

## Introduction

Mild-traumatic brain injury (mTBI), or concussion, is a socioeconomic and medical hindrance to all affected individuals. According to the World Health Organization, “TBI is and will remain the most important cause of neurodisability in the coming years.” With no pharmacological therapy available, a concussion is a difficult injury to effectively treat.(1-2)

Although virtual reality or VR is an emerging technology, it is being explored in healthcare as a safe and effective therapy for patients experiencing schizophrenia, PTSD, and autism (3-7).

The goal of the project is to design, create, and test the feasibility of a VR experience that acts to complement treatment for mTBI. The application will focus on the areas of vestibular (balance and dizziness), visual, motor, memorization, and neuropsychological, including cognition and brain function, treatments.

## Methods

### Physical Therapy Virtual Suite

A virtual physical therapy suite was created using Blender 3D computer graphics software

- Windows, parking lot, landscaping, and lighting were all designed to establish a strong sense of presence (10).
- The room dimensions were made such that multiple exercises could be performed in different areas, similar to a physical therapy office layout.

The suite was imported into Unity (Unity Technologies, San Francisco, CA). Materials and lighting were changed to ensure the authenticity of the original model design.

### Exercises

Baseline (level 1) exercises were created in different areas of the room. Some imported assets were used. If needed, additional assets were created using Unity and functionalized using C# scripting. The room is designed to house **four exercises**, including the ability to teleport to each exercise in the room, and to control the level of difficulty within each exercise to improve user experience (8-9). The exercises will be performed using the Oculus VR headset and hand controllers.

- Gaze Stabilization (stationary)
- Gaze Stabilization (movement)
- Balance
- Memory

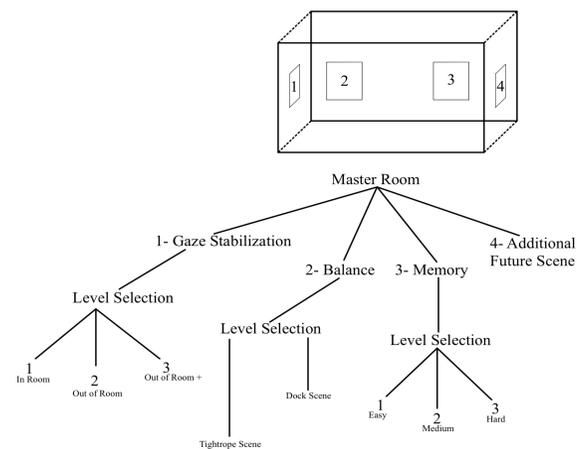
## Methods (continued)

### System and Layout

Figure 1. shows the layout of the exercises. Once inside an exercise, the user can select the level of difficulty of the exercise. The level of difficulty may include changes to

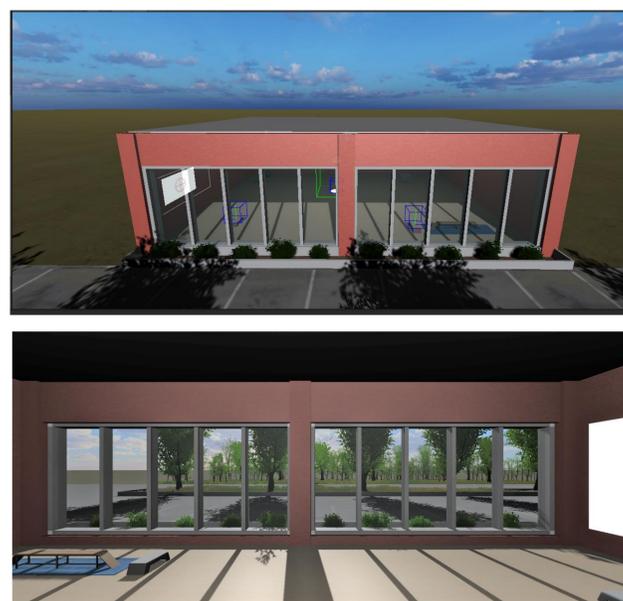
- Lighting
- Audio
- Distractors
- Environment\*

\*Each exercise has a high difficulty level experience in a separate scene (not in the physical therapy room).



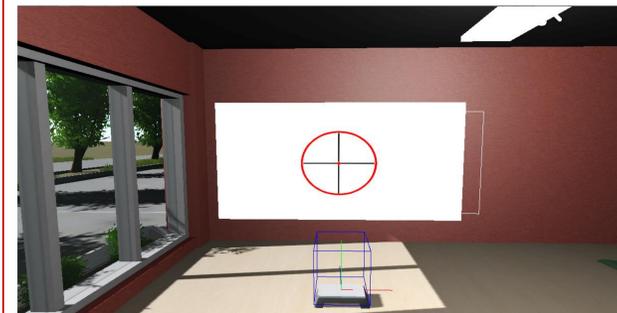
**Figure 1.** Room layout as well as the system hierarchy for each exercise offered.

## Results



**Figures 2 and 3.** The outside and inside of the physical therapy virtual model.

## Results



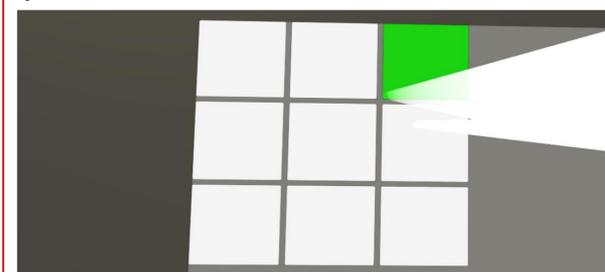
**Figure 4.** Gaze Stabilization (stationary)

The Gaze Stabilization Exercise is an exercise with a red dot in the middle. The exercise also has an image connected to the Oculus headset to track the movement of the user’s head. The user is to fixate their eyes on the red dot in the middle of the screen while moving his or her head in line with the perpendicular lines. The user will be guided along the lines with the yellow dot in the middle of the screen.



**Figure 5.** Balance

The Balance exercise provides a balance beam at a comfortable height. The users are teleported to the beginning of the beam and a movement script slowly moves the user along the beam a slow rate. The users are instructed to stand in proper balance position as provided by a trainer.



**Figure 6.** Memory Recall

The Memory Recall exercise provides a grid of squares. Random squares are highlighted and then the color disappears. The user remembers and selects the correct squares corresponding to the previously revealed configuration.

## Discussion and Future Directions

The physical therapy virtual suite and three baseline exercises have been designed and imported into the therapy experience.

Additional more challenging scenes have been created and have been imported into the suite.

Attention to detail has established a sense of presence within the experience to reduce the possibility of cybersickness (10-11).

Future directions include:

- Customize the balance exercise movement script.
- Complete difficulty level menus and functionality.
- Finish Gaze Stabilization (movement) exercise
- Quantify the progress of the user for each exercise in the experience to provide feedback.

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