

Virtual Reality Provides Leisure Time Opportunities for Young Adults with Physical and Intellectual Disabilities

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ABSTRACT

Due to limitations in their physical abilities, adults with cerebral palsy (CP) have relatively few opportunities to engage in independent leisure activities. This pervasive lack of opportunity often leads to the development of dependent behavioral patterns and learned helplessness. The objective of this pilot study was to explore ways in which virtual reality can provide positive and enjoyable leisure experiences during physical interactions with different game-like virtual environments and potentially lead to increased self-esteem and a sense of self-empowerment. The study sample consisted of five young male adults with CP and severe intellectual disabilities who are non-speaking and who use wheelchairs for mobility. Each participant experienced three game-like virtual scenarios via VividGroup's Gesture Xtreme video capture virtual reality (VR) system. The participant's video captured image was processed on the same plane as screen graphical animations that react in real time in response to his movements. Outcome measures included the participants' responses to a five-item presence questionnaire, a 6-item task specific questionnaire and observation of their videotaped performance while participating in the virtual games. Participants' responses to the questionnaire showed a high level of presence in all three scenarios. These participants demonstrated an exceptional degree of enthusiasm during each VR experience; some reacted to the various stimuli via appropriate and goal-oriented responses, in other cases the response was more arbitrary. Documentation of behaviors during and following the VR experiences may provide insight into the important role that VR may play in nurturing their self-esteem and sense of empowerment.

INTRODUCTION

IN RECENT YEARS, virtual reality (VR) technologies have begun to be used as an assessment and intervention tool in rehabilitation.¹⁻⁸ Virtual environments provide patients with safe access to interactive, true-to-life situations that would otherwise be inaccessible to them due to motor, cognitive and psychological limitations.^{4,5} The ability to change the virtual environment relatively easily, to grade task difficulty and to adapt it according to the pa-

tient's capabilities are important advantages of VR, since these features are essential to cognitive and motor remediation.⁴ In addition, patients such as those who have used a virtual environment in Rose et al.'s³ study reported the experience to be very enjoyable; it appears that participating in such activities can increase motivation for treatment.⁹

In addition to the more traditional therapeutic goals, VR also provides a platform in which individuals with disabilities, who would be unable to perform leisure activities in "real life" settings, may

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be able to engage in them. In such cases, the experience of the virtual environment would not be primarily a means to improve body functions or activities; rather, it would directly enhance that individual's level of participation as an end goal. Due to limitations in their physical abilities, individuals with cerebral palsy (CP) have relatively few opportunities to engage in independent leisure activities. The pastimes that are available to them tend to involve sedentary activities such as viewing movies and modified arts and crafts activities.¹⁰ Other leisure activities for people with disabilities include the playing of games on computers that have been adapted to provide greater accessibility,¹¹ swimming,^{12,13} and horseback riding.¹⁴ Some of these activities are readily available; others are expensive and not widely available, and personal safety may be a concern. Other barriers to participation in leisure activities for individuals with CP and spina bifida include accessibility to facilities, problems of transportation limitations, and apprehension on the part of the caregivers.¹⁰ Some leisure activities such as going to the park or eating out in a restaurant may be made possible only with the cooperation of a companion.

A review of the literature on leisure for people with disabilities highlights the need for increased exposure to augmented leisure opportunities and the positive correlation between life satisfaction, self-esteem, companionship, enjoyment and relaxation and leisure satisfaction.¹⁰ Greater involvement in leisure activities appears to improve the participant's coping skills, decreased stress, and adjustment to a life with disabilities.^{10,15} The power of leisure is emphasized as being a key link to psychosocial adjustment, which, in turn, has some benefit to the person's health.¹⁶ The pervasive lack of opportunity for a wide choice of independent leisure time activities may lead to the development of dependent behavioral patterns, learned helplessness and depression.^{10,17} Specifically, the motor, sensory and cognitive impairments of people with severe motor and cognitive disabilities impede the opportunity to influence their environment and to become aware of the results of their actions. Reduced participation in activities limits the opportunity to make choices, and even the realization that one has the right and need to exert control over one's own lives.¹⁸ The provision of opportunities to exert control over one's environment and to influence and interact with other people is thought to help to reduce learned helplessness.¹⁹

In recent years, VividGroup's Gesture Xtreme video capture VR system [www.vividgroup.com], originally developed as an entertainment system

designed to demonstrate VR in science museums, has begun to be used in rehabilitation.²⁰⁻²⁵ We have adapted it for use in rehabilitation settings such that the level of difficulty experienced by users within the various environments can be graded, and a report of performance can be generated.²² The Gesture Xtreme system differs from other VR systems for several reasons. The user does not have to use head-mounted display or other special apparatus in order to feel immersed within the virtual environment. He views himself actively participating within the environment rather than some representational avatar; this has been suggested to add to the realism of the environment and to the sense of presence.²⁶ The user completely controls his movements within the virtual environments, and while interacting within the virtual environment, the user can, and is encouraged to, use all body parts. Finally, a therapist can guide a client verbally as well as physically while immersed within the virtual environment. The objective of this study was to explore ways in which this system can provide positive and enjoyable leisure experiences during physical interactions with different game-like virtual environments.

MATERIALS AND METHODS

Participants

Five young male adults (mean age = 25.6 years; SD = 1.95) with severe spastic CP and severe intellectual disabilities were included in the study. All participants are non-speaking, use wheelchairs and are completely dependent for help with activities of daily living. They all use different techniques for alternative and augmentative communication, including communication charts, Voice Output Communication Aides and specialized communication software that they access via customized assistive technology devices.

Instruments

VR system. When using the Gesture Xtreme VR system, users stand or sit in a demarcated area viewing a large monitor that displays one of a series of simulated functional tasks, such as catching virtual balls or playing goalie in a virtual soccer game. The participant's video-captured image is processed on the same plane as screen graphical animations that react in real time in response to his or her movements. This system has been used to provide occupational therapy intervention with

adult neurological patients,²⁰⁻²² to provide graded physiotherapy exercises,²³ and for recreational activities for children with CP.^{24,25}

Virtual environments. As shown in Figure 1, the user sees himself on the screen, in the virtual environment, and his movements entirely direct the progression of the task. The upper half of the figure shows one of the participants engaged in the Birds & Balls environment. He sees himself standing in a pastoral setting watching different colored balls float towards him. Touching these balls causes them to turn into doves or to burst, depending on how abruptly they are touched. The level of difficulty may be graded by controlling the ball's direction and speed, and by adding stimuli of a different shape (e.g., a star) as distracters. In the lower half of Figure 1, a second environment, Soccer, is shown. Here, the participant sees himself as the goalkeeper in a soccer game. Soccer balls are shot at him from different locations and his task is to prevent balls

from entering goal area. The level of difficulty is graded by changing the number of balls that appear simultaneously, ball direction and ball speed. In a third environment, snowboard (not shown), the participant sees a back view of himself mounted on a snowboard. As he skis downhill he needs to avoid rocks and trees by leaning from side to side or moving his whole body. The level of difficulty is altered by changing the speed of skiing.

Outcome measures

Although performance during participation in the virtual environments may be recorded (e.g., response time, accuracy) these data were not examined during the present study since the objective was to use the virtual environments to provide recreational experiences, rather than as therapeutic interventions. The outcome measures used in this study included the participants' responses to a five-item presence questionnaire (based on Witmer and Singer's²⁷ presence questionnaire) and a six-item task specific questionnaire. The items included queries about how much the participant enjoyed the game, how realistic it appeared to him, how much control he felt he had within the environment, how much he was disturbed by noise or movement in the real environment, how understandable was the feedback provided during the game, how comfortable did he feel during the game, how hard the game was, and whether the game was too fast or took too much time. Responses, assessed on a five-point scale, were reported to the researcher with the help of a communication partner, one of the day residence staff who was familiar with the specific augmentative communication system used by each participant. Subjects were also asked several open-ended questions such as "How would you describe your experience?" Care was taken to ensure that the participants understood the questions and that the answers reflected their own views of the VR experience. All sessions were recorded on videotape and examined afterwards to note participants' behaviors and movements during each game.

Procedure

All testing took place at the day residence where the participants come daily for therapy and occupational activities. On two prior occasions (about 15 months and about 3 months prior to testing), the participants had either observed or had experienced several virtual games using the same VR system when it had been part of a recreational fair at this day residence. They were thus familiar with



FIG. 1. Subject "D" playing birds and balls (top) and playing virtual soccer (bottom).

the experience and, in fact, were interested in having an opportunity to use it again. Four out of the five participants engaged in two 60-sec repetitions of each of three virtual environments. The fifth participant was only interested in playing soccer and declined to engage in the other two environments. A 5-min break was given between successive environments during which time the participants were asked to respond orally to the presence and task-specific questionnaires. The environments were always presented in the same order, Birds & Balls, Soccer and Snowboard. Testing took place during a single session lasting approximately 30 min.

RESULTS

To date, we have tested the responses of five individuals who have experienced the three different virtual scenarios. These participants demonstrated an exceptional degree of enthusiasm during each VR experience, although they did indicate preferences amongst the different games. Soccer, a game more familiar to them than the other two virtual games, was the preferred virtual environment and, as indicated above, one participant only agreed to play it.

Their responses to the presence questionnaire, shown in Figure 2, indicated a high level of presence in all three scenarios (Birds & Balls, 3.94 ± 0.43 , Snowboard, 3.5 ± 0.71) and especially in Soccer (4.45 ± 0.57). In their responses to the task-specific questionnaire, all participants indicated that the games were fun to play. Most of the participants found some of the environments to be tiring, especially the soccer game. They indicated that playing these games made them happy, and one said that

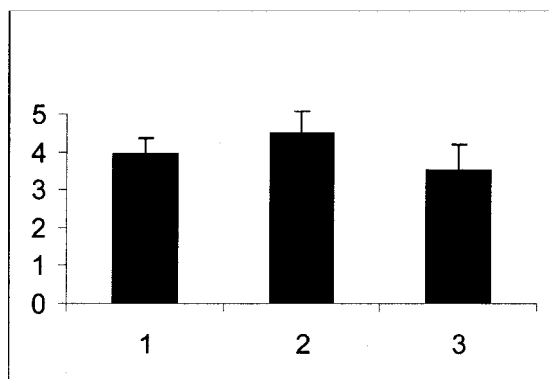


FIG. 2. Mean response and one standard deviation to the mean of the five items on the presence questionnaire for each virtual environment. 1 = Birds & Balls; 2 = Soccer; 3 = Snowboard.

he found the experience to be a “new and special thing.” Others described some of the games, especially snowboard, an activity quite remote from both their direct and indirect experience, as being strange or surprising.

The videotaped sessions were viewed and analyzed by an occupational therapist who has worked for more than 20 years with young adults who have severe motor and intellectual disabilities. She noted that some of the participants responded to the various virtual stimuli via appropriate and goal-directed movements; in reaction to the appearance of the virtual balls, they raised their arms and attempted to hit and repel them. Although these movements were highly spastic (and, in one case, athetoid) in quality, they appeared to be voluntary, directed and deliberate. However, in at least two cases, response to the virtual stimuli appeared to cause the participants to enter into highly abnormal and pathological movement synergies and to adopt maladaptive postures. Moreover, in these cases, responses often appeared to be arbitrary and not particularly goal-directed.

Although these participants appeared to understand the objectives of the three virtual games, their responses may have been global in nature to the general ambience of the environment (e.g., reactions to the cheering crowd during the soccer game or to the sound of balls bursting during Birds & Balls) rather than to the specific stimuli (i.e., hitting a particular ball as it approached them). Finally, it is important to note that none of the participants complained of any side effects such as nausea, discomfort or disorientation during any of the games.

DISCUSSION

Despite their very severe motor, cognitive and intellectual disabilities, all five young adults who participated in this study indicated their considerable enjoyment of the virtual games. With only minimal instruction and opportunity to practice, they understood how to use the system and performed in a natural manner. All three games caused them to feel enjoyment and generated a high sense of presence. The participants had preferences for one game over another and felt more immersed in some and less immersed in others. Their physical responses differed as well; for example, they found soccer to be a more fatiguing experience for them than the other two games. We view the diversity of responses, both within and between participants, as a positive indication of the authenticity

of the virtual experiences; it would appear that the participants did not respond primarily to the uniqueness of exposure to a novel situation but rather were able to distinguish, and selectively choose between certain games over others. The ability to make choices and to indicate preferences is a first step towards the achievement of a sense of independence and responsibility,^{18,19} and it is thus encouraging to see such behaviors expressed during the virtual games. It was clear that the Gesture Xtreme system is feasible for use by people with severe disabilities.

The results of this study demonstrated the potential of the Gesture Xtreme video projected VR platform for providing recreational opportunities for people with severe physical and cognitive limitations. The Gesture Xtreme system is unique from other immersive VR systems for several reasons, and these attributes clearly help to make it suitable as a medium for providing positive leisure experiences. First, the user does not have to use head-mounted display (HMD) or other special apparatus in order to feel immersed within the virtual environment. This may minimize the likelihood of developing side effects and, in the case of severe intellectual impairment, provides a high immersion environment without the potential discomfort and disorientation that may be engendered by isolation from the user's surroundings.

Second, when using this system, the user views himself actively participating within the environment rather than as represented by an avatar; this has been suggested to add to the realism of the environment and to the sense of presence.²⁶ Although this gives the user a "third person" viewpoint (as compared to the "first person" viewpoint provided by HMD wearers), it may also serve to reinforce the sense of control by a user with a severe intellectual disability.²⁸ It may also give him a unique opportunity to see himself perform and succeed at exerting control over the environment. The use of mirrors to reflect an image of a person during physical and occupational therapy for range of motion and balance training is not uncommon since the patient benefits from the visual feedback of his body's postural alignment.²⁹ Due to the constraints associated with conventional therapy, such displays are usually restricted to relatively rote activities such as placing loops or blocks from one location to another. The integration of the user's image within the dynamically changing virtual environments greatly expands the potential of mirror image feedback such that the patient can not only enjoy playing a game but can also observe himself enjoying it. We are currently exploring whether, and how

much, such third person observations interfere with the user's ability to become immersed within the virtual environment and the effect that this has on his enjoyment.

A third important characteristic of the Gesture Xtreme approach relates to the method by which the user interacts within the virtual environments. Rather than manipulate virtual objects via less direct interfaces such as a joystick, this VR system uses a video camera to track the user's movements and record the position of the body at all times, allowing for real-time movement and interaction with background graphic displays and foreground graphic stimuli. Thus, the user avoids an obstacle while skiing by inclining his body to one side or repels balls from the goal crease by extending an arm or leg. Such direct and natural cause-and-effect interactions within the virtual environments may reinforce the user's sense of control. The use of such interactivity is not new to the field of assistive technology and computers and microswitch technologies have long been used to provide individuals with severe motor disabilities with opportunities to achieve greater control over the environment during leisure and activities.³⁰ The use of such technologies during early intervention for young children with disabilities has also been shown to reduce passivity and "learned helplessness," especially in the early stages of development.³¹

A fourth attribute of Gesture Xtreme VR is that the user can, and is encouraged to use all body parts while interacting within the virtual environment. This means that the cognitive and motor abilities the user is required to use in order to perform the tasks in this system are similar to real world activities. The presentation of the game-like stimuli (e.g., their number, speed, directionality) can be successively graded in order to match the user's current abilities and to prevent him from becoming discouraged by performance targets that he cannot yet achieve.

Finally, this VR system may be used together with other users in a truly game-like setting. On previous occasions when the Gesture Xtreme system had been made available during a recreational event at the day residence, a crowd of onlookers observed users as they played the various games. These cheering onlookers added an element of encouragement, competition and realism to the virtual experience. In some cases more than one user interacted with the environments at the same time. Indeed, several of the games (e.g., snowboard) are designed to support a competitive component.

The overall impression given by the results of this pilot study is that VR experiences such as those made possible by the Gesture Xtreme system have great potential in terms of expanding opportunities for leisure time activities. Nevertheless, it is important to note certain limitations which must be taken into account before promoting its use on a wider basis. The first of these limitations relates to the uncertainty about how much of the participants' responses was goal directed and how much was more global in nature and due to the general ambience of the overall experience. As indicated above, the level of difficulty can be graded. However, the levels selected in this pilot study were not the most basic since, in order to maintain a "gaming" atmosphere that would be perceived as exciting, large numbers of stimuli came simultaneously and rapidly. These levels were beyond the motor and cognitive capabilities of some of the participants making the task too difficult to be performed in a completely voluntary manner. Moreover, success was sometimes achieved coincidentally; stimuli that randomly struck a body part (e.g., the user's head) were repelled in the same manner as those that were actively and deliberately hit. Since both deliberate and inadvertent "hits" were recorded as successful (with concomitant visual and auditory feedback), the participant may in fact have been occasionally negatively reinforced in the very concept of cause-and-effect that we have indicated is so important to provide. A similar problem may have occurred as a result of the general feedback by the cheering crowd; some users may have responded more to this than to actions that he had specifically caused.

A second concern relates to what we will refer to as a trade-off between goals related to the provision of therapy and those designed to give recreational experiences. Two of the five participants very clearly displayed involuntary movement synergies, increased reflexes and maladaptive postures while engaged in the virtual games, particularly during soccer. A therapist who would use this VR platform for motor or cognitive intervention would most certainly grade the stimuli to ensure that the participant's movements were isolated, directed and controlled. Learning would be systematic and a close relationship between cause-and-effect would be maintained. On the other hand, rigid control over the setting and participant action may be counterproductive in terms of achieving the type of free-form recreational experience we set out to provide. Determining an appropriate balance between VR as a therapeutic tool and as a recreational opportunity will be our next objective.

Another limitation relates to the absence of a haptic interface, one that would provide participants with real-time indications of contact with the virtual stimuli. Such feedback could serve as an important addition when used in therapy since the balls, for example, could be rendered to appear to have progressively greater mass, making the task more or less difficult. It would also add an additional element of realism to the gaming experience, and ensure that feedback to participants was more realistic. This could be accomplished via a quasi-haptic effect that might use vibration to simulate a true haptic interface.³²

A final limitation relates to the type of games that are currently available for use with this system. In addition to games, recreational activities include many leisure pursuits such as shopping for clothes, cooking, driving a car, visiting a museum and looking for a book in the library. We are currently programming a more functional environment that would provide some of these opportunities with the aim of broadening the avocational pastimes available for young adults with severe physical and cognitive disabilities.

There is considerable research dealing with strategies designed to help increase independent behaviors such as the promotion of independent decision making,^{33,34} providing additional leisure opportunities³⁵ and teaching empowerment strategies.¹⁸ We have suggested that independent leisure experiences such as those provided within virtual environments will serve to expand the repertoire of avocational opportunities available to adults with severe physical and intellectual disabilities. This is one of the first studies that focus on using an immersive VR system for adults with intellectual disabilities in order to enable them to participate in leisure activities that would otherwise be inaccessible to them. Further documentation of their behaviors during and following the VR experiences may provide insight into the important role that VR may play in nurturing their self-esteem and sense of empowerment.

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