Virtual Reality Interventions for Rehabilitation: Considerations for Developing Protocols

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Abstract. This paper is a preliminary report on a work in progress that explores the existence of practice effects in early use of virtual reality environments for rehabilitation purposes and the effects of increases in level of difficulty as defined by rate of on-screen objects.

Keywords. Virtual reality, rehabilitation, practice, difficulty, rate

Introduction

It has been suggested in the rehabilitation literature that an inconsistency in outcome of traditional physical and occupational interventions could potentially be addressed with new training approaches that incorporate technology [1]. Recent research addressing the use of technology in rehabilitation has provided some encouraging results. Specific to virtual reality (VR) applications, there is a reasonable amount of research that indicates “people with disabilities can learn motor skills in VR and transfer this learning to real world performance” [2].

Although such results are encouraging, there is a call for caution and continued systematic evaluation in the literature. For example, “more rigorous studies are warranted to further investigate the conditions under which VR can be implemented effectively, including: optimum scheduling and intensity of intervention, profiling those patients who are most likely to benefit from VR-training and appropriate follow-up.” [3]. The current study addresses one aspect related to VR scheduling, practice effects, and one aspect of intensity of intervention, rate of on-screen objects.

Toward determining optimal scheduling for VR interventions, we addressed the possibility of practice effects occurring in the early phases of VR interventions. We define practice effects as the degree of improvement in performance due to increasing familiarity with therapeutic equipment during initial treatment sessions. As virtual reality equipment can be complex and foreign to the average person, it is not unreasonable to expect that participants will need to develop a certain degree of familiarity with the equipment before meaningful therapeutic progress can be made. The enhancements in performance that can be observed during initial treatment sessions may not all be due to the demands of the treatment regime but could instead be

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a reflection of the initial adjustment process to the VR equipment that each user must experience. Practice effects could occur no matter the degree of impairment of the individual and should be separated out from real therapeutic improvements in motor skill. Therefore, we address the question - Do practice effects occur on a once-a-week, four-week schedule of VR use?

Another consideration in using VR applications for rehabilitation is the initial choice of level of task difficulty. There are a number of parameters that could be adjusted in such programs to alter level of difficulty (e.g., range of motion, speed of response). One benefit of VR environments is that they allow for the high degree of motor repetition in treatment that is associated with neuro-reorganization [2] and, subsequently, improvements in post-stroke function [1]. Given these findings, it would seem desirable to increase repetition by increasing the rate of on-screen objects but how might we determine optimal rates at the outset of treatment? This study investigates how the performance of persons with normal mobility varies as the rate of on-screen objects is manipulated.

1. Methods

1.1. Materials

The VR system used in this study is the IREX (Interactive Exercise and Rehabilitation Systems) by Xperiential Systems. The IREX system uses cameras to capture a person's image against a green background and project it onto a monitor. A virtual scene is inserted by the program and combined in real-time with computer-generated action. The user can then see themselves in a virtual world on the monitor placed in front of them. The applications are similar to video games, but the patient uses their body to control the game, not a game controller.

There are numerous activities to choose from in the IREX software, (e.g., snowboarding, soccer, boxing, racing, and even mountain climbing). Each virtual scenario is designed to employ a specific type of movement to complete the exercise successfully. For example, in the scenario reported in this paper, Birds and Balls, the user must direct controlled upper limb movement and grasping of a series of balls falling from the top of the screen. If the user exhibits the optimal speed and fluidity of movement as his/her hand makes ‘contact’ with the virtual balls, the balls will transform into birds and fly away. If the movement is too fast or jumpy the balls will “pop.” Thus, this particular virtual scenario would be an option for upper-limb rehabilitation.

1.2. Procedures

Participants were seven persons with normal mobility (no motor or balance deficits). Only participants over the age of 55 were tested. Participants engaged in a forty-five minute session spaced one week apart for four weeks. Sessions occurred in the Glenrose Rehabilitation Hospital in Edmonton, Alberta, Canada. Participants were tested at four different rates of on-screen objects – Level 1, M=42 objects/minute, Level 2, M=47 objects/minute, Level 3, M=57 objects /minute and Level 4, M=117 objects/minute. Rate reflects both speed of individual objects and number of objects.
The mean rate of on-screen objects for each level in the program was not a statistic that was available to us at the outset of the study. Levels could only be chosen according to the numerical labels given by the program, which ranged from 1-10. For our four levels we chose the program labels of 1,3,6,9 with the assumption that the increments between levels would represent an equal increase between levels. As the means indicate, this was not the case as there is a much larger increase between the third and fourth levels than between the lower levels.

2. Results

Proportion correct was analyzed with two non-parametric repeated measures analysis of variance tests (Friedman’s). First, the variable “week” was tested as a within subjects variable. In order, the means for Week 1 through 4 were .843, .860, .884, .845 respectively (SDs = .107, .106, .071, .102 respectively). The analysis indicated there was no significant difference in performance across the four weeks, \( \chi^2 (3, N = 7) = 4.54, p = .208 \). Therefore, no practice effects occurred on this schedule of intervention. Following this, an analysis of the level of test difficulty as represented by rate of on-screen objects (Level1, M=.953, SD=.063 Level2, M=.971, SD=.040, Level3, M=.912, SD=.112, Level4, M=.597, SD=.202) was conducted and showed a significant difference between levels, \( \chi^2 (3, N = 7) = 13.8, p = .003 \). Participants performed poorly on the level with the highest rate of on-screen objects.

3. Conclusions

The results suggest that practice effects are not a concern for assessing therapeutic improvement on a once a week, four-week VR schedule. However, the initial choice for rate of on-screen objects needs to be carefully considered as a rate of 117 objects/minute was a challenge even for persons with normal mobility. Minimal increments increasing from 42 objects/minute up to 57 objects/minute were not a challenge for persons with normal mobility. Therefore, for applications involving upper-limb rehabilitation, a reasonable choice for initial sessions for persons with mobility impairment would be a rate of between 42 and 57 objects/minute.

References