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The use of VR cue exposure for treatment of substance use disorders: A pilot study of presence and immersion

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Abstract

Background: *Virtual reality cue exposure (VRCE) places individuals with a substance use needs in controlled virtual spaces mirroring their "in vivo" use environments, safely exposing them to their most salient substance use cues and practice skills such as substance refusal and craving management. However, the effectiveness of VRCE is often influenced by the levels of presence and immersion that users experience within virtual environments.* ***Methods:*** *Twelve substance use treatment professionals and eleven peer support specialists tested and evaluated a new VR-based digital therapeutic, HelixVRTM as an adjunctive treatment for those misusing opioids and other addictive substances. Data were collected on participants' experiences of presence and immersion while in the virtual space.* ***Results:*** *Overall, high levels of presence and immersion were reported. Independent t-tests investigated the difference in scale/subscale scores based on respondent demographics. Results indicate that significant differences were found between non-Hispanic White and Black, Indigenous and other People of Color (BIPOC) participants (particularly Hispanic/Latino participants) with BIPOC participants rating their experiences within the virtual space more positively in regard to their overall levels of technology acceptance, spatial situation, self-location, and immersion/adaptation. Minimal differences on outcome measures were found in relation to gender and age.* ***Conclusions:*** *Results lend preliminary support to the acceptability of this VR based tool based on users' levels of presence and immersion, potentially filling a gap in current substance use intervention approaches. Considerations for the integration of this tool into routine substance use treatment will be offered.*

Keywords: Virtual reality, addiction, substance use treatment, cue exposure, opioids

Introduction

Virtual reality (VR) technology has been increasingly utilized in various healthcare fields as a clinical intervention [1-4] and as a healthcare training tool [5-7]. The acceptability, feasibility, and usability of VR interventions for substance use treatment have been the subject of growing interest in recent years [8]. VR based interventions are currently being used to address anxiety disorders [9-11], post-traumatic stress disorder (PTSD) [12,13], and pain management [3,14-16]. Some authors suggest that by combining it with other modalities, the gains associated with VR-based interventions may increase and produce better results than in vivo intervention approaches that may be neither feasible nor safe [8,17].

Virtual reality has also emerged as a promising tool for the treatment of substance use disorders, offering a novel approach to therapy that is both immersive and interactive [18-21]. VR technology offers a unique and innovative approach to substance use treatment by providing immersive and interactive environments that can simulate real-world scenarios related to substance use [20,22]. This technology allows individuals to engage in virtual experiences that can help them develop coping skills, practice refusal strategies, and learn to manage cravings in a controlled and safe environment [19,23-25]. The first randomized trial assessing feasibility of VR-based coping skills training showed smoking rates and craving were lower in the VR group vs. the non-VR group. In addition, confidence and coping skills were also higher and number of cigarettes smoked at follow-up was significantly lower [26].

VR-based cue exposure therapy been used in multiple studies among people with alcohol use disorder (AUD)

[28]. Bordnick et al. [27] provided early evidence for the feasibility and efficacy of VR-based cue exposure, showing that alcohol-related virtual environments reliably induced craving in individuals with alcohol use disorder AUD. Overall results indicate that participants who participated in the VR-based intervention experienced a significant decrease in craving and cue-induced arousal. Another randomized controlled study explored the use of a VR-based intervention to prevent relapse for individuals with alcohol use disorder [29]. It demonstrated that participants who received the VR-based intervention showed a significant reduction in alcohol cravings and consumption compared to those who received standard relapse prevention training. Lebiecka and colleagues [22] also found that cue-exposure therapy could be used effectively to address AUD due to its ability to exposure clients to environmental and individual cues related to their substance use, supporting relapse prevention training.

VR-based craving research across diverse substances of misuse has consistently shown that VR is a reliable and effective tool for eliciting craving, while also offering meaningful opportunities to study and manage craving in treatment contexts. Prior studies support the use of VR for those with a diagnosis of alcohol use disorder [28,30-32], those with nicotine use disorder [26,28,33-35] or both [36]. This work highlights the potential of VR based exposure as an effective relapse prevention strategy for individuals struggling with substance misuse [37].

Additional studies also support the use of VR as an emerging intervention approach for those misusing cannabis [20,38], opioids [39-41], and stimulants [20,42-44]. VR-based craving research across alcohol, nicotine, cannabis, stimulants, and opioids demonstrates that VR is a reliable and effective method for eliciting craving responses in ecologically valid environments [27,28,33,34,38,41-43]. However, a number of these studies did not assess users' presence and immersion while in the virtual space.

Presence and Immersion

Two key psychological constructs that influence the effectiveness of VR-based craving interventions are presence and immersion, both of which are key to optimal engagement with any VR based digital therapeutic. [36,45,46] While these terms are sometimes used interchangeably, they represent distinct but interrelated aspects of the VR experience. Presence refers to the subjective feeling of "being there" in a virtual environment [47], whereas immersion describes the technological aspects that enable a user to feel fully engaged with the virtual setting, such as sensory fidelity, interaction capabilities, and narrative depth [48]. Research indicates that higher presence in VR environments enhances emotional and cognitive engagement, which is particularly relevant in the context of substance use interventions [49].

Moreover, presence has been linked to greater acceptability and usability of VR interventions, as users who feel more immersed tend to report higher satisfaction and willingness to engage in repeated sessions [46,50]. This is critical for SUD treatment, where long-term adherence to multi-session interventions is frequently a challenge.

Immersion, as a technological enabler of presence, plays a key role in modulating treatment outcomes. Studies have found that greater sensory and interactive realism (e.g., high-quality visual and auditory stimuli, responsive environments) contribute to deeper emotional involvement within the virtual space [51,52]. In the context of VR-based SUD interventions, high levels of immersion can enhance the ecological validity of exposure therapy, making virtual scenarios more comparable to real-world substance-related cues and stressors [53]. This heightened realism not only facilitates better transfer of learning but also enables more personalized and engaging therapeutic experiences. Prior VR-based craving research consistently demonstrates that presence and immersion amplify cue reactivity, supporting VR as a valid method for both assessment and treatment [27,38,44,46,54].

Despite the benefits, the relationship between presence, immersion, and treatment efficacy is often complex. Over-immersion may lead to negative side effects, such as cybersickness or emotional overstimulation, which can reduce user engagement and limit intervention effectiveness [50]. Similarly, a recent review by Weech et al., [82] found an inverse relationship has also been found between one's levels of presence within the virtual environment and experiences of cybersickness, making adequate levels of presence essential to a positive overall user experience. Therefore, designing VR-based SUD interventions requires a balanced approach that optimizes presence and immersion without overwhelming the user. Thus, it is also important to explore how individual differences (e.g., sociodemographic characteristics of the user, prior VR use, and overall acceptance of technology) may influence presence and immersion within the virtual space. By understanding and leveraging the mechanisms of presence and immersion, VR-based interventions can be better tailored to enhance engagement, reduce substance cravings, and potentially improve treatment effectiveness for individuals with substance use disorders [46].

Prior VR use and overall technology acceptance are thought to impact perceptions of VR and other technology enhanced behavioral health intervention approaches. The Technology Acceptance Model (TAM) [56,57] posits that users' level of technology acceptance may influence their intention to use technology as a part of their jobs. Hu and colleagues [77] first applied this model to physicians' acceptance of telemedicine technology in Hong Kong and found that the TAM model was able to "provide a reasonable depiction of physician's intention to use telemedicine technology" (p. 92). They further found that while perceived usefulness of the technology was associated with participants' intention to use it, perceived ease of use was not significantly associated with use intentions. Based on this model, Holden and Karsh

[55] later reviewed 20 published quantitative studies and 16 data sets from where clinicians including physicians, nurses, occupational therapists, pharmacists and medical technicians used health information technology (IT) as a part of patient care and found that, although there was substantial variability among studies, overall the TAM partially predicted participants use and/or acceptance of IT as a part of patient care.

More recent studies have focused on technology acceptance in relation to substance use treatment, rather than general medical care. For example, Skeva and colleagues [25] investigated the views of practitioners and researchers on the uses of virtual reality in substance use treatment. They found that overall participants had a positive view on the integration of VR as an adjunctive treatment for SUDs and that they felt it was appropriate for use with adults with SUDs, along with those who have experienced trauma or mental health concerns as long as potential risks associated with VR use were appropriately controlled. Moreover, due to the COVID-19 pandemic, researchers have called for greater integration of telehealth-based interventions into traditional outpatient substance use treatment [58] to improve access to care and decrease potential for return to use.

When taken together, these studies suggest that VR technology can be a valuable tool in supporting individuals with substance use disorders in managing cravings and reducing the risk of relapse [8,28]. The current literature supports the potential effectiveness of VR-based interventions as an adjunct to traditional methods of substance use treatment, and further research in this area has the potential to improve the overall quality of care for individuals living with substance use disorders [37].

A novel-VR based digital therapeutic, HelixVR, was developed by InnateVR LLC in 2020 to be used as an adjunctive treatment for those with opioid use disorder who are also using other addictive substances. This digital therapeutic is unique in that it does not focus exclusively on one substance and can be used in conjunction with any other therapeutic modality including cognitive-behavioral therapy (CBT) and medications for opioid use disorders (MOUDs). This tool offers a new form of treatment for those experiencing problems with stimulant abuse, such as issues with cocaine or methamphetamine, conditions for which there are currently no FDA approved medications [59]. Data on those misusing addictive substances indicates that polysubstance misuse is widespread and is often associated with premature treatment termination and increased mortality [60,61], indicating an ongoing need for intervention approaches that are not substance specific. Thus, our research team set out to answer the following research questions:

1. What levels of presence and immersion were reported by users of the digital therapeutic *HelixVR*?
2. Was there a relationship between users' levels of technology acceptance and their experiences of presence and immersion while using *HelixVR*?
3. Are levels of presence and immersion reported for *HelixVR* consistent across all product testing groups based on the sociodemographic characteristics of product testers?

Description of the Digital Therapeutic

HelixVR is a novel digital therapeutic for adjunctive use for those in treatment for a variety of substance use disorders. The HelixVR software is designed for use with any VR enabled computer and is compatible with a variety of head mounted displays including the HTC Pro series and the Pico 3. Although an active internet connection was required to run the VR software at the time of product testing, the developers have made improvements based on feedback from this product testing to allow HelixVR to have full functionality without a high-speed internet connection.

The version of HelixVR employed for preliminary user testing featured 8 different virtual environments that are designed to simulate typical substance use environments such as a car, a basement of a house, a bedroom in an apartment, male and female public restrooms, an abandoned alleyway, an abandoned building, and under a bridge. Users choose from a variety of substance use cues (such as a syringe, pipe, baggie, lighter etc.) to be placed in the chosen virtual substance use environment, allowing for safe and ethical repeated exposure to their most salient substance use cues. Repeated exposure to substance cues in the absence of substance use is believed to be associated with decreases in substance craving through the process of habituation, thus weakening the paired association between presentation of substance use cues and substance use [28,62]. Photos of some of the virtual environments are included as supplemental materials.

Methods

Recruitment

Twenty-three adult participants (12 peer support providers and 11 master's level substance use treatment providers) were recruited for this study. The first author leveraged her existing relationships with four (state masked for review) substance use treatment agencies (2 public, 2 private) to engage in product testing and an evaluation of the digital therapeutic. One private agency provided peer support services and supportive housing, the other provided residential treatment including Medications for Opioid Use Disorder (MOUDs), intensive outpatient treatment (IOP) and outpatient treatment. One public treatment agency provided peer support services, outpatient treatment and referral to MOUDs and/or residential care, while the other provided residential treatment, peer support services and outpatient follow up care.

The first author contacted the clinical leads at the various organizations by email to notify them of an opportunity to use a new VR based digital therapeutic which could be used as adjunctive treatment to usual care. As a part of this opportunity, participants would engage in on site "product testing" of the tool and offer feedback on the feasibility, acceptability and usability of this tool along with experiences of cybersickness by completing standardized measures. Participants who completed the product testing could also opt to participate in follow-up focus groups that would gather more in-depth qualitative information about their product testing experience. Results of the usability and cybersickness assessment are presented in a separate article [39]. The clinical leads then recruited colleagues to engage in the product testing. The product testing session and completion of standardized measures took approximately 90 minutes and participants were given a $25 Amazon e-gift card for their assistance.

Procedures

Human subjects' approval for this project was received from the institutional review board (IRB) of (university name and protocol number masked for review). The first author or one of her research associates (RAs) conducted the product testing in Spring and Summer 2023 at each of the participating substance use treatment agencies. The member of the research team brought a HTC Vive Pro head mounted display and the VR compatible laptop with the HelixVR software loaded on to it to the provider agency so that the product testing could be conducted on site. Each user tested the software on their own and provided individual feedback via a survey which included demographic questions and standardized measures of technology acceptance, presence and immersion hosted on the secured Qualtrics data collection site. Participants could "opt out" of answering any of the questions included in the survey per IRB requirements.

Measures

Sociodemographic Characteristics of Participants

Participant sociodemographic characteristics that were collected for this study included gender, race/ethnicity, age, if they were a Masters level treatment provider or peer support specialist, how long they had been working as a treatment provider or peer support specialist, if they were in recovery and what (if any) technology based tools they used in their work with clients with substance use disorders.

Presence Questionnaire 3.0 (PQ3)

The Revised Presence Questionnaire [63] was used to assess participants' subjective experience of being in the simulated substance use environments. 29 items assessing four domains of presence (involvement, sensory fidelity, adaptation/immersion and interface quality) are evaluated on a 7-point Likert-type scale ranging from 1 = Low to 7 = High. Items are summed to get a total score, with higher scores indicating higher levels of presence within the virtual environment. Cronbach's alpha for the PQ 3.0 in this sample was .80 indicating adequate reliability.

The Measurement, Effects and Conditions Spatial Presence Questionnaire (MEC-SPQ - Short Version)

The thirty-two-question version was used for this study due to the length and participant burden associated with the sixty four item version of this measure. The measure captures eight domains of immersion and presence within the virtual space including attention allocation, spatial situation model, spatial presence: self-location, spatial presence: possible actions, higher cognitive involvement, suspension of disbelief, domain specific interest, and visual spatial imagery [64]. Responses on each item range from 1 = I do not agree at all to 5 = I totally agree. Items were reverse scored on the suspension of disbelief subscale as recommended by the authors. The mean scores of each question on each subscale are summed and divided by four to determine the subscale score. Higher scores are indicative of higher levels of immersion and presence. This version of this scale evidenced strong to adequate reliability for each of the subscales in this sample (ranging from alpha = .92 to alpha = .77) other than the higher cognitive involvement subscale (alpha = . 66) which demonstrated less than adequate performance.

The Technology Acceptance Measure for Preservice Teachers (TAMPST)

The modified Technology Acceptance Measure for Preservice Teachers (TAMPST) measures participants perceived levels of acceptance of technology. The measure was originally used to measure teacher's levels of acceptance of technology in general. The measure was adapted for this pilot study to focus on the experiences of using virtual reality as a part of routine care, in this case, substance use treatment. The adapted sixteen item measure (see Appendix) maps on five domains of acceptance including perceived usefulness, perceived ease of use, subjective norm, facilitating conditions and attitudes toward the use of virtual reality.

Participants are asked their levels of agreement with statements focusing on various aspects of using VR, ranging from 1 = *Strongly Disagree* and 5 = *Strongly Agree*. Item scores are summed to calculate the subscale scores with higher scores indicative of higher levels of technology acceptance. A cut score of 48 is recommended by the authors to indicate high levels of technology acceptance. The coefficient alpha for the adapted measure used in this study was .92 indicating high levels of reliability.

Data Analysis

All analysis was conducted in IBM SPSS version 29. Counts and percentages were calculated for all categorical variables. The mean and standard deviation were calculated for all continuous variables. Pearson correlations were conducted to determine if there was any association between users' levels of technological acceptance and their experiences of presence and immersion. Some demographic data was missing, as participants could opt out of answering any survey items, and for those analyses, listwise deletion was used. Missingness on continuous variables were addressed using mean imputation, however missing data was less than 3% for any non-demographic variable. Several independent sample t-tests were then conducted to determine if there were significant differences on the outcome measures based on dichotomized participants demographic variables such as gender, race/ethnicity and professional role.

Results

Sociodemographic characteristics of participants and their mean scores on the technology acceptance, presence and immersion measures are summarized in Table 1.

Table 1

Sociodemographic Characteristics of Participants (N = 23)

Categorical Variables	*n*	%
Gender		
Male	15	65.2
Female	8	34.8
Race/Ethnicity		
Black/African American	1	05.2
White/Caucasian non-Hispanic	14	73.6
Hispanic/Latine	2	10.5
Asian/Pacific Islander	2	10.5
Missing	4	_-
Type of Service Provider		
Professional	12	52.2
Peer	11	47.8
Used Any Technology Working with Patients		
No	15	65.2
Yes	2	8.7
Missing	6	26.1
Currently Provides Services Via Telehealth		
No	12	70.5
Yes	5	29.5
Missing	6	-
Has Use Phone Apps in Clinical Practice		
No	9	52.9
Yes	8	47.1
Missing	6	
Has Used VR in Clinical Practice		
No	15	88.2
Yes	2	11.8
Missing	6	-

Continuous Variables	*n*	*M*	*SD*	*Range*
Age (years)	19	44.21	11.62	23 - 68

Note: * = responses were not mutually exclusive, participants could endorse multiple substances of addiction.

The average age of participants was 44.21 years of age (SD = 11.62), ranging from 23-68 years of age. The majority of participants were male (65.2%, n = 15) , and 73.6 % (n = 14), identified as non-Hispanic White. Eleven (47.8%) of participants were peer support specialists, while twelve (52.2 %) of participants were Masters level substance use treatment providers. The majority of the sample (n = 10, 66.7%) were ages 40 and older. A large number of participants (n = 15, 65.2%) reported that they had not used technology at all as part of their work with clients experiencing substance use disorders, with 29.5% (n = 5) of participants reported using telehealth to provide behavioral health services, while 47.1% (n = 8) reported using cell phone apps and 11.7% (n = 2) reported using VR for behavioral health treatment at some point in their careers. Use of technology categories were not mutually exclusive.

Scores on Standard Measures

Table 2 shows the full scale and subscale scores on the standardized measures.

Table 2

Scale and Subscale Scores for Measures of Technology Acceptance, Presence and Immersion

Variable	*n*	*M*	*SD*	Range	Max
Technology Acceptance Total	23	68.74	7.95	56-78	80
Perceived usefulness		18.00	2.20	13-20	20
Perceived ease of use		12.47	2.21	8-15	20
Subjective norms		8.61	1.47	6-10	10
Facilitating conditions		11.96	1.69	9-15	15
Attitudes toward computer use		17.70	2.69	13-20	25
Spatial Presence and Immersion Total	23	124.87	10.60	102-146	160
Attention allocation		19.30	1.60	16-20	20
Spatial situation model		18.17	1.83	15-20	20
Spatial presence self location		16.36	3.04	8-20	20
Spatial presence possible actions		15.04	3.41	8-20	20
Higher cognitive involvement		17.39	2.35	12-20	20
Suspension of disbelief		7.39	2.87	4-12	20
Domain specific interest		16.08	2.83	8-20	20
Visual spatial imagery		15.09	2.70	9-20	20
Presence Total	23	115.57	20.80	78-146	203
Involvement		46.47	10.80	30-64	84
Sensory fidelity		22.15	4.34	15-33	41
Immersion/adaptation		29.95	5.78	18-39	56
Interface quality		12.99	12.99	5-19	21

Note: Max= maximum possible score on measure or subscale.

Overall, participants reported high levels of technology acceptance, as participants' mean scale scores (ranging from 56-79) exceeded the cut score of 48. As shown in Table 2, Participants scored highest (as a percentage of possible total scores) on the perceived usefulness scale and lowest on the perceived ease of use scale.

Participants also indicated high levels of presence (as measured by the presence scale) and immersion (as measured by the MEC-SPQ) within the virtual environments. Overall immersion scores were high (all above 75% of the total possible score for all subscales, except the suspension of disbelief subscale), with scores being reported on all of the other subscales ranging from 15.04 to 19.30 (SD ranging from 1.60 to 3.41). The suspension of disbelief subscale was notably lower than all of the other subscale scores ($M = 7.39$, $SD = 2.87$) indicating the VR tool performed the least well on this subscale with high levels of variability within the response set.

There was decidedly more variability in participants' experiences of presence while in the virtual environment with mean total scale scores ranging between 78 and 146. Subscale scores were all slightly above the midpoint score for each scale, with scores on the interface quality subscale being reported as highest and those on the sensory fidelity subscale being reported as lowest.

Association Between Technology Acceptance, Presence and Immersion

Pearson correlations were used to determine if there was any significant relationship among technology acceptance, presence and immersion scores. Results indicate that although there were very small correlations among study measures, none of these correlations were statistically significant.

Table 3

Correlation Among Study Measures

Variable	1	2	3	M	SD
TAMPST	-			68.74	7.97
PQ3	.13	-		115.57	20.80
MEC-SPQ	-.07	.21	-	124.87	10.60

Note. $N = 23$. Correlations are Pearson's r. No comparisons were significant at $p < .05$. Means and standard deviations were calculated for full scale scores.

Between Group Comparisons

Independent t-tests were used to assess if there were any differences in users' presence or immersion scores based on their sociodemographic characteristics or based on if they had used technology and specifically virtual reality as a part of patient care. Table 4 shows the significant results of independent t-tests of dichotomized variables to determine if scores on each of these measures was consistent across product testers based on their sociodemographic characteristics. Effect sizes (strength of this association) for these differences as measured by Hedge's g were large ranging from .74 to 1.76.

Table 4

Significant Between Group Comparisons on Standardized Measures

Scale/subscale	n	M	SD	*t*	df	*p*	*g*
TAMPST							
Technology Acceptance Total							
Hispanic/Latino	2	72.50	2.12	-2.49	18	.024	.75
Not Hispanic/Latino	17	66.47	7.86				
Perceived ease of use							
BIPOC	5	13.60	1.14	-2.13	18	.025	.77
NH-White	14	11.86	2.38				
Attitudes toward technology use							
Hispanic/Latino	2	19.00	0.00	-3.12	18	.003	.74
Not Hispanic/Latino	17	17.00	2.65				
MEC-SPQ (32 item)							
Spatial situation model							
Hispanic/Latino	2	20.00	0.00	-1.60	17	<.001	1.19
Not Hispanic/Latino	17	17.77	1.92				
Spatial presence self location							
Hispanic/Latino	2	20.00	0.00	-2.36	17	0.015	1.76
Not Hispanic/Latino	17	16.06	2.30				
Higher cognitive involvement							
Ages 40 or older	13	16.31	2.32	2.02	17	.021	1.04
Under age 40	6	18.67	1.75				
Peer support	11	16.00	2.24	-3.26	21	.002	1.31
Professional	12	18.67	1.67				
PQ3							
Involvement							
Under age 40	6	37.74	6.10	-2.31	17	.017	1.09

40 and older	13	49.24	11.32				
Sensory fidelity							
Male	8	25.53	4.13	-3.39	21	.001	1.43
Female	15	20.35	3.11				
Immersion/adaptation							
BIPOC	5	35.21	2.86	-2.83	17	.006	1.41
NH-White	14	28.13	5.25				

Note: Only significant results were reported.

Findings indicate that for the TAMPST, higher levels of overall technology acceptance and positive attitudes towards technology use were reported by Hispanic/Latino participants, while BIPOC participants reported significantly higher levels of perceived ease of use that their White non-Hispanic peers. Significant differences based on respondent demographics were also found on subscales of the PQ3. Participants over the age of 40 reported higher levels of involvement, while male participants reported higher levels of sensory fidelity relative to female participants. BIPOC participants reported higher levels of immersion/adaptation relative to White non-Hispanic participants. Finally, for the MEC-SPQ, Hispanic/Latino participants reported significantly higher levels of spatial situation and self-location within the virtual space, while those over the age of 40 and professional treatment providers reported lower levels of cognitive involvement relative to younger participants and those who were peer support professionals.

Discussion

In regard to the first research question, results of this pilot user testing lend preliminary support for HelixVR users evidencing overall high levels of presence and immersion while within the virtual environments. However, users' overall scores on the PQ3 tended to be lower than those for the MEC-SPQ (based on percentage of maximum total score) indicating that there are still some opportunities to further improve user's general sense of presence while using HelixVR. Similarly, based on low scores on the suspension of disbelief subscale of the MEC-SPQ, there also appears to be opportunities for improvement in terms of the tool being able to engage users to the point that they feel that the simulated environments are real, creating a more engaging and compelling experience within the virtual space. Additional product development focused on improving this aspect of the user experience is currently underway.

Individuals in this sample scored high on their overall levels of technology acceptance, all scoring higher than the cut score of 48 out of a possible 80. This was not surprising given that participants could self-select to participate in user testing, and it is reasonable to think that individuals who would indicate an interest in participating in these activities may already be "bought in" to using technology as a part of their work with clients with substance use disorders.

In regard to the second research questions, no relationship was found between participants levels of technology acceptance, presence and immersion, indicating that levels of technology acceptance was not predictive of scores on presence and immersion measures. This finding was unexpected as it is inconsistent with results found by Holkden and Karsch [55] by who found that individuals who were more positive towards the use of technology in practice tended to report higher levels perceived ease of use, perceived usefulness and perceived behavioral control. Although this finding potentially may have been impacted by small sample size, it is encouraging, given that the larger population of community-based treatment providers may express more variability in terms of technology acceptance [25] than the respondents in this sample. This lends support to the potential use of VR in substance use treatment regardless of individual provider's baseline levels of technology acceptance.

Finally, regarding the final research question, results revealed some key differences on PQ3 and the MEC-SPQ scores based on participant demographics. Effect sizes associated with these differences were large. The greatest number of differences were found between Hispanic/Latino participants and those not identifying as Hispanic/Latino. Hispanic/Latino participants reported higher levels of overall technology acceptance and more positive attitudes towards technology acceptance relative to their non-Hispanic colleagues. These participants also reported higher levels of spatial presence in terms of self-location, or one's perception of their body position within the virtual environment relative to the objects within the environment. Since the vast majority of currently published VR studies include small numbers of Hispanic/Latino/e participants [65] additional research including larger number of participants from this ethnic/cultural background are warranted to determine if these trends are consistent across various VR based applications.

In terms of gender, the only significant differences that were found in regard to full scale scores or subscale scores on key outcome measures were for the sensory fidelity dimension of the PQ3. Male users perceived greater levels of realistic sensory experiences (sights, sounds, etc.) relative to female users. This finding is consistent with prior work of Felnhofer and colleagues [76] and Melo and colleagues [78] indicating that men tend to experience a greater degree of presence within the virtual space and higher degrees of presence related realism relative to women within the virtual environments. Although the number of women who report engine in online gaming or using game consoles such as Microsoft's X Box and Sony PlayStation continues to rise [66], men are still engaging in these online platforms at higher rates than women [67,68] and may focus on different aspects of the virtual experience, which may in part explain these results due to higher levels of exposure to virtual spaces as a part of game play.

Small differences on presence and immersion measures were reported between peer support specialists and masters level substance use treatment professionals, with peer support specialists reporting lower levels of cognitive involvement on the MEC-SPQ indicating that they may have experienced lower levels of attention, focus and overall cognitive functioning within the virtual space. This may be related to differences in prior VR use, as only master's level substance use treatment professionals (rather than peer support specialists) reported prior VR use with clients, potentially orienting them to what to normally expect in terms of navigating the multiple aspects of the virtual space. When comparing non-Hispanic White and BIPOC participants, two significant differences were found, with BIPOC participants reporting higher levels of presence in regard to immersion/adaptation within the virtual environments and also reporting higher levels of ease of use. These two findings may be connected as high levels of perceived usability are thought to positively impact one's sense of presence and immersion within the virtual space [46,50]. This finding was consistent with those of a recent meta-analysis indicating that Black/African American participants tended to report higher levels of presence while using VR relative to their White non-Hispanic peers [69].

Finally, users over the age of 40 reported lower levels of cognitive involvement (attention, focus and overall cognitive functioning) within the virtual space relative to users under the age of 40. Conversely, older users also reported higher levels of overall involvement within the virtual environments, meaning that they reported feeling more engaged with and connected to the virtual world. These contrasting findings are interesting, as they indicate that overall, older users felt more engaged with the virtual environments, yet they still reported lower levels of attention and focus while in the virtual environments. This may be due, in part, to the normal cognitive decline associated with the aging process [70] or potentially due to greater levels of overall fatigue while in the immersive virtual space [71].

Limitations

The majority of the users were male and identified as non-Hispanic White, limiting the potential generalizability of these findings. However, it was encouraging that there were minimal differences on key outcome measures in regard to gender or provider type, indicating similar performance of the tools across various subsamples of participants. Small sample size did not support the use of multivariate data analysis techniques. Additionally, some participants did not report some demographic data, necessitating that between group comparisons could only be performed for participants who reported data for each planned comparison. It is possible that those who opted to not report some demographic data (age, ethnicity) may have evaluated their experiences with this tool differently than those who reported these data. Subsequent studies with larger samples including equally diverse participants pool are warranted to further determine if these results may extend to the overall population of potential end users. Finally, this study tested the tool with only with providers and individuals in sustained recovery. If feasible, it is recommended that future evaluation studies should also include participants who are currently active in their addiction.

Conclusion

Digital health tools are increasingly being explored to support the treatment of substance use disorders, yet many emerging technologies are developed without sufficient input from people with lived or professional experience in recovery-oriented care. This study examined the usability and perceived relevance of a virtual reality–based digital therapeutic designed to support individuals with opioid use disorder and other substance use concerns. The research team solicited feedback from both licensed professionals and peer support specialists, a workforce uniquely positioned at the intersection of lived experience and service delivery.

Using structured usability testing and qualitative feedback, the research team assessed how easily the system could be used, how realistic and meaningful the virtual environments felt, and whether the intervention aligned with recovery-oriented values. Overall, participants reported that the technology was easy to navigate and that the virtual scenarios reflected real-world substance-related cues in a way that felt both engaging and clinically relevant. Importantly, peer specialists emphasized the potential for this type of tool to complement—not replace—human support within treatment and recovery settings.

Our findings suggest that virtual reality–based interventions may offer a promising, scalable addition to existing substance use treatment approaches when they are designed with end users in mind. These results lend support for the HelixVR tool demonstrating adequate levels of presence and immersion within the virtual space, and minimal differences were found regarding the use of this tool based on participant demographics. This work highlights the importance of incorporating not only professional but also peer perspectives early in digital health innovation to enhance acceptability, ethical use, and real-world impact.

These findings have important implications for clinical practice in the field of substance use treatment. There are many clinical scenarios in which the use of in-vivo or imaginal exposure may been used to expose those using addictive substances to their most salient substance use cues and build relapse prevention skills. However, the research regarding the use of imaginal exposure versus VR exposure for other common conditions such as depression or PTSD indicates that imaginal exposures have limitations in regard to realism and intensity [84-86] which may also apply to the use of VR for the treatment of substance use disorders.

Moreover, VR serves to fill a “gap” in treatment where in vivo exposures may be theoretically helpful, but are neither feasible nor safe. Thus, integration of virtual reality based interventions in into both residential and structured outpatient substance use treatment could serve to move the field forward by providing a vehicle through which clients can build substance refusal and relapse prevention skills while truly feeling like they are in “real world” situations that trigger substance craving [72]. As many clients return to use following within the first 90 days of residential treatment [73-75], this tool may serve to better support their transition back into the community, and support them through the integration of tailored, client specific approaches to care.

Although preliminary, these findings are important because they suggest that the HelixVR tool performs similarly across various groups of potential end users, indicating this tool that may be acceptable for use with multiple provider populations comprised of diverse individuals. Moreover, the authors found acceptable levels of usability and low levels of cybersickness to be associated with this tool [39], indicating its potential for integration into routine substance use care. As the cost of VR technology continues to decrease, and more and more individuals are becoming comfortable using technology-based tools in the workplace, such as cell phone apps and artificial intelligence (AI), there appears to be great potential for the use of VR as a part of usual care to support ongoing substance use recovery.

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