Using Virtual Reality to Regulate Affect for Patients with Substance Use Disorder

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CHAPTER I

Introduction

Drug overdose deaths are now the leading cause of injury death in the United States—approximately 72,000 people died last year from overdose deaths (CDC, 2017). An additional 23.5 million people need treatment for alcohol abuse or illicit drugs (NIDA). Of the 23.5 million people who have substance use disorders, only 2.6 million seek intervention and approximately 85% experience a relapse within 1 year (Sinha, 2011). Substance abuse disorders often develop in response to strong emotional processes and negative experiences - intoxication becomes a way to cope with negative affect. During early abstinence, patients often experience strong negative affect, distress, and anhedonia that lead to drug cravings (Sinha, 2001; Sinha, 2008; Enoch, 2011). Given the strong connection between negative affect and relapse, tools that promote affective regulation may help to reduce triggers, cravings and subsequently relapse. Additionally, these tools must be immediately accessible to break maladaptive cycles of self-regulation.

Technological interventions may be particularly helpful in immediately providing affective regulation. One such technology is virtual reality (VR), which may be a particularly efficacious tool in the treatment of substance use disorders. Immersive VR involves the use of a head-mounted display to immerse the user into a 360-degree 3D environment. This technology differs from 2-D displays in that it facilitates a greater sense of presence—the extent to which a person thinks, feels, and behaves as if the virtual environment is real (Slater, 1999).

Thus far, most VR clinical interventions are designed to elicit negative affective reactions. Exposure therapy in VR has comparable efficacy to in-vivo exposure for disorders including PTSD (Rizzo & Kim, 2005), phobias (Maples-Keller et al., 2017) and cue exposure for addiction (Bordnick et al., 2008). In these VR treatments, stimuli are generated (e.g., a war zone, spiders,

alcohol bottles, heroin needles) to generate negative affect and help the patient learn to reduce the fear response.

A less common clinical application of VR is to immerse patients in environments that increase positive affect. In the area of clinical psychology, positive virtual environments have been used to help train mindfulness skills (e.g., Navarro-Haro et al., 2017). However, the majority of positive virtual environments have been used to facilitate distraction for physical health issues like coping with pain (e.g., Morris et al., 2009; Hoffman et al., 2000) or coping with anxiety prior to medical procedures (e.g., Wolitzky et al., 2005). The mechanism of these interventions differ from that of the former ones, in that they immerse patients in an environment designed to soothe distress rather than generate activate negative affect.

Virtual reality (VR) may be a particularly effective technological medium for delivering a "just-in-time" intervention during potential moments of relapse. An alternative behavior (wearing a VR headset) could be an accessible alternative to using substances and, critically, it could be available on impulse, in effect replacing access to the drug of choice. It is a well-known principle in behavior therapy that it is easier to replace a problematic behavior with another that is less noxious in its effects but fills the same reinforcement space. This could address a barrier of cognitive interventions for substance abuse, which often focus on teaching patients cognitive strategies to handle physiological cravings. This approach can be challenging since cognitions can be overpowered by both physiology and impulsive behavior (Beck, 2011).

The current study resulted from an exploration of how virtual reality could be used to help patients cope in the process of detox at an inpatient drug rehabilitation facility. The first patient to experience VR was a female in her late 20s with severe opioid use disorder, PTSD, anxiety and depression who had been in detox for three days:

Prior to arriving at the treatment facility, M reported she was forced by her parents to do prostitution to get money for all of them to use heroin. She attempted suicide by jumping out of a moving car and was transferred to the rehabilitation facility shortly after a brief hospitalization.

M relayed this information in a biopsychosocial assessment administered by a therapist in training. After M completed the assessment, the therapist asked her if she would like to use VR before returning to the detox unit. M appeared to be aroused, anxious, and withdrawn. Despite this, M was curious and interested in the VR, so she consented to trying it. The moment M put on the headset, she was immersed in a cabin on a mountain (SteamVR Home). M broke into a smile and said, "Wow! I've never been hiking, but this is so beautiful! Look at the mountains and nature!" The therapist was surprised at M's immediate change in affect—she proceeded to engage with an automated robot in a tutorial, laughing as she inflated balloons and shot confetti from her controllers.

The therapist then showed M a series of recreational applications and asked M to let the therapist know when she would like to transition to the next application. After 30 minutes of playing games, M took off the headset and said "All of my anxiety is gone! I have no cravings either!" M thanked the therapist and went back to the detox unit, where she later noted she was more active and alert. M reported that the VR helped her to calm down, and that she felt different throughout the rest of the day after her brief experience.

After M's experience, more detox patients were asked if they would like to try virtual reality. As patients experienced VR, they reported similar reactions to M. After 20 to 30 minutes, patients emerged from virtual experiences and reported reductions in anxiety, depressive symptoms, racing thoughts, and other negative emotional states that often cause relapse. Patients reported that these effects lasted for a period of hours or days, much like the effects of an illicit substance, but that the changes in mood they experience from VR seemed more "authentic" :

"It made my day and had a big impact"

"It felt like a psychological reset"

"I no longer felt the need to lay around in bed"

"It felt like an emotional blanket"

"I was able to talk to my family and not cry—I could stay calmer"

"It consumed my attention and brought my mind away…I felt like I had a fresh start afterwards. It brought my anxiety down and I could talk to others."

These self-reported experiences led to an exploratory study to quantify changes in mood as a result of VR. Archival clinical data from recreational VR (exposure to engaging environments with no specific therapeutic content) at an in-patient drug rehabilitation center were used to explore the effects of VR on mood. We hypothesized that recreational VR could significantly increase positive affect and decrease negative affect. Exploratory interviews were conducted with a subset of 21 patients to better understand their experiences and develop testable hypotheses for future research.

CHAPTER II

Method & Results

Method

VR was offered to patients as a recreational activity at the rehabilitation center. They were exposed to 30-60 minute sessions of recreational VR, and completed a self-report questionnaire in order to quantify the observed affective changes reported by initial patients. Data were collected as part of routine clinical care at the rehabilitation center. The Vanderbilt Institutional Review Board approved the use of the data as an exercise in program evaluation.

Patients

Archival clinical data were analyzed from 241 patients (62% male, 38% female) at an in-patient drug rehabilitation center for co-occurring mental health disorders. Average age for patient was 32 years (SD = 11.78), with an average length of stay of 26 days (SD = 11.43). Patients were diagnosed upon a biopsychosocial interview during intake, and therefore the rates of certain diagnoses may not be accurate (e.g., rates of personality disorders). However, these rates can provide limited insight into possible comorbidities in these populations. A large majority of patients had at least one comorbid psychiatric disorder (73.97%), and 79.34% had polysubstance abuse. Alcohol was the most common substance of abuse (63.64%), followed by opioids (53.31%), marijuana (47.52%), amphetamines, cocaine or unspecified stimulants (41.32%), benzodiazepines (33.06%), and hallucinogens (3.72%). Mood disorders were the most prevalent psychological diagnosis (79.75%), followed by anxiety disorders (64.46%), history of trauma (37.6%), and personality disorders (6.2%).

Procedure

Patients could elect to try virtual reality for 30-60 minute sessions, with the approval of each patient's therapist. Recreational activities are a core part of inpatient drug rehabilitation facilities, often including activities such as: ropes courses, outdoor sports, horseback riding, yoga, and other activities. Virtual reality was offered as one such elective activity, and mood data was collected as part of routine clinical care.

Interviews

Patients were interviewed to evaluate the programmatic implementation of recreational VR at the rehabilitation center. A volunteer at the rehabilitation center asked patients eight open-ended questions and used follow-ups as needed (Appendix A). After interviews were recorded and transcribed, quotes were identified to provide insight into the experiences of patients.

Measures

The Positive and Negative Affect Schedule (PANAS, Watson et al., 1988) is a five point Likert scale that is comprised of two subscales each consisting of 10 emotions: positive affect (*active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud,* and *strong*) and negative affect (*afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset* and *distressed*). The PANAS was used to track mood before and after each VR session. De-identified data were used to analyze each patient's first VR session. A subset of the patients (n = 21) was asked about their experiences to better understand how the VR affected their mood A subset of patients was interviewed to better understand how the VR affected their mood.

Virtual Reality

The HTC Vive is a head-mounted display virtual reality device that is tethered to a VR-enabled PC. It provides six degrees of freedom via two sensors mounted on opposite sides of the

room. The “play area,” or space in which participants could physically walk, was approximately 10’x7’. The HTC Vive includes two hand controllers that allow participants to interact with the environment. Each controller has several buttons, including a trackpad (often used for movement), trigger, grip buttons, menu button, and system button.

Environments

Virtual applications can be launched on the HTC Vive through an app store called Steam, which has a variety of games and other experiences available for download. A selected set of applications was used during 30-60-minute VR sessions. The applications were presented in the same order for each participant’s first session. Participants were asked to indicate when they would like to move on to the next application—some chose to stay on one application for the entire duration of the session. The applications used included: **SteamVR tutorial** was used to teach participants how to operate the virtual reality equipment. Participants began in a kitchen that collapses into the ground to reveal a giant warehouse. A friendly robot guides participants through each button as patients shoot lasers, pop confetti, and inflate balloons. **Audioshield** is a music rhythm game that involves blocking beats to any song that could be found on YouTube. Patients were able to choose their own music and several noted this was one of the only times they could listen to their own type of music during treatment. **Tiltbrush** allows users to paint in a customizable 3-D space with a variety of brushes, some of which are animated. One controller becomes a paintbrush while the other allows for brush selection. **Space Pirate Trainer** is an arcade shooting game that involves shooting successive waves of robots, using one controller as a gun and the other as a shield. **Superhot** is a fighting game in which time is frozen; as the user moves in 3-D space, time progresses. The game becomes a puzzle involving planned motor movements to evade and fight enemies. **Cyberpong** is a virtual paddleboard game during which each controller is a paddle that is used to hit a ball towards bricks (brick-breaker). **Holopoint** is an archery game that requires users to shoot arrows and dodge projectiles that are fired back.

Data Analysis

Paired-sample t-tests were conducted to compare change in affect from pre- to post-VR for both positive and negative affect and each of their respective subscales. Effect sizes were calculated by dividing the mean differences between pre- and post by the standard deviation.

Results

PANAS Data

There was a significant increase in positive affect from PRE (M=3.28, SD=0.90) to POST (M=3.94, SD=.85,); t(238)=17.53, p <.001, d = .74, and a somewhat smaller decrease in negative affect from PRE (M=1.85 , SD=.80) to POST (M=1.37, SD=.56); t(238)=-13.43 , p < .001, d = .60 (Figure 1). In addition, all positive emotions increased and all negative emotions (with the exception of hostility) decreased. Effect sizes are reported in Table 1 and mean changes shown in Figure 2. Table 1. Associations among the SEE Scale and Key Variables in Experiment 1

Table 1. Change in PANAS Self-Reported Affect as a Result of VR

Valence	Emotion	*M (diff)*	T value	Df	Cohen's d
+	**Pos Affect**	.66*	17.53	238	.74
–	**Neg Affect**	-.47*	-13.43	238	.60
+	Active	.91*	12.86	236	.71
+	Inspired	.91*	11.85	236	.73
+	Excited	.81*	12.06	238	.69
+	Proud	.74*	10.18	237	.56
+	Enthusiastic	.71*	11.26	238	.59
+	Interested	.63*	11.19	237	.61
+	Attentive	.63*	10.08	238	.57
+	Alert	.50*	6.63	238	.47
+	Strong	.46*	8.08	237	.40
+	Determined	.30*	4.65	236	.24
–	Nervous	-.78*	-11.31	236	.63
–	Ashamed	-.63*	-9.29	238	.50
–	Irritable	-.62*	-9.82	238	.59
–	Guilty	-.59*	-9.86	238	.48
–	Scared	-.45*	-8.24	238	.40
–	Jittery	-.43*	-6.07	237	.35
–	Distressed	-.41*	-6.16	236	.41
–	Afraid	-.41*	-8.04	238	.38
–	Upset	-.38*	-7	238	.42
–	Hostile	-0.03	-0.92	238	.07

*$p < .001$

Interviews

When asked about their experiences in VR, patients consistently reported how the immersive technology helped them leave the real world and enter a new, more comfortable environment that separated them from negative affect and cognitions. Three anecdotes are presented below, with additional quotes provided in Table 2.

T was a 27-year old male who abused opioids and cannabis. He described his experience of using VR while in detox: "I was going through withdrawals. I had no energy. But coming in here to do [VR] it just went away for a little. You know you just want to lay there in detox, but coming up here to do this...it's just like going on a mini-vacation or something. It brings you up for a little bit…escaping my own mind… you've got to duck and dodge, so you are worried about that. I wasn't thinking about 'I have messed up a bunch in my life.' You are so submerged…there is nothing else on my mind…it just relieves the stresses. [After VR, another patient and I] talked for a good thirty minutes about a game we played. Just even talking about it, it's better than sitting there stuck in your own thoughts, in your own mind…self-pity and woe and all that." It appears that T was able to reduce his symptoms of detox by immersing himself in the virtual reality. It also seems that reflecting on his experience of VR provided a distraction from typical automatic negative thoughts.

M was a 28-year old female who abused opioids and cannabis. She had Major Depressive Disorder, an Unspecified Anxiety Disorder, and Unspecified Personality Disorder. She described her experience, "Being able to paint for a little, and be as free and open as I wanted to be, is satisfying. We get caught up in our heads a lot, and it's hard to get out of them. VR was true freedom — expressing myself fully without any judgements coming, even from myself. Just literally feeling and being in that moment. It allows me to just have fun and enjoy doing something other than being in reality. It's like a mental vacation, but a really cool vacation." M's experience demonstrates how VR could release her from automatic negative thoughts, and allow her to feel as free as she could be present in the current moment—an effect that could be similar to that of

mindfulness.

J was a 22-year old male who abused alcohol, stimulants, benzodiazepines, and cannabis. He had a history of childhood sexual abuse and neglect and was homeless prior to arriving at the rehabilitation center. When asked about VR, he noted: “It tricked my brain…made me believe I was in another world…I had to focus and see something else instead of my current situation and life. On the walk back up (after doing VR) I felt good - I was in some sort of state of bliss. I felt more positive and comfortable. My anger and anxieties went down. Then you come back to the house and somebody is complaining about something stupid. It is like dude…what is there to complain about?” It appears that J’s experience in VR not only allowed him to forget about his real-world problems, but also potentially decreased his reactivity to real world events.

Table 2. Additional Selected Quotes from Patient Interviews

Patient	Diagnoses	Quote
M, 55	Alcohol, Benzos, PTSD	"You feel like you've left all the issues you normally deal with in this environment, and you're all of a sudden opened up to a whole different world."
F, 23	Alcohol, Stimulants, MDD, GAD	"It loosened me up a bit. I felt like I was comfortable in my own skin, kinda warmed me up for this whole experience and made me realize, 'Hey maybe rehab is not so bad'"
M, 24	Opioids, Stimulants, Cannabis, MDD, GAD	"My first day in detox, I was kinda like I'm ready to go. I was thinking about shit, and then [VR] put me in a good mood, a better mood. It was literally another world. I felt like I was in the actual game….When people want to change their feelings they just go to use drugs. Instead of using drugs you can just go to a new world and play some games. Escape from reality for a little bit."
M, 37	Alcohol, MDD, GAD, Intermittent Explosive Disorder	"It got me away from reality and put me in my own little world. I was living in an alcoholic world…VR made me a lot happier and put me at ease. I was relaxed, calm…it cleared my mind. VR was…mind altering in a good way. It got me away from reality for a little bit…I kinda forgot you know, what was going on the planet. Then I took the headset off and I was like, 'Oh, cool…'"
M, 37	Alcohol, MDD, Anxiety	"I've had a huge problem with feeling tired throughout the day. It is a cure for the midday drag for sure…The first time I took the helmet off, I didn't know where I was for a minute - and that is exactly what I needed at the time, to get away from all this. One of my triggers was being bored…. [VR] excites me, wakes me up. It's definitely a distraction. I'd rather reach for a VR helmet than a beer, anytime."
Anonymous	N/A	"I have PTSD…[VR] is more calm and relaxing…I don't have to think about all the nightmares or bad things. [Virtual Reality is] exhilarating…you are not worried about the outside."
F, 23	Opioids, Stimulants, GAD	"I could tell my mood changed. I'm learning about myself…peaceful things to help my stress and anxiety. When I was using, I was numb to emotions…I was never excited, happy, sad. I was j just like 'bluhh,' but virtual reality…made me happy. It's like feeling live."
M, 51	Opioids, Alcohol, MDD, GAD	"Being an addict, you are kind of stuck in your own head. Being able to escape that for a little while is a big positive. VR gets you up and moving, motivated [and] into the game. It takes your mind of the other stuff…drugs, alcohol…trauma. It keeps you focused on something else."

Interviewed patients were also asked how long they perceived the effects of VR to last (Table 3, *Figure 3*).

Table 3. Self-Reported Duration of Effect from VR

Duration of Effect	Percentage
Less Than 30 Minutes	4.76%
30 Minutes to 1 hour	9.52%
Multiple Hours	47.62%
Longer Than a Day	14.29%
Unclear Duration	23.81%

CHAPTER III

Discussion

Substance use disorders can develop as a result of people trying to reduce stress or generate pleasure (Sinha, 2008). It appears that some VR environments may reduce stress *and* generate pleasure without the introduction of an external pharmacological agent. Carefully designed VR environments, if accessible from home on impulse, might help break the cycle of addiction. To cope with the negative affect that causes craving and relapse, patients could enter a virtual world to experience a temporary relief from negative affect. It is even more difficult to generate positive affect with pharmacological treatments. VR might prove to be an especially efficacious non-pharmacological alternative means to regulate affect.

Interviews with patients helped to provide insight into potential mechanisms that can be tested in future research. Patients described how VR took them away from problems in the real world—they "left the issues" behind and were "opened up to a whole different world." VR may elicit a positive hedonic response through reducing the saliency of real-world triggers that are conditioned to negative automatic thoughts and affect.

This reduction in saliency may be facilitated through immersion. Once immersed in VR, patients could engage in activities that may facilitate behavioral activation (Dimidjian et al., 2006). Patients stood and moved around as they engaged in VR—several discussed how VR could help to "get the blood pumping" or "cure the midday drag." There may be synergistic effects between removing a patient from the real world and facilitating behavioral activation in the virtual world.

In the context of the cognitive model (Greenberger & Padesky, 1995), VR may work by changing the patient's "experienced" environment. By changing the context of a person's thoughts, feelings, behaviors and physiology through immersion, VR may shift affect directly. This

"cognitive behavioral immersion" (CBI) could be used to alter a patient's mood state and enhance learning of cognitive behavioral skills. Zbozinek and Craske (2017) propose that positive affect induction could help to optimize extinction learning and exposure therapy. Interviews in this study suggest that patients became more present in the current moment and experienced fewer automatic negative thoughts while in VR. It is possible that CBI could not only enhance exposure therapy (behavioral) but could also help patients learn cognitive skills more effectively such as reframing automatic negative thoughts (cognitive). Future research should examine the effects of teaching cognitive behavioral skills through CBI.

Limitations & Future Research

There are inherent limitations relying on archival clinical data, given that this was not a randomized study. Instead, these data do allow a glimpse into immersing patients in recreational virtual environments. Data were only analyzed from each patient's first VR exposure—so that what we found may be a novelty effect, although unstructured observations (patients often asked for subsequent VR exposures) suggest that it may be more than that.

It would be beneficial to include a control group in future research to better isolate the potential effects of VR on affective regulation. Additionally, exposing patients to VR over an extended period of time would help to determine any potential dose-response patterns. It may also be beneficial to compare these affective changes to a nonclinical control group. Lastly, initial exploration suggests that CBT with individual patients in calming virtual environments may lead to better skill retention. We are in the process of constructing therapeutic environments to facilitate that process. Further research (e.g., controlled study) is needed to better understand the effects of VR on affect and skill acquisition in CBT.

Conclusion

It appears that virtual reality might not only be helpful in reducing negative affect, but also

to create positive hedonic experiences. Immersion in such experiences shifts a patient's context and appears to provide relief from negative affect and unpleasant ruminations. It may be possible through cognitive behavioral immersion to create compelling virtual environments that can help to regulate affect and teach coping skills that protect against relapse. Additionally, these positive environments may be used to break the cycle of addiction by providing an immediately available alternative behavior to drug use.

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