Virtual Slots Game for Rehabilitation Exercises

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Abstract*—Research has shown that compliance to interactive training in tasks such as movement therapy following injuries, stroke and major surgeries is sub-optimal. Efforts are being made to make the rehabilitation process a more engaging experience to motivate patients to adhere to therapy. The use of games and virtual reality has gained interest among researchers and clinicians as it may cost less than clinical therapy and can be made portable for use at home. However, without the encouragement of a physical therapist, motivating patients may be difficult. In this paper, we propose a virtual slot machine game and hypothesize that it can potentially make individuals increase time devoted to therapy. Since this game requires minimal skill for gameplay, patients can simply reach a target to trigger a reel spin. We propose that the anticipation and uncertainty of this game will capture patients' interest and motivate them to play longer. This preliminary study with able-bodied individuals may be used to tune the testing designs for future efforts on patient populations that need to repetitively practice arm movements.

Keywords— ***rehabilitation, exercises, games, slot machines,***

I. INTRODUCTION

Studies have shown that adherence to rehabilitation tasks following injuries, surgeries and stroke is minimal [1], [4], [7]. To increase compliance, the use of games in virtual reality rehabilitation exercises has gained interest among researchers and clinicians. However, efforts to make rehabilitation exercises more engaging and to motivate the patients to adhere to therapy have met with mixed results [1].

Slot machine games are one of the most widely played casino games. They require less effort compared to table games and other commercially available skill-based games [3]. Some of the reasons for its popularity versus table games are (a) little or no training is needed (b) one can play for hours without being judged about skill, and (c) it offers immediate win/loss feedback [3]. According to Harrigan et al., factors such as near-misses (missing by one symbol), reinforcement schedules (regular and frequent small wins), losses disguised as wins, illusion control (illusion that one has control over the outcome) and bonus rounds contribute to longer playing times [3]. Smedley et al., examined rehabilitation using an actual slot machine as the exercise device along with traditional exercises. They found that a slot machine as additional therapy contributed to greater rehabilitation progress in patients [2]. In our virtual slot machine game, we have carefully incorporated reinforcement schedules, illusion control and near-misses in reel-stop combinations.

Adapting this non-skill-based slot machine game into a virtual reality rehabilitation exercise might produce the feeling of anticipation, excitement and thrill in users thus increasing the time patients are willing to devote to therapy exercises. It could eventually be integrated into Individualized Physical Therapy exercises. The patient's anticipation and uncertainty of the outcome of winning or losing could keep them playing, thereby making this method an effective means of home physical therapy. Home therapy is envisioned where a minimum of therapist guidance is needed, and the main motivation comes from the patient. Using a virtual reality environment with a hand tracking device has the potential to give users a feeling of being immersed in the game environment. The ability to reach a movable target in the game environment can give the subject the feeling of accomplishing a task.

II. RELATED WORK

Literature has shown that games in virtual reality can be effective in delivering engaging and high-repetition practice while being as efficient as conventional approaches such as physical therapy[8]. Several games and virtual reality therapy programs have been developed in the past which have been tested for efficiency in performing rehabilitation exercises. There are mainly two types of gaming systems used for rehabilitation programs: controller based systems such as Nintendo, Wii and PlayStation with targeted candidates having the ability to grasp the controller and perform push/ release actions, and camera tracking based systems such as Kinect and Leap Motion with targeted candidates having the ability to move their arms in any capability. Our game uses the latter of the two approaches in this paper.

A. Controller Based

Several controller-based games have been used to perform rehabilitation exercises[9]. The gameplay is made possible by a handheld controller with a built-in accelerometer and gyroscope to detect the direction and magnitude of acceleration of a player's movement [9]. Kilbride et al. used the Neurofinix platform which consists of a hand controller or Neurobands that facilitate upper-limb exercise via games displayed on a tablet. This experiment was used to assess safety, feasibility and acceptability of using such devices for rehabilitation at home[11].

B. Camera Tracker Based

Camera Tracker based devices can be used to perform both simple movements such as moving hands from one place to another to touch an object or more complex movements such as using pinch and grab gestures. We can measure movement time, peak velocity and functional arm use [9]. Lohse et al. showed that VR therapy can be beneficial for both body function outcomes as well as activity outcomes. Sapsonik in their meta-analysis article reviewed 12 studies consisting of 195 participants in total who performed upper extremity rehabilitation exercises in the studies. Eleven of the studies showed significant benefit of VR for outcomes such as improvement in motor impairment and motor function [10].

III. Experiment

A. Set up and infrastructure

We used a PARIS-like [5] environment to display the game to the participants. This system has a stereo TV and a half silvered mirror mounted on a stand. A Leap Motion device along with associated libraries was used to track hand movements of the participants. The game was built in Unity and implemented using JavaScript and C# and ran on a laptop computer. The participants used active stereo glasses to view and play in the stereoscopic environment of the game. The Leap device was fixed below the display and the participants were asked to move the chair if needed to get the best view of the avatar of their hand in the game and to be able to comfortably move their hand in the setup.

B. Implementation

We used a 2D Slot Machine Game available freely on the Unity asset store as the base for our development and converted it into a 3D game. Leap Motion libraries were used to control hand tracking and a stereoscopic script was used to convert the environment from 2D to 3D. We also used several freely available 3D assets from the asset store to create the casino environment. Additionally, we created our own primitive objects such as the moving target, casino floor, reel background in Unity and textures needed for the objects using Gimp. An invisible collider around the moving target helps detect a touch. A touch is detected when the Leap hand enters the collider and a reel-spin is generated. We use the side-by-side stereoscopic mode for our game. We used custom reel stops to make sure that every participant views the same outcome on the screen to prevent contamination of data by the pseudo-random nature of a traditional slot game.

C. Methodology

The experiment is broadly divided into 3 major parts – a) Study setup consisting of recruitment of participants, consent for participation and filling out pre-study questionnaire; b) Experiment Core consisting of training on the environment, explanation of the experiment, participants performing the given experiment; c) Data Collection and Analysis consisting of recording time, taking survey and analyzing the data (Fig. 1).

Our experiment consisted of two groups, control and test. The control group had 11 participants and the test group had 12 participants. Tasks to be performed were explained in detail to both groups. Leap Motion's Flower Robot project was used to familiarize the participants with the tracking device in which they needed to pluck the petals of a flower. After the users were able to easily pluck the petals of the flower and move their hands to reach the edges of the display they were asked to go ahead with the given exercise.

The control group played the game without reels being visible. Only the casino environment, credit meter, win meter, bet value and moving target were visible to the subject. The test group played the game with casino environment, credit meter, win meter, bet value, moving target and the reels visible. Both groups of subjects used their non-dominant hand throughout the study. In all but one case the left hand was the non-dominant hand.

Both games have a credit meter which starts with 1000 credits. By touching the target, a reel-spin is generated which in turn generates an outcome. For each reel-spin the participant bets 50 credits. Based on a predetermined set of reel-stop combinations that are unknown to the subject, they may win or lose in the game. Since each bet costs 50 credits, if the subject does not hit any winning combination, they will eventually exhaust all 1000 credits (provided at the start of the game) and lose the game. One row of the reels is fully visible and the top and bottom rows of reels are partially visible. This is done to mimic the effect of near hit/miss as in the traditional games. In Fig. 2 we see that a user has three consecutive A

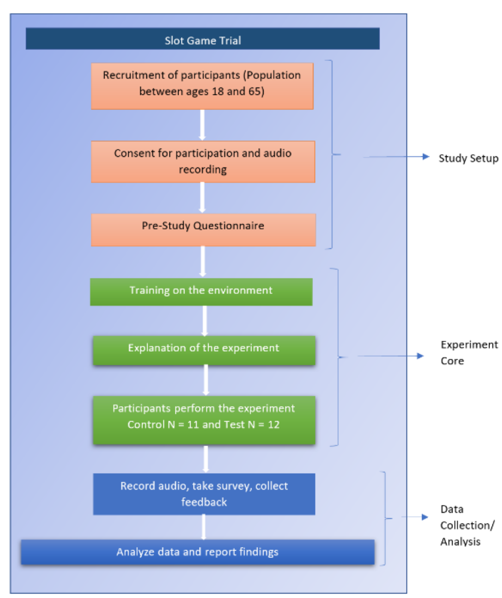

Fig. 1. The entire experiment broadly divided into 3 major parts – a) Study setup; b) Experiment Core; c) Data Collection/ Analysis

symbols in the middle row but missed a fourth A by just one place which is partially seen in the top and bottom rows. The game has sound playing in the background to simulate the casino environment. Additionally, we use audio and animated visual

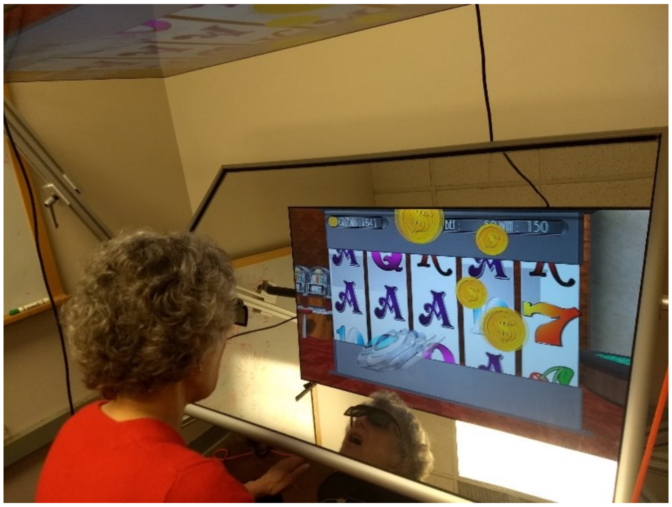

Fig. 2. shows a user testing the game and the interface. *Image courtesy of the Electronic Visualization Laboratory at the University of Illinois at Chicago.*

cues during the gameplay to indicate wins.

Based on the reel-stop combinations, wins may be as low as 150 and as high as 1000 credits. The goal is to win as many credits as possible. Subjects may play the game as long as they wish and at their own pace. The subjects were given a pre-study questionnaire to gauge their familiarity with the environment and a post study survey to receive feedback for the exercise. Subjects' playing time (rounded to nearest minute) and audio throughout game-play were also recorded.

IV. Results and Discussion

In this experiment we compared the playing times between the control and test groups (Fig. 3). The control group had a mean of 4.00 (±2.32 s.d.) minutes and the test group had a mean of 6.58 (±5.25 s.d.) minutes. A t-test (two-tailed, with two sample equal variance) showed no significance between playing times of the two subject groups (p-value = 0.15). Fig. 3 also shows an outlier at 10 minutes for control group and at 21 minutes for test group.

After the study, the subjects were asked to complete a survey consisting of questions on a Likert scale of 1-7, 1 being *Strongly Agree* and 7 being *Strongly Disagree* and a few open-ended questions for comments and feedback. From their feedback we can say that many subjects had issues with hands tracked by Leap Motion not aligning with their perceived orientation of their own hand. In spite of these issues, most participants shared positive feedback about the game. Most participants also mentioned they would continue playing for a longer period of time but had to pick an arbitrary time to stop. During the study we also observed that most players were more focused on hitting the target rather than observing the result of the trial i.e., potential outcome (win/loss). Another important feedback from the subject who played for 21 minutes in the test group was that they knew there were wins of bigger denominations (500, 1000 credits) and believed they could recover what they lost which in turn motivated them to play longer.

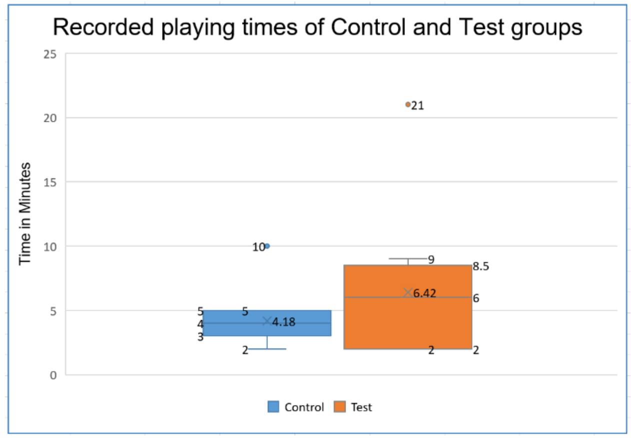

Fig. 3. Box Plot for recorded playing time of Control and Test groups

Based on the participants' feedback for enjoyment of gameplay we have the following interesting result. The control group has a mean of 3.09 (±1.87 s.d.) whereas the test group has a mean of

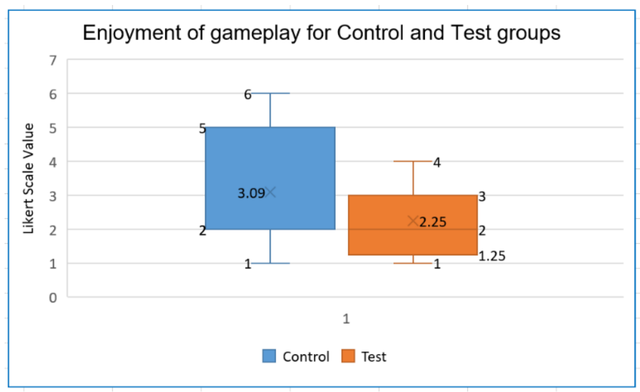

Fig. 4a. Box Plot for enjoyment of gameplay on a likert scale of 1-7 for Control and Test groups

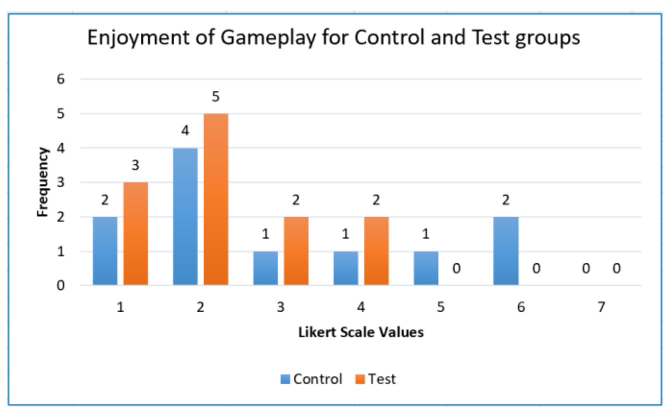

Fig. 4b. Histogram for enjoyment of gameplay on a likert scale of 1-7 for Control and Test groups

2.25 (±1.06 s.d.) (Fig 4a). We also notice less variability in the opinion of the population. Also, in Fig. 4b we see that most users from the test group agree more strongly with the enjoyment.

In Fig. 5 we see that most users agree that using a hand tracking device like Leap Motion made the game more engaging than if they had used a keyboard instead. This finding is important since this game is to be used in home based rehabilitation.

Fig. 6 shows histogram for winning credits as a motivating factor for gameplay for control and test groups. We see that winning credits does not become a compelling factor for motivation of gameplay. However, it has the potential to be a helpful factor overall. The fact that we see no significant difference between the two groups, aligns with our assessment that the participants in both groups concentrated more on reaching the target rather than paying attention to the changes in the credit meter of the game.

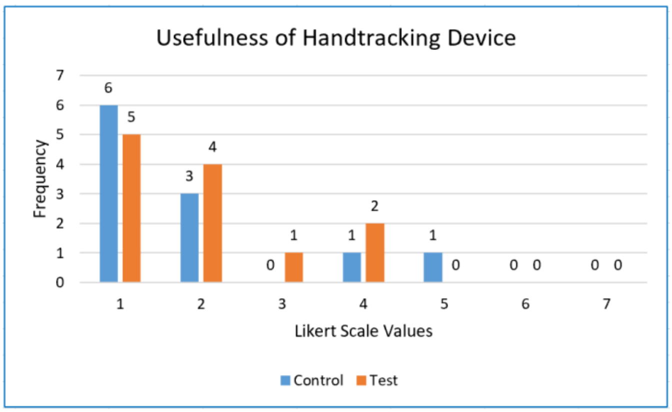

Fig. 5. Histogram for usefulness of handtracking device on a likert scale of 1-7 for Control and Test groups

Thus, a protocol where the subject is attentive to the game outcomes needs to be implemented since we believe it is critical to prolonged engagement in the task.

V. Future Work

In our second iteration of the experiment we plan to implement a two-touch system (commonly known as skill stop [6]). We also wish to test this game on other interfaces such as HTC Vive and Oculus Rift in the future and draw comparisons between using Head-Mounted Displays and large collaborative display systems such as the CAVE2.

VI. Acknowledgement

We are grateful to the National Institute on Disability for funding this project during its initial stages. We also thank Josyah Dooley, Tasqin Zehra, Kholoud Baste, Sri Vadrevu, Jagjit Bhatia, Harsheta Kumar for their work at various stages during the course of this project.

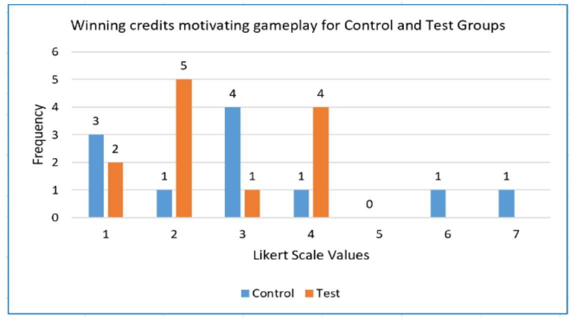

Fig. 6. Histogram for winning credits motivating gameplay on a likert scale of 1-7 for Control and Test groups

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