Guest Editorial

The potential of virtual reality for rehabilitation

Today's clinician is privileged to have access to a variety of technologies that provide tools for both research and clinical intervention. The papers in this issue illustrate some of the ways in which technology improves therapy and enhances evaluation. We learn how dynamic posturography can lead to a better understanding of standing balance in clinical settings, how a variety of innovative biomechanical techniques (e.g., polycentric knee mechanism, optical scanner imaging of the transtibial residua) may improve gait for people with amputations, how automatic speech recognition is being used as a computer input method, and how ultrasound and laser treatments may benefit wound healing.

An equally innovative technology that has not yet been presented within these pages is virtual reality (VR), the use of interactive simulations created with computer hardware and software to present users with opportunities to engage in environments that appear and feel similar to real-world objects and events [1–3]. VR is considered one of the most innovative technologies and promises to have a considerable impact on neurorehabilitation over the next 10 years [4].

Virtual environments are usually experienced with the aid of special hardware and software for input (transfer of information from the user to the system) and output (transfer of information from the system to the user). The selection of appropriate hardware and software is important because their characteristics may greatly influence the way users respond to a virtual environment [5]. The output to the user can be delivered by different modalities including visual, auditory, haptic, vestibular, and olfactory stimuli, although, to date, most VR systems deliver primarily visual-auditory feedback. Visual information is commonly displayed by head-mounted displays, projection systems, or flat screens of varying size. In addition to specialized hardware, application software is also necessary. In recent years, off-the-shelf, ready-for-clinical-use VR software has become available for purchase. However, more frequently, special software development tools are required for the design and coding of an interactive simulated environment that will achieve a desired rehabilitation goal. In many cases, innovative intervention ideas may entail customized programming for the construction of a virtual environment from scratch, with the use of traditional programming languages.

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VR technologies have now begun to be used as an assessment and treatment tool in rehabilitation [3,6]. Applications have been directed at a variety of clinical populations including those with cognitive [7–11] and metacognitive [12–14] deficits. Other applications are being directed at the rehabilitation of motor deficits [15–17] to help provide recreational opportunities for people with severe disabilities [18]. VR also shows promise for training in activities of daily living with different populations, including use of a virtual kitchen and vending machine, street crossing, and a hospital and university way-finding environment [11,19,20]. The rehabilitation of driving skills following traumatic brain injury is one example in which individuals may begin at a simple level (i.e., straight, nonpopulated roads) and gradually progress to more challenging situations (i.e., crowded highways, night driving) [21].

The rationale for the use of VR in rehabilitation is based on a number of unique attributes of this technology [3,22]. These attributes include the opportunity for experiential, active learning that encourages and motivates the participant [23]. Another is the ability of therapists to objectively measure behavior in challenging but safe and ecologically valid environments, while maintaining strict experimental control over stimulus delivery and measurement [24]. VR also gives therapists the ability to individualize treatment needs, while providing increased standardization of assessment and retraining protocols. Virtual environments provide the opportunity for repeated learning trials and offer the capacity to gradually increase the complexity of tasks while decreasing therapist support and feedback. Moreover, the automated nature of stimulus delivery within virtual environments enables a therapist to focus on the provision of maximum physical support when needed without detracting from the complexity of the task. For example, objects within a video-capture environment (e.g., the GX VR System by Vivid Group, Toronto, Ontario, Canada) can be displayed simultaneously from different directions while the therapist supports the patient's paretic shoulder. Finally, the ability to change the virtual environments relatively easily enables clinicians to assess more efficiently different environmental modifications, which endeavor to enhance clients' accessibility.

Indeed, the future holds great promise for the further development of applications of VR to rehabilitation. In addition to the many exciting rehabilitation applications just mentioned, VR-based therapy has been very effective in other realms of medicine such as in the treatment of phobias [25] and the reduction of pain during burn care [26] and venipuncture [27]. VR has also proven highly effective for providing alternate modes of feedback in cases of sensory impairment such as the substitution of auditory [28] and/or haptic [29] cues for individuals with severe visual impairment via interactive virtual environments.

The cost of equipment is decreasing and the availability of off-the-shelf software is growing such that many clinical facilities can now feasibly embrace this new technology. As just presented, the literature to date strongly suggests that these technologies are poised to have a major impact on evaluation and intervention for cognitive, motor, and functional rehabilitation because of the unique attributes of VR-based therapy. These attributes make it highly suitable for the achievement of many rehabilitation goals, including the encouragement of experiential, active learning; the provision of challenging but safe and ecologically valid environments; the flexibility of individualized and graded treatment protocols; the power to motivate patients to perform to their utmost ability; and the capacity to record objective measures of performance.

Nevertheless, further development of VR-based rehabilitation depends, to some extent, on the resolution of certain issues that currently present either technological or financial limitations. The cost of some of the more immersive VR systems is still prohibitive, rendering them more suitable to investigative studies than to routine clinical applications. Continued development of off-the-shelf, low-cost virtual environments that can be displayed on standard desktop equipment or via dedicated microprocessors (e.g., the Sony PlayStation II's "EyeToy" application, www.eyetoy.com) will make the use of VR affordable to a variety of treatment and educational settings. Of course, the clinical effectiveness of these less-expensive applications must be verified prior to their wide promotion and adoption.

A need also exists to address issues related to the number and quality of feedback channels used with virtual environments. As just indicated, visual and auditory feedback is extensively used; haptic, vestibular, and olfactory feedback is far less commonly available. The cost of devices capable of transmitting high-quality feedback is often high, and their potential for encumbering users is also significant. Neither is the relationship between feedback quality and effectiveness certain nor is the relationship between the number of feedback channels and effect of therapy known. Considerably more research on the impact that VR feedback has on clinical intervention is therefore needed.

Finally, it is encouraging to note that much progress has been made in the demonstration of the transfer of abilities and skills acquired within virtual environments to the real-world performance. Although continued efforts are needed to firmly establish that attainments with virtual environments are both transferable and generalizable to function within the real world, the evidence to date substantiates the initial promise of these dynamic technologies.

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