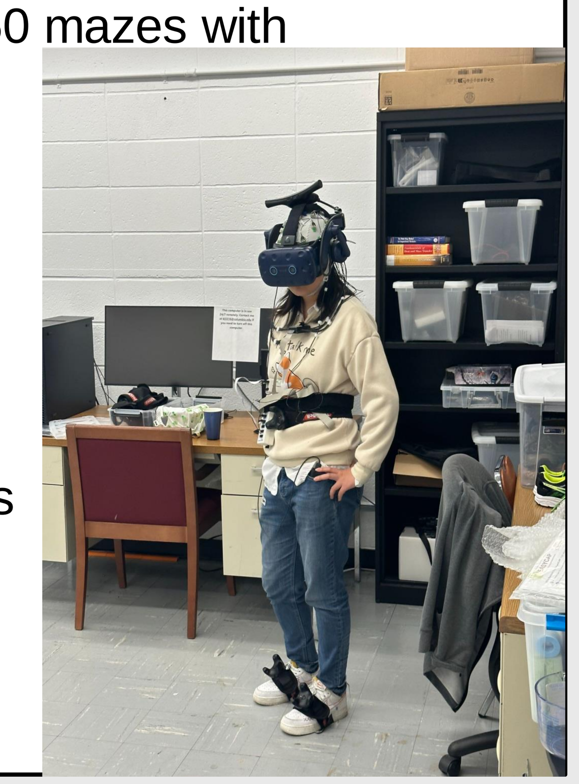
Materials and methods

Participants: Each subject go through 50 different mazes

Conditions:
- Experimental condition: Participants navigated 40 mazes in VR while performing a cognitive task.
- Control condition: Participants navigated 10 mazes randomly selected from the pool of 50 mazes with no additional cognitive task.

Apparatus:

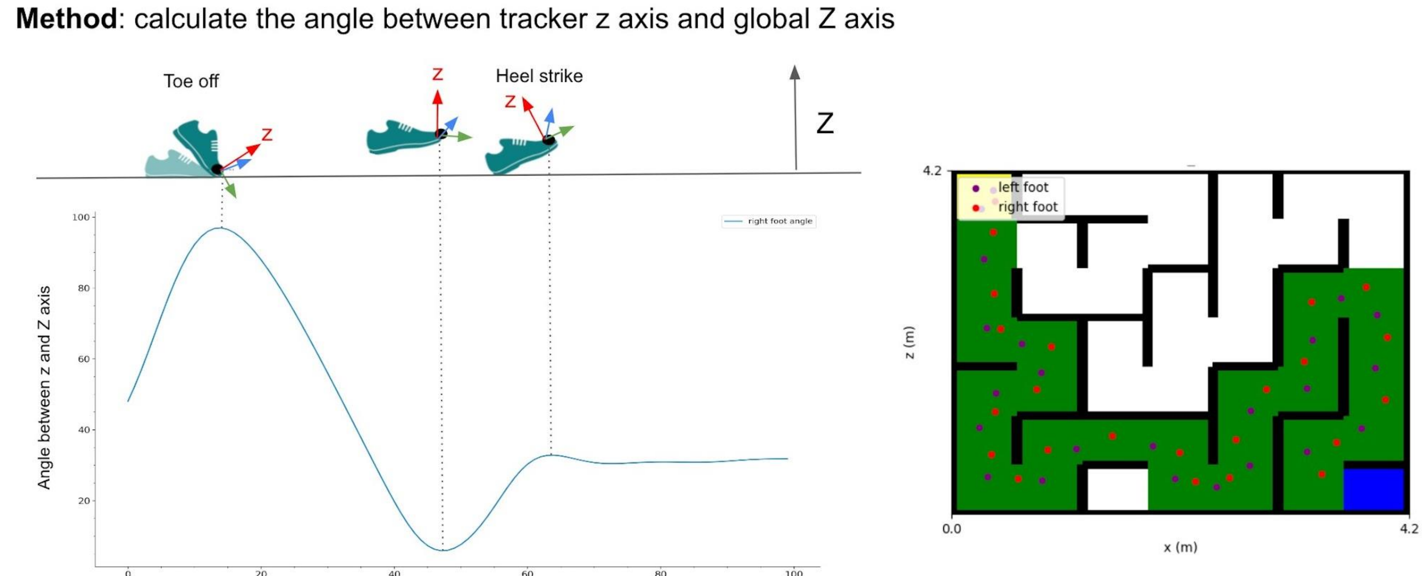
- HTC VIVE Pro VR headset
- VIVE foot trackers
- Pelvis tracker
- EEG cap for recording brain signals
- Procedure:
- Participants fitted with EEG cap and trackers.



Gait Event Detection **Figure 2**

: Find the key points during the gait cycle. 1) when the foot hits the ground and 2) when it pushes off the ground.

Method: calculate the angle between tracker z axis and global Z axis



Acknowledgments

I am deeply grateful to Columbia University and Amazon for selecting me to participate in this amazing program. I also want to thank my mentors, Jiawei Chen and Professor Sunil K. Agrawal, for their guidance and support throughout the program. I truly learned so much, and you've inspired me to keep striving for more in my academic journey.

Results

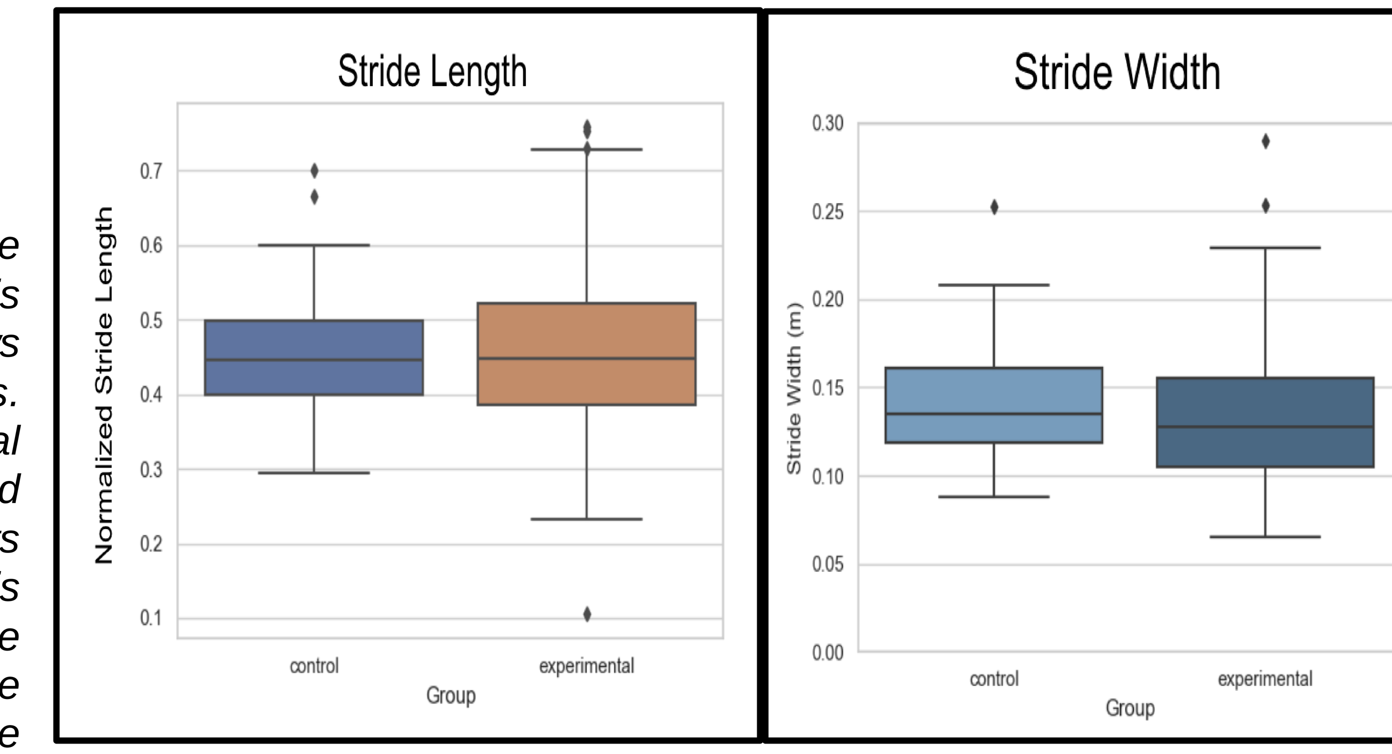


Figure 3:
Excluding turning, in this analysis, i.e., the angle difference between two consecutive heel strike is greater than 30 degree. The diagram on the left shows the foot length for the participants in the two conditions. The individuals who navigated the VR maze with mental demands such as remembering a path had a significantly longer foot length than the participants who navigated the maze without mental demands. This suggests that mental needs can help to improve pace by encouraging participants to take longer, more deliberate steps. The diagram on the right shows the foot width for the participants in the two conditions. As there is a difference in the experimental condition showing how cautious the subjects were compared to being given the path.

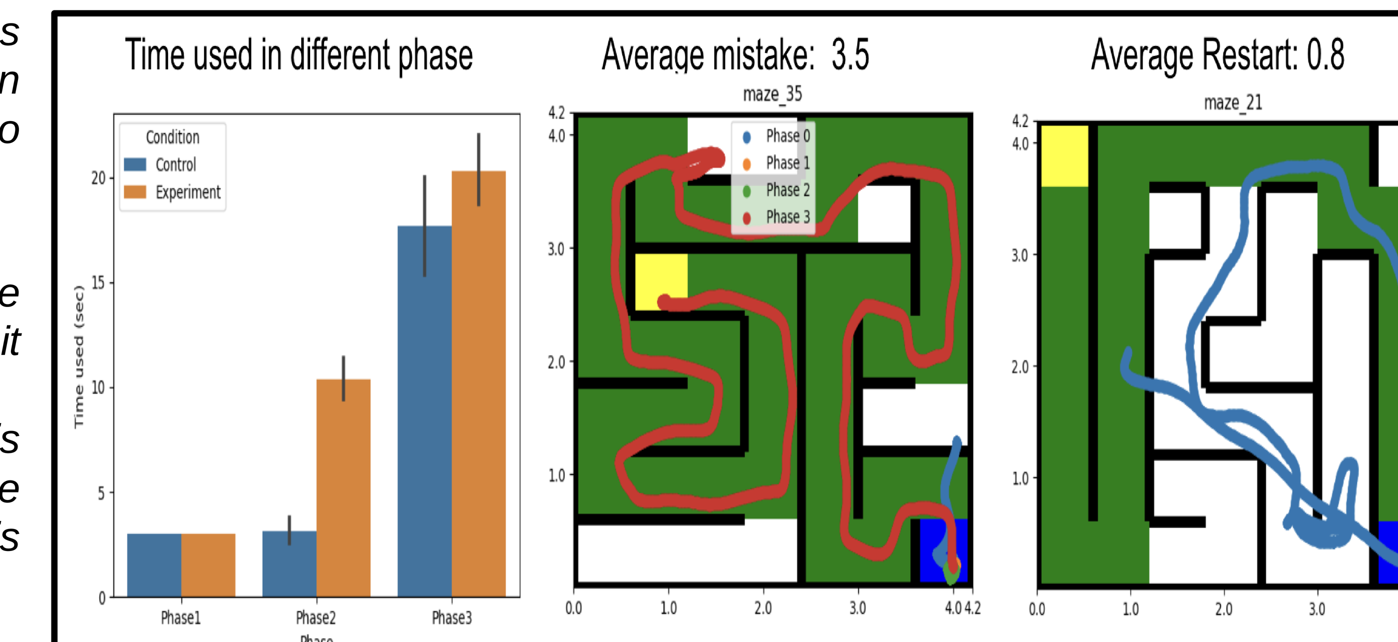


Figure 4:
The image shows that subjects given a map of a maze are learning the layout of the maze faster and navigate it more efficiently than subjects who are not given a map.
Time used to encode the maze in control condition is significantly different from experimental condition, while the difference between time used to navigate the maze is smaller.
Subject made very few mistakes over the 50 mazes.

Medio-lateral Stability

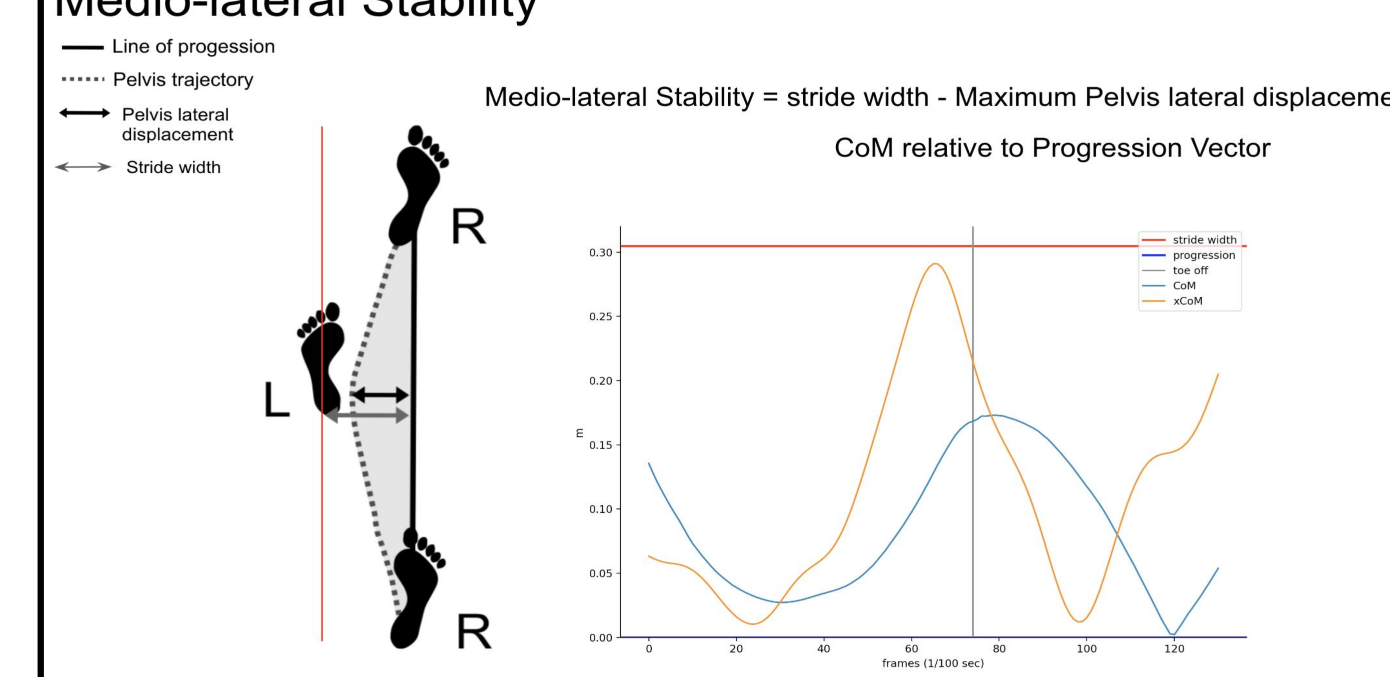


Figure 5:
Visualization of the connection between medium-lateral stability and stride width is depicted in the image and graph. Medio-lateral balance declines as foot width rises. This is due to the fact that maintaining stability requires the foot to pronate more during a wider stride. Pronation is the foot's inside rolling, which, if done excessively, may cause instability. Pronation may cause instability for a variety of reasons. it might make it harder to maintain finger position in space. Next, pronation can broaden the ankle joint's range of motion. Next, pronation can alter how the foot and ankle are positioned.

Conclusion-Future Work

No significant differences were found between the different conditions in straight walking. This may be due to the effects of turning overshadowing the effects of cognitive load during spatial navigation. Alternatively, the task may have been too simple for healthy young subjects. Hence, more testing on a target group such as patients with gait and balance issues is needed to further expand this research to be used for broader implications.