Accuracy and Precision in Virtual Reality

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Abstract

This study investigates the effect of accuracy training in a virtual environment (VE) and the impact that the training has on a subject's accuracy in the real world when performing the same task. Six male undergraduate students served as test subjects. The study measured the subjects' accuracy in hitting a target from 10, 15, 20 and 25 feet using a standard tennis ball as the thrown object. A baseline was taken for each subject in the real world. Then, the subjects performed the same tasks in a virtual environment designed to simulate the real world accuracy test. The virtual environment was created using the Unity game development platform. The HTC Vive Virtual Reality System was used to provide user interaction with the virtual environment. Accuracy was measured by the distance that the ball hit from the target. The difference in each subject's performance was calculated by comparing the baseline exercise to the final exercise. Based on the accuracy comparison between the baseline and final accuracy exercises for each subject, the research concludes that performing the same tasks within a virtual environment causes slight improvement to one's accuracy across all distances in regards to the percentage of throws to hit the target area from the total number of attempted throws.

Keywords:
Virtual Reality, Virtual Accuracy, Virtual Precision, Virtual Perception, HTC Vive, Unity, throwing, optimal planning

Figure 1. HTC Vive Virtual Reality System

I. Introduction

Virtual Reality has become a key tool for a variety of private professions. Virtual Reality-based Training Systems (VRTS) may provide a valuable alternative to training when either the cost or possible negative consequences of exposing trainees to the real task environment are considerable (Nathanial, & Mosialos, 2010). Virtual Reality Human-Computer Interaction (VRHCI) is still a new field, however, and still needs some guidelines for designing in virtual reality. For example, when designing a computer program on a windows-based PC, the designer makes a few assumptions, such as that the user is aware that he is using a machine and that there are common peripherals used such as a monitor, keyboard, and mouse. When a user is immersed into a virtual environment, the designer has to think about the different kinds of inputs. In the case of the HTC Vive, there are two SteamVR Tracking controllers and the dual AMOLED 3.6” diagonal screen headset. The headset uses “room scale” tracking technology, allowing the user to move in 3D space and use motion-tracked handheld controllers to interact with the environment. Few studies have evaluated how the human mind reacts and perceives space in a VE. Unity uses the International System of Units (SI Units) and the user is able to scale everything to meters (m). The question still remains, ”Does the perceived space in VR affect the user and how well can we improve accuracy and precision in reality using VR?” Once the projectile has been launched, there is no possibility of control, differentiating this task from much better studied tasks such as pointing and tracking. Instead, one has to learn strategies from an iterative process of error estimation and correction from one trial to the next (Venkadesan, & Mahadevan, 2017). Here we complement those studies by using them and proving them to be useful in a virtual environment.

II. Literature Reviews

Since virtual reality was introduced back in the 1960’s it has been improved so much, as to make it look almost the same as present reality. According to Anshel, a Moor Insights & Strategy technologist and technical writer focusing on consumer platforms, HTC Vive is the best virtual reality device that is cheap and “premium”. It is “premium” because of its amazing features such as having the best tracking system and the best designed controllers. Space perception in the Vive was comparable to real-world space perception when measured by blind-walking but slightly underperformed real-world perception when measured by verbal reporting. Furthermore, space perception in the Vive was more accurate when compared to older head-mounted-displays (HMDs) (Kelly, Cherep, & Siegel, 2017). This leads us to hypothesize that one’s ability to aim and perform will be less efficient in a virtual environment as opposed to a real environment and that the ability to have accuracy in virtual reality will result in even better accuracy and precision in a real life environment when performing the same task.

III. Methodology

We are interested in observing the accuracy and precision of a person's ability to hit a target at varying distances in both the physical world and the virtual one. In order to assess this, we are conducting tests where we throw a tennis ball at a target from four distances, and then recreate the same environment in the HTC Vive, testing the same thing. These will test the assumed under-perception that most people experience within the VR Space (Kelly, Cherep, & Siegel 2017).

Participants

The initial sample size is six participants. This consists of the members of the study, and presents a subject group that is not adept at aiming, shooting, and targeting.

The subjects will be given a few minutes to familiarize themselves with the Virtual Environment prior to conducting the tests, in order to reacquaint themselves with how to interact with and properly perceive the space that they are in.

This familiarization is mitigated in the testing, as all of the members have had some degree of experience in designing and testing the room while in development.

Physical Tests

The tests outside of the VR System will be used as a reference point for performance within the Virtual Environment. Multiple tests were conducted standing directly in line of the target from 10, 15, 20, and 25 feet (presented as 3.1, 4.6, 6.1, and 7.6 meters) to allow for results with differing amounts of preparation and requirements for the subjects.

Figure 2. Target used to measure accuracy. Measured in imperial inches.

In recording the data for these tests, we set-up two cameras to record every throw, so as to guarantee a greater degree of precision in the recording.

Participants were allowed to throw the tennis ball however they pleased, whether it be underarm or overarm. This allows the participant to have a greater degree of comfortability and produce more accurate results.

Figure 3. Participant in physical trial.

VR Tests

When performing these same tests in the Virtual Environment, our primary goal is establishing a similar environment so as to limit any outside factors that may skew the results.

The room we have set up is designed to mimic the initial testing room. The room is of the same dimensions, with a target at the same height and size of the initial target. The ball is the same size and weight as the tennis ball, and there are markers set for 10, 15, 20, and 25 feet from the target.

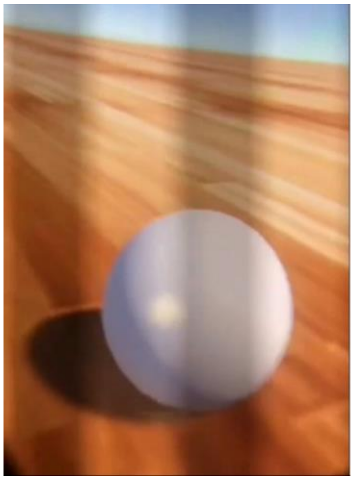

Figure 4. Initial state of VR Space

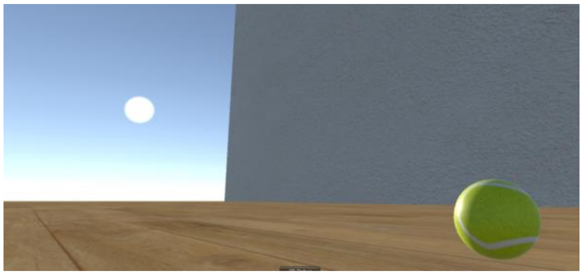

Figure 5. Final State of VR Space

The biggest difference between these tests is the physical action of throwing the ball. When attempting to recreate this experience in the VR Space, it is necessary to use a controller, instead of simply throwing the ball.

With this in mind, the tasks will be affected, but efforts have been made to mitigate these issues. The controller is actually of a very similar weight to the tennis balls used, which creates a, likewise, similar experience. We have also managed to add gloves to the controllers in the VR Space to allow the subject to visualize their hands that react to any button that is pressed, in order to make everything feel more natural and similar to the physical environment.

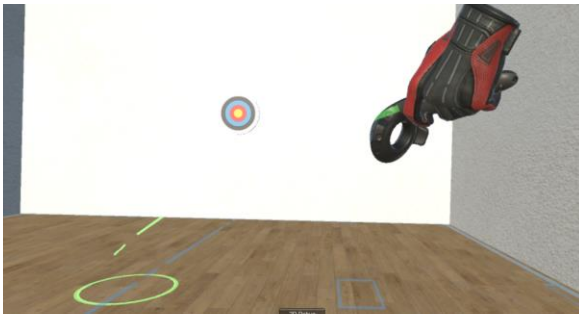

Figure 6. Gloves that mimic users' hands.

There is also a very minor issue of there being no wind resistance within the Virtual Environment. The effect that this has on the tennis ball is negligible, but should still be taken into account.

At this point, the only major and noticeable difference between the two tests will be in the release of the ball. The physical test requires the subject to throw the ball, and release their entire hand. The VR test does the same thing, but requires the subject to release a trigger before the ball releases. While these are different, they are similar enough that they should not be the cause of too major of a difference in results.

These factors have gone into mitigating any potential discrepancies between the two tests, and will yield more accurate results as a consequence.

Scoring

Each subject's throws were scored under a point system. A point value was assigned to each throw based on the distance away from the center of the target. Throws up to 2 inches away from the center were assigned 15 points. Throws up to 6 inches away were assigned 12 points. Throws up to 9 inches away were assigned 9 points. Throws up to 12 inches away were assigned 5 points. Throws more than 12 inches away but still in the target area were assigned 3 points. Throws that were outside of the target area were assigned 0 points.

IV. Initial Physical Tests

Using the determined scoring system, an average number of points per distance was calculated and tabulated for each subject. Cumulative throws from all of the users are represented in Figure 7 for each distance. The change in precision is apparent, where precision becomes lower as the distance away from the target increases. This means that the spread of throws became greater as the distance increased. Additionally, the accuracy of the cumulative throws was calculated. The accuracy was measured as the number of throws that hit the target divided by the total number of attempted throws. The accuracy for the 10-feet distance was 0.9, the accuracy for the 15-feet distance was 0.76, the accuracy for the 20-feet distance was 0.56 and the accuracy for the 25-feet distance was 0.46. This shows a direct relationship between the accuracy and the distance away from the target. Statistical analysis will be performed to determine the differences between the initial physical tests and the final physical tests.

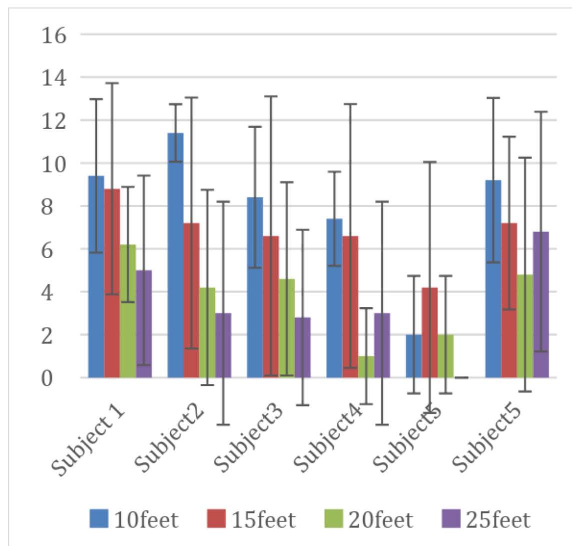

Figure 7. Average points scored by each subject from the specified distance. Each subject performed 5 throws from each distance and points were assigned to each throw based on the distance to the center of the target. Throws that missed the target area completely were assigned zero points.

	Distance			
Sub.	**10 feet**	**15 feet**	**20 feet**	**25 feet**
1	9.4 ± 3.57	8.8 ± 4.92	6.2 ± 2.68	5 ± 4.42
2	11.4 ± 1.34	7.2 ± 5.85	4.2 ± 4.55	3 ± 5.20
3	8.4 ± 3.29	6.6 ± 6.50	4.6 ± 4.51	2.8 ± 4.09
4	7.4 ± 2.19	6.6 ± 6.15	1 ± 2.24	3 ± 5.20

5	2 ± 2.74	4.2 ± 5.85	2 ± 2.74	0 ± 0
6	9.2 ± 3.83	7.2 ± 4.02	4.8 ± 5.45	6.8 ± 5.59

Table 1. Average points scored accumulated by each subject from each distance that the ball was thrown. A value is shown with the standard deviation.

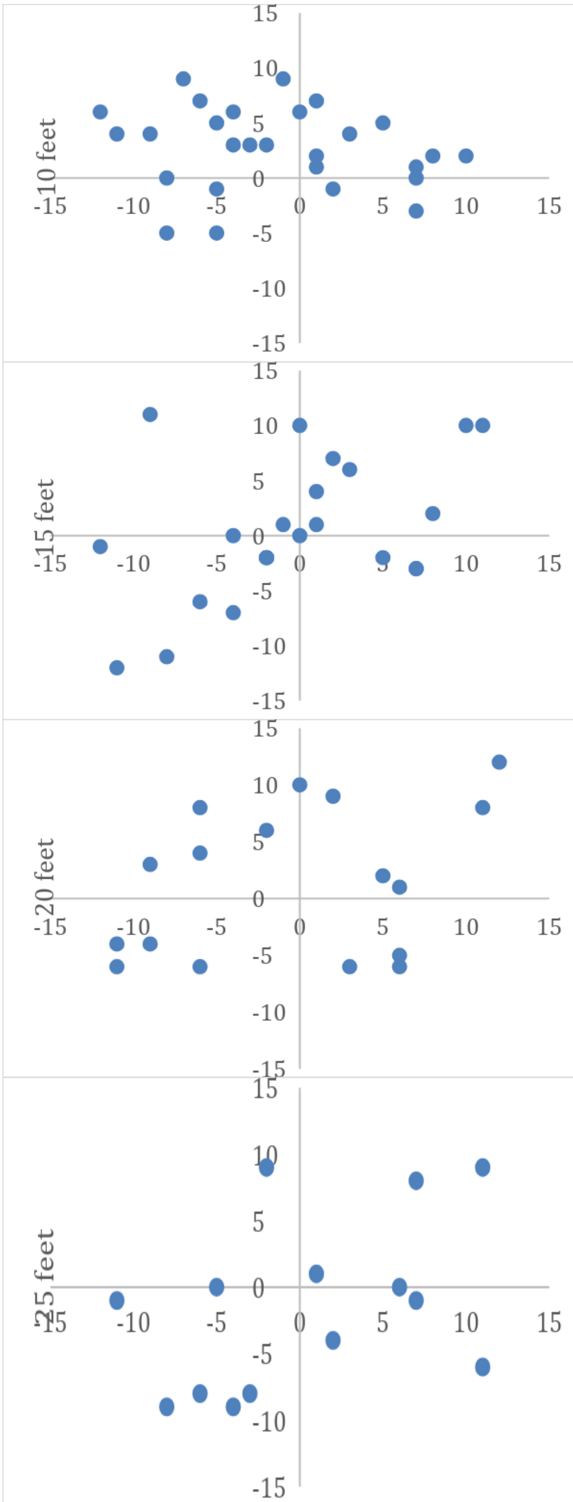

Figure 8. Location of throws by all subjects from 10 feet, 15 feet, 20 feet, and 25 feet. Throws that missed the target area are not represented. The accuracy for each distance was 0.9, 0.76, 0.56, and 0.46 respectively, where the accuracy was calculated as throws made divided by the total number of attempted throws. The spread from the center of the target becomes larger as the distance away from the target becomes larger.

V. Final Physical Tests

After the virtual environment was made, each of the subjects were given time to practice in the space with similar conditions to physical tests. Like the physical tests, each subject was allowed a set number of throws to practice in the environment until the real throws were logged and counted. Actual throws that were counted were recorded using a script written to log the coordinates of each successful hit. Once throws in the virtual environment were completed, each subject once again returned to physical throws to note any differences in the accuracy and precision of their throws. Utilizing the same scoring system that was implemented in the initial set of physical tests, we compared our final set of cumulative throws to that of the first set. The points attributed are represented in Figure 9. It is also shown in Table 2, that while there were slight improvements in accuracy across all differences, the largest improvement comes at the 25 feet distance mark, showing a near double improvement.

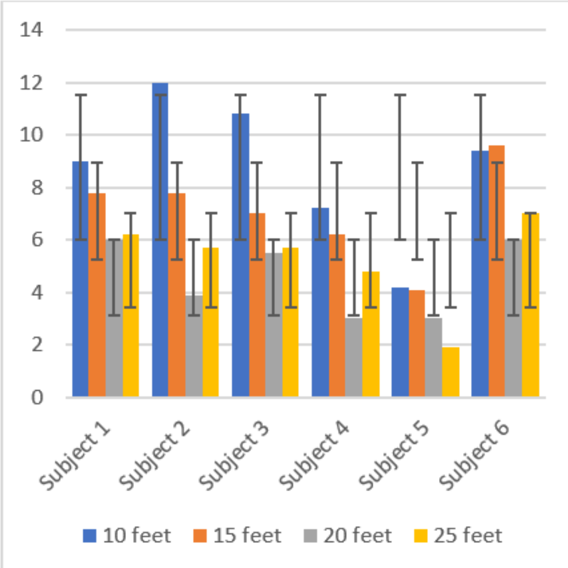

Figure 9. Final average points scored by each subject from the specified distance. Like the first set of throws, each subject performed 5 throws from each distance and points were assigned to each throw based on the distance to the center of the target. Throws that missed the target area completely were assigned zero points.

	Distance		
Distance	**Initial Physical Test Mean**	**Initial Physical Test Mean**	**T-test P-value**
10 feet	0.9	1.0	0.21
15 feet	0.76	0.9	0.71
20 feet	0.56	0.7	0.29
25 feet	0.46	0.76	0.04

Table 2. FInal result of the accuracy measured of the initial throws and the final set of throws. The results of each subject's throws was combined the produce the means of each distance. A T-test was also conducted to reveal significant differences with the sets of data.

VI. Acknowledgements

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VII. References

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