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Comparison of a Virtual Game-Day Experience on Varying Devices

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Abstract

Collegiate athletics, particularly football, provide tremendous value to schools through branding, revenue, and publicity. As a result, extensive effort is put into recruiting talented students. When recruiting, home games are exceptional tools used to show a school's unique game-day atmosphere. However, this is not a viable option during the offseason or for off-site visits. This paper explores a solution to these challenges by using virtual reality (VR) to recreate the game-day experience. The Virtual Reality Application Center in conjunction with Iowa State University (ISU) athletics, created a VR application mimicking the game-day experience at ISU. This application was displayed using the world's highest resolution six-sided CAVE™, an Oculus Rift DK2 computer-driven head mounted display (HMD) and a Merge VR smart phone-driven HMD. A between-subjects user study compared presence between the different systems and a video control. In total, 82 students participated, indicating their presence using the Witmer and Singer questionnaire. Results revealed that while the CAVE™ scored the highest in presence, the Oculus and Merge only experienced a slight drop compared to the CAVE™. This result suggests that the mobile ultra-low-cost Merge is a viable alternative to the CAVE™ and Oculus for delivering the game-day experience to ISU recruits.

Introduction

Every year, universities across the United States spend significant resources and time to build the most competitive football teams possible. They do this not only because it builds morale for their students, alumni and fans, but because it brings revenue to their school. In fact, in 2014, the top Division I schools in the nation brought in $150 million from their football programs alone [1]. This sort of success starts with recruiting exceptional athletes. The ideal recruitment tactic is to bring recruits to a home game, where they can stand on the sidelines and experience the school's traditions with several thousand cheering fans around them. Unfortunately, game-day recruitment is only available to a select number of recruits every season because of limited frequency of home games. However, advancements in technology allow virtual reality (VR) simulations to replicate the game-day experience for any recruit at any time, and even in off-campus locations. This can ultimately help build a stronger football program for the university by bringing in more revenue, publicity, and better recruits.

The team and its fans come together to create a unique brand that comes to define a school. This brand is advertised through many televised sporting events. Football games are the most nationally publicized events for NCAA division I institutions. The National Football Foundation reported 500 million television viewers during the 2015 regular season. Additionally, in 2015, 49 million fans attended home, neutral site, and post season games [2]. These games bring income and attention to the institutions and surrounding communities. Universities sponsor their football programs, because they are the largest source of publicity for the institution [3]. One of the ways in which schools try to distinguish themselves and their football programs from others is through branding. For example, the University of North Texas is known for their "We Mean Green" slogan based on the school colors and a sense of pride for their green recycling methods on campus [4]. Another example is The University of Oregon, who spent 5 million dollars on a campaign to rebrand the institution and athletics. They became known for their bright green and yellow football uniforms while the academic brand is exploring the power of "if" [5]. Iowa State in particular has a "choose your adventure at Iowa State" brand for academics, while football has its own unique game-day experience. Some valued game-day traditions include a weather alert sound upon the team's arrival and playing the Sweet Caroline song during the game. The fans expect these unique, signature components at each game. Therefore, it is important to incorporate the iconic traditions in the VR simulation to define ISU's game-day brand. Overall, the branding techniques are instrumental in attracting the top athletic talent, which can passively impact the future of the university [6]. However, branding alone is not always enough, the recruitment experience is essential to securing talent as well.

The athletic department uses a variety of recruiting techniques to continue to build their football teams. Some examples include scouting visits to hometowns or sending materials to prospective athletes. Usually, these materials consist of facility highlights, game footage, or discussions revolving around financial benefits associated with NCAA division I programs [7, 8]. However, a more effective option over the traditional videos is a campus visit, which provides a chance to walk through empty facilities and envision the experience of being a part of the team. The home institution, Iowa State University (ISU) utilizes videos and the walk-through methods for football recruitment. The ultimate VIP recruiting experience, though, is coming to a home game and experiencing school traditions during the limited number of home games. However, there are many conflicts which may prevent a potential player from having the VIP recruitment experience.

Some challenges of current recruitment methods that may prevent prospective athletes from having the optimal game-day experience are time, space, and location. The main issue is the limited number of home games and the ability of recruits to time their visits accordingly. There is also limited space for recruits to be on the field during a game or to interact with the team, therefore the opportunity is only available for a select number of top recruits. If a non-elite recruit can't make it to a game, then they must be recruited through less desirable means that do not give the recruit the integrated feeling that the game-day experience presents. In addition, some recruits may not have time to travel to the university, and therefore cannot have the game-day experience. This can prevent the university from gaining favor with the athlete. These game-day challenges present an opportunity for VR technology. By replicating the game-day experience, a VR simulation can create a sense of presence or a similar feeling to actually being there [9]. In

VR, recruits can be out in the field during a play or observe the game from vantage points which would be otherwise unreachable. The more realistic the simulation is through immersion and presence, the more effective the application will be to football recruits. For this project, a game-day VR simulation was developed for the Iowa State Cyclones by the Virtual Reality Application Center (VRAC) in partnership with the ISU athletic department. The application can be deployed on many different VR devices, but the devices need to be evaluated to determine the ideal platform for non-game-days or offsite recruitment.

A VR simulation on various devices could be an effective solution to the game-day challenges. The ideal VR device for the game-day application would offer the most immersion, while being portable and cost-effective. A VR system that offers a fully immersive environment is the conventional multi-walled CAVE™. The system requires sophisticated synchronization between stereo projectors, active stereo glasses, head tracking and computer clusters to render the scene. Although it is the most effective system, it requires a substantial investment in time, money, space and operation. These draw backs make the CAVE system a non-ideal system for the recruitment application. A lower cost alternative to the CAVE is a HMD. For this particular application, the Oculus Rift DK2 was used. The system is on the higher range of consumer pricing at $600 (USD) [10]. The Oculus Rift is a portable display which still requires a tethered connection to a strong graphics computer. A powerful enough computer can cost anywhere from $900-$2000 (USD) [11, 12]. Although the system offers the needed portability for a smaller investment, it is not an ideal system to take on off-site visits. A more portable solution is an ultra-low-cost smart phone powered Merge VR HMD. It retails to consumers at $80 (USD) and is compatible to a majority of today's smart phones [13]. The Merge VR runs off the phone's processor making it extremely portable. However, the immersive capability of this system has not been previously tested. The portability and cost of the Merge VR are ideal for the recruitment application, but the performance will be the ultimate determining factor. Some research has already been done to compare the tradeoffs between the more expensive VR systems. Havig et al and Kim et al analyzed the trade-offs between CAVE™ systems and HMDs through presence results. They found computer tethered HMDs, are alternatives to CAVE™ systems as they offer an immersive experience for a lower cost [14], [15]. There has not been a lot of research completed, which discuss the tradeoffs of ultra-low-cost VR systems compared to more sophisticated systems.

The authors of this paper conducted a formal user study to quantify the effectiveness of the application on multiple VR devices (C6, Oculus Rift DKS, and Merge VR) compared to the traditional video recruitment method. The Witmer and Singer questionnaires were used to quantify the user's presence during the study [16]. The application deployment on the devices will identify the tradeoffs in immersion and presence between the VR systems.

Background

The background section discusses relevant research in the fields of immersion and presence, and how they can be used to measure realism in VR. It will also detail several studies which have used VR to replicate real scenarios. Finally, a summary of studies which have used VR in sports specific scenarios will be presented.

Immersion and presence in virtual environments

Creating a certain level of realism in a VR application is important in conveying the game-day experience to the recruits. A common way to measure a user's experience in VR is using questionnaires which evaluate the user's sense of immersion and presence. Immersion is an objective measurement of factors that make the simulation realistic, like frame rate, field of view and screen resolution [17]. Presence is a subjective measurement that convinces an individual to interact with a virtual simulation through sensory stimulation and environmental factors [16, 18] . Witmer and Singer performed a series of experiments to identify the key factors that contribute to presence in a virtual environment. They ran a reliability analysis on the experiment results and used the questions with highest reliabilities to create the Presence Questionnaires. The questions aim to identify qualities of a virtual environment that may affect how much presence is experienced by the user [16]. Other research has been done to validate the effectiveness of Witmer and Singer's questionnaire. Youngblut analyzed the results of experiments that had been conducted with a sense of spatial presence in virtual environments. They found influential factors which had a good probability of manipulating presence [19]. The research results found by Youngblut et al. had similar factors to Witmer and Singer's results, which supports the effectiveness of the presence and immersive tendencies evaluations. Presence and immersion measurements, using established questionnaires, can be helpful to test the effectiveness of the virtual environment for users.

A certain amount of presence and immersion needs to occur for the football recruits to be equally excited about seeing a game-day virtual environment as opposed to a real game. Research conducted with VR psychology has shown virtual environments can induce similar emotional responses compared to real events. Meyerbroker and Emmelkamp presented an example of exposure therapy conducted through VR that is a viable option to exposure in vivo. Patients were exposed to a realistic virtual environment which created presence to help patients treat their anxiety [20]. The next example, suggests effective immersion and presence does not have to be delivered through a sophisticated, immersive system. Kwon et al. go on to explain that even low amounts of graphical realism in a VR environment can replicate similar anxiety levels as in a real job interview [21]. The VR therapy yeilds enough presence to affect patients, therefore the technology used in VR psychology can be used to produce a response for football recruits. Schuemie et al. did an overview of research in psychology VR and found a focus of presence concepts in a variety of applications. They evaluated presence through analyzing questionnaires, along with behavioral and physiological cues. The results support why VR psychological therapy could work for humans. [22]. VR technology has impacted clinical psychology, but it has also impacted cognitive psychology, specifically in training scenarios. Loftin et al. researched military checkpoint training through an immersive VR environment. The process allowed individuals to accelerate from a novice to expert level in a short amount of time [23]. The level of immersion for performance in VR amounts to the technology. Pausch et al. concluded immersion presented in a VR environment helps the user to understand a scene more efficiently then a desktop screen for informed decisions on their surroundings [24]. In other words, a virtual environment that can induce presence and immersion will have greater levels of performance over a 2D screen. This suggests a virtual game-day simulation will be more effective with presence than the video recruitment tactic. Ware and Mitchell researched the difference of peoples' perceived distance in a mono display versus a stereo display and found the stereo display had an increased performance over a mono display [25]. The stereo displays allowed the user to be more immersed in the environment, which ultimately increased the performance of a task. The recruitment devices will utilize stereo technology to provide an ideal experience for recruits.

The evidence provided on immersion and presence make the researchers of this paper believe a game-day simulation of Iowa State's Jack Trice stadium can accurately depict a semi-realistic representation of the actual event.

In order to provide an immersive and realistic game-day experience, VR devices need to be evaluated to choose the correct platform for portable recruitment. Lower cost VR devices such as HMDs can create enough presence to make the experience believable for an individual. For example, Krijin et al conducted a study of participants who have a fear of heights. Participants experienced similar levels of anxiety whether they were in a CAVE™ or HMD, indicating the presence and immersion were similar enough to elicit the same response [26]. Another study by Bastiaens et al. investigated the fidelity difference between a computer screen and HMD. The results suggest a task on the computer compared to a task in an HMD simulation have similar reactions and performance. This shows that it may not be necessary to use the highest level of immersion to successfully depict a scene [27]. Although previous research indicates positive levels of presence in low-cost HMDs, there is less reported research on ultra-low-cost devices that might use a phone for the display. The authors of this paper decided to investigate how an ultra-low-cost portable HMD compares to other VR devices. The ultra-low-cost HMD option allows for a portable and affordable football recruitment tool to take on home visits. Although the feasibility for VR recruitment has not been rigorously tested, several studies have shown viability for the use of this technology in sports training.

VR in sports

VR simulations are proving to be feasible options that provide training for sport applications. For example, Correia et al. conducted a user study for all athlete levels with a virtual 3 vs. 3 rugby simulation. The study aimed to research the decision-making process of ball carrying in particular running channels. The results suggested the user's ability to understand the events around them is correlated to the actions that were being performed and can be used to train athletes to analyze their surroundings faster [28]. A preliminary study by Thiele et al, created a 3D simulator for traditional archery to try to give users a realistic experience as they practiced motion sequences to develop the best body-eye coordination for accurate shooting. Positive feedback and indications of presence showed that using VR as a training tool was feasible for this application [29]. Other research completed by Mulder et al, created a virtual simulator and feedback indicators for competitive sailing. The research goal was to identify the factors that contributed to the participants' sense of presence in the virtual environment. The results illustrated the users' ability to rotate around the front-to-back axis and side-to-side axis as an indication of presence in the virtual environment [30]. The use of accurate models, flexibility over traditional practices, and analyzing decision makes VR an attractive asset to sports. In all of these applications the authors created features in their systems to make the simulations more realistic and akin to the actual event. It is important for the recruitment application to have real world features of the game-day experience.

VR research with sport applications on different platforms of technology have also been conducted. For example, Thalmannn et al. conducted a user study with a virtual volleyball game on different VR devices. Results indicated a CAVE™ and a low-end portable HMD provided a better sense of presence and overall experience than a single stereoscopic or mono screen [31]. However, the factors that influence the user's perception are hard to define and understand, therefore a number of researchers recommend conducting user studies to evaluate how stimuli are perceived in each VR system [9, 32, 33]. The authors of this paper decided to investigate, through user studies, how users perceived the game-day experience on several different delivery platforms. The study answers the effectiveness of the virtual environment on portable VR devices for recruitment.

A formal user study was conducted by Kalivarapu et al. as the first iteration of VR game-day on dissimilar platforms for football recruitment. The study evaluated the game-day application on the C6, Oculus Rift DK2 and was compared to the traditional video recruitment method. The user study results indicated the C6 and HMD were effective manners of recruitment over the standard video through the analysis of presence and immersion [34]. The outcome was satisfactory for recruitment methods, but the systems are costly and do not have the ideal portability. The C6 is not a practical recruitment system, because of its complexity, size and cost. The HMD is a reasonable system for cost compared to the C6, but still requires a tethered connection to a high-end graphics computer. This makes it an unideal system for off-site recruitment. The authors of this paper decided to research other HMD systems to better suit the portability needs of the Iowa State Athletics department.

Methodology

The methodology section describes the work required to develop the application for the VR systems followed by the procedure for conducting the user study. The purpose of this section is to allow for the reproducibility of the experiment and results.

Application Development

The Game-day VR application was created using the Unity 3D game engine. Collaborating with the ISU athletic department, elements were modeled to emulate the atmosphere of an ISU football game. The application was deployed onto the following three display modes: Oculus Rift DK2, Merge VR and C6. The Oculus Rift is a computer-driven HMD, the Merge VR is a smart phone-driven HMD and the C6 is the world's highest resolution CAVE™. The C6, shown in Figure 1, is a six-sided virtual reality room that consists of six 10' x 10' display screens arranged in the shape of a cube. Rear projection with active stereo glasses allow the user to be completely immersed, while tracking system adjusts the user's view based on their head position. The Oculus Rift DK2, shown in Figure 2, is a low-cost computer driven HMD. The display device is capable of 960x1080 resolution per eye with a 100 degree

FIGURE 2. *ISU TEAM HUDDLE*

field of view. This device uses an inertial measurement unit to adjust the visual content relative to the users head position and orientation [10].

The Merge VR paired with an iPhone 6 Plus, shown in figure

FIGURE 3. *GAME-DAY APPLICATION ON THE OCULUS RIFT DK2*

3, is able to display the application with a field of view of 85 degrees and a resolution of 1920x1080 pixels. The application tracks the users head movements by using the smartphone's inertial measurement unit. The Merge VR is adjustable to interpupillary distance and is compatible for a variety of smartphones [13].

FIGURE 4. *GAME-DAY APPLICATION ON THE MERGE VR*

The application development was done in the game engine Unity 3D, as it offered the best compatibility in three main areas: 1) easily clustered application, 2) easy programmability of avatars such as football players and marching band models, 3) ability to replicate the environment on both immersive CAVEs™ and HMDs. The deployment to the Oculus Rift was managed by a plug-in that was developed by Oculus [35], which did not require any overhead scripting. A third-party Unity 3D plug-in was used with the C6 to pipe the application through the clustered computer system. The getReal3D plug-in was developed by Mechdyne. A series of programs and configurations allowed for the deployment to occur in the C6. The actual elements of the game-day application were dictated by the ISU athletic department. They characterized and defined what makes an ISU game unique and different from other schools, while also showcasing the school's traditions. The simulation has animations of the marching band doing an ISU formation, team huddle and cheer routine. The frame rates had to be manipulated through-out the development of the application. There was too much demand on the system from the high number of polygons in the models. As a result the crowd in the stadium along with other models in the scene had to be simplified [34].

User Study

A formal experimental user study was approved and conducted according to the ISU Intuitional Review Board standards. The participant pool were mainly undergraduate engineering students at ISU. The study was designed to be between subjects with each participant only seeing their assigned mode. The study lasted for about 45 minutes and participants were compensated $20 (USD) for their time. Any participants with known seizure disorders were excluded and those with uncorrected vision were asked to not participate.

The VR application modes had participants witness five different components of the game-day experience. The ISU athletic department stipulated that these components be incorporated in the VR application to demonstrate the school's football culture and branding. The sequence of events took 10 minutes of the allotted time and were triggered by a timer, which was out of the participant's control. The components include:

1. Marching band and cheerleading performances
2. Cyclones storm warning video played on north and south scoreboards in the field
3. Opposing team's players taking the field while being booed by the stadium crowd
4. Cyclones entering the field through an inflatable tunnel and forming a huddle, Figure 4
5. Stadium crowd singing Sweet Caroline

The video mode was viewed by participants on a 32" Dell LCD monitor. ISU athletic department supplied a variety of clips which showcased game highlights and traditions defining the ISU game-day experience. The clips were edited into one video that featured the Cyclone nation football experience.

Participants were brought to their assigned study station (C6, Oculus, Merge VR, video), which followed the between subject experimental design. Individuals were asked to fill out an informed consent and demographics questionnaire. Participants were then asked to fill out a Witmer and Singer Immersive Tendencies Questionnaire to gauge their ability to become immersed in the scene [16].

At the completion of the pre-study forms, participants were given instructions for their specific mode. Those assigned to the VR application modes were instructed how to navigate through the environment using the game pad controller. They were also told to navigate to specific locations: 1) ISU Jack Trice Stadium sideline, 2) Center of the ISU huddle, 3) Top of the end zone scoreboard, and 4) Press box on the west side. These instructions could be referred to at a later time as they were displayed in yellow text within the VR application modes. Individuals were limited to 10 minutes in the simulation to reduce simulator sickness. After viewing the field from all the points listed, participants could explore for the remainder of the time. The proctor notified the participant and stopped the simulation after 10 minutes had elapsed.

Upon the completion of the simulation, participants were asked to complete experience/attention and presence questionnaires. These questionnaires asked for a rating of their experience and was intended to gauge the level of information each participant retained, while the presence questionnaire evaluated how realistic the environment was to the participants. Participants were thanked for their time and excused to receive their monetary compensation.

Results

A total of 57 males and 25 females participated in the study with an age range of 18-40 years old (Mean, M=21, Standard Deviation, SD=3.9). The eighty-two participants were divided between the four modes: C6 (20), Oculus (20), Merge VR (22) and video (20). Statistical analysis was performed on the collected data from the presence questionnaire.

PQ Questionnaire

A presence questionnaire developed by Witmer and Singer was used to assess the presence felt by users during the simulations [16]. The questions from this questionnaire were broken up into six categories based on a verified French Canadian method of evaluation [36]. These categories included: 1) realism, 2) possibility to act, 3) quality of interface, 4) possibility to examine, 5) self-evaluation of performance, and 6) sounds. Statistical analysis was performed on these categories to compare various level of presence between the four different modes.

ANOVA

A series of one-way ANOVA tests were performed with each device as the independent variable and the six presence categories as the dependent variables. While most of the data collected was normally distributed, there were multiple violations of normality found throughout the six categories. The one-way ANOVA is robust to deviations from normality, particularly if sample sizes between groups are equal or nearly equal, as is the case in this study [37]. The one-way ANOVA depends on the assumption of homogeneity, assessed by Levene's test for equality of variances. This was met for possibility to act ($p = 0.071$), quality of interface ($p = 0.254$), possibility to examine ($p = 0.150$), self-evaluation of performance ($p = 0.233$) and sounds ($p = 0.706$). Realism violated the assumption of homogeneity so a Welch ANOVA was used for this category instead of the one-way ANOVA.

Table 1 shows that in all categories there was a statistically significant difference between device groups. Statistical significance was found using α value of 0.05. The statistically significant differences across all categories suggested that users felt varying levels of presence between device groups. While this test does show there were differences, the ANOVA alone cannot indicate which device performed better. Post hoc tests were performed to explore how well each device performed relative to each other.

Table 1. One-way ANOVA

Category	Degrees of Freedom, F(df1, df2)	p-value
Realism*	F = (3, 40.017)	p= 0.002
Possibility to act	F = (3,76)	p < 0.0005
Quality of Interface	F = (3,76)	p = 0.001
Possibility to Examine	F = (3,76)	p < 0.0005
Self-evaluation of performance	F = (3,76)	p = 0.005
Sound	F = (3,76)	p = 0.047

* Welch ANOVA used

Post Hoc

In the realism category, Games-Howell post hoc tests revealed statistically significant differences in mean realism between the C6 (M = 26.60) and Oculus (M = 22.50) ($p = 0.034$) device groups and the C6 and Merge (M = 21.82) ($p = 0.001$) device groups, but not between any other group combinations. These results, shown in Figure 5, indicate that the users felt a higher sense of realism while in the C6 than when using the Oculus or Merge. Since the same application was displayed on all three devices it suggests that the hardware was what caused this difference. Since the C6 is a six-sided CAVE™, the user is able to see their body relative to the virtual environment. In a previous publication it was found that there is a logical correlation between the user's ability to see themselves, or a virtual representation of themselves, and the degree of presence reported [38]. This is not possible in either HMD as there is no representation of one's self which may have contributed to lower realism scores.

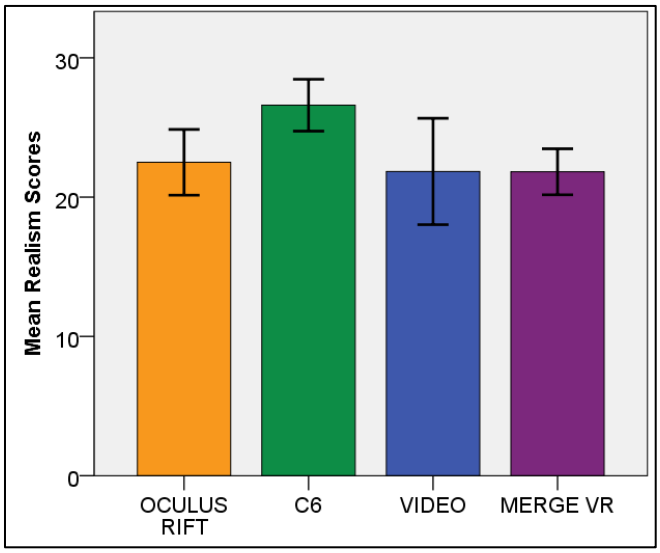

Figure 5. *Comparison of Realism Scores*

Also, the C6 has a much higher resolution than both HMDs. This may have been another contributing factor to the higher realism score. However, while the Oculus does have a larger resolution than the Merge, there were no statistically significant differences between the realism scores of the two devices. This indicates that the lower resolution of the Merge did not impact its realism scores when compared against the Oculus. As a result, the Merge and Oculus would be able to give college recruits a similar game-day experience in terms of realism.

In the possibility to act category, Tukey-Kramer post hoc tests revealed statistically significant differences in mean possibility to act between the Video (M = 6.83) and the three other device groups: C6 (M = 10.30) ($p < 0.0005$), Oculus (M = 9.85) (p = 0.002), Merge (M = 9.59) (p = 0.004). There were no other statistically significant differences between any other group combinations for possibility to act. These results, shown in Figure 6, indicate that participants were better able to interact with the environment when using one of the three VR devices. This is important for recruiting as an increase of engagement with players is valuable for forming opinions about the school's football program [6]. There were no statistically significant differences between the three VR device groups in the mean possibility to act category. This is to be expected as the participants used the same game pad control system in these groups.

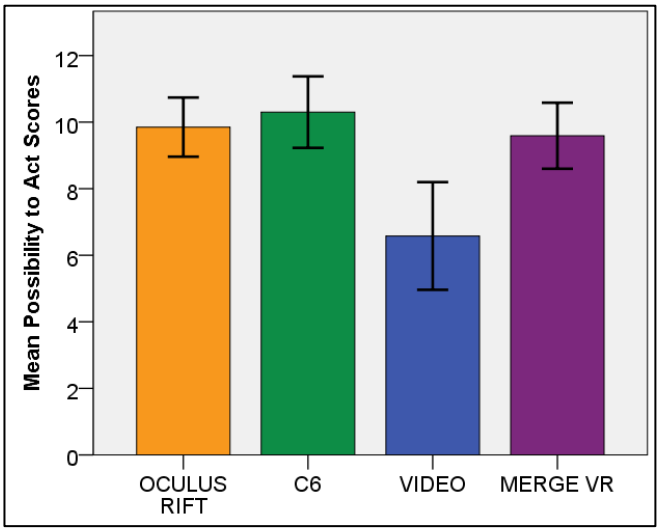

FIGURE 6. COMPARISON OF POSSIBILITY TO ACT SCORES

In the quality of interface category, Tukey-Kramer post hoc tests revealed statistically significant differences in mean quality of interface between the Video (M = 5.11) and Merge (M = 3.41) (p = 0.001) device groups and the Video and Oculus (M = 3.85) (p = 0.022) device groups. There were no other statistically significant differences between any other group combinations for quality of interface. These results, shown in Figure 7, indicate that participants may have been distracted by the lower quality visual displays of the Merge and Oculus since this difference was not found in the higher resolution C6. However, there were no statistically significant differences between the C6 and the two HMD devices. It is possible that the lower resolution of the two HMDs was significant enough to make a difference when compared against the video but it was not significant enough when compared against the C6.

In the possibility to examine category, Tukey-Kramer post hoc tests revealed statistically significant differences in mean possibility to examine between the Video (M = 7.00) and the three other device groups: C6 (M = 11.15) ($p < 0.0005$), Oculus (M = 10.10) (p = 0.002), Merge (M = 9.82) (p = 0.005). There were no other statistically significant differences between any other group combinations for possibility to examine. Similarly, to the possibility to act category, these results, shown in Figure 8, show that all three VR devices equally allow the user to examine their surroundings while the video does not. This is to be expected as the user cannot directly interact with anything in the video so they are limited to a fixed point of view. The added ability to examine and explore their surroundings is a great advantage for the VR application. Feelings and perception are a large contributing factor in the decision making process of high school football players when choosing a university [6]. The ability to examine their surroundings further amplifies the feelings and perceptions they have about the ISU game-day experience.

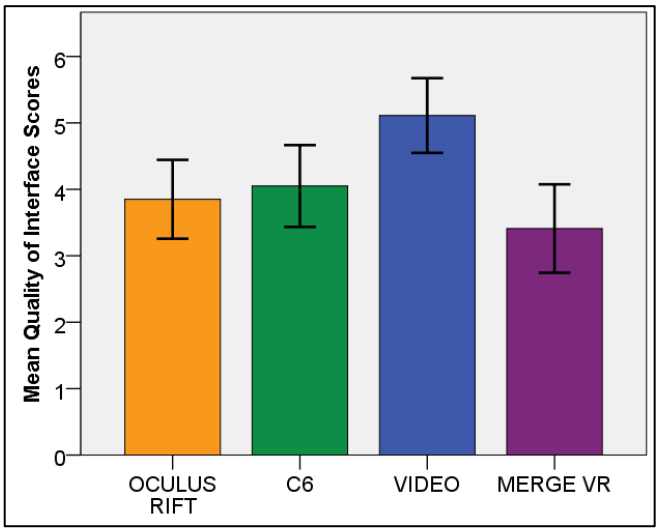

FIGURE 7. COMPARISON OF QUALITY OF INTERFACE SCORES

In the self-evaluation of performance category, Tukey-Kramer post hoc tests revealed statistically significant differences in mean self-evaluation of performance between the Video (M = 6.06) and Oculus (M = 4.45) (p = 0.002) device groups, but not between any other group combinations. While users did feel that they performed tasks better in the video than the Oculus, there were actually no tasks

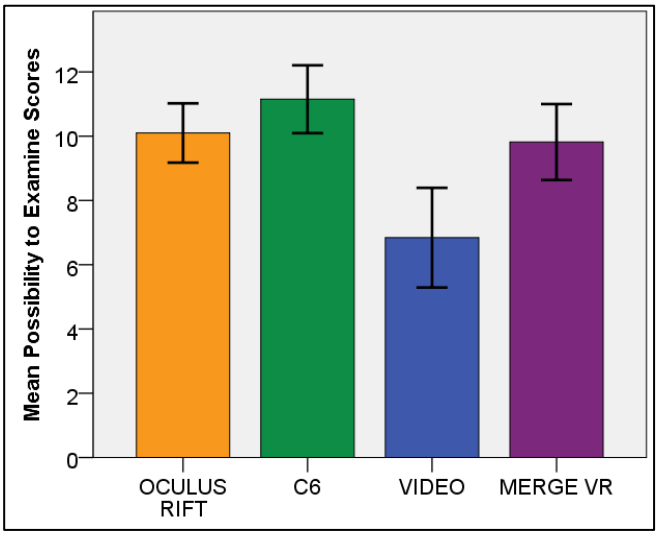

FIGURE 5. COMPARISON OF POSSIBILITY TO EXAMINE SCORES

included in the video. Since there were no statistically significant differences between the three VR device groups, it can be concluded that users felt satisfied with their performance in all three modes.

In the sounds category, Tukey-Kramer post hoc tests did not reveal any statistically significant differences in mean sounds between any group combinations. Even though the sounds in the video were professionally produced and the sounds in the application were programmed/scripted, users were indifferent about the sounds. It can be concluded that either the sounds in the application were sufficient or that the users were not concerned with the sounds.

Discussion

Post hoc examination indicated that the C6, Oculus, and Merge outperformed the Video in the possibility to act and examine categories. This allows recruits the unique experience of getting up close and personal with the stadium. Since there were no differences between the three modes, the Oculus and Merge are both viable alternatives for the expensive C6 in this aspect. However, the C6 outperforms the Oculus and Merge in the realism category. This shows the C6 still has advantages over the lower cost HMDs despite the HMDs being competitive in the five other categories. There were no statistically significant differences between the Oculus or Merge in any categories. While the Merge does have a smaller field of view and lower resolution when compared against the Oculus, it did not make a significant impact on the user's experience. Since the users did have a similar experience when using the two devices, it would be advantageous to use the Merge for recruiting since it is far more mobile and less expensive. Recruiters would be able to take the Merge with them without the need for a bulky computer and still deliver the same experience to the recruits.

Conclusion

A virtual game-day experience application was developed and deployed onto three VR devices: C6, Oculus Rift, and Merge VR. In terms of presence, this application on all three devices improved over the standard recruiting video mode in almost every category. In addition to this the C6, Oculus and Merge produced similar results in most presence categories. However, the C6 was superior in terms of realism. This was likely due to the greater resolution compared to the Oculus and Merge and the ability to see one's body when in the C6. The Oculus and Merge both proved to be viable alternatives to the C6 for recruitment using the game-day application by being comparable in every other measure of presence. When comparing the Oculus and Merge there were no statistically significant differences in any category. The Merge does have significantly lower resolution and field of view but still managed to provide a similar experience to the user. Since study results indicate very minimal trade-offs in experience for the user, the Merge is a viable alternative to the Oculus at a lower cost and with an increase in mobility. These advantages will allow recruiters to reach out to a much larger number of recruits, hopefully, adding to the future success of the ISU football program.

In the future, the authors would like to compare this game-day application to the real-world experience in two different ways. The first would be to give questionnaires from the study to attendees of an actual ISU football game and study how the application compares to the real game day experience. This will help the authors gauge the accuracy of the application and how well it lives up to the real experience. The second would be to capture actual ISU football game footage using a 360^0 camera to be displayed using the same VR devices. Since the graphics of the game-day experience application are entirely computer generated it would be worthwhile to compare this with real life footage using the same devices and see how the user experience is affected.

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