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ABSTRACT

Virtual environments have been increasingly used in conjunction with traditional cognitive behavioral treatments for disorders, such as posttraumatic stress disorder and social anxiety disorder. Research has found that virtual environments can be effectively used as an alternative to in vivo or imaginal exposure. However, research has yet to compare the costs and benefits of different platforms, such as virtual reality and 360° video, for creating virtual environments. The current qualitative study compares the experiences of veterans with symptoms of posttraumatic stress disorder and social anxiety disorder as they interact with a virtual grocery store environment. Participants were randomly assigned to experience the virtual reality ($n = 7$) or 360° video ($n = 5$) environments. After experiencing the virtual environments, the participants were interviewed about their perceptions of immersion, feasibility, and acceptability of the modality. Portions of the interviews are presented along with recommendations for clinical researchers seeking to use virtual technology with clinical treatments.

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Social anxiety disorder (SAD) is a persistent and intense fear lasting 6 months or more of one or more social situations during which a person is exposed to unfamiliar people or personal scrutiny from others resulting in intense anxiety about humiliation or embarrassment (American Psychological Association, 2013). This persistent fear often manifests in a variety of anxiety symptomology such as increased heart rate, rapid breathing, sweating, trembling, difficulty with concentration, insomnia, dizziness, uncontrollable worry, and panic attacks (American Psychological Association, 2013). To decrease symptoms, individuals with anxiety often avoid situations that trigger discomfort, resulting in less frequent exposure to social situations (Hereen & McNally, 2018). Avoidance contributes to reduced social engagement and increased isolation, increased risk for social

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functioning problems, worsened mood, and increased anxiety (Knowles, Sripada, Defever, & Rauch, 2018). Veterans with PTSD and co-morbid SAD are at significant risk for suicidal ideation (McMillan, Asmundson, & Sareen, 2017).

Past year prevalence rates of SAD in both civilian and military populations are somewhat comparable, with 2.8% of the general and 3.6% of military populations meeting diagnostic criteria (Grant et al., 2005; Kashdan, Frueh, Knapp, Hebert, & Magruder, 2006). However, veterans suffering from PTSD are significantly more likely to have SAD than those without PTSD (22% vs. 1.1%). Likewise, veterans are more likely to have PTSD than the general population (11%-22% vs. 8%) (Ainspan, Penk, & Kearney, 2018; National Center on PTSD, 2018). Increasing the concern for veterans is that comorbid PTSD and SAD has been shown to increase risk of suicide (Kashdan et al., 2006) and aggression (Van Voorhees et al., 2018).

Even withstanding social anxiety, veterans face significant challenges to transitioning to civilian life. Factors such as mental health and substance abuse are often key barriers to reintegration to work or academic environments (Kukla, Rattray, & Salyers, 2015). Veterans transitioning to academic settings may suffer from feelings of alienation on college campuses, problems with intimate relationships, and problems with alcohol (name deleted to maintain the integrity of the review process, 2018; Vogt et al., 2017). Mental health problems such as PTSD also may negatively affect the quality of personal and intimate relationships (Vogt et al., 2017). Furthermore, comorbid PTSD with depression and/or substance abuse may further reduce levels of employment functioning and satisfaction, increasing risk for unemployment (Smith et al., 2017).

Social support has been conceptualized as a protective factor for veterans returning from deployment and may buffer against challenges during this transition such as from developing depression, PTSD, and anxiety symptoms (Ciarleglio et al., 2018; King, King, Vogt, Knight, & Samper, 2006). Social support also appears to positively affect PTSD treatment outcomes, increasing potential for recovery, and reducing negative outcomes, such as substance abuse and aggression (Van Voorhees et al., 2018). Workplace social support is helpful for returning combat veterans to establish employment, return to school, and alter their mission from military goals to civilian goals (Campbell & Riggs, 2015; Harris et al., 2017).

Social avoidance behaviors associated with SAD negatively affects the development and maintenance of intimate social relationships which are crucial for social support during the transition from combat. Returning veterans are more likely to seek friendships with other veterans, who also may share deficits in relationship building (name deleted to maintain the

integrity of the review process, 2018). They also may use drugs or alcohol to control feelings of discomfort and anxiety, resulting in potentially risk-taking behavior and deleterious personal relationships (Gros et al., 2016). Thus, SAD diminishes potential for building a social support network, increasing risk for other mental health issues and suicidality (Kashdan et al., 2006; McMillan, Asmundson, & Sareen, 2017).

Given the important role that social support plays in building resiliency and reducing at-risk behavior among returning combat veterans (Van Voorhees et al., 2018), identifying treatment modalities for boosting social engagement that are perceived as being acceptable, feasible, and usable to transitioning veterans is important. Presently, cognitive behavioral interventions are the "gold-standard" treatments for SAD (Otte, 2011). These interventions focus primarily on changing thoughts, feelings, and behaviors that are related to areas of impaired functioning, such as social engagement, negative evaluation of situations, and misinterpretation of social cues (Cuijpers et al., 2016).

Cue exposure therapy and virtual reality

Another related approach, cue exposure therapy, has been used for addressing phobic anxiety disorders and obsessive-compulsive disorders. It uses classical conditioning principles to loosen the associations between cues in the environment and habitual anxiety responses (Marissen, Franken, Blanken, Brink, & Hendriks, 2007). One potential mechanism for implementing cue exposure therapy is to create virtual environments purposefully developed for cue reactivity (e.g., Rizzo et al., 2015). In fact, research on using virtual reality in mental health treatment have primarily focused on anxiety disorders and provide good evidence that virtual cue-based exposures is effective in reducing anxiety symptoms (Freeman, Reeve, Robinson, Ehlers, Clark, Spanlang, & Slater, 2017). Once anxiety is stimulated through exposure to the virtual environment, habituation by continual exposure increases tolerance to cues (Meyerbröker, & Emmelkamp, 2010). Additionally, coping skills may be taught in the intervention during exposure (Maples-Keller, Bunnell, Kim, & Rothbaum, 2017).

Preliminary research on VR exposure therapy for SAD with exposure to public speaking stimuli and social interaction appears to have long lasting positive effects (Anderson, Edwards, & Goodnight, 2017) and to be an effective way to teach social skills (Reichenberger, Diemer, Zwanzger, Notzon, & Mühlberger, 2017). The use of virtual environments for the treatment of related disorders, including PTSD and specific phobia, also has demonstrated good therapeutic outcomes (Beidel et al., 2017; Morina, Ijntema, Meyerbröker, & Emmelkamp, 2015). Interestingly, research on the

use of virtual environments in PTSD treatment has found that patients who demonstrate larger physiological responses to cue exposure also demonstrate larger reductions in symptoms (Norrholm et al., 2016), which may indicate that more emotionally evocative environments could increase the therapeutic benefit of incorporating a virtual environment into treatment.

Virtual Reality Exposure Therapy (VRET) has demonstrated clinical efficacy in reducing PTSD symptoms (Roy, Costanzo, Blair, & Rizzo, 2014). This therapy exposes patients to anxiety-provoking combat situations within simulated environments, ultimately decreasing anxiety and other PTSD related symptoms via habituation (Gerardi et al., 2010; Rizzo, Reger, Gahm, Difede, & Rothbaum, 2009). Current VRET interventions are trauma-focused, placing veterans into threatening combat situations inducing a flooding effect, often leading to temporary reexperiencing of symptoms including intrusive recall of memories, nightmares, and psychological arousal (Maples-Keller et al., 2017). This may account for high attrition rates in VRET (Beidel et al., 2017) and do not address social avoidance symptoms. To date, although there is research to support the use of VR exposure for PTSD, SAD, and in military populations (e.g., Kampmann, Emmelkamp, Hartanto, Brinkman, Zijlstra, & Morina, 2016; Reger et al., 2016), research has yet to examine the effectiveness of VR exposure therapy with returning combat veterans on comorbid SAD and PTSD symptoms.

Simulation of socially stimulating scenarios through VR delivery could utilize a graduated approach without the initial treatment shock of combat exposure increasing tolerable response in PTSD/SAD patients. Furthermore, it appears that veterans with PTSD/SAD are interested in adapting to common socially stimulating situations, such as navigating a grocery store, but may avoid these places as hypervigilance is stimulated by crowded places, noises, and appearance-based cues (author removed for blind review). Previous research also has highlighted several advantages associated with the use of virtual cue exposure as compared to traditional imaginal or in vivo exposure that may be applicable to treating individuals with SAD. First, participants perceive virtual exposure to feared stimuli as more acceptable than in vivo exposure and, in turn, may be less likely to opt out of exposure-based treatments (Garcia-Palacios, Botella, Hoffman, & Fabregat, 2007). Second, meta-analyses on the treatment of anxiety disorders have found that virtual exposure may be more effective than in vivo exposure, although the observed effect sizes were small (Powers & Emmelkamp, 2008). Third, it may be a cost-effective option for providing cue exposure opportunities for feared situations that may be difficult or costly to repeatedly access in real world settings (e.g., crowded concerts or sports events; Gerardi, Cukor, Difede, Rizzo, & Rothbaum, 2010). Finally, in vivo exposure may provide more sensory stimulation and make it more

difficult for participants to engage in avoidance behaviors than imaginal exposure approaches (Gerardi et al., 2010).

For the purpose of exposure to social scenarios, two different platforms for an immersive experience are compared for their feasibility to provide a realistic scenario that engages the user while stimulating anxiety related symptoms. Three dimensional virtual reality (3 D) scenarios are computer generated graphics that provide a fully immersive environment in which a user may engage in both movement and manipulation, with options for human autonomy and user choices. With the help of a device such as a joystick, user engagement may include moving through the space, picking up objects, or actively engaging with computer generated avatars. Another immersive technology for exposure to social situations is 360° video. Two dimensional (2 D) 360° video provides user with a fully immersive experience using a headset; however, the participant is more of a viewer of the scenario, rather than an actively engaged participant. Thus, 360° video functions more like a fully immersive movie, with an observer experiencing a very realistic scenario, but with no mobility or engagement with items or objects within the scenario. To develop 360° video, videotaping requires panoramic scene capture and foveated stitching, a process for combining panoramic pictures to create a continuous scene (Lee, Chen, Chen, Shen, & Chen, 2017). While user quality rating for presence and acceptability rates tend to be high, participants may also be at risk for cybersickness, a common experience to virtual engagement mimicking motion sickness symptomology (Tran, Ngoc, Pham, Jung, & Thang, 2017). While a variety of technologies, such as VR and 360° video, are becoming increasingly available to enhance exposure protocols, researchers have yet to compare the relative advantages and disadvantages for the clinical application of these modalities. The dearth of findings comparing these two platforms leaves researchers with little direction for platform selection. Research comparing the immersion, feasibility, and acceptability of these platforms may provide important guidance for clinical research.

Current study

The current study is an ancillary study nested within a larger project on VR interventions for SAD with military veterans (author blinded for review). To determine the most potent exposure platform for VR cue exposure therapy to address social anxiety symptoms, this project sought to examine participants' reactions to two modalities, VR and 360° video. Previous qualitative interviews produced a hierarchy of low, medium, and highly stimulating social environments for student veterans with social anxiety and PTSD (author blinded for review). From these interviews, a

hierarchical model of low to highly stimulating environments were derived based on factors of crowding, potential for uncertainty, and triggers related to noises. Several different scenarios were identified as moderate to highly stimulating including sporting events, crowded buses or transportation, and grocery stores. As participants were often likely to avoid these environments, and visiting a grocery store was identified as a necessary routine, a grocery store was chosen for prototype in both VR and 360° video (author blinded for review). Both prototypes were developed to be experienced through fully immersive headsets. Qualitative and quantitative measures are presented in this paper to describe the participants' symptom presentations and reactions to VR and 360° video environments, both viewed through an Oculus Rift (Desai, Desai, Ajmera & Mehta, 2014). Interviews were analyzed to identify themes related to experiences of anxiety. It was expected that participants would find participation in both modalities to be acceptable, feasible, and immersive. The current study was exploratory in nature and no specific hypotheses were made regarding differences in participants' perceptions of the VR and 360° video environments.

Method

Measures

Demographics

This self-report measure collected information about age, gender, ethnicity, marital status, mental health diagnosis, military experience, and education.

Social avoidance and distress scale (SAD; Watson & Friend, 1969)

The SAD is a 28-item self-report measure used to assess social anxiety. The questionnaire has demonstrated good internal consistency ($\alpha = .94$) and test-retest reliability ($r = .68$-$.79$; Watson & Friend, 1969). In order to be eligible for the current study for inclusion in the study, participants needed to report a minimum score of 4 for men and 1 for women, which is indicative of a medium range of symptomology. Participants in the current study endorsed all endorsed medium ($n = 3$) or high ($n = 9$) levels of social anxiety using this measure.

PTSD checklist for DSM-5 (PCL-5; Weathers et al., 2013)

The PCL-5 is a 20-item self-report questionnaire that is commonly used to screen for symptoms of posttraumatic stress disorder. Previous research on the PCL-5 has demonstrated good psychometric properties including internal consistency ($\alpha = .94$), test-retest reliability ($r = .82$), and convergent validity ($r = .74$–$.85$; Blevins, Weathers, Davis, Witte, & Domino,

Table 1. Demographic and questionnaire data.

	Virtual reality	360° video
Demographics		
Age	$M = 32.00$ ($SD = 9.26$)	$M = 30.00$ ($SD = 4.06$)
Gender		
Female	$N = 0$ (0%)	$N = 2$ (40%)
Male	$N = 7$ (100%)	$N = 3$ (60%)
Ethnicity		
Hispanic	$N = 2$ (29%)	$N = 2$ (40%)
Non-Hispanic White	$N = 5$ (71%)	$N = 3$ (60%)
Marital Status		
Divorced	$N = 1$ (14%)	$N = 1$ (20%)
Married	$N = 4$ (57%)	$N = 1$ (20%)
Never Married	$N = 2$ (29%)	$N = 3$ (60%)
Years of Military Service	$M = 7.50$ ($SD = 6.41$)	$M = 8.40$ ($SD = 4.83$)
Number of Deployments	$M = 1.71$ ($SD = 1.11$)	$M = 1.40$ ($SD = 0.89$)
Questionnaires		
PCL-5	$M = 50.00$ ($SD = 17.98$)	$M = 40.20$ ($SD = 16.12$)
SAD	$M = 21.14$ ($SD = 4.71$)	$M = 18.20$ ($SD = 6.57$)
CEQ	$M = 18.71$ ($SD = 8.16$)	$M = 13.00$ ($SD = 7.11$)
PSQI	$M = 11.14$ ($SD = 3.24$)	$M = 9.40$ ($SD = 1.95$)

2015). Using the PCL-5, a scores above 31 are considered to be indicative of a probably diagnosis of PTSD (Bovin et al., 2016). In the current study, 66.7% ($n = 8$) of participants met this threshold.

Combat exposure scale (CES; Keane et al., 1989)

The CES is a 7-item self-report measure that assesses the frequency, duration, and degree of loss associated with exposure to combat stressors. The measure has good internal consistency ($\alpha = .85$) and test-retest reliability ($r = .97$; Keane et al., 1989). In the current study, participants' scores indicated a range of combat exposure experiences (light ($n = 2$); light to moderate ($n = 5$); moderate ($n = 2$); and moderate to heavy ($n = 3$)).

Pittsburgh sleep quality index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989)

The PSQI is a self-report assessment of 7 components of sleep quality (e.g., subjective sleep quality, sleep latency) that has demonstrated good internal consistency ($\alpha = .80$) and convergent validity ($r = .65$-$.77$) across diverse populations (Carpenter & Andrykowski, 1998). In the current study, all participants had scores above 5 which is the cutoff score that indicates probable presence of a sleep disorder.

Reactions to simulation

Participants' reactions to the VR and 360° video stimuli were assessed using three items that asked participants to rate their experience of anxiety, motion sickness, and imersiveness on a 10-point Likert scale (1 = not at all

Figure 1. Exterior and interior large grocery store environment with light customer traffic in warped 360° view.

to 10 = extremely). The items were assessed after the participant had completed their experience in the virtual environment.

Content interview

A semi-structured phenomenological interview was developed to inquire about experiences, such as places, situations and groups, related to veteran social avoidance/anxiety (author blinded for review).

Participants

Participants were randomly assigned to two groups for prototyping two different virtual environments, a 2-dimesional (2 D) 360° video ($n = 5$) and 3-dimensional (3 D) VR ($n = 7$) representation of a grocery store. After exposure to the virtual environment, both groups were interviewed about their experiences to collect data on feasibility, acceptability, and immersion. Interviews for both groups were audio and video recorded by the research team and transcribed by a third-party transcription service. Participants in both groups were similar in their demographics, military service, and mental health symptoms. Summary data of the participants' demographic and questionnaire data is provided in Table 1.

Procedure

All procedures were conducted with approval from the university's Institutional Review Board. Student veterans registered at a large southwestern university (with approximately 1100 student veterans) were recruited via an email explaining the purpose of the study and including a link to the prescreen survey. The campus has been recognized for its veteran supportive programing. Participants were randomly selected from the prescreen pool. Upon receipt of consent to participate, student veterans were invited to a virtual reality laboratory where they were debriefed about the goals of the study and the research procedures. A research assistant

Figure 2. Exterior and interior large grocery store environment with ligh customer traffic in 3-D VR computer generated environment. Three stages of the session are shown: beginning of the session in the parking lot of the grocery store (left), shopping process (middle), checkout at register (right).

placed biometric equipment on the participants while they were seated in a chair, and a baseline reading was obtained during the first five minutes. Participants then completed the assessment battery. For 3 D VR, participants completed a 2-5 minute sandbox training on controlling movement in the space. Participants were then exposed to either a 360°video (see Figure 1) or 3 D VR grocery store (Figure 2). The 3 D VR grocery store was developed to align with similar socially stimulating cues as the 360° video including crowd size and noise. However, due to differences related to structural feasibility of designing the 3 D VR version, the design of the store structure was slightly different in the two modalities. Additionally, noises in the store were slightly different, as the 360° video sound was recorded during filming. The 3 D VR sounds were created by developers and applied to the digital space. Participants from both groups were asked to explore the environment for five minutes. While exploring the space, the 3 D VR participants were asked to complete a task of obtaining an item and placing it in their basket. This instruction was to ensure that participants in the 3 D VR condition utilized the interactive capabilities of this modality while in the environment. After the five minute exposure, VR headset equipment was removed. Participants were then asked to provide a quantitative rating, using a scale from 0-10, on the immersiveness of the environment, their level of anxiety during the simulation, and the extent to which they experienced motion sickness. A summary of these findings are presented in Table 2. Participants were also asked qualitative questions related to user experience, emotional triggers of anxiety, and potential changes to the environment that would induce greater anxiety. A guide for these interviews was designed by the research team. Sample questions include “Are there specific social situations that you try to avoid because of your concerns or anxious feelings?” and “What is it about these situations that create anxiety for you?”. The questions were directly derived from Emotional Processing Theory (Foa & Kozak, 1986) investigating potential of activation of emotional structure based upon stimuli paired with an associated fear based experience.

Table 2. Quantitative environment data.

	Virtual reality		360° video	
	M	*SD*	*M*	*SD*
Immersiveness	4.83	1.69	6.38	2.50
Anxiety	4.33	2.44	3.63	1.80
Motion Sickness	1.33	2.44	2.50	2.18

Table 3. Frequencies of qualitative themes.

Theme	Virtual reality	360° video
Immersiveness		
Cognitive awareness of simulation	71.4% ($n = 5$)	60% ($n = 3$)
Adverse reactions		
Symptoms of nausea, perspiration, and dizziness	71.4% ($n = 5$)	20% ($n = 1$)
Inconsistency in visual and kinesthetic experiences	42.9% ($n = 3$)	0% ($n = 0$)
Glitches in visual images	28.6% ($n = 2$)	80% ($n = 4$)
Anxiety		
Audio cues	100% ($n = 7$)	40% ($n = 2$)
Crowd density	100% ($n = 7$)	60% ($n = 3$)
Line of sight	85.7% ($n = 6$)	40% ($n = 2$)
Control	71.4% ($n = 5$)	40% ($n = 2$)
Physical characteristics and behaviors of others	57.1% ($n = 4$)	80% ($n = 4$)
Usability		
Applicability to real world scenarios	42.9% ($n = 3$)	60% ($n = 3$)

Upon data collection, the interview transcripts were analyzed by the first two authors of this manuscript using a phenomenological approach to qualitative data analyses and using commonly accepted guidelines (Hycner, 1985). Each coder independently reviewed the transcripts in their entirety prior to coding data for meaningful units or thematic content. Once the coders had completed their independent analysis of the transcripts to compare qualitative themes. No significant differences were noted between coders. These themes included content related to immersiveness, intensity of anxiety, cues related to anxiety, motion sickness/adverse reaction, technological limitations, strengths, and usability. Using the final list of themes, the transcripts were again reviewed to identify patterns, both within- and between- virtual environments. See Table 3 for a comprehensive listing of themes and information about the frequency that themes were discussed by participants.

Results

Immersiveness

Participants who experienced a 360° video virtual environment reported that the experience was slighly more realistic than participants who experienced a VR virtual environment ($M = 6.38$ versus $M = 4.83$ on a scale of 0-10). Participants in both conditions noted that glitches in the visual images were related to decreased immersiveness in the environment (e.g.,

insufficient stitching of 360° video images or delays in visual images as a participant moved through the VR environment). These weaknesses in technology will be discussed in more detail in a subsequent section. Some users noted that although they were highly present in the virtual environment, they maintained awareness that the environment was a simulation. For example, one participant in the VR condition noted that "I was immersed, but is was still a game … The anxiety was still there, but it wasn't uncomfortable because I knew I could get away from it-not like being in a store … So it's like playing a normal game, but you know, more intense. You are sitting here experiencing something and you can still take it off, or change it, if you want to".

Adverse reactions and motion sickness

Participants in both conditions reported few adverse reactions and endorsed minimal experiences of motion sickness ($M = 1.33$ in the VR environment versus $M = 2.50$ in the 360° video virtual environment using a scale of 0-10). However, there were large individual differences related to the experience of motion sickness in both conditions (range = 0-6.5 and $SD = 2.44$ in the VR environment versus range = 1-6 and $SD = 2.18$ in the 360° video virtual environment). Participants who endorsed higher levels of motion sickness described symptoms of nausea, perspiration, and dizziness. In the virtual reality environment, individuals who experienced motion sickness noted that going around corners in the environment and instances where the visual experience did not match the participants' kinesthetic movements (e.g., when the participant moved their head and the image didn't change as quickly). In contrast, participants in the 360° video virtual environment noted that their motion sickness was associated with instances when "you're moving and the image is bouncing a bit more" and that the experience was worst "at the very beginning, until I got oriented to how things were moving".

Anxiety

On average, participants experienced low to moderate levels of anxiety while in the VR and 360° video environments ($M = 4.33$ and $M = 3.63$ on a scale from 0-10, respectively). Several sub-themes related to specific cues associated with anxiety were identified. These themes were largely consistent across both modalities.

Audio cues

Participants in the virtual reality environment noted background noises, including a baby crying, a car alarm, and grocery items breaking, that were

strongly associated with increased anxiety. Additionally, avatars who spoke directly to the participant (e.g., a cashier asking how your day is going) or conversations between avatars who were in close proximity to the participant also were associated with increased anxiety. One participant offered an explanation related to the relationships between audio cues and his anxiety, "When you're in combat, sound has a lot to do with it, people don't usually think about that. When I was in combat, we would get shot at from over a mile away sometimes and you would hear it before you would ever see it. So being able to hear clearly is very important if you're in situations where your anxiety is coming up and you're in survival mode and can't hear as much". In contrast, participants in the 360° video condition did not comment on the noises with one participant noting that "the noises seemed normal, I didn't hear anyone screaming. If there were kids screaming their heads off, I wouldn't be able to concentrate".

Crowd density

Participants in both conditions noted that their anxiety would have increased if the number of other individuals present in the environment increased. Several participants in the 360° video environment noted that there were fewer people in the environment than would be typical at their usual grocery store. One individual in the VR environment noted that there anxiety would increase "if it was a little more crowded, or if the aisles were a little narrower. Because I know, at least for me, that I'm more comfortable at Walmart where it's bigger. At (local grocery store), where aisles are only like two people wide, it makes me uncomfortable where I need to weave through traffic." Similar themes were noted by individuals in the 360° video environment, with one participant suggesting that future videos be filmed "on a Saturday, in the middle of the day, or Sunday right after church".

Line of sight

Areas in both of the virtual environments that had obstructions preventing participants from being able to visually survey their surroundings were associated with higher levels of anxiety than areas that had a clear line of site. One participant in the 360° video environment noted that they were most anxious when "we were walking down the meat section with all the aisles on your left, because whenever I'm going down a section like that I look at each aisle, each one of them, like going down a road". Similarly, a participant in the VR condition noted that "The most uncomfortable aisles were the more crowded ones that had a lot of people and different things in it. You would have to sit and figure out what everything was." Finally,

audio cues that were not associated with a visible source were associated with increased anxiety in the VR environment, such as "hearing people talk in the corner or in my blind side".

Control

Themes related to the participant's ability to control elements of the experience emerged across both modalities. Participants in the 360° video condition noted a relationship between not being able to interact with the environment as an element that increased their anxiety. For example, a participant in the 360° video condition stated that "the video went on routes where I wouldn't go that way, you know? Like, through a group of people? No way." This participant noted a connection between not having control over physical location within the environment and an increase in anxiety. In contrast, participants in the VR environment reported using strategies that would increase their control over the environment and, in turn, decrease their anxiety. These strategies included spending time in less densely populated areas of the grocery store: "In the end, there were places with less sound, like the produce section. I'm over there like- there's nobody in the aisle, sounds were totally down, and it was like I was alone for a second." Additionally, participants in the VR environment utilized distraction techniques to manage their anxiety, such as "(my anxiety) was a lot better when you told me to get three things and then go check out because that's what I do (in real life scenarios)". Similarly, participants in the VR environment moved through the environment in ways that helped alleviate anxiety: "If there were people who cut in front of me, I would stop and let them pass. I never walk in front of somebody and let them walk behind me".

Physical characteristics and behaviors of other individuals

Many participants noted physical characteristics and behaviors of other individuals present in the environment to be associated with their experience of anxiety. However, the cues that were highlighted by participants varied widely across individuals, both within- and between- conditions. In the VR condition, participants discussed a variety of characteristics associated with other individuals, including "I mean, obviously, the guy peeking through the door." and "I was more suspicious about certain people but not so much about others, like the girls. But I'm suspicious about men. Their clothing, the length of their hair, those kinds of things. Whether they were whiter, darker." In the 360° video environment, participants also noted a variety visual or behavioral cues related to others in the environment, including focusing on specific individuals: "There was a bigger guy

that made me feel a bit uncomfortable but I can't point to the reason why" or "The old man when I walked into the group of people who were at the deli and the bakery area. There was a guy with brown hair walking by me who kept getting closer to me".

Weaknesses in technology

A number of weakness associated with the technology used to create the VR and 360° video environments were noted by participants in both conditions. In the VR environment, the primary concerns noted by participants were related to inconsistency between the visual environments and the participant's movements and programing glitches that resulted in strange visual cues (e.g., two avatars walking into one another). Interestingly, one participant in the VR condition had a controller that was low on battery power and impeded his movement around the environment. He reported a significant increase in his anxiety level when he could no longer control his movement in the grocery store, further confirming the role of control in managing anxiety. In the 360° video environments, participants primarily noted inconsistencies in the videos that were distracting which included the perspective of the video being positioned to high which resulted in a participant "feeling too tall" in the simulations, the quality of the video being "grainy" or "blurry", and problems with stitching images from different cameras.

Usability of virtual environments

Participants in both conditions of the current study noted aspects of their experiences in the virtual environments that could be helpful for reducing anxiety in real-world settings. These comments highlighted the potential for virtual exposure to decrease anxiety through habituation in a safe environment which could allow users to process their cognitions and emotions more effectively. For example, one participants in the 360° video condition stated that it could be helpful for coping with similar, real-life situations because "I think my method is to avoid, so if you're exposed to a situation more often, then it could help to ease some of the anxiety that you're feeling, maybe help you reevaluate why you're feeling so anxious, is it so bad?". Similarly, a participant in the virtual reality condition was able to note similarities in his responses to the virtual reality environment and his local grocery store: "My anxiety felt around where it would normally feel. I think sometimes I feel more intense (anxiety) in a normal grocery store just because I notice myself being anxious … and it kind of overwhelms

you. It was not quite as much as it would've been at the store … but I had the fight or flight, the wanting to leave".

Discussion

Both environments were associated with minimal adverse effects, were experienced as being immersive, elicited moderate to strong anxiety responses from the participants, and were viewed as being usable modalities from an intervention perspective. Participants in the current study did not report any adverse effects associated with their participation beyond mild symptoms of motion sickness. This finding is consistent with previous research that has demonstrated that although there are several possible side effects, such as motion sickness, associated with virtual environments, adverse events are uncommon (Sharples, Cobb, Moody, & Wilson, 2008). Most participants also experienced increases in anxiety within minutes after beginning exposure to the virtual environments, suggesting that both VR and 360° video environments are feasible options for facilitating cue-based exposure protocols. Similarly, the simulated environments were found to be highly immersive. Although participants noted differences between the virtual environments and real-world settings, the participants reported that both the VR and 360° video environments were reflective of situations that typically evoke their social anxiety. Finally, participants using both modalities were able to articulate specific benefits of using virtual environments as a component of treatment for social anxiety disorder.

Both platforms, 360° video and 3 D VR, offer unique benefits and limitations for clinical research for social anxiety with veterans. One benefit of 360° video includes realistic imagery founded in panoramic video that may be more realistic than 3 D computer graphics. Without high quality foveated stitching, seams between video segments are a barrier to obtaining high quality film providing a true to life exposure in a social setting (Lee et al., 2017). Lack of autonomy and control associated with 360° video may stimulate more anxiety for the participant than VR, as socially anxious individuals will often avoid by removing themselves from distressing stimuli or finding coping strategies when confronted with discomfort (name deleted to maintain the integrity of the review process, 2018). Finally, 360° videos do not allow participants to make choices to remove themselves from situations, as the film is static and moves at the pace of the original filming.

Juxtaposed to 360° video's lack of autonomy, 3 D VR offers users opportunities to control and move within the virtual space. While current 3 D VR computer graphics are not completely realistic, they appear provide environments that sufficiently evoke anxiety for treatment. Furthermore, 3 D VR graphics may provide a greater sense of immersion than 360° video

due to level of active engagement with the environment. For example, VR's 3 D graphics may increase self-awareness and emotional safety, allowing participants to work on anxiety related cues without needing to withdraw from the scenario. However, 3 D computer graphics require many hours of design (Jeffrey & Al-Gharaibeh, 2015); thus, a significant drawback to VR is the feasibility of creating environments for exposure. Furthermore, there may be scenarios that are unable to be created, such as a sporting event or concert, due to the complexity of programing.

Limitations

As with all research, the current study has a number of strengths and limitations that should be considered in interpreting the results. First, the relatively small sample size associated with this study is a significant limitation and, as a result, the findings of this study should be interpreted as a preliminary contribution to understanding the experiences of individuals using 3 D VR and 360° video environments for cue exposure. Although the sample size does represent a notable limitation, the sample size in the current study is comparable with previous qualitative research and consistent with guidelines set forth for phenomenological qualitative research (Creswell, 1998; Morse, 1994). Nonetheless, future research should seek to replicate the current findings with a larger sample to ensure generalizability.

To our knowledge, the current study is the first to compare the experiences of participants using 3 D VR and 360° video environments for cue exposure. As technology continues to evolve, it will be important for researchers to continue to examine the advantages and limitations of emerging platforms for the treatment of anxiety disorders. Previous research has highlighted the importance of method triangulation, or the inclusion of multiple data sources, in qualitative research designs (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014). Although, the current study included both qualitative interview and quantitative survey data and the current study was unable to use statistical analyses to compare data across conditions. Additionally, although the current study lacked the statistical power to examine interactions between individual difference variables (e.g., measures of psychopathology) and participants' perceptions of the virtual environments, understanding these interactions through future research is important for determining how to maximize the clinical benefits of virtual cue exposure.

Future directions

The experiences of the participants involved in this case study suggest that both VR and 360° video environments can be used to enhance existing

treatment protocols for anxiety and PTSD. Customized virtual environments for cue-based exposure could be used to provide repeated exposure to feared stimuli that can enhance treatment outcomes. One advantage of virtual environments is that they can easily be modified to titrate the level of anxiety an individual would experience. Both participants were able to identify specific stimuli that contributed to their level of anxiety in the simulation. These variables could be used to create a stepped hierarchy of environments that gradually increase in intensity as individuals progress through treatment. Additionally, the presence of stimuli could be individualized based on the factors that are most strongly associated with anxiety in each individual patient. Additionally, future research could use subscales on the SAD assessing distress and avoidance to examine whether individuals with different symptom presentations (e.g., primarily avoidance versus primarily distress symptoms) engage with the virtual environments in disparate manners.

It is not always feasible for therapists to accompany patients to in vivo exposure sites and providing therapeutic feedback in public settings has the potential for compromising a patient's right to confidentiality. Although the current study was focused on the development and validation of VR and 360° environments, future research could examine the effectiveness of combining skills training with exposure to virtual environments. For example, patients could engage in virtual cue exposure to a variety of environments while therapists coach them on using coping skills that can help reduce their anxiety (e.g., cognitive restructuring, mindfulness). In addition, the current study did not include assessment of participants' anxiety throughout the exposure to the virtual environment. This represents a notable limitation in the current study's findings because patterns during exposure, such as habituation over time, are not able to be assessed. In fact, many gold-standard, exposure based treatments for PTSD, such as prolonged exposure, includes regular assessment of an indivudal's experience of anxiety throughout imaginal or in vivo exposure exercises (Foa & Rothbaum, 1998). Future research including real-time measurement of anxiety or subjective units of distress would expand upon the findings of the current study and allow researchers to make more specific recommendations regarding the duration and intensity of virtual exposure protocols.

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