Virtual Reality Applications in Neuropsychiatric Disorders

Essay

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By
Hassan Samir Sayed Morsi
M.B., B.Ch.

Prof. Mohammad Osama Abdulghani

Professor of Neuropsychiatry
Faculty of Medicine - Ain Shams University

Prof. Nagia Aly Fahmy

Professor of Neuropsychiatry
Faculty of Medicine - Ain Shams University

Dr. Haytham Mohammad Hamdi

Lecturer of Neuropsychiatry
Faculty of Medicine - Ain Shams University

Faculty of Medicine
Ain Shams University
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Hassan Samir Sayed Morsi

Contents

List of Abbreviations

3D	:	3Dimensional
ABI	:	Acquired Brain Injury
AR	:	Augmented Reality
ADHD	:	Attention Deficit Hyperactivity Disorder
ADL	:	Activates of Daily Living
AN	:	Anorexia Nervosa
ANOVA	:	Analysis of Variance
AUD	:	Alcohol Use Disorders
BBS	:	Berg Balance Scale
BRU	:	Balance Rehabilitation Unit
CAPS	:	Clinician Administered Posttraumatic Scale
CAVE	:	Cave Automatic Virtual Environment
CBT	:	Cognitive Behavioral Therapy
CG	:	Control Group
CIMT	:	Constraint Induced Movement Therapy
COP	:	Center Of Pressure
CRT	:	Cathode Ray Tubes
DASS	:	Depression Anxiety Stress Scales
ECT	:	Experiential Cognitive Therapy
ED	:	Eating Disorders
EDEQ	:	Eating Disorder Examination Questionnaire
EDI	:	Eating Disorder Inventory
EG	:	Experimental Group
ERC	:	External Rhythmical Cues
FMRI	:	Functional Magnetic Resonance Imaging
GAD	:	Generalized Anxiety Disorders
HMD	:	Head Mounted Devices
HPO	:	Hyperbaric Oxygenation
MIT	:	Massachusetts Institute of Technology
MTBI	:	Mild Traumatic Brain Injury
NWFP	:	Nintendo Wii Fit Plus
OCD	:	Obsessive-Compulsive Disorder
OD	:	Olfactory Displays

List of Abbreviations

PANSS	:	Positive and Negative Syndrome Scales
PD	:	Parkinson's Disease
PTSD	:	Posttraumatic Stress Disorders
PTSD	:	Post Traumatic Stress Disorder
RGS	:	Rehabilitation Gaming System
SBMO	:	Sensory Based Machine Olfaction
SIT	:	Stress Inoculation Training
SNRI	:	Serotonin Norepinephrine Reuptake Inhibitor
SPECT	:	Single Positive Emission Computerized Tomography
SSRI	:	Selective Serotonin Reuptake Inhibitor
SST	:	Social Skills Training
SSTTR	:	Social Skills Training using Traditional Role play
SSTVR	:	Social Skills Training Using Virtual Reality
TAU	:	Treatment as Usual
TDCS	:	Transcranial direct current stimulation
TMS	:	Transcranial magnetic stimulation
TUG	:	Timed Up & Go
UE	:	Upper Extremity
UVL	:	Unilateral Vestibular Loss
VE	:	Virtual Environment
VOCS	:	Volatile Organic Compounds
VR	:	Virtual Reality
VRAMMA	:	Virtual Reality Apartment Medication Management Assessment
VRAT	:	Virtual Reality Assisted Therapy
VRET	:	Virtual Reality Exposure Therapy
VRGET	:	Virtual Reality Graded Exposure Therapy
VRMB	:	Virtual Reality and Mobile Group
VRMT	:	Virtual Reality Memory Training
WL	:	Waiting List

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Introduction

Virtual reality (VR) is a technology which allows a user to interact with a computer simulated environment, whether that environment is a simulation of the real world or an imaginary world. In medicine, it may be defined broadly as a bidirectional interface between the patient and the computer. By extension of this concept, the computer can be used to recognize patterns of patient behavior in space and react to such behavior **(Steffin, 2008).**

In 1966, Eliza was unveiled as a virtual therapist with which a computer user and a computer could engage in a non-directive "psychotherapy session" in a text-based conversation. Although it was never used as an actual treatment tool, a seed was planted; computers and computer simulation could become important tools in the treatment and diagnosis of mental illness (**Groves and Gorrindo, 2009).**

Standard paradigms of VR interaction present a computer-generated environment for the patient with measurement of patient response, usually followed by stereotyped changes in the computer-generated presentation. The patient's behavior is thus molded to the computer's conception of reality, but in many medical applications, the reverse philosophy must be adopted.The computer must sense the environment generated by the patient and then react intelligently to the patient **(Steffin, 2008).**

The principle benefits of the VR in a therapy setting are: A 3 dimensional (3D) virtual environment (VE) can "immerse" the patients to the degree that they will demonstrate appropriate limb & postural corrections in response to VE perturbations. This illusion coupled with the patient's ability to directly manipulate the VE display will produce a considerably stronger learning environment than conventional therapy

approaches. The ability of the patient to explore, interact and make errors in the VE will provide a facility for motor relearning unparalleled outside of a VE setting. The novelty and intrinsic appeal of such an interaction will also provide a powerful motivation factor for rehabilitative exercise **(Wann, 1996).**

Using VE, it is possible to provide patients with "ecologically like" situations that could enhance even more efficient goal oriented planning behaviors in rehabilitative tasks performances. Moreover, the immersive experience in VR induces patients in forgetting they are involved in evaluative or training session, supporting a more spontaneous performance. This aspect turns VR based treatment an effective user centered training approach, even more because patients may have a detailed monitoring of rehabilitative progresses they are reaching. According to these advances it is possible to obtain a congruous therapy modification. VR training settings made patients able in acting within a safety environment firstly avoiding anxiety linked to particular performances, thus enhancing confidence in action execution and finally increasing motivation improving autonomy within everyday like situation. Moreover acting in a sheltered scenario made patients aware of limitations the pathology cause them and of risk he/she could run up against with and imprudent conduct, such as crossing the street or moving around within the kitchen **(Morganti et al., 2003).**

Parkinson's disease has provided an initial focus for the use of VE augmentation. Using a VR technique called augmented reality, projected virtual objects on to the patients' physical world give them the impression that they were walking over or through them, thereby restoring their mobility. Dyskinesia, too, was found to respond to augmented reality, suggesting a more complex mechanism underlying kinesia paradoxa **(Weghorst et al., 1995).**

A computer-generated VE represents a reproducible tool to assess selected cognitive functions and can be used as a supplement to traditional rehabilitation assessment in persons with acquired brain injury **(Zahng et al., 2001).**

VR augmented rehabilitation for patients following stroke has the capability of creating an interactive, motivating environment where intensity of practice and feedback can be manipulated to create individualized treatment session **(Merians et al., 2002).**

VR technology will radically alter concepts of biofeedback, physical therapy, and desensitization therapy in pain management and psychiatry **(Steffin, 2008)**.

VR has many uses of for the treatment of mental illness, specifically exposure-based therapy, support groups, social skills training, patient education, personal health coaching, and assessment of functionality **(Groves and Gorrindo, 2009)**.

Autism and attention disorders involve abnormal stimulus response to the external world. VR offers the potential to regulate an artificial computer environment to better match the expectations and needs of individuals with these problems. Numerous studies going on around the world indicate that this regulating effect may be of value in helping these individuals learn to better react to their real world **(Strickland, 1997).**

In treating post traumatic stress disorders people, they re-experience the traumatic event in the safe environment of VR. VR makes it possible for a virtual therapist to accompany the patient while revisiting a traumatic scene. In this virtual scene, subjects have a walk-through while the virtual therapist goes with them and assures them that it is a safe place. The virtual scene with minimal cues may evoke the original traumatic memory and allow the patient to become

desensitized. By repeating the virtual experience the fear would be gradually reduced **(North et al., 1998).**

There are Promising first steps towards using VR as an assessment and treatment for patients with obsessive compulsive disorder (OCD). Moreover, a number of researchers have utilized a variety of computer-based assessments and treatment tools for OCD patients, and demonstrated reliable results using those computerized methods **(Kwangju et al., 2009).**

Demonstration of cue reactivity to VR cues represents an advance in drug addiction research by providing a standardized method to investigate addictive drug use behaviors. In addition, VR cue reactivity provides a viable method for evaluation of putative anticraving and cessation agents in addicted persons. Expanding current research using VR is clearly warranted based upon these findings. Further, success in this study leads directly to generation of hypotheses about other substance abusing populations (e.g., cocaine, alcohol).Also it defines standardized specific complex cue situations and environments (e.g., social gatherings, bars, crack house) that might be useful in research and treatment **(Bordnicka et al., 2004).**

VR is an acceptable experimental technique for use with individuals with at-risk mental states**.** Paranoia in VR was understandable in terms of the cognitive model of persecutory delusions **(Valmaggia et al., 2007**).

The ability to study multimodal performance simultaneously by using virtual reality technology opens new possibilities for the diagnosis of schizophrenia with objective procedures, not only will distinguish schizophrenic patients from healthy subjects but also will reveal subdivisions within

the patient population that will result in better diagnostics and treatment **(Sorkin et al., 2006).**

Using VR techniques raises ethical considerations, especially when mentally challenged or very young people are involved. In addition, virtual reality could have undesirable side effects due to equipment failure, fatigue, or motion sickness. It could also cause unintended changes in the patient's attitude and behavior, worsen existing difficulty in distinguishing between reality and delusion (for example in patients with schizophrenia), or cause distress from the virtual experiences themselves **(Regan and Price, 1994).**

Presently, VR represents a broad range of techniques that are rapidly evolving from the melding of diverse fields of computer graphics and haptics, coupled with the increasing availability of sufficiently powerful hardware platforms. VR applications to clinical neurology and psychiatry are in their infancy, but they will revolutionize many concepts in rehabilitation, neurophysiology, and neuropharmacology **(Steffin, 2008).**

The applications described above exemplify how VR can help even severely disabled people to participate and contribute safely even in hazardous and complex tasks. The new technology can provide corrective experiences that can ameliorate attitudes and anxieties. It could also yield new insights into disease mechanisms while providing ingenious and effective tools to re-enable handicapped people **(Andreae, 2008).**

Aim of the Work

To explore the potentials of VR as a new, promising method in the diagnosis and treatment of neuropsychiatric disorders.

An Overview of Virtual Reality Technology

The Concept of Virtual Reality

VR is a technology which allows a user to interact with a computer-simulated environment, whether that environment is a simulation of the real world or an imaginary world. In medicine, it may be defined broadly as a bidirectional interface between the patient and the computer. By extension of this concept, the computer can be used to recognize patterns of patient behavior in space and react to such behavior **(Steffin, 2008)**.

In this respect, VR may be seen as the sixth generation of human-computer interface. It goes by such cognate terminology as VE, artificial reality, synthetic environment, and cyberspace. Definitions vary as well **(Powell, 2007).**

Historical Background

VR is not a new concept. The origins of VR can be traced as far back at least as The Ultimate Displays a seminal paper that introduced the key concepts of immersion in a simulated world, and of complete sensory input and output, which are the basis of current VR research **(Sutherland, 1965).**

In the late 1960's and 1970's, research on a number of fronts formed the basis of VR as it appears today (e.g:head-mounted displays) **(Sutherland, 1965 ; Sutherland, 1968)** projection-based VR **(Krueger, 1977 ; Krueger, 1983).**

VEs have existed before that, as telerobotic and teleoperations simulations. The display technology, however, in these cases was usually panel-mounted rather than head-mounted **(Carr et al., 1996).**

In the mid-1980's, the different technologies that enabled the development of VR converged to create the first true VR systems. At Massachusetts Institute of Technology, at the beginning of the 1980's, a limited 3D virtual workspace in which the user interactively manipulates 3D graphical objects spatially corresponding to hand position was developed **(Schmandt, 1983).**

Although VR technology has been developing over this seemingly long period the possibilities inherent in the new medium have only recently crossed a cultural threshold **(Biocca, 1992).**

Types of Virtual Reality

Immersive VR provides an immediate, first-person experience. With some applications, there is a treadmill interface to simulate the experience of walking through virtual space, the user is placed inside the image, the generated image is assigned properties which make it look and act real **(McLellan, 1996).**

A variation of immersive VR is Augmented Reality where a see-through layer of computer graphics is superimposed over the real world to highlight certain features and enhance understanding **(Isdale, 2001).**

With this kind of system, also known as "desktop VR," the user sees the 3D world through the window of the computer screen and navigates through the space with a control device such as a mouse **(Fisher and Unwin, 2002).**

Cyberspace is a global artificial reality that can be visited simultaneously by many people via networked computers. Cyberspace is where you are when you're hooked up to a computer network or electronic database or talking on the telephone **(McLellan, 1996).**

Telereality or telepresence, is one where the user is virtually transported to a reality which exists somewhere else. Abstract reality is the creation of a VR which does not really exist otherwise. A simulated reality is one where the VE is a fabrication of an environment or scenario **(Haywood, 1996).**

The concept of cyberspace is linked to the notion of telepresence, the feeling of being in a location other than where you actually are. Related to this, teleoperation means that you can control a robot or another device at a distance **(McLellan, 1996)**.

In contrast to the first-person systems described above, Mirror Worlds (Projected Realities) provide a second-person experience in which the viewer stands outside the imaginary world, but communicates with characters or objects inside it. Mirror world systems use a video camera as an input device. Users see their images superimposed on or merged with a virtual world presented on a large video monitor or video projected image. Using a digitizer, the computer processes the users' images to extract features such as their positions, movements, or the number of fingers raised. These systems are usually less expensive than total immersion systems, and the users are unencumbered by head gear, wired gloves, or other interfaces **(Lantz, 1992)**.

A Chamber World is a small VR projection theater controlled by several computers that gives users the sense of freer movement within a virtual world than the immersive VR systems and thus a feeling of greater immersion. Images are projected on all of the walls that can be viewed in 3D with a head-mounted display showing a seamless VE **(McLellan, 1996)**.