Cognitive Therapy Using Mixed Reality for Those Impaired by a Cerebrovascular Accident (CVA)

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Abstract. There is new research showing that interactive multimodal rehabilitation may enhance cognitive therapy after cerebrovascular accident. A well-designed Mixed Reality system provides a diverse, controllable and versatile therapeutic environment to help promote neural plasticity during recovery. In addition to stroke patients, there are other groups, such as those with traumatic brain injury (TBI) that could benefit from the system. Initial results, both paper-and-pencil measures and physiological measures, in a trial with fourteen participants are discussed.

Keywords. stroke, traumatic brain injury, cerebrovascular accident, rehabilitation, mixed reality, cognitive rehabilitation, physical rehabilitation.

Introduction

For over a decade, researchers have used virtual reality (VR) as a useful tool in therapy for a wide variety of applications, including treatment of anxiety disorders and pain distraction. One of the newest and most exciting applications of VR is in the field of rehabilitation. Research in VR applications for stroke patients in particular has made considerable progress.

Approximately 700,000 Americans are affected by stroke annually, costing an estimated $62 billion in 2008. At the age of 55, the risk of having a stroke is one out of every six. This risk doubles for every decade after 55. Once the Baby Boomer generation starts turning 65 in 2011, the risk will exceed the growth rate of the total population. More than 50% of stroke victims suffer from impairment of the upper limb, hindering their ability to carry out simple tasks such as dressing, picking up objects, and preparing meals. Recent evidence shows that intensive and repetitive rehabilitation, even a year after the cerebrovascular accident (CVA), can improve patient functionality. One challenge to all rehabilitation is that after an initial period of recovery, patients prematurely plateau in their recovery. Related challenges include limited rehabilitation resources and low levels of interest and participation.

The Mixed Reality Rehabilitation System (MRRS) was developed to overcome these deficits in traditional therapy by providing an interactive, engaging rehabilitation
tool that patients want to use. Mixed Reality (MR) is a parallel technology to VR with many possibilities in the area of healthcare. MR is generally viewed as being along a continuum from VR to physical reality and extends VR by blending real and virtual into a seamless landscape. Wearing a visual see through head-mounted display (VST-HMD), a user can see a virtual environment blended into their view of the real environment, which effectively “mixes” the two realities. The paramount advantage of MR is that it creates an altered or augmented reality without losing the benefits of the physical setting—touch, smell, hearing, taste, and visual contact with other humans.

In addition to stroke patients, there are other groups, such as people with traumatic brain injury (TBI) who could benefit from the system. A recent RAND survey found that 19.5% (over 320,000) of service members may have experienced at least a mild traumatic brain injury (mTBI) while deployed. Multiple re-deployments, unprecedented in this all-volunteer U.S. military, may compound the risk for physical and psychological injuries potentially resulting in more severe and chronic difficulties.

Cognitive assessment for TBI as well as assessment for stress injuries such as Post Traumatic Stress Disorder (PTSD) could be achieved in MR by capturing and analyzing a user’s reaction while experiencing the environment.

Initial MR scenarios were developed to increase stroke patients’ rate of physical and cognitive recovery and also increase their activities of daily living, enable at-home physical therapy, relieve some of the burden of caregivers, and decrease costs in lost productivity and hospital length of stay.

1. Methods

A prototype system of MRRS was designed, and the system has been used in two trials in the context of both physical and cognitive rehabilitation. Initial MR scenarios were developed to increase stroke patients’ rate of physical and cognitive recovery and also increase their activities of daily living, enable at-home physical therapy, relieve some of the burden of caregivers, and decrease costs in lost productivity and hospital length of stay.

Therapy programs and protocols were developed within the context of the virtual worlds. Patients were evaluated prior to being considered candidates for MRRS. The therapist subjectively evaluates the patient’s performance during a therapeutic activity while the MRRS monitors the patient’s motion and evaluates the patient’s performance relative to the prescribed motions and tasks. Patients were immersed in interesting environments and assigned entertaining and interactive tasks relevant to the virtual environment while still addressing their physical and cognitive therapeutic goals.

2. Results

Fourteen participants were enrolled in the cognitive rehabilitation study. Participants ranged from 18 years of age to 63 years of age. They varied in their experience and familiarity with video games and Mixed Reality.

The B-Alert EEG was used to acquire 6 channels of high-quality electroencephalographic (EEG) signals 30 feet from the computer data collection station - allowing for mobility. Engagement, workload, and distraction levels of healthy participants were measured while they performed tasks in the MR environment.
Distracters within the scenario demonstrated affected performance from a cognitive processing perspective.

Physiological measures were collected from all study participants, displaying higher overall readings for heart rate, skin conductance, and breaths per minute when comparing the scenario readings to baseline.

Based on subjective user feedback, participants found the MR scenarios engaging. Tasks provided during the scenarios were sufficient to maintain the interactive experience.

3. Conclusions

Initial trials with MRRS seem to indicate that it has many capabilities and great potential to extend the services offered in the rehabilitation field. Other scenarios for additional task training and varied levels of difficulty are being developed and testing is ongoing.

Study results concluded that a uniform standard for developing software is required as is a universal platform for delivering worlds. Given the amount of physiological data collected during each scenario, it would be ideal to integrate physiology into the MRRS such that the VR world and associated scenarios are dynamically controlled by the patient’s physiology. Clinically, we aim to improve the ability to objectify presence and immersion. Additionally, it would be ideal to individualize the virtual world for each patient.

There are some basic reasons to believe that MR applications may be effective for rehabilitation. First, MR, like VR, engages the user. It is unlike watching a video, in that the user must interact, and experience, the world first hand. MR users report direct engagement with the experience. MR also creates a safe environment [1] where users may explore without feeling as though they are threatened. In addition, the computer is infinitely patient, unlike a “human trainer”. The patient may feel less fear in “pushing the envelope” in this setting, since mistakes are not dangerous, humiliating, or “real”.

In both cognitive and physical rehabilitation, an advantage over the real world includes the fact that the MR can be manipulated in ways extending beyond the real world. This allows for overlearning to occur and for abstract concepts and rules to be conveyed without the need for language. This is important when supporting the skill development of those with intellectual difficulties [2].

MR offers a significant opportunity to test new treatment paradigms for a wide variety of physical and cognitive rehabilitation tasks.

References

