Virtual Reality Technology Offers A Promising New Direction For Assessment and Intervention for Depressive Disorders

THE OVERVIEW

Virtual environments have been used for more than two decades in research laboratories and university clinics to facilitate cognitive behavioral therapy and other therapeutic approaches in behavioral medicine. There is an impressive body of research literature demonstrating the efficacy of virtual reality (VR)-based tools in behavioral therapy, but the use of VR in clinical care has yet to become commonplace. Until recently, the cost of VR technology has been a barrier for acceptance outside of the university environment. Now, the reduced costs of virtual environments have made them practical for everyday use. In addition, technological advances are enabling the creation of increasingly realistic virtual environments that can more effectively simulate real-life experiences. A new generation of VR-based behavioral therapy has evolved, based on low cost and portable display systems, the emergence of multi-user social virtual worlds, and aided by the application of evidence-based protocols.

With rapid decline in cost, and increased flexibility of software programs that provide the ability to create customized assessments and intervention tools, it is not surprising that VR technologies are gaining attention in the cognitive therapeutic realm..

In this paper we provide a brief overview of current virtual environment systems, and explore their utility in behavioral medicine. Specific examples are provided that highlight the use of virtual environments to treat post-traumatic stress disorder (PTSD), phobias and anxiety disorders, in studies of cue reactivity in substance abusers, and for other applications in clinical psychology and behavioral medicine.

MOOD DISORDER ASSESSMENT AND INTERVENTION

This paper provides an overview of the research literature on VR technologies developed for the purposes of mood assessment and intervention. We discuss the utility of using VR technology to improve assessments. We then review several examples of research studies that utilize the unique assets VR technologies to explore key aspects of depressive disorders. We discuss how VR technology can be used to:

- Increase positive affect
- Increase empathy
- Increase compassion toward self and others
- Increase attention to positive stimuli

BACKGROUND

Virtual Reality (VR) is the term used to describe computer-generated, multi-sensory worlds in which users navigate simulated three-dimensional (3-D) environments, interacting with objects and other individuals there. VR has been used for more than two decades in research laboratories and university clinics to facilitate recovery from injury and to treat psychiatric and behavioral problems, including phobias and post-traumatic stress syndrome (PTSD). Until recently, the cost of VR systems has been a barrier for acceptance outside of university environments. However, the current generation of low-cost, high-capability personal computers has made sophisticated technology accessible to the general public, and online virtual worlds and VR-based computer games currently attract large numbers of users. VR technology made its first inroads to widespread use through the computer game industry and the military, where it is used in flight simulation and other training scenarios. Applications in medicine shortly followed, with VR seeing increasing use as a medical teaching tool, for planning and conducting surgical procedures (including remote surgery), and for interactive diagnostic imaging. In the realm of behavioral medicine, VR has now seen several years of

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successful use in the treatment of PTSD and phobias. Recent technical advances in the graphical power of personal computers have provided dramatically increased levels of immersion and "presence" in VR environments, opening up new possibilities for the use of VR in behavioral medicine. In the hands of trained clinicians, VR tools offer great potential for increasing treatment efficacy and reducing treatment time. Moreover, the use of VR in a telemedicine context enables the expansion of clinical reach to underserved populations.

THE VR PARADIGM IN BEHAVIORAL MEDICINE

In traditional behavioral therapy, patients and therapists typically meet face-to-face in an office once a week. Behavioral issues are explored through recall of past events, development of strategies for use in future situations, and skills practice in imagined scenarios or through role-playing. The patient is then left on their own until the following appointment to contemplate insights and themes and practice new strategies in the real world. Patient compliance is based largely on the patient's ability to self-motivate, and to find additional informal sources of emotional support for their behavioral change beyond what is offered inside the therapist's office. Frequently, the challenges that confront a patient in real life between office visits are often not the ones they or their therapists would have predicted, and may provoke entirely different emotional or behavioral responses than the patient had been prepared to manage. Finally, many individuals who could benefit from clinical help fail to seek it in the first place because of practical or psychological barriers, including financial constraints, difficulty of travel to see a therapist, or social stigma associated with engaging in therapy.

Internet-based behavioral therapy programs can overcome many of the limitations of traditional therapy. The Internet is available 24/7, and anywhere the patient can access a computer, pad, or smart phone. Patients who are reluctant to engage in face-to-face therapy may be willing to seek it in a more anonymous, impersonal setting. Internet-based programs may be particularly attractive to and engaging for younger individuals, who increasingly use the Internet not only as their primary educational resource but also their preferred milieu for social interactions. Through messaging and chat room features, Internet-based programs can provide large networks of peer support and additional social motivation for behavioral change.

The use of VR training and coaching tools in conjunction with Internet-based behavioral therapy programs holds special promise for increasing patient compliance and therapeutic effectiveness (Ershow, Peterson, Riley, Rizzo, & Wansink, 2011). VR technology enables the creation of controllable, interactive scenarios in which the patient, represented as an avatar, can respond to specific behavioral challenges similar to those they would encounter in the real world. They can also interact with their therapists and other individuals represented as avatars. VR-mediated behavioral therapy offers many potential advantages over traditional therapy:

- VR can be used to generate behavioral training exercises targeted to the specific needs of individual patients, using scenarios relevant to the patient's real-life daily activities and behavioral triggers.
- VR training scenarios and exercises can be tailored to fit the patient's skill level, and rapidly modified to generate more or less challenging tasks.
- Clinicians can participate in patient training sessions to provide instructions, encouragement and/or intervention.
- The heightened sense of experience and game-like features of VR training help motivate patients and engage them more fully in the treatment process.
- Patients can be taught skills and practice them in real time while being exposed to realistic cues, an approach that is believed to improve generalization of therapeutic gains into the real world (Bordnick, Carter, & Traylor, 2011).
- The use of avatars also appears to promote the transfer of healthy behaviors from the virtual world to the real world. For example, VR users have been found to increase their physical activity after their avatar does (Yee & Bailenson, 2007).

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- In virtual environments, every element in a scenario can be tightly controlled, enabling near-perfect replication of environments between participants, studies, laboratories, and time points.
- VR training sessions can be recorded and replayed for review and quantitative analysis.

TYPES OF VIRTUAL ENVIRONMENTS

VR can be immersive or non-immersive. In immersive VR, the user is equipped with head-mounted displays and body-tracking sensors so that the simulated environment changes in a natural way with the user's head and body movements. The user becomes part of the virtual environment through his or her body. In non-immersive VR, the simulated environment is presented on a flatscreen monitor, and the user interacts with the environment through a computer keyboard, mouse, or joystick.

Immersive VR System with Head Mounted Display

Non-immersive VR is compatible with most traditional computer displays and interface devices, and is by far the more commonly used form. Users operate within VR environments as "avatars," 3-D graphical representations of themselves that can navigate, gesture, and assume different postures and facial expressions based on user commands. (Non-immersive VR is also the form more likely to be familiar to readers of this article, as it is the one used in most VR-based computer games.) Current generations of computer-based VR typically make use of two modalities (visual and audio), but olfactory and haptic modalities have been included in some VR environments developed for research studies and are likely to see increasing use in the future.

Virtual Exposure Therapy for Combat PTSD

Behavioral medicine has also benefited from the evolution of networked synthetic environments. Using shared virtual spaces and multi-user internet worlds, clinicians can accompany patients into virtual training sessions, monitor sessions, and provide guidance and support. Shared virtual spaces also make possible for groups of users to practice together in virtual scenarios, and to participate in virtual support group meetings.

INITIAL USE OF VIRTUAL REALITY IN BEHAVIORAL MEDICINE

VR was initially pioneered in the treatment of trauma, and more specifically in exposure therapy for the treatment of phobias and PTSD. VR is particularly amenable for use in exposure therapy, which involves repeatedly presenting a patient with emotion-provoking stimuli, toward the goal of desensitizing the patient's emotional response (e.g., anxiety) to those stimuli. In traditional exposure therapy, the patient is typically asked to imagine emotion-triggering stimuli or situations. With VR, stimulus exposure can be provided in the form of complex, interactive scenarios and social situations that closely resemble those of the real world. VR-based exposure therapy does not require the patient to imagine scenarios while experiencing them, and offers a safer, more cost-effective alternative in cases where real-life exposure to the stimulus would be expensive (e.g., flight phobia), potentially dangerous (e.g., driving phobia), or impossible (e.g., PTSD in victims of terrorist attacks). In addition, the therapist can titrate the intensity of the stimulus to produce an optimal level of emotional response – i.e., a level that will produce desensitization without overwhelming the patient.

VR exposure therapy has now been used successfully to treat specific phobias, including fear of flying (Rothbaum,

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Hodges, Smith, Lee, & Price, 2000), fear of public speaking (Anderson, Zimand, Hodges, & Rothbaum, 2005), claustrophobia (Botella, Villa, Banos, Perpina, & Garcia-Palacios, 1999), acrophobia (Coelho, Waters, Hine, & Wallis, 2009), and arachnophobia (Bouchard, Cotes, St-Jacques, Robillard, & Renaud, 2006). VR-based therapy has also proven effective in the treatment of PSTD in military personnel (McLay, McBrien, Wiederhold, & Wiederhold, 2010; McLay et al., 2011; Rizzo et al., 2008) and World Trade Center attack victims (Difede et al., 2007).

VR FOR IMPROVED ASSESSMENTS

The assets of VR technology now available are particularly well suited for addressing the unique challenges of accessing mood disorders. It would be difficult if not impossible for clinicians to observe and assess individuals with depressive disorders performing everyday tasks in a naturalistic environment. VR technology offers simulated environments that mimic real life, providing a means to create controllable, multisensory, interactive stimulus environments, within which human behavior can be motivated and measured, and one in which emotional regulation and other cognitive skills can be taught.

Use of VR technology for assessing cognitive function and mood, particularly for problems related to depressive disorders, is in early stages of development and testing. However, a growing base of research suggests VR assessment tools produce more ecologically valid, and sensitive measures of function than the standard pencil and paper approaches that have been used for decades, detecting deficits at earlier stages of development and providing a more ecologically correct assessment.

Virtual environments actively engage participants by encouraging them to be autonomously involved in a task, decreasing attention to the testing environment, and offering a realistic depiction of mood and behavior. As long as the VR scenario resembles the real world and is well designed, individuals are able to suspend disbelief and respond as though the virtual environment is real. This response facilitates early detection of functional deficits, enhancing the ability of clinicians to develop earlier stage, customized interventions, and potentially increase the success of cognitive intervention therapies. Thus, there appears to be growing body evidence that VR technologies can play a key role in modifying the trajectories of cognitive pathologies.

HOW VR CAN PROMOTE POSITIVE AFFECT

Several studies have shown that virtual reality can successfully alter the moods of those who are exposed to it. In a study that examined how affective components of a virtual reality experience can affect mood, Riva and colleagues (2007) found that participants whose virtual reality experience included a "relaxing park" scene saw an increase in quietness and happiness, and a reduction in negative affect such as anger and sadness. While further work must be done to understand whether these results are applicable to individuals who have mood disorders (i.e., depression), the study provides promising evidence that virtual reality may be a valuable tool for increasing positive affect.

There are several explanations for why virtual reality can successfully induce positive emotions. A study conducted by Villani, Lucchetta, Preziosa, & Riva (2009) found that there is a positive correlation between engagement and positive affect. This suggests that meditative activities that hold an individual's attention have the potential to alter one's mood. These results were supported by Gorini and colleagues' work, which found that virtual reality significantly reduced arousal in all of the study's participants, suggesting that VR can trigger a state of relaxation (Gorini et al., 2009). Villani et al.'s study went on to explore how virtual reality can facilitate this process: in the end, the authors determined that media form and media content have a moderating role in the connection between engagement and positive affect. Specifically, the results indicate that media form (i.e., the way that the media was displayed, such as through photos or animated graphics) has a critical part in inducing positive affect, while media content (i.e., the theme or narrative portrayed by the media) has a critical part in influencing an individual's affect (Villani et al., 2009; Banos et al., 2008). This suggests that an intentional selection of both media form and content can benefit individuals with

chronic negative affect (Banos et al., 2006; Mar, Botella, & Alca, 2006; Liebert, 2001).

HOW VR CAN PROMOTE EMPATHY

Empathy is an adaptive prosocial behavior that allows us to form connections with other people; as social connections have a vital role in our psychological wellbeing, it is important to address issues with our empathetic capabilities (Eisenberg & Miller, 1987). Mood disorders, such as depression, and intellectual disabilities, such as autism, can negatively impact empathy.

Recent studies have shown that virtual reality can help individuals build empathetic connections. A longitudinal study conducted by Cheng, Chiang, & Cheng (2010) examined whether viewing animated empathetic scenarios could increase empathy in autistic individuals. The study found that the system had a positive significant effect on the empathy levels of participants, and that these results were stable in post-manipulation follow-ups.

Equally promising results were found in Hasler and colleagues study (2014), which investigated how interacting with a virtual human can affect empathy. The study asked a group of Jewish participants to interact with a virtual Palestinian, a group that they have historically had conflict with. The results were surprising: in the end, even participants who had explicitly reported negative feelings towards Palestinians before the interaction reported increased feelings of sympathy towards the group after the interaction (Hasler et al., 2014).

There are several theories about why virtual reality can successfully increase empathy levels. Some researchers suggest that the same theoretical frameworks utilized by those who study aggression in video games can be applied here: that is, in the same way that video games are thought to encourage violence by modeling aggression, virtual reality may be able to increase empathy by modeling prosocial behaviors (Gillath et al., 2008).

Another theory for success of virtual reality is the proximity theory. Proponents of this theory argue that people experience more empathetic emotions when the incidents they should empathize with happen to people they are close to or feel similar to. Thus, when a virtual reality experience can introduce characters that are realistic and similar to the perceivers, they can form bonds and learn empathy towards their virtual counterparts (Paiva et al., 2005; Rosenberg, Baughman, & Bailensen, 2013). These lessons can potentially be expanded outwards.

Although further research is needed to determine which theory comprehensively captures the processes that are occurring, these results are promising for clinicians who hope to increase empathy levels in individuals with deficits.

HOW VR CAN INCREASE COMPASSION TOWARDS SELF AND OTHERS

Mood and anxiety disorders have many insidious effects, including a reduction in the compassion that the afflicted feel towards themselves and others. Virtual reality can potentially be used as a way to reverse these effects.

Kalyanaraman and colleagues (2010) conducted an experiment that explored whether taking the perspective of a person with schizophrenia through a virtual reality experience could increase compassion and perceptions towards individuals with mental illnesses. The study found that cognitively embodying the perspective of a person with schizophrenia reduced negative perceptions towards the group in a way that simply reading about schizophrenia could not. This indicates that a virtual reality experience can offer changes that more traditional techniques cannot achieve.

Galinksy & Moskowitz (2000) suggest that this occurs because perspective taking can lead to "…decreased stereo-

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typing and increased overlap between representations of the self and representations of the (stigmatized)…" (p. 1), indicating that taking the perspective of another person can cause an individual to make cognitive associations between the self and the other person. This encourages an individual to be more cognizant about their feelings toward the stigmatized group, thereby increasing their compassion and understanding.
For individual with a mood disorder, perhaps more alarming than a reduction in compassion towards others is the lack of compassion towards themselves (Neff, 2003). This often manifests in self-criticism and other negative self-directed behaviors. Fortunately, virtual reality has also empirically been shown to increase levels of self-compassion. Falconer and colleagues (2014, 2016) performed several studies that examined whether embodiment and mindfulness techniques can increase levels of self-compassion and reduce self-criticism in individuals with depression. Both studies found that participants did experience a significant reduction in depression severity and self-criticism and an increase in self-compassion; these results were robust, and continued at their increased rate at a four-week follow-up.

HOW VR CAN INCREASE ATTENTION TO POSITIVE STIMULI

In general, research has shown that people tend to devote more attention to negative information than positive information (Ito, Larsen, Smith & Cacippo, 1998). However, this proclivity can be even stronger for individuals with depression and other mood disorders because, as stated previously, emotions can affect perception; thus, negative affect can lead an individual to especially perceive more negative stimuli (Riva et al., 2007).

Although little work has been done to see how virtual reality can attenuate our bias towards negativity, existing research suggests that VR may be a potentially successful method. For example, in a study that investigated whether this bias is reduced by a person's affective context, the authors found that attention bias to negative information is attenuated or eliminated when positive constructs are made accessible (Smith et al., 2006). In other words, when individuals are primed with positive stimuli, the bias towards giving attention to negative stimuli is significantly reduced. While additional research is needed to provide empirical evidence, because research has shown that the affective components of virtual reality are not only perceived, but also effective at altering the mood states of individuals who experience the program, it is reasonable to hypothesize that "positive experience" virtual reality programs can attenuate the bias towards negative stimuli (Smith et al., 2006; Wegener & Petty, 1994).

Additional evidence for the success of virtual reality in reducing attention to negative stimuli comes from a study conducted by Pratto & John (1991). The experimenters used the Stroop task to assess the cognitive demands of positive and negative stimuli. The results showed that negative words had longer color-naming latencies than positive words, suggesting that negative words were automatically drawing more attention than positive words; this supports the idea that we have a bias towards negative stimuli. Although natural biases are difficult to overcome, we can posit that virtual reality may help participants reduce this bias. This reasoning comes about because while negative stimuli demands more attention than positive stimuli, when attention is already occupied by a virtual reality experience—an experience with positive images—one consequence might be that individuals will not have the cognitive resources to give attention to the negative stimuli, and they will pay attention to the less cognitively demanding positive stimuli instead.

Additional testing is clearly needed to provide support to these hypotheses, but the research that is currently available on virtual reality supports the theoretical framework from which the hypotheses were developed.

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