Training in a Modern Age

by

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ABSTRACT

This study was undertaken to ascertain to what degree, if any, virtual reality training was superior to monitor based training. By analyzing the results in a 2x3 ANOVA it was found that little difference in training resulted from using virtual reality or monitor interaction to facilitate training. The data did suggest that training involving rich textured environments might be more beneficial under virtual reality conditions, however nothing significant was found in the analysis. It might be possible that significance could be obtained by comparing a virtual reality set-up with higher fidelity to a monitor trial.

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INTRODUCTION

Technology in our modern era has advanced to a point where it is possible to co-opt a person's senses into believing they are flying over a vast mountain chain or lounging along a sunny beach all while they are actually sitting in the comfort of their own home. How is such an amazing feat possible? Virtual reality technology, which is not new by any standard, has been improved upon to such a point as to allow a realistic rendering of any environment imaginable. The entertainment value of such technology is self-evident, yet what practical, functional, uses could such instrumentation be utilized for?

To begin our discussion, let us think about the work that is required to become an expert. The road towards mastery has always been long and often complex, full of challenges and unexpected pitfalls that could easily derail even the most surefooted of novices. Attempting to master skills such as musical instruments or foreign languages are challenging enough, yet such pursuits can be practiced endlessly with little chance of harm coming to the novice learner if they should make a mistake. How does this scenario change when the attempted skill to be mastered is a more dangerous one? For example, piloting an aircraft is certainly as complex as learning any language, but the risks involved in failure are far more immediate. However, the question still remains, how is one to become proficient if never allowed to practice? Even early aviators simulated flight by attaching ropes to barrels.

Through the utilization of virtual reality technology, the danger of real-world situations can be mitigated in a secure virtual training environment, thus allowing novices to safely practice the skills they will need in order to master the complicated art of flight. Adding to the safety benefits of flight training via simulation are the monetary benefits. Operating a flight simulator requires a fraction of the costs associated with flying an actual airplane. Thus, training via flight alone, such as through the utilization of ride-alongs, is prohibitively expensive (Orlansky, 1980). Although the benefits of training via simulation are beyond reproach, current standards of research have failed to provide a standard of measure against which virtual reality flight training can be compared. In flight training, it is often assumed that more realistic renderings of flight scenarios will always prove superior to conditions with less fidelity to the actual experience of flight. Utilizing this line of reasoning, a virtual experience where the trainee is provided a measure of immersion ought to provide better training results than having a similar experience mediated through a monitor. However, such assumptions may not prove correct.

It cannot be argued that flight simulators do aid in skill acquisition for piloting procedures, the question then becomes how close does the simulated experience need to be to the thing being simulated in order for the attempted training to be effective? Research has shown that a simple mock-up of a cockpit using plywood and photographs to train for piloting procedures can be as effective as training in a high-fidelity trainer as well as the actual cockpit of the aircraft (Dougherty, 1957), (Prophet, 1970). Through the utilization of three separate training mechanisms, Dougherty found that the higher fidelity training set-ups initially resulted in higher levels of transfer, however the transfer effects were virtually the same after five trails with the aircraft. Prophet revisited the idea of various training set-ups in order to test for necessary levels of fidelity in order to assure a proper level of learning and corroborated the results that Dougherty had suggested, using a similar design that included photographic mock-ups, a realistic simulator, and the actual plane's cockpit. Prophet found that piloting procedures could be trained just as well in a low, medium, or high-fidelity scenario.

Providing further evidence that transfer can take place using high fidelity content introduced in a low fidelity manner Korteling's work (Korteling, 2017) tests three separate groups of flight students using individualized methods of instruction. One group received training via an F-16 flight simulator computer program, Falcon 4.0, while another used a general aviation simulator meant for civilian piloting, Microsoft Flight Simulator. Both groups played the simulation games via an ordinary computer set-up. These two groups were joined by a third which acted as a control and did not receive any flight-simulator gaming experience. Obviously video games are not comparable to actual flight outside of a few basic concepts and what can fit onto a monitor, thus a video game would represent a low fidelity training experience. Even though the experience did not have high levels of fidelity, when compared to the control group participants, those with flight simulator-like game training outperformed those in the control group when tested in a high-fidelity flight simulator. This shows that low fidelity content can provide a superior training experience for novice pilots when compared to receiving no training at all.

As mentioned at the start of this paper, current flight simulation attempts are based on a number of assumptions that have recently come under question (Salas, 1998). Perhaps the most questionable assumption of all is based around the idea that closer fidelity, a more realistic simulated training experience, will result in better learning processes. Salas refutes this idea by examining an array of studies culminating in attention being drawn to the fact that the human side of the training paradigm has been ignored in favor of the advancement of the technical part of the simulation program. Instead of pursuing ever more realistic programs, training simulations need to be created utilizing what has been learned about individual and team learning styles and methods of cognition. Salas puts forward the idea of an unequal distribution of human and machine components in current simulation technologies. While the advances in computer science are being utilized to their utmost, the same level of advancement in psychological science and educational experience have not been leveraged to a similar degree in order to maximize the simulation's ability to provide for the acquisition of the complex skills intended by the simulation. Thus, in the quest for a realistically rendered simulation, we have left out basic educational tenants that would provide for greater absorption of the skills the simulator was designed for.

In conjunction with Salas' work, it has been noted that simulations are often developed without any kind of front end analysis being performed regarding the training that is to be carried out or the behavioral support that should be included (Caro, 1988). Sadly, this trend seems to be the rule instead of the exception (Burniston, 1996). In the end, the quest for realistic simulation seems to have driven the development of simulation apparatus into the weeds, as it were, leading developers to neglect training effect outcomes in favor of training appearance (Roscoe, 1980). Scenic detail and highly rendered graphics look and feel impressive, leading many to laud more detailed renditions of simulated flight, yet what trainees and developers fail to take into account is that the more realistic experience offered by high fidelity simulations is not synonymous with increased learning outcomes or developmental capacity.

Exacerbating the quest for unnecessary levels of realism in simulation are the numerous studies that point toward realistic simulations showing a lack of results in training efficacy. For example, in a study examining simulation detail, higher levels of scenic detail failed to correlate to improved performance on flight tasks for pilots (Taylor, 1993). This begs the question, should the high costs of realistic flight simulators be paid? Additionally, attaining an exact rendering of physical fidelity has been shown to rarely be needed in order to allow for effective training to transpire (Flexman, 1987). It seems the move toward more and more realism in simulation has primarily been driven by trainee's appreciative reactions to realistic training procedures, which has failed to show increased performance (Tannenbaum, 1992). The original shift to flight instruction via simulation was a practical decision in two ways. First, simulations are of course safer, however, at least for the military, simulated flight experiences were cheaper to implement as well (Orlansky, 1980). Therefore, why should more expensive flight simulators with higher levels of realism be used if a more cost effective, less flashy but possibly more effective simulator could be utilized instead?

Noble's work continues in the vein of flight simulation assumption contradiction, in particular, Noble has focused on dispelling the assumption that more fidelity is always better (Noble, 2002). Instead, the idea of a fidelity line is described past which diminished gains in quality of flight performance and associated learning for novice pilots has been observed. (Alessi, 1988). Noble also draws attention to the idea of different types of flight simulators being good at different things. For example, perhaps one design is better at training new pilots, while another is more suited to testing whether or not overall training has taken hold, instead of using one machine for everything, perhaps different tasks can be conducted using different machines. This line of thought has been corroborated by Miller and again by Feifer in their studies showing that real-world flight simulation environments with high levels of realism might be overwhelming for novice pilots, thus detracting from their learning abilities, whereas flight-trainers specific to certain procedural conditions can help to build confidence and create a safe space form which mistakes might be learned from (Miller, 1974), (Feifer, 1994). Noble allows a new picture to take shape, one showing a possible edge beyond which further fidelity is unnecessary and potentially harmful to the learning process.

Taking the idea of a ‘fidelity line’ one step further, researchers have theorized that the amount of fidelity pilots in training may be able to handle changes over time as novices progress towards experts. As learners develop their abilities further, they are more able to interact with high levels of fidelity in simulation in a meaningful way (Hays, 1989). Adding to the idea that novices can learn from higher levels of realism as they progress in their training, a series of stages were introduced wherein the level of realism presented could be adequately adjusted to take into account the growth of the learner (Alessi, 1991), (Kahneman, 1973), (Norman, 1975). Thus, high fidelity, very realistic simulations are shown to have their place in the overall scheme of training, however, greater realism is not always better and can in fact prove detrimental to pilots in their early stages of learning. A sliding scale of realism, taking into account the learners’ level, ought to be used instead of always attempting to have greater fidelity and more intricate simulations. The following figure was created by Alessi to express the differing levels of necessary fidelity which would allow for optimal learning at varying levels of experience (Alessi, 1988). It shows three curves representative of pilots at varying stages of their careers mapped against high and low fidelity simulators on the x-axis and the amount of learning derived from their interactions with the simulators on the y-axis. As can be seen, experts are best able to utilize a high-fidelity simulator for the best potential learning outcomes, whereas experienced students and novice pilots will suffer from greater amounts of realism.

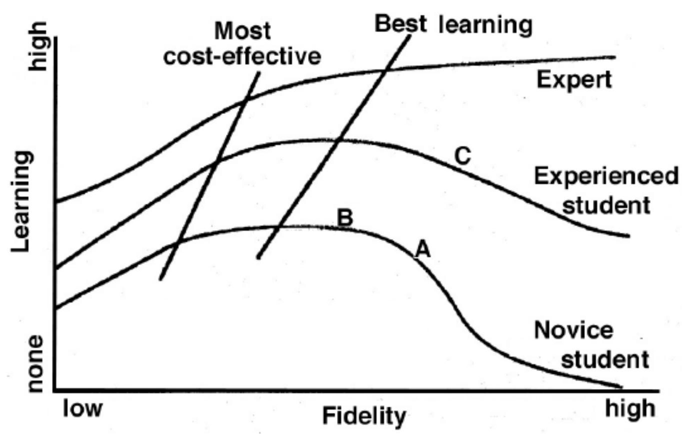

Figure 1, optimal levels of fidelity VS experience

Proof of excess fidelity comes to us from several sources. Two independent studies both found no difference in rate of learning and transfer of abilities for flight simulation effects based on different degrees of fidelity (Cox, 1965), (Grimsley, 1969). Further, to truly attain realistic fidelity flight motion should be accounted for as well, however, several studies have shown that flight connected motion effects in mechanical flight simulators have shown no significant effect for learning (Hopkins, 1975). Further studies have clarified the position of motion fidelity for mechanical flight simulators, proposing that motion effects can be useful for experts to further hone their skills, yet holds little importance for novices (Koonce, 1974), (Hays, 1992). Therefore, at the most basic stages of flight training, motion has no beneficial effect on pilot's skill acquisition. Are there other features that also lack their intended effect? Does the potential exist to reduce the costs associated with highly realistic training experiences in favor of lower fidelity models, models better designed to allow for knowledge acquisition in novice pilots? Questions like this are at the heart of the decision to embark upon this research inquiry.

The current study is not the first to attempt some form of evaluation of simulation effectiveness. Indeed, several others have looked at how well simulation training has been able to transfer into real world application. Roscoe, (Roscoe, 1980), in addition to Feinstein, (Feinstein, 2002), have both collected data and gathered resources with the aim of ascertaining how well various flight simulation training aspects can transfer into the actual application of the skills the training was designed for. The current study continues in the vein of Hopkins, Cox, and Grimsley, mentioned above, in its attempt to compare one form of simulation against another. The unique aspect this study is that it will attempt to find out how well virtual reality flight simulation compares to a much cheaper desk-top monitor mediated experience.

The study proposed herein will attempt to assess whether an immersive experience mediated through the Oculus Rift's virtual reality system is better than a standard video-monitor mediated training experience. As the literature has exemplified, assumptions in the field of flight simulation training would put a more realistic training experience above one with less fidelity. Virtual reality, due to its immersive nature wherein a person can feel they are actually present in the simulation, is posited to be a more realistic experience than interacting with a typical monitor-based computer set-up. This training scenario will delve into the previously accepted idea that a more realistic experience will provide a better model through which to learn piloting procedures. As has been shown through the review, higher levels of realism do not necessarily link to better training results. The rule for flight simulation has been and continues to be more is better. More fidelity wrought through increased use of technology will provide better training outcomes, however, as technology advances there will surely come a point past which increased fidelity of simulation no longer proves beneficial. Indeed, it is quite possible that such a point has already been reached. Thus, it would behoove manufacturers and consumers of flight simulation technology to find the ideal point for a simulated experience, thereby not allowing additional resources to be squandered to affect the same training outcome as a less expensive, less realistic simulator.

The objective of this proposed course of research seeks to ascertain whether, and to what degree, Virtual Reality flight training delivered in a game-format is superior to a standard computer gaming experience mediated through a traditional desk top monitor. Through the utilization of Microsoft Flight Simulator, a series of tests will be conducted using the same landing task performed by two different training groups. One group will interact with the simulation software via an Oculus Rift in order to test for the efficacy of a training simulation mediated by a Virtual Reality experience. The second group will engage in the same landing task with the same software only changing the manner in which the training experience is interacted with.

Because of the many benefits associated with gaining flight experience through simulation, heightened safety and cost-effective implementation, the inclusion of simulated training methodologies has been highly recommended by pilot trainers from every corner of the aviation field. However, the current simulation status quo is inclined towards highly realistic representations of the flight experience, believing that more fidelity in the simulation will inherently lead to improved performance. Unfortunately, this is not always the case. Research has shown that low-fidelity renderings of certain simulated flight operations have proven just as effective as high-fidelity models. Additionally, novice pilots have been shown to suffer diminished returns when interacting with highly realistic training simulations. When this knowledge is combined with the consideration that front-end analyses are often not performed prior to consumers interacting with the system, trust in the status quo becomes less certain. Indeed, it seems apparent that producers of simulation equipment have not taken into account advances in the psychological understanding of learning to create the most ideal learning experience. Further studies have led to the opinion that there is an optimal ceiling for fidelity in simulation that grows along with the learner. However, finding the measure of, and interacting with, the optimal point for fidelity is impossible if exploratory research is not conducted with the aim of investigating the issue further. Thus, the proposed study herein seeks to address one aspect of this scientific oversight by examining the levels of educational applicability for virtual reality in the realm of flight simulation training. I hypothesize the results will show little significant difference between training under VR and training using a computer monitor.

METHODS

In order to conduct this experiment a between subjects, quasi experimental method was adopted. A non-equivalent groups design was chosen because the research team took measures to control for several factors, including age and experience with video games. Participants were divided into two pools where they underwent one of two treatments. Participants in one category underwent training for flight simulation via interaction with a computer monitor running the Microsoft flight simulator computer program. Participants in the other category performed training via an Oculus Rift mediated immersive virtual reality simulation. Training was conducted via a pre-test with feedback and then analyzed afterwards using two post-tests. Data from the flight simulator program was aggregated for each of the participants and compared across both testing groups. Participant ages ranged between 20-25 years of age, with varying levels of familiarity with both flight simulators and video games overall. All participants exhibited fluidity in the English language. The study included 24 participants allowing for 12 individuals to be included in each group.

The landing task was conducted under a variety of circumstances in order to allow for the greatest potential benefit of the virtual reality experience to be ascertained. During the pre-test, participants flew over an urban environment. Under the simple post-test landing conditions, participants flew over large fields with scattered trees. In the rough post-test landing scenario, participants flew near a mountain, over a river, and towards an ocean. The varying landscapes were chosen to see whether rich or plain textures introduced a variation on the task. Each landing scenario used the same software running the same program, using the same plane, flight conditions, airport, and runway attempted between groups. The only difference between groups was that one group attempted the landing tasks using a desk-top monitor as their medium while the other used an oculus rift headset for a more immersive experience. The order in which participants attempted the rough or simple landings was varied in order to control for effects of training, with some participants attempting the simple landing first, while others attempted the rough landing first.

Data was collected using the Microsoft flight simulator flight recorder add on in order to gain measurements on glide slope, touchdown velocity, and angle of approach. Each approach started with the participant approximately three nautical miles away from the runway. Before participants began the study, they reviewed, acknowledged that they understood, and signed the consent form and completed a survey on relevant prior experience. Participants then sat at one of two training set-ups, depending on their group, then preceded to use the flight simulator they were training with. Each participant used the training set-up for their group, either utilizing the single monitor set up or using an Oculus Rift. In both cases participants attempted three different landing scenarios with feedback given after the first attempted scenario. In order to analyze the results of the experiment three graphs were created in excel based on 2x3 ANOVAs prepared in SPSS. The dependent variables used were touchdown velocity, the speed of the plane as it first makes contact, standard deviation, and mean glide slope, which is the descent angle resulting in the loss of air speed as a plane comes into land. For both glide slope and touchdown velocity, a good result would be a low value, implying a controlled descent into a safe landing.

RESULTS

Figure 2 shows the mean touchdown velocity for the different groups and phases of the experiment. Consistent with the idea that higher fidelity might aid training, touchdown velocities were lower for the oculus group after training. The 2x3 ANOVA conducted for the touchdown velocity shows a significant main effect of condition, F (2,44) = 4.149, p = .022. The effect seems to stem from training, as the touchdown velocities are consistently lower after the pretest phase. However, there was no significant main effect of group, p = .179, or group x condition interaction, p = .661, was observed.

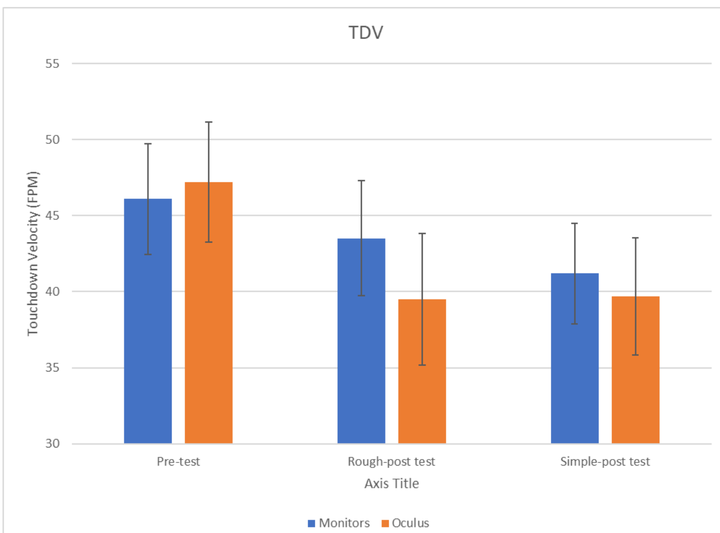

Figure 2 Touchdown Velocity

Figure 3 displays the results of the 2x3 ANOVA for the standard deviation of glideslope. It was decided to use standard deviation of the glideslope to see to what degree participants varied from the mean. The ANOVA performed on these data revealed no significant main effect for condition, p = .303, group, p = .870, or the group x condition interaction, p = .524.

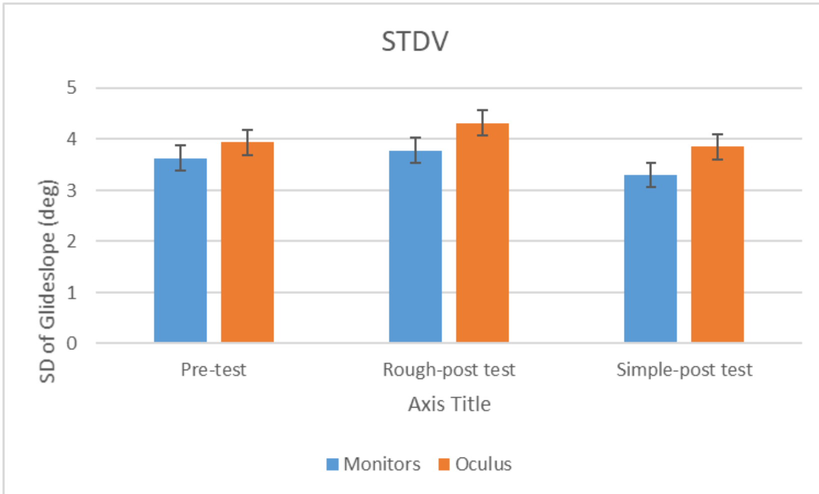

Figure 3 Standard Deviation of Glideslope

Figure 4 shows the mean glideslope. The 2x3 ANOVA performed on these data shows a significant main effect of condition, F (2,44) = 31.47, p = .000. Like in the touchdown velocity graph, this appears to be the result of training, since values in both post-tests are lower (indicating better performance) than values in pre-test. There was no further significant main effect of group, p = .165, or group x condition interaction, p = .595. The error bars represent the standard deviation.

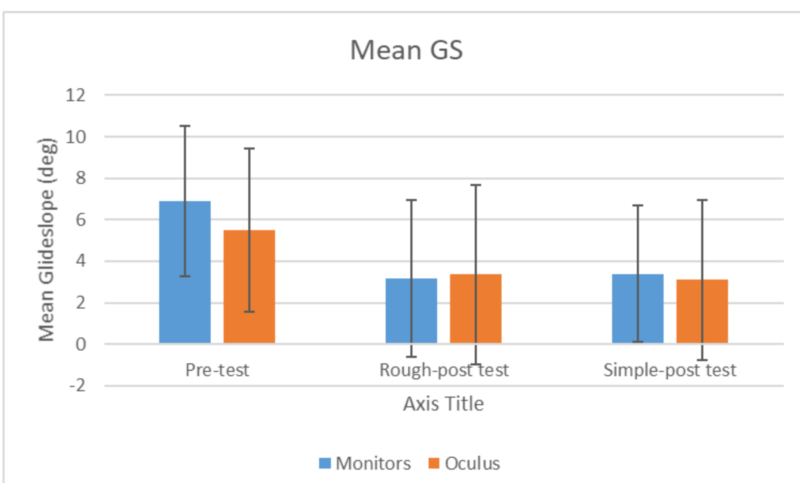

Figure 4 Mean Glideslope

DISCUSSION

In order to ascertain the degree to which training under virtual reality conditions affected learners' ability to internalize training procedures this study was undertaken. The researcher questioned whether the greater expense associated with increased fidelity would translate into greater efficacy of training. At present, the results do not appear to support the idea that oculus-rift mediated virtual reality is superior to training with a computer monitor, although it is possible such effects could be seen under alternative conditions. One promising avenue for future researchers can be seen in figure 2, where the suggestion of an Oculus mediated experience providing a better training platform is present. This is derived from the oculus touchdown velocity being higher than monitor based touchdown velocity in the initial trial, before any training had been applied. As soon as the participants were able to familiarize themselves with the set up however, Oculus touchdown velocity was lower in both rough and simple landings. An interesting note is that the greatest difference between Oculus and monitor touchdown velocity results seen comes from the comparison under rough landscape conditions. As was theorized, the Oculus group seems to perform better when there are rich textures evident. Perhaps this is because the Oculus' environmental rendering is able to more closely compare to a real scenario when it is able to display rich textures for the participant to interact with. After all, seeing a three-dimensional representation of a flat plain is not dissimilar from a two-dimensional flat plain. Therefore, it is possible that virtual reality training experiments involving rich textured backgrounds could prove more beneficial than if the same training scenario were conducted using a simple monitor as the medium of training. However, if there is little to no interaction with rich textures needed, the evidence above would imply that the training results would be similar whether one used a three-dimensional or two-dimensional interface. Unfortunately, the other two figures are less illuminating. Figure 3 shows that standard deviation for both Oculus and Monitor trial results are very similar, with Oculus standard deviations being slightly higher across the board, but to a negligible degree. Finally figure 4 shows how the mean glide slope improves as a result of training in both monitor and oculus rough and simple trials when compared to the pre-test values. Of course, all conclusions drawn can only be evaluated as results garnered from near transfer, since the two training setups were compared directly to each other. It might be possible to see a difference in the realm of far transfer, but that would require interaction with an actual plane and conducting real flight tasks.

FUTURE RESEARCH

Researchers interested in furthering this aspect of virtual reality training could use this study in a number of ways. Initially the study's aims were to compare training for oculus rift mediated virtual reality and a similar training setup utilizing a computer monitor. In actuality, a slight difference was suggested in rich textures leading to better outcomes within a virtual training environment. Researchers could further examine this possible phenomenon and devise a test in which rough textured backgrounds are tested against simple designs to ascertain the effective difference rich textures provide to a three-dimensional training routine. Additionally, future studies could attempt an improved training regime prior to the trials, allowing participants to ascertain, and become better prepared to adopt, an appropriate glide slope that would allow for a more accurate rendering of abilities on an analytic graph. Lastly, moving forward with the basic application of the current study, researchers could attempt to pinpoint the degree of efficacy difference in virtual training compared to less technologically modern methods. Namely by using two training groups with greater variety amongst training setups. One group could use a system with a much lower degree of fidelity, cardboard cutouts and pictures for example, while another group uses a professional grade flight simulator. Comparing the results of actual flight trails between the two groups would allow for a measurable effect size difference between virtual reality training and less technologically advanced training methods.

CONCLUSION

This study attempted to gauge the effectiveness of modern training methods utilizing virtual reality, defined here as feeling immersed within the training environment, when compared to the utilization of a computer monitor, a lower-immersive scale version of virtual reality, for interaction with the training setup. Although the researcher did not believe a large effect would be observed between the training setups the suggestion of a possible effect due to rich textures was uncovered allowing for further study to identify to what degree rich textures play a role in the acquisition of training techniques.

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