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The effects or practicing a golf putting task in virtual reality

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Chancellor’s Honors Program Capstone Project: The effects or practicing a golf putting task in virtual reality

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Abstract

Previous studies have compared motor performance improvements between virtual reality (VR) and real world (RW) motor skill practice. While the empirical evidence suggests VR practice leads to similar pre- to post-test improvements, these studies typically only report the pre- and post-test results and thereby forego publishing performance data during the acquisition phase. Thus, the purpose of this study was to determine the performance differences observed during skill acquisition between RW and VR practice. Additionally, the psychomotor efficiency hypothesis was tested for differences between RW and VR conditions by collecting electroencephalographic (EEG) data during the practice phases. Two groups practiced golf putting in a RW (N=21) or a VR environment (N=24) for 3 blocks of 20 putts per day for three days. Radial error was calculated as the distance from the golf ball to the center of the target for each trial. A mixed repeated measures ANOVA was used to analyze conditions across each day of practice. Results from the analysis showed there was a significant interaction between condition and trial block. Contrary to the RW condition, a follow-up simple effects analysis found that the VR condition had significantly lower golf radial error (i.e., greater accuracy) in the first trial block (M = 1.18, SE = 0.08) compared to trial blocks two (M = 1.33, SE = 0.10) and three (M = 1.40, SE = 0.10). Interestingly, no significant performance changes were observed for the RW practice group through the same period of acquisition. Specifically, practice in VR resulted in a significant decrease in accuracy in blocks 2 and 3 compared to block 1 during each day of practice. Whereas, the RW group showed no change in performance during practice. There were no significant differences in the EEG data collected. Previous bodies of motor learning research have demonstrated that practice performance is not a reliable indicator of learning. For example, practicing with low contextual interference artificially inflates practice

performance while learning is masked during acquisition while practicing with high amounts of contextual interference. Future research should investigate if practicing in a VR setting has a masking effect on motor learning.

Introduction

Developing a level of mastery for a motor skill requires a significant amount of quality practice (Ericsson et al., 1993). However, depending on the skill, numerous barriers exist that make it difficult to attain an adequate amount of practice. For example, many sports require a field or gymnasium, as well as at least one if not multiple individuals to assist in practice. Pilots require access to a plane, helicopters, or a simulator to gain experience, which comes at the cost of personal injury or financial expenses. The use of virtual reality (VR) has been considered a method for overcoming such logistical, inconvenient, and costly obstacles (Michalski et al., 2019). Additionally, it allows for the utilization and implementation of optimal learning principles that have been rigorously tested for numerous decades (Wulf, 2007). Previous research has demonstrated practice in VR can outperform traditional practice when the VR practice difficulty is adapted based on the skill level of the individual (Gray, 2019). While VR should not be recommended as a replacement for traditional practice, it does potentially offer numerous advantages.

The psychomotor efficiency hypothesis proposes that as one develops proficiency and expertise in a motor skill, it will be accompanied by a refinement of the neural network recruited to complete the task as relevant processes are enhanced and irrelevant processes are reduced (Gallicchio et al., 2017). In regards to practice, as performance improves, it is expected that conscious processing will decrease (Gallicchio et al., 2017). When examining and measuring this process, alpha oscillations (frequencies ranging from ~8-12 Hz) are thought to be the important figure of shaping functional architecture in the cortex (Gallicchio et al., 2017). This allows for examination of the inhibition of task irrelevant processes (Hatfield, 2018). This study examined the EEG data relative to the alpha oscillation frequency range from the moment of initiation of the back swing of the golf club to contact with the golf ball. The moment leading up to the put was the crucial period to examine as that is when the participants would be focused on completing the motor skill.

Methods

Participants were presented with the consent form and the warning document upon arrival at the Motor Behavior Lab on day one of testing. Each participant was in the study for four days within a five day period. Day one is the pre-test and beginning of the practice phase, days two and three were a continuation of the practice phase, and the fourth day was the post-test phase. On day one, following participants' signed consent to the approved IRB consent form and after the opportunity to review the warning document, the participants were provided video instructions regarding how to perform the to be practiced motor skill for their respective group. A simple motor learning task - a straight line golf putt- was used. A miniature golf putting task was used and was created inside a laboratory and a virtual environment. The golf putting task was created on a carpeted surface (1.829 x 3.658 m) inside the laboratory. The participants used a standard length (90 cm) golf putter to put a regular sized golf ball towards a standard hole (diameter 10.795 cm). The hole was 2.438 meters away from the starting line. A web camera was fixed perpendicularly above the hole to capture the golf ball position. The camera application (Microsoft Corporation; version 2021.105.10.0) on an Alienware computer was used. Tracker software (version 6.0.1) was used to determine the x- and y-coordinates of the golf ball. In the virtual reality groups, a custom golf putting simulation built with the help of Unity 3D using the

Oculus headset was used. The virtual reality environment replicated the real world environment task so that the environment and task look, sound, and feel the same between groups.

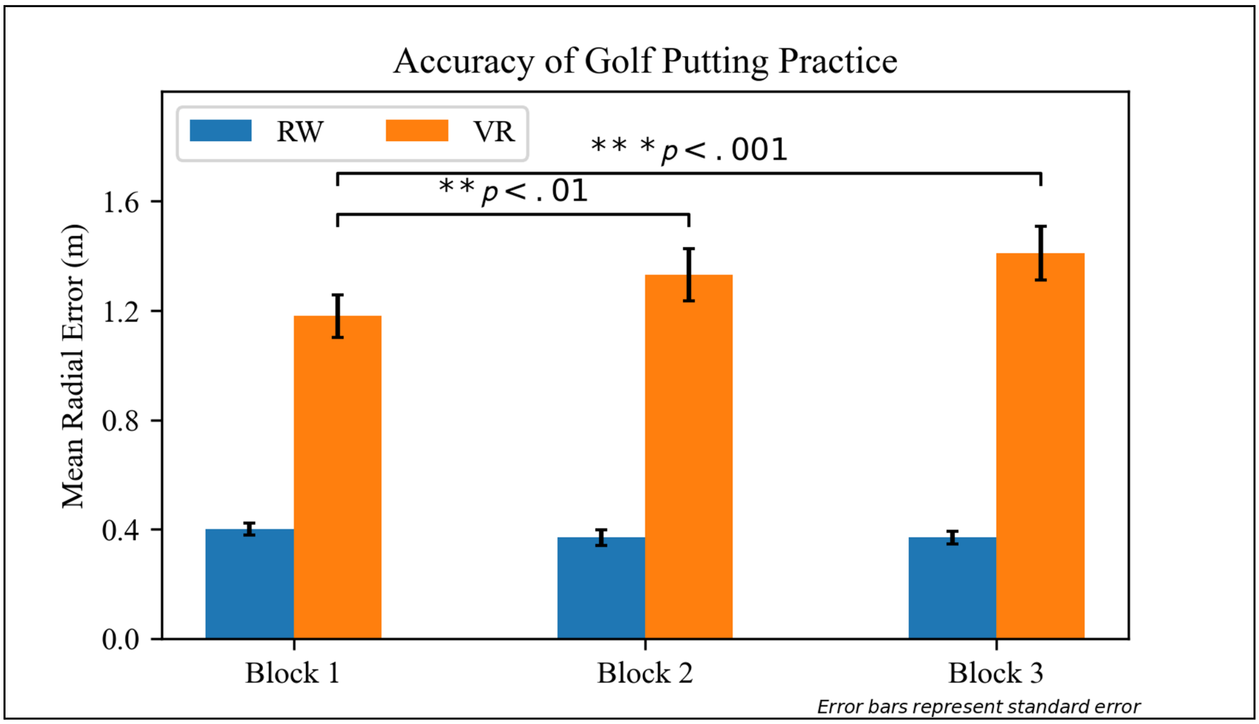
In all groups, participants performed a total of 3 blocks of 20 practice putts during day one, two, and three of the study. Half of the participants performed the task virtually (N= 24), while the other half of the participants will physically perform the task (N=21). During the practice phase, an EEG headset was used to record brain wave activity. The goal was to score as many points as possible for both conditions. After the participants performed all of the practice trials of the task, the researcher provided the participant with two different questionnaires. The questionnaires were given in a counterbalanced order. One of the questionnaires was the Intrinsic Motivation Inventory (IMI) and assessed levels of motivation. The second questionnaire was the Individual Self-Report Engagement Scale which measured the participants level of engagement.

On day four of the study, participants will return to the lab to perform a retention and a transfer test to assess learning. During the retention test, participants performed the same task performed during the practice phase in their respective environments. During the transfer test, all the participants performed the practiced task in the real environment in the motor behavior lab. The data were analyzed using IBM SPSS Statistics version 28.0.0. A mixed repeated measures ANOVA was used to analyze performance differences among environmental conditions across each trial block of practice.

Results

Results from the analysis showed there was a significant interaction between condition and trial block. Contrary to the RW condition, a follow-up simple effects analysis found that the VR condition had significantly lower golf radial error (i.e., greater accuracy) in the first trial block (M = 1.18, SE = 0.08) compared to trial blocks two (M = 1.33, SE = 0.10) and three (M = 1.40, SE = 0.10). Interestingly, no significant performance changes were observed for the RW practice group through the same period of acquisition. Specifically, practice in VR resulted in a significant decrease in accuracy in blocks 2 and 3 compared to block 1 during each day of practice. Whereas, the RW group showed no change in performance during practice.

Figure 1



There was no significant difference found in the analysis between condition or trial block with regard to EEG data. When looking at the psychomotor efficiency hypothesis, there was not enough evidence to support it; however, there were significant limitations with the use of the equipment that recorded the EEG data. The use of two headsets, the virtual reality headset as well as the multiple electrode EEG headset concurrently resulted in electrodes shifting from the position they were initially set in. Additionally, even in the RW condition where only the EEG headset was used, the quality of the signals that were picked up varied dramatically from different factors from hair style to texture that also contributed to unwanted shifting of the electrodes. These unintended movements could have decreased the precision of the data that was collected and contributed to the lack of significance between groups or trial blocks.

Conclusion

This study is involved in the beginning of a wave of information surrounding motor skill acquisition through Virtual Reality that can have a major impact in several fields. By having clear significant differences in performance between these groups through practice phases, there is a clear indication that more studies need to be conducted to analyze the extent of transferability of skills learned in Virtual Reality to the real world. While the psychomotor efficiency hypothesis was not clearly visible in these results, there should be more precise data collection through practice phases to verify this phenomenon.

Previous bodies of motor learning research have demonstrated that practice performance is not a reliable indicator of learning. For example, practicing with low contextual interference artificially inflates practice performance while learning is masked during acquisition while practicing with high amounts of contextual interference. Our findings reveal there is much we do not understand regarding how motor skills are learned in virtual reality. Therefore, future research should investigate if practicing in a VR setting has a masking effect on motor performance.

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