Applications of Virtual Reality for Cognitive Training amongst Older Adults

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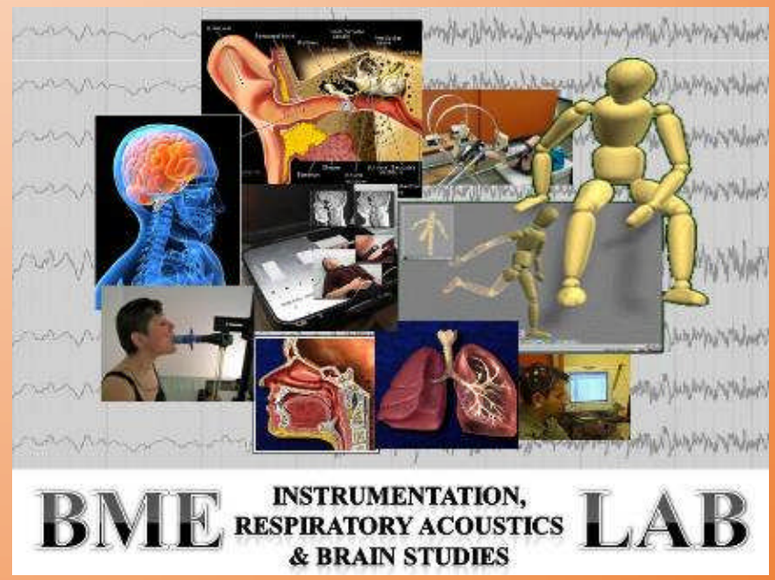
RIVERVIEW HEALTH CENTRE FOUNDATION



Alzheimer's Condition

A blank state: lost in time and space

We have been developing VR environments with embedded serious games for:

- Diagnostic purposes, e.g. Alzheimer's disease
- Treatment monitoring
- Cognitive treatment
- Understanding how our brain works

Hypotheses

- ✓ Spatial cognition is one of the earliest symptom of Alzheimer's disease.

- ✓ It does deteriorate by aging but not as significant as that in people with Alzheimer's.

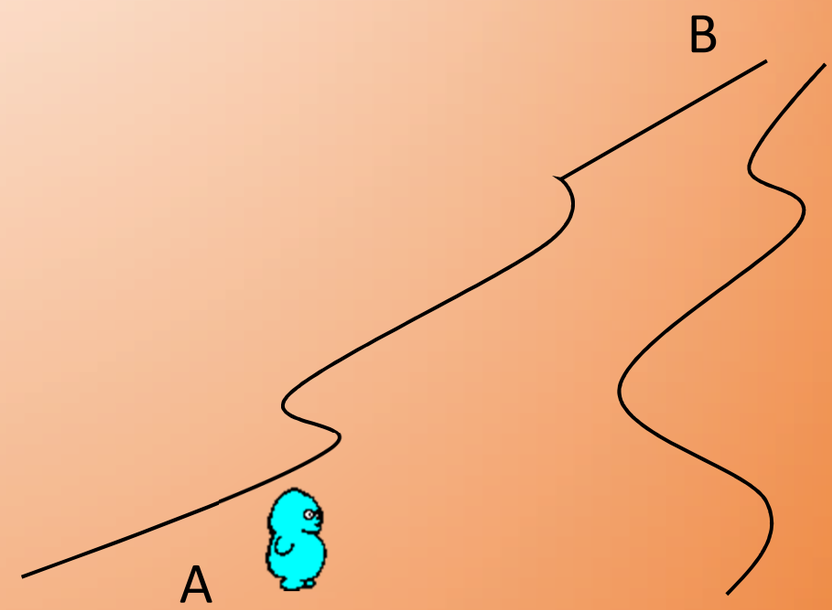
Temporal and Spatial Cognition

A journey from "A" to "B":

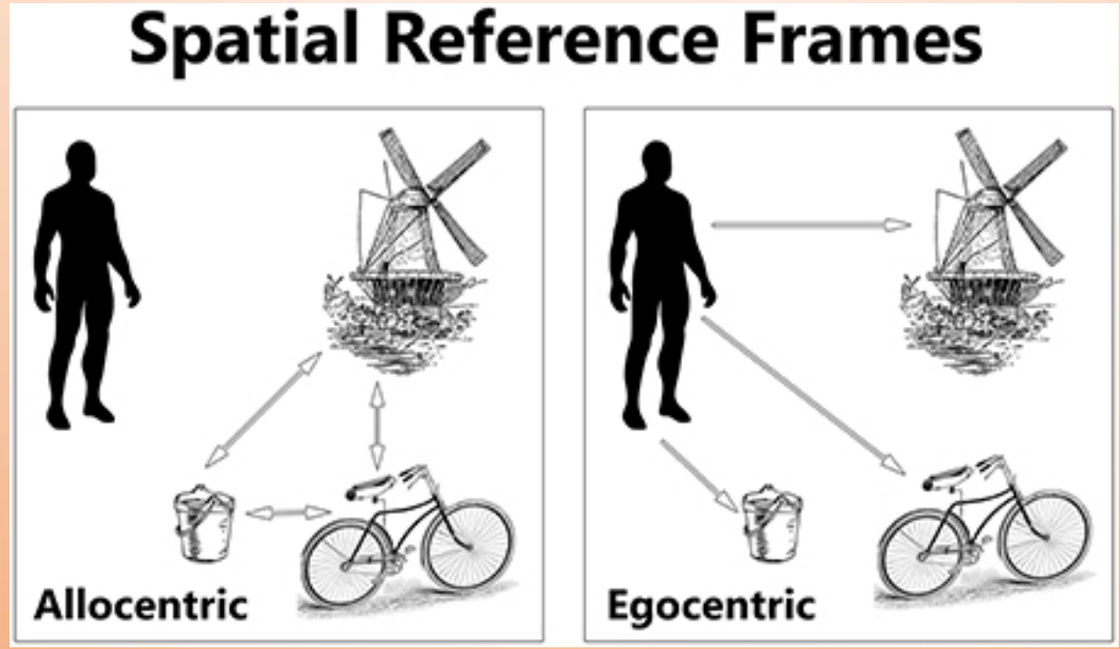
- Optimization in terms of time and space

Requires:

- Temporal cognition
- Spatial cognition



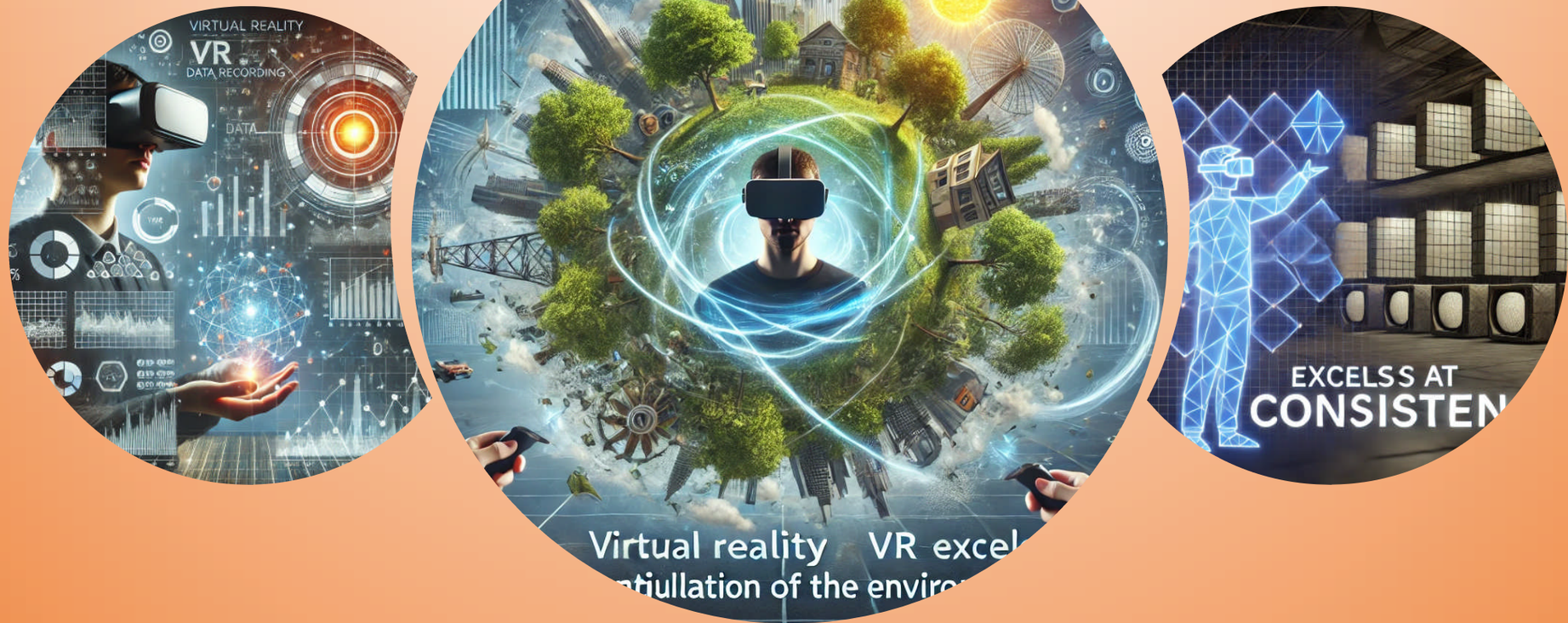
Spatial processing to orient self in an environment:



<u>I assess egocentric orientation in a landmark-less virtual environment.</u>

Why using Virtual Reality?

Data Recording, Manipulation of Environment, and its Consistency and Repeatability

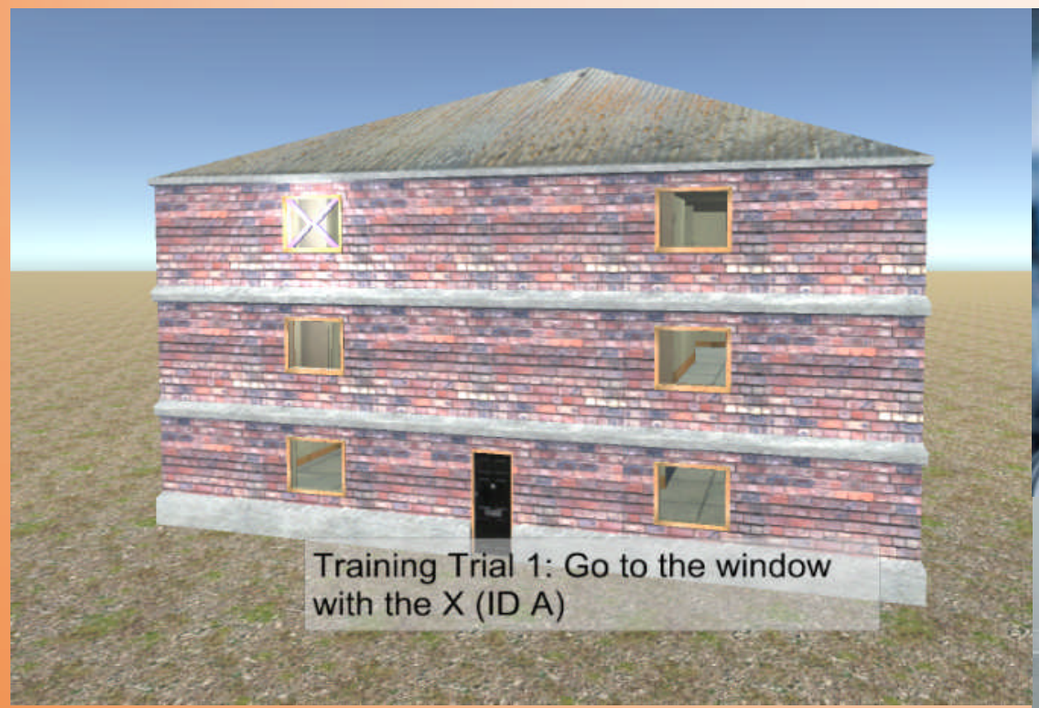


Our Virtual Reality Navigational (VRN) Experiment: VR-building

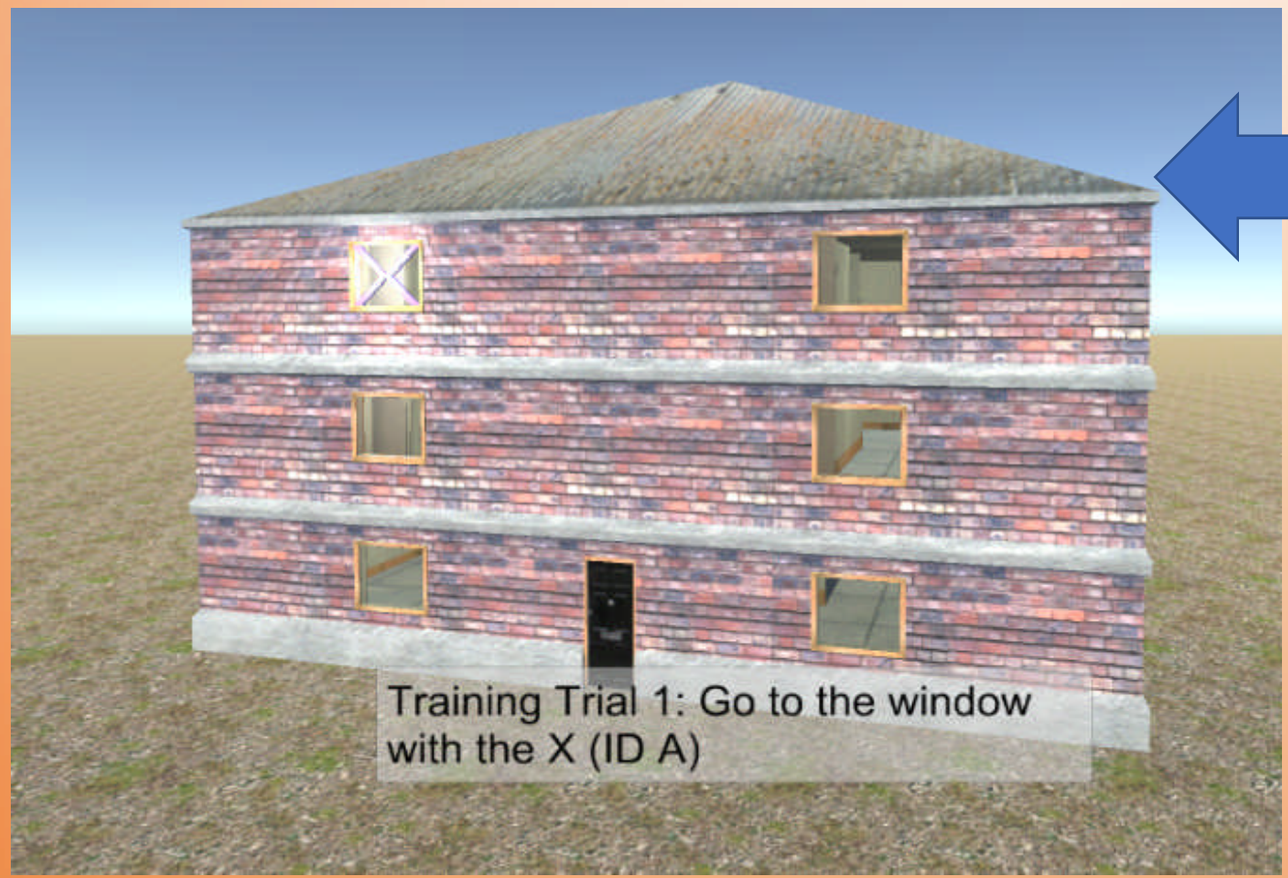
Challenges

- ❑ Naturalistic Virtual Reality Simulation
  - Naturalistic Visual Engine (Stereoscopic 3D)
  - Naturalistic Auditory Engine
- ❑ Gaze stabilization if there are navigation in VR
- ❑ Motion estimation and real time body posture estimation without any external frame (e.g. designs in MR)
- ❑ **Cybersickness (Motion Sickness) due to immersion**
- ❑ Sustaining engagement and compliance over time
- ❑Ensuring accessibility (e.g., vision, mobility)
- ❑Design of suitable serious games with meaningful embedded scoring

Our Virtual Reality Navigational (VRN) Experiment: VR-building



Our Virtual Reality Navigational (VRN) Experiment: VR-building



Our Virtual Reality Navigational (VRN) Experiment: VR-building

https://www.youtube.com/watch?v=ww5o67pJIXo

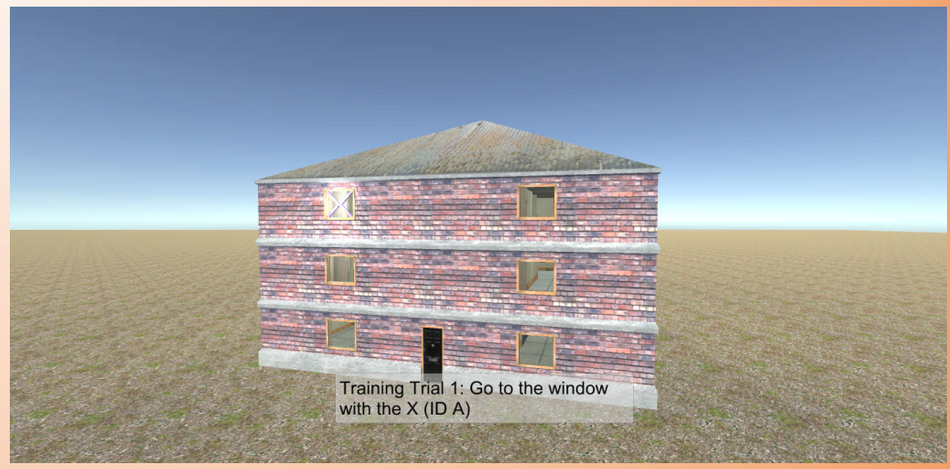
Diagnostic Means: 1) Spatial Orientation Test

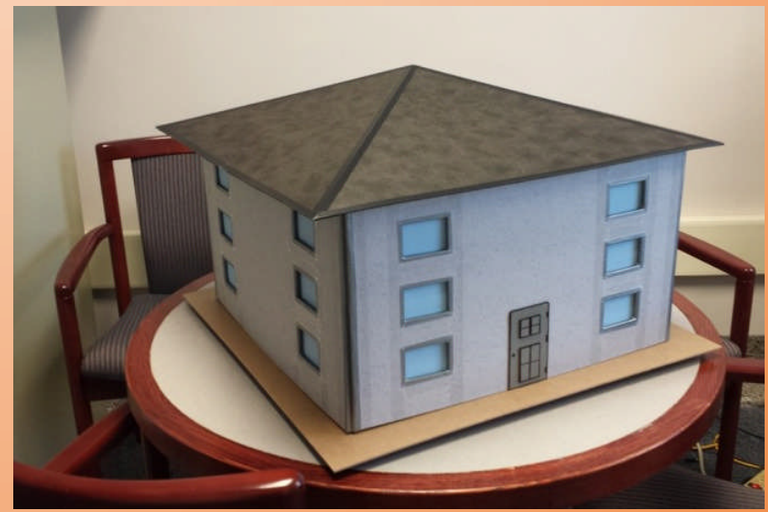
Two Stage:

1. Localization of the target from outside the building
2. Target finding by navigating inside the building

MCI/AD patients cannot do the stage 2. For this group, we test them with a physical model as well.

So far tested on >500 older adults – it can raise a warning flag if someone is on the path of developing a major neurodegenerative dementia.





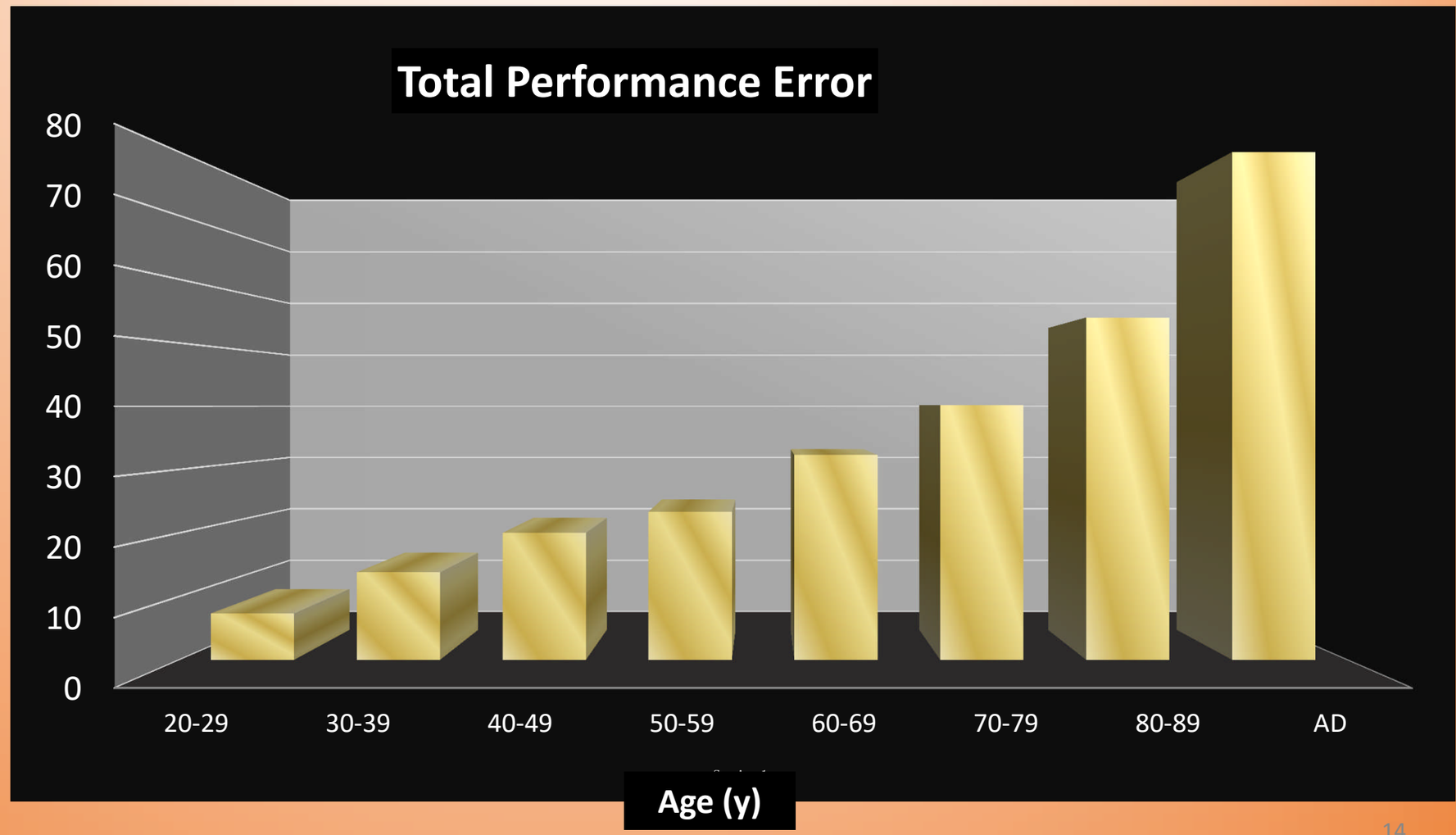
VRN Results of Cognitively Healthy People & Individuals with MCI or AD

Note:

Age range of suspected AD subjects:

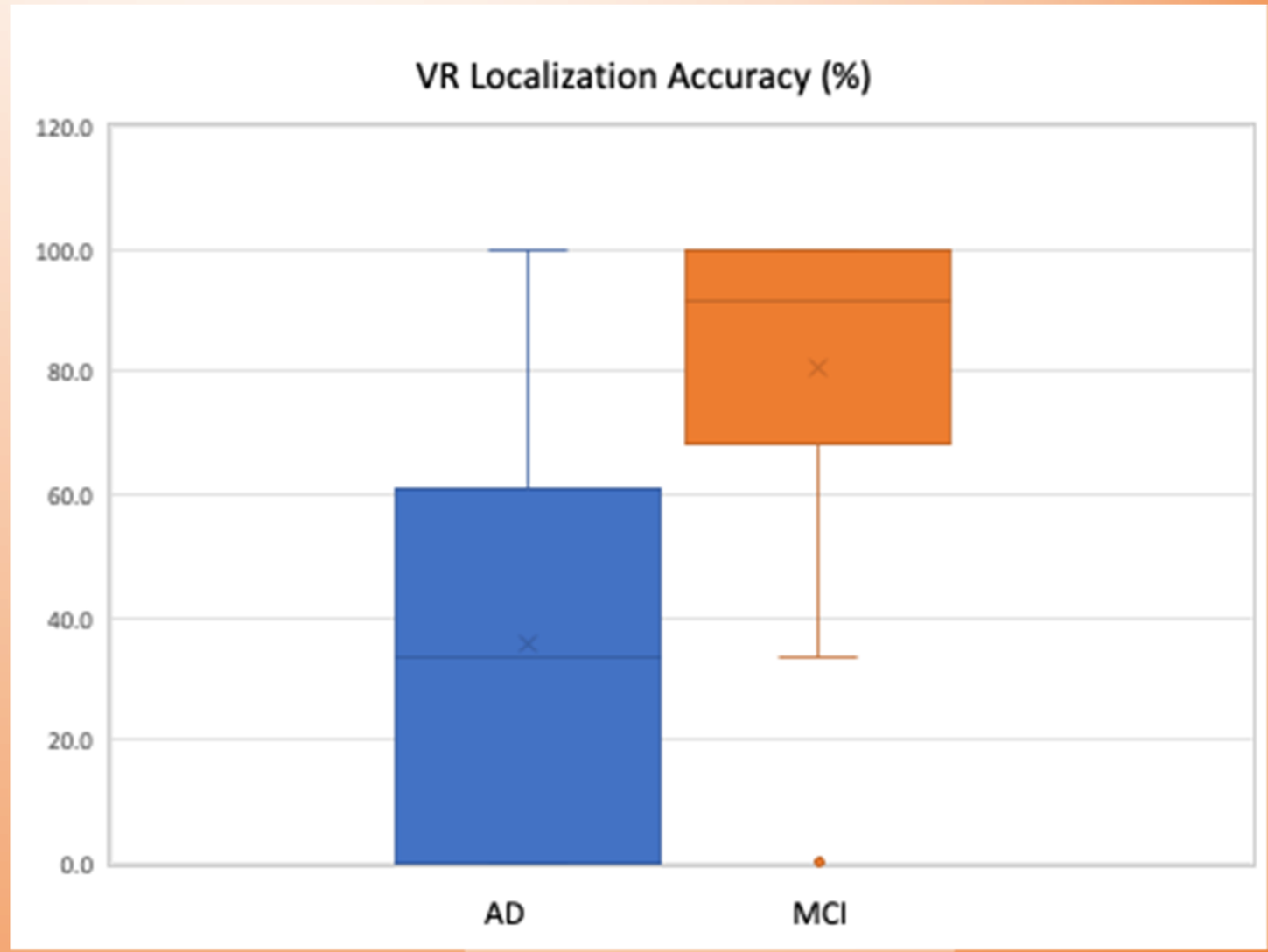
58-87 y

No age relationship in suspected AD population



Stage 1 Localization of the target from outside the building Results:

Distinguishing Alzheimer's from mild cognitive impairment



Cybersickness Challenge

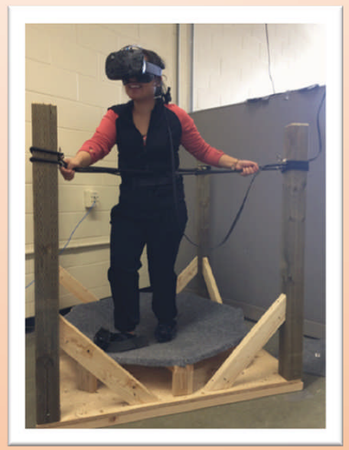
Cybersickness in a VR environment depends not only on the immersion level and input device, but also on the design of the environment, e.g. # of turns, width of pathway in VR, ratio of the movement in real versus VR, duration of the exposure, etc.

The use of wheelchair as an input device in VR reduced cybersickness in >90% of participants, much better than all other input devices

A Comparative Simulator Sickness Study using 3 Different Input Devices

Controllers:

1. TiltChair
2. Omni-directional Treadmill
3. VRNChair
4. Joystick

Head mounted displays (HMD):

1. Oculus Rift CV1
2. HTC Vive


Over the last 15 years

We have tested >650 adults from 20 to 91 years old.

However, we did not collect cybersickness by SSQ questionnaire in every study.

-- 450 individuals played non-immersive version.

-- **179 used the immersive version of the games**

Results of Cybersickness study

- A history of motion sickness predicted 3.72 times higher odds of the likelihood of cybersickness in an immersive environment.
- Males had 78% lower odds of experiencing cybersickness compared to females.
- For each one-year increase in age, the odds of experiencing cybersickness increased by 3%. While the age effect was small, it was still statistically significant.

Key Takeaways on Cybersickness Issue

- If one has experienced motion sickness before, it increases the chance of feeling cybersickness.
- Females are more susceptible to cybersickness than males.
- Susceptibility to cybersickness increases with age.

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VR House for Cognitive Training of Alzheimer's Patients

Using VRN for Neruo-Rehab

Shopping in a farmer market

Our VR Driving Simulator for Cognitive Training of patients with Dementia

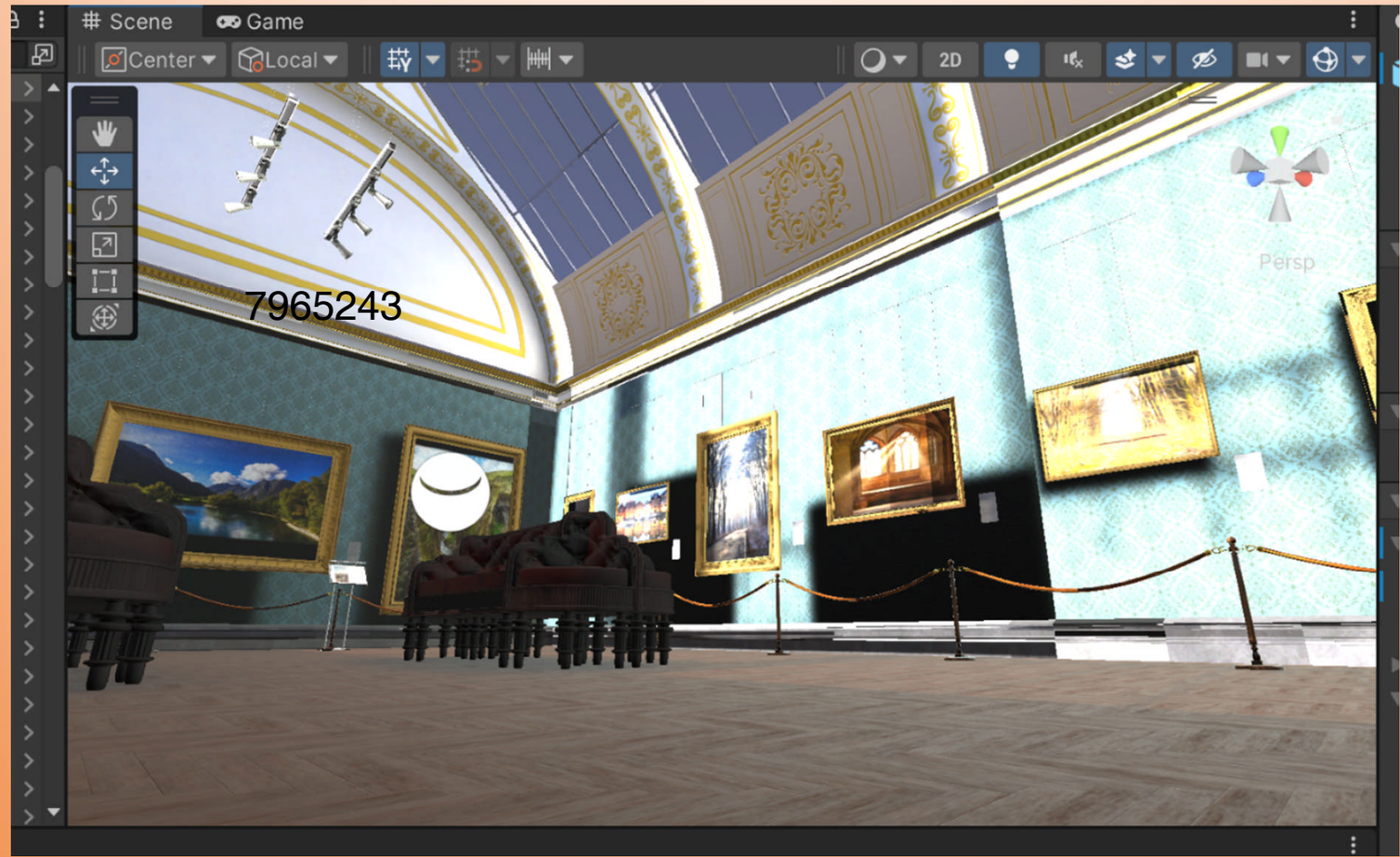
https://youtu.be/1B4ioKKE820

City VR Driving Simulator for Cognitive Training of patients with Dementia

In progress

https://youtu.be/8I0IZCnqciM

Work in Progress: Designing Winnipeg City VR Driving, Visiting Chicago Art Museum, etc. all as serious games for cognitive training



General Conclusions

- **The usage of VR/AR/MR hold great promise for:**
  - Better understating of brain aging
  - Designing **engaging** and effective intervention for neurorehabilitation

- **Future Directions should consider:**
  - Greater personalization with AI integration
  - Multisensory environments
  - Longitudinal studies to validate long-term impact
  - Wider adoption in clinical home-setting

General Conclusions, cont.

- **When designing a VR for applications targeting older adults**
  - Need intimate knowledge of their mental and physical health condition
  - Be aware of cybersickness issue and other plausible adverse effects
  - Sustaining engagement and compliance over time
  - Ensuring accessibility (e.g., vision, mobility)
  - The game score must represent the status of the intended cognitive function

Thanks to my team and volunteers!

Thank you for your attention!

Questions?