Emotional and Performance Attributes of a VR Game: A Study of Children

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Abstract. In this paper we present the results of a study to determine the effect and efficacy of a Virtual Reality game designed to elicit movements of the upper extremity. The study is part of an on-going research effort to explore the use of Virtual Reality as a means of improving the effectiveness of therapy for children with motor impairments. The current study addresses the following questions: 1. Does a VR game requiring repetitive motion sufficiently engage a child? 2. Are there detrimental physiological or sensory side-effects when a child uses an HMD-based VR? 3. Are the movements produced by a child while playing a VR game comparable to movements produced when carrying out a similar task in the real-world?

Based on study results, the enjoyment level for the game was high. ANOVA performed on the results for physical well-being pre- and post-VR showed no overall ill-effects as perceived by the children. Playing the game did not effect proprioception based on pre- and post-VR test scores. Motion data show similar, but not identical, overall movement profiles for similar tasks performed in the real and virtual world. Motor learning occurs in both environments, as measured by time to complete a game cycle.

1. Introduction

The idea of using Virtual Reality (VR) to assist in the rehabilitation of persons with disabilities was first introduced more than a decade ago. Since that time, several researchers have explored the use of VR for a diverse set of rehabilitation activities, including training in the use of motorized wheelchairs [1]; rehabilitation of balance disorders [2]; training spatial skills for mobility-impaired children [3]; and rehabilitation of cognitive and motor impairments caused by stroke [4]. Since most children play computer or video games, the use of VR as a rehabilitation tool for children with disabilities seems particularly promising. A VR therapy game could engage a child in play while delivering the needed therapy in a more palatable manner. Indeed, Reid [5] has shown that allowing children with severe handicaps to “participate” in virtual play activities from which they would normally be excluded in the real-world increases their sense of self esteem and self image. There is also evidence that spatial skills acquired by exploring a virtual world transfer to the real-world [6] and that motor tasks practiced in a virtual environment improve the performance of the same real-world tasks [7].

We are exploring the use of Virtual Reality to improve the effectiveness of therapy for children with motor impairments (for example, CP.) Our presumption (like those before us) is that VR can provide engaging “games” that will motivate the child to repetitively produce the desired therapeutic movements. Previous work in this area has been lacking in two ways: First, there has been no systematic study of the physiological and/or sensory effects of using VR on children (especially when a head-mounted display is used.) Second, the size of the population studied in most cases has been relatively small, making it difficult to generalize the results. As a first step in our work, we are addressing the first question: Does using VR have negative effects on children, and, equally important, do children enjoy playing VR games.

2. Study Design and Method

2.1 Experimental Setup

The virtual reality equipment used for the study consisted of a head-mounted display (HMD) and two position trackers: one tracker was mounted on the HMD and was used to update the virtual scene as the child moved his/her head. The other tracker was mounted on the child's hand and was used to update the position of the virtual hand and to permit the child to interact with the virtual game. The VR game consisted of a fantasy castle with 5 blocks displayed in front of the child. The child was instructed to "touch" each block with their virtual hand after it began to rotate. The rotating block then changed into an animated object (such as a rocket that blasted off accompanied by sound effects.) A cycle consisted of touching all five randomly positioned blocks sequentially and each child played 6 cycles. Data from the tracker worn on the hand was recorded during each reach (to the rotating block and back to the lap.)

2.2 Method

Twenty four children between the ages of five and twelve participated. Sixteen were male and eight were female. All children were prescreened for normal vision and motor skills. Children used their non-dominant hand for all tasks. Each experiment was comprised of the following phases: The child first filled out a survey to record their level of motivation and current sense of well-being (i.e. were they dizzy, nauseous, etc.) The child then took a pre-VR proprioception test in order to quantify his/her proprioceptive motor skills. Each child was randomly assigned to one of two groups. Depending on his/her group, the child either played the VR game and then performed a real-world pointing test or the reverse. During the pointing test the child was instructed to point at each of five blocks mounted in front of him/her, with the sequence changed for each cycle. A cycle consisted of pointing at all blocks and there were six cycles. During each cycle, the motion of the child's hand was recorded and each data point was time-stamped to provide timing data. For both groups, the proprioception test was then re-administered. Finally, the child filled out a post-VR survey to record his/her enjoyment of the game and any changes in how they felt physically.

3. Results and Discussion

Emotional attributes: All children indicated high motivation to play the game in the pre-experiment questionnaire and indicated they thought it would be fun (average response to this question was 4.30/5.0.) Post experiment responses indicate that the children thought the game was fun (average response was 4.35/5.0) and that they would like to play the game again (average response 4.48/5.0). ANOVA performed on the results for well-being pre- and post-VR showed no overall ill-effects (i.e., increased nausea, dizziness, trouble walking or seeing) as perceived by the children.

Performance attributes: ANOVA was performed on the results of the pre-VR and post-VR proprioception test data. Separate analyses were performed for each group (those who took the proprioception test immediately after playing the VR game and those who took the test after also performing the real-world pointing test.) No significant effect on proprioception was found for either group.

We also compared the average time to complete a cycle for cycles two (real world timing: 15.05 sec, VR game: 39.4 sec) and five (real world: 13.77 sec, VR game: 37.3 sec.) Performance in both cases improved (real world: 1.27 sec, VR game: 2.09 sec.) This indicates that learning occurred in both situations.

Figure 1 charts the average efficiency of movement by age. (We assign an efficiency score as the ratio of distance to travel in a straight line from the lap to the block over actual distance traveled during the reach.) Movement within the VR game appears to be less efficient than in the real-world task. There may be several reasons for this: We observed that children moved their arms and hands more during the VR game. For example, some of the children followed the rotations of the block with their finger, while others raised their hands and moved them as they visually acquired the block to be touched. Other children found that they could cause the virtual block to transform by swiping their hand through it either from above or from the side – a motion they did not perform in the real world. In our next set of planned experiments, we will attempt to control for these variations. We will also compare movements for real, static blocks, virtual, static blocks, and virtual spinning blocks to attempt to extract whether the difference in motions was due to the nature of virtual reality itself or whether the differences in the two tasks (simply pointing at static blocks vs. attempting to make something interesting happen) was the primary cause of the additional movements.

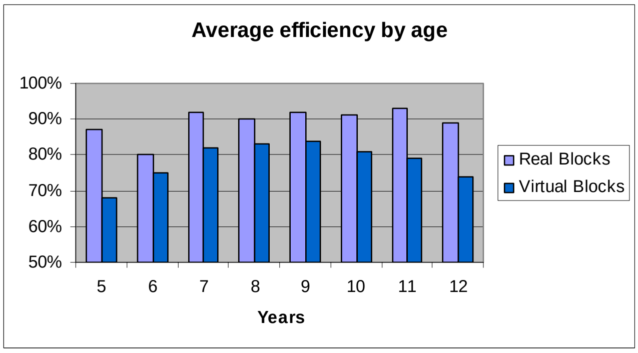

Figure 1: Chart showing efficiency of movements

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