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Review of Virtual Reality Treatment for Mental Health

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Abstract

This paper describes recent research that proposes virtual reality techniques as a therapy for patients with cognitive and psychological problems. Specifically this applies to victims of conditions such as traumatic brain injury, alzheimers and parkinsons. Additionally virtual reality therapy offers an alternative to current desensitization techniques for the treatment of phobias Some important issues are examined including means of user interaction, skills transfer to the real world, and side-effects of virtual reality exposure.

Keywords:

virtual reality, mental health,, cognitive rehabilitation , daily living skills, phobias, desensitization.

Introduction

Recent publications describe the potential virtual reality (VR) technology may provide for treating patients with cognitive or psychological impairments[1,2,3]. Conditions such as stroke, traumatic brain injury (TBI), parkinsons and various psychological problems such as phobias may benefit from VR-based therapy. VR offers the opportunity to create environments where all stimuli and content are controlled and can be defined as an interactive computer-generated simulation of the real world. Software displays the environment using 3D graphics and added realism is obtained using head-mounted-displays (HMDs), special force-feedback gloves and 3D sound. The term virtual environment (VE) is often used instead of VR since, in even the most expensive systems, the reality falls far short of the real world. For a comprehensive description of VR systems there are several texts available[4,5]. This paper describes VR research applied to mental health and includes, very broadly, cognitive and psychological problems.

Cognitive & Motor Deficits

Many traditional methods of assessment for the cognitively impaired include simple motor tasks or pencil and paper psychometric tests such as the Vandenberg Mental Rotations Test. One standard test, the Mini Mental State Exam, is a series of questions that measure such as orientation, attention, memory, verbal fluency and judgement. In cases of visual neglect, the patient may be asked to indicate the centre of a straight line or to mark all cases of a specific symbol on a sheet of paper. There is already software available for the testing and rehabilitation of cognitive function, such as memory, attention and problem solving (www.bungalowsoftware.com). This software uses simple graphics/text and may take the form of a word game or traffic sign recognition. Motor function can be tested to an extent using simple programs which prompt the user to press various keys as quickly as possible. A common criticism of the current tests is that the patient is not being examined in a real world task. A study by Andrews et al. supports the lack of ecological validity in current assessment tests[6]. A more relevant method of testing and assessing an individual would be to monitor their performance in a daily living task such as boiling water using a kettle. This can of course be performed in the real world but using a VE there are several advantages including; total control and consistency of stimulus delivery, the capability to record performance data, the ability to add gaming factors such as a "high score" to increase motivation, the capacity to easily alter the "level of difficulty" depending on performance and a safer learning environment which reduces risks caused by errors[7].

Examples in the use of VEs for those with cognitive problems include a driving simulation[8] and a virtual kitchen[9]. VEs to help patients with aphasia, a speech disorder caused by TBI, have been suggested[10]. One study indicated that VR used in conjunction with physical exercise may improve the cognitive rehabilitation of patients with TBI[11]. Also systems to test and assess spatial skills have been developed[12]. In this case the user wears a VR glove and interacts with a virtual peg-in-the-hole simulation. All movements by the user are recorded allowing playback later. Myers, intriguingly, suggests a VR HMD application for the treatment of a patient with left unilateral neglect syndrome [13]. A lesion on the right parietal lobe causes the patient to ignore the world on their left side. Constant cueing, by a therapist, for the patient to focus on the world on the left side is the traditional treatment for this condition. Using an HMD, however, the image on the right side could be blacked out leaving only

the left view. By default the patient would have to focus on the left world view.

Psychology

Phobias

De-sensitization techniques are the traditional therapy for phobic individuals. This involves a graded exposure of the patient to the feared stimuli and involves either in-vivo (real world) exposure or the use of the patient's imagination. Problems with this approach include the fact that some patients are unable to face even mild exposure to the real world fear and, in the case of imagination techniques, many have difficulty visualising the said feared object or situation. Virtual reality therapy, or VRT, presents a solution to these problems. The patient can be exposed to a realistic environment and can exit the simulation at any time if the anxiety is too great. Additionally the patient can use VRT at home and can avoid the potential embarassment of talking to a therapist. Other advantages of computer based therapy include the recording of all performance data over a series of sessions, enabling playback, analysis and the creation of a complete record of the patient's progress. With phobias such as fear of flying, there are also obvious advantages of cost savings and greater convenience.

As an example, one study involved a forty-two year old woman who had avoided flying for two years and who was sufficiently motivated to seek therapy[14]. Initially the patient was subjected to standard anxiety management techniques such as breathing exercises and thought-stopping. Self report questionnaires indicated the patient's anxiety had decreased. The patient was then subjected to an immersive VRT simulation of an aeroplane flight. Stormy and calm weather was simulated and real life recordings of aeroplane engines, takeoffs and landings were provided. The patient was in total control of the simulation and could progress to the next stage when ready. The first stage was simply sitting in the plane, the next stage turning on the engines, then taxiing and so on. After several forty minute sessions the patient's self-reported anxiety decreased further. Many researchers have experimented with VRT on a number of phobias such as public speaking[15], spider phobia[16] and acrophobia[17] all with promising results.

Relaxation, Pain Relief

A fundamental task of a psychologist is to induce a state of relaxation in the patient. One study investigated the effects of exposure to VEs and stress levels[18]. A flight simulation over mountains using projection VR was exposed to adults, who reported lower levels of stress and anxiety. Similarly VR techniques are being used to creating relaxing, pain distracting environments for cancer patients[19]. A study examining the effects of VEs on 9 seriously ill, hospitalized children reported a lessening of pain intensity and anxiety[20]. Some other examples include dental patients being exposed to immersive VEs when undergoing dental surgery and, similarly, burns patients being distracted from often tortuous treatment.

Motivation

Stroke victims or indeed anyone who has been hospitalized or seriously injured require at some stage to undergo physical therapy. In many cases, however, the patient has difficulties becoming motivated to do physical exercise which is often repetitive and tiring. In order to motivate a spinal cord injury victim to walk an immersive VR system, in conjunction with a gait inducing orthopaedic device, was developed [21]. The VE, designed with commercial PC-based software, displays an Alpine mountainscape, showing paths, forests and mountains. Realism is improved using photographs and pre-recorded sound and voices. A twenty-six year old paraplegic patient has been used as a test case. Two fifteen minute trials were performed in which the patient walked along paths to the top of a snow covered mountain. The patient reported almost no side-effects to immersion and questionnaire results indicated improved levels of self-confidence, improved mood and higher levels of optimism, motivation and relaxation.

Imagination

Vincelli and Molinari examine imaginative psychological techniques and how VEs can improve this kind of therapy [22]. Imagination and memory, which occupy central roles in psychotherapy, present fundamental limits to individual potential. They believe VEs potentially enable these limits to be exceeded.

The MythSeeker software makes imaginative use of visual imagery to help physiotherapists in treatment and diagnosis of patients with psychological conditions [23] . It is based on idea of personal methodologies and how these influence each person's relationships and view of the world. VEs, by their nature, are ideal for displaying abstract and imaginative environments. It is suggested that the software can help users identify their aspirations and a purpose to life. There are three phases in Mythseeker. In the assessment phase tests such as temperament analysis are performed. The facilitation phase suggests an appropriate VE and role-playing. The enaction phase is where the user interacts with the VE. Some of the elements of the VEs include mythic agents which are the VEs beings, and enactments which are the role-playings by the user. Possible applications include psychological assessment, drug rehabilitation, hospice care and education.

Similar techniques were applied to heterosexual males who had either been impotent for 6 months or were affected by primary premature ejaculation were the subject of research involving VEs[24]. These displayed pathways through a forest each leading to experiences of childhood and adolescence, just when interest in the opposite sex was beginning. Seventy-three percent of the patients recorded improvement in their sexual dysfunction and this was maintained throughout a six month period.

Immersion and Sense of Presence

When VEs are being considered for the treatment of phobic individuals it is important that the user can suspend belief and experience the fears and anxieties associated with the

real world situation. An HMD increases realism by immersing the patient in the VE and excluding the real world view. A study investigating the effects of immersion on physiological responses was carried out by Wiederhold et al. The heart rate, respiration rate, skin temperature and skin resistance levels of subjects were measured when a small group comprising phobics and non-phobics were exposed to a VE [25]. The VE consisted of an aeroplane flight in good weather and which also consisted of both landing and take-off scenarios. The tests were applied in both immersion and non-immersion scenarios and the results indicated that the sense of presence was dependent on immersion with the phobic individuals experiencing higher stress levels when wearing the HMD.

Recent study has examined how sense of presence within a VE affects the user's perception. A study by Regenbrecht showed that, with fear of heights at least, a greater sense of presence increased the degree of fear[26]. Research into perceived presence within VEs has indicated that field of view, sound and headtracking had almost three times as much influence as visual display resolution, texture mapping, stereopsis and scene update rate[27]. Another factor that may increase presence in a VE is the amount of body movement. Body motion such as head yaw and bending down/standing increased the sense of presence reported by the participants in an immersive VE[28].

VEs : Important Considerations

There are several considerations to take into account before VR applications, as described above, are developed. We describe 3 factors here; input devices, side-effects and skills transfer. Additionally the cost of a solution weighted against its potential benefit should be examined. In many cases low-cost solutions comprising 3D software and a PC may be sufficient as already demonstrated by several researchers[3,29]. For a comprehensive discussion on these and related issues see Rizzo et al.[30].

Input Devices

Although it is possible to argue that in some, mainly therapeutic applications of VR, user-interaction is not required, in the majority of cases interaction is not only necessary but desirable. One study suggests that actively participating in a VE as against simply watching an active participant's progress results in a better memory of the VE. A study showed that those navigating a VE using a joystick later recalled the spatial layout better than passive participants who simply watched[31]. This has implications for the rehabilitation of brain injured patients who are trying to relearn daily living skills.

From our own experience many sufferers of stroke or TBI are often able to use a computer mouse satisfactorily although clearly this depends on the severity of impairment. For more severe cases personal augmentative devices (PADs) can be used. These are devices which address the specific disability of the patient and enable communication with the outside world. Examples include a headclicker for a young quadraplegic girl (www.pulsar.org/brooke/index.html) and a sponge/hand input device (wwwpulsar.org/IdeaLab/dan/April.html). Several commercial PADs are available. Headmaster Plus (www.pentrom.com) is a system that enables mouse control using head motion. Blowing on a tube simulates mouse-clicks. A similar device, Jouse, is a mouth controlled joystick. Eye trackers (or gaze trackers) monitor the position of the pupil and this enables the position of a mouse to be controlled. The patient simply "looks" at the required position although considerable practice is required. Recently President Clinton used the EyeGaze system (www.eyegaze.com) and managed to "type" a simple message. This system consists of a special video camera and image processing software which determines the position the user is looking at on the screen. It is possible for the user to type, operate a telephone, operate a computer mouse, and access the Internet. Indeed some severely disabled people have even managed to write books (www.eyegaze.com/doc/book.htm). Currently these devices are being used to enable the disabled interact with computers but there may be other applications in the area of psychological assessment. If a user is immersed in a VE, then by noting the eye position, the length of time the eye is at each position and matching this information with the specific part the VE being watched, important information can be derived[32]. Pupil size can also be measured and this gives an indication of mental load.

When objects are to be manipulated within the VE not surprisingly VR gloves are the best solution.. A group of students were selected to grasp, pitch, roll and position a virtual dice using both a virtual glove and a 3D mouse[33]. A stereoscopic display is required to provide the necessary depth cues.

SideEffects

Aftereffects of exposure to VEs currently pose a serious problem when their use is being considered for use by people with cognitive defects. When symptoms such as coordination difficulties, motion sickness and visual disturbances are reported then there is a danger that the therapy can cause more harm than good. Immersive applications offer a greater probability of side-effects, the main reason being latency with the position tracking and display systems, causing conflict within the vestibular system. This is borne out in a study that compared the nausea inducing effects of navigation in an immersive VE using 2 different methods of navigation[34]. Both used a joystick to move backwards and forwards but one used an orientation tracked HMD for turning and the other used a joystick. Both systems caused degrees of nausea but the head tracked system caused greater discomfort Immersive systems also often cause physical problems such as head/neck pain and shoulder discomfort[35]. These symptoms are caused by the weight of the HMD and the surprisingly strenuous effort required to use a VR glove for anything other than short periods. For a comprehensive review on aftereffects and their causessee Stanney and Salvendy[36].

Transfer of Skills

There is considerable evidence to support transfer of knowledge from the virtual world to the real world for healthy individuals[37]. Flight simulators, used by airlines to train pilots, are an obvious example. A recent high profile case was the use of VR to train astronauts to repair the Hubble space telescope[38]. An increasing number of studies confirm this skills transfer applies to people with some form of impairment. An amnesia patient improved her memory of routes in a hospital[39] and children with mobility impairments appear capable of learning the layout of buildings after spending time navigating VEs[40]. Inman et al. used VEs to train disabled children how to use a wheelchair[41]. They found that children who used the VEs could handle a real wheelchair better.

Conclusion

This paper gives a brief overview of the considerable number of applications for VR technology in the area of cognitive and psychological health. In some cases, notably in the treatment of phobias, case-study subjects have reported marked improvements in their condition. However VR research for many medical conditions is still at an early development stage and validation using well-controlled case studies with an ample number of subjects is necessary. Side-effects of VE exposure pose an immediate obstacle to commercialisation. Most research into side-effects of VR usage concentrates on healthy individuals and it is therefore of great importance that further studies are carried out on those with cognitive problems. Huang mentions the importance of the creation of a set of standards for VEs applied to mental health[42]. Despite the technology limitations, which will surely be overcome in the future, VR technology offers great potential as a next generation health care tool.

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