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# Feasibility of Virtual Reality Exposure Therapy in the Treatment of Danish Veterans with Post-Traumatic Stress Disorder: A Mixed Method Pilot Study

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## Abstract

The BraveMind virtual reality exposure therapy (VRET) has been developed and has shown efficacy for U.S. service members and veterans. As the first study to date, the present study examined the feasibility of BraveMind VRET for non-U.S. military veterans. Moreover, the study sought to explore in-depth the participants' experiences with BraveMind VRET. Nine Danish veterans with post-traumatic stress disorder (PTSD) after deployment to Afghanistan participated in the study. PTSD, depression, and quality of life were assessed at pretreatment, post-treatment, and 3-month followup. The treatment consisted of 10 BraveMind VRET sessions. Semistructured interviews with treatment completers were conducted post-treatment to ascertain views about the treatment, in general, and the BraveMind VR system in particular. Thematic qualitative analysis was conducted at the semantic level using an inductive approach. There were significant reductions in pre- to post-treatment self-reported PTSD and significant improvements in quality of life. Treatment gains were maintained at 3-month followup. Pre- to post-treatment Cohen's *d* effect sizes were large for self-reported PTSD (PTSD Checklist–Civilian Version [PCL-C]:  $d = 1.55$ ). Qualitative results indicated that the virtual environment of the BraveMind VR system does not entirely map the reality of Danish soldiers in Afghanistan. However, this was not experienced as a hindering factor in therapy. Findings indicate that BraveMind VRET is an acceptable, safe, and effective treatment for Danish veterans with PTSD. The qualitative results emphasize the importance of a strong therapeutic alliance, as VRET is experienced as more emotional straining than regular trauma-focused therapy.

**Keywords:** virtual reality, virtual reality exposure therapy, PTSD, mixed methods, client experience, military medicine

## Introduction

THE DEMANDING CHARACTERISTICS of war result in high rates of post-traumatic stress disorder (PTSD) among military personnel deployed to conflicts in Afghanistan and Iraq. Among Danish soldiers deployed to Afghanistan in 2009, self-reported rate of probable PTSD has been estimated

to 10 percent 2.5 years postdeployment.<sup>1</sup> These rates are similar to the rates observed in British, Australian, and U.S. military samples involved in similar deployments.<sup>2–5</sup>

The Military Psychology Department (MPD) within the Danish Veteran Centre, Danish Defense, offers evidence-based psychological treatment to Danish veterans with deployment-related psychological problems. In light of the

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limited effect of evidence-based treatments for PTSD, such as cognitive processing therapy (CPT) and prolonged exposure (PE),<sup>6,7</sup> there is a persistent need to examine new treatments for PTSD. This is important because research suggests that military and veteran populations experience more modest treatment outcomes than civilians do, with approximately two-thirds retaining their PTSD diagnosis after treatment with CPT or PE.<sup>6,7</sup>

Acknowledging these military behavioral health needs, the U.S. Department of Defense has invested extensively in developing and testing new treatment options for PTSD, including treatments that integrate virtual reality (VR) as a tool to deliver exposure therapy (VRET). One form of exposure therapy is PE, which is based on the Foa and Kozak<sup>8</sup> emotional processing theory. According to this, successful treatment of phobic disorders and PTSD requires emotional processing of fear structures so that the stimuli no longer invoke fear. In this form of therapy, participants revisit traumatic memories through imaginal exposure, where they approach feared, but objectively safe, real-world stimuli. This procedure is meant to activate pathological fear structures and provide corrective information leading to new more adaptive associations and beliefs.<sup>8,9</sup> While the efficacy of PE for PTSD has been established in multiple studies,<sup>6</sup> research has shown that many patients are unwilling or unable to effectively visualize the traumatic event.<sup>10,11</sup> This might be due to avoidance, one of the cardinal symptoms of PTSD.

VRET is expected to offer a way to circumvent the natural avoidance tendency in PTSD by delivering multisensory cues in a highly interactive and emotionally engaging virtual environment that aids the retrieval and processing of traumatic memories.<sup>12,13</sup> Moreover, younger persons with PTSD who have grown up with digital gaming technology may be more attracted to and comfortable with such treatment approaches.<sup>14,15</sup>

In 2011, the BraveMind VR system was developed at the University of Southern California Institute for Creative Technologies through funding from the Department of Defense as a VRET procedure developed explicitly for U.S. military service members and veterans with PTSD from Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF). BraveMind VRET has demonstrated efficacy similar to that of imaginal PE.<sup>12,14,16,17</sup> All empirical studies on BraveMind VRET have been conducted with U.S. military service members and veterans. Therefore, there is a need to investigate the feasibility of this new and promising treatment option for non-U.S. soldiers and veterans.

This study aimed to determine the feasibility of the BraveMind VRET procedure for Danish veterans with PTSD after deployment in Iraq or Afghanistan. The primary goal was to assess the clinical outcomes of VRET in Danish veterans with PTSD. First, we hypothesized that VRET will be safely delivered as a treatment for PTSD, as evidenced by dropout rates consistent with other studies of PE for PTSD (30–40 percent<sup>6</sup>). Second, we expect that participants who complete VRET will improve clinically and statistically pre- to post-treatment in self-reported and clinician-assessed PTSD symptoms, self-reported symptoms of depression, and quality of life. These improvements are expected to be maintained at the 3-month followup assessment.

Given the lack of qualitative studies on the mechanisms of change in BraveMind VRET, a secondary goal is to investigate Danish veterans' experiences of VRET with a special

focus on (a) potential barriers for use and (b) experienced mechanisms of client change. In summary, we chose a mixed-method design that enabled us to (a) assess the clinical outcomes of VRET for Danish veterans with PTSD and (b) investigate in-depth how Danish veterans create meaning in a therapeutic setting using VR technology.

## Materials and Methods

### Setting

Participants were recruited from the MPD within the Danish Veterans Centre. The MPD is the largest provider of psychological treatment for Danish veterans and receives ~800 referrals annually. To be accepted for treatment at the MPD, individuals have to be Danish veterans and to be currently experiencing mental health difficulties related to their deployment.

### Participants and procedure

Veterans who referred themselves to treatment at an MPD clinic located in the capital area of Denmark between November 19, 2018 and June 8, 2020, and who had previously deployed to Afghanistan or Iraq, were invited to participate in the study. Interested veterans participated in a pretreatment assessment to identify a probable diagnosis of deployment-related PTSD. The exclusion criteria were active suicide risk, alcohol or drug dependence, and psychosis. Twelve participants agreed to schedule a pretreatment assessment, with nine completing the assessment. During the pretreatment assessment, participants were informed about the study, they signed consent forms, and their PTSD diagnosis related to deployment in Afghanistan or Iraq was assessed and confirmed using the *Clinician-Administered PTSD Scale for DSM-5* (CAPS-5) and *MINI International Neuropsychiatric Interview* (MINI). All other self-reported measures were conducted at this time.

Once the treatment was completed, treatment completers participated in the Client Experience of VRET Interview (described below), which provided the qualitative embellishment of the findings. The CAPS-5 and all self-report measures were also conducted at the end of treatment and 3-month followups.

### Measures

The CAPS-5<sup>18</sup> is a semistructured interview that corresponds to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5) criteria for PTSD. The CAPS provides a measure of PTSD severity and diagnosis.

The MINI<sup>19</sup> is a semistructured interview that screens for DSM-5 Axis 1 disorders.

The *PTSD Checklist–Civilian Version* (PCL-C)<sup>20</sup> is a 17-item self-report measure designed to assess DSM-IV symptoms of PTSD.

The *Beck Depression Inventory-II* (BDI-II)<sup>21</sup> is a 21-item self-report measure that assesses the severity of depression.

The *WHO-Five Well-being Index* (WHO-5)<sup>22</sup> is a 5-item self-report measure of psychological well-being.

*Client experience of VRET interview.* Participants were interviewed following an expanded version of Elliott's Client Change Interview Schedule,<sup>23</sup> which we customized for

the current study and termed the *Client Experience of VRET Interview*. Comparable customizations of Elliott's Client Change Interview Schedule have been used in similar qualitative studies of client experiences of psychotherapy.<sup>24</sup> The Client Experience of VRET Interview is semistructured, and the overall purpose is to help participants express their experience of VRET as freely as possible. At the same time, the interview also yielded information about specific hindering and helpful aspects of using VR technology in therapy and about possible therapeutic changes in participants during and after VRET. The interviews lasted ~45 minutes and were conducted only at the end of treatment.

### Apparatus

The BraveMind VR system was developed at the University of Southern California Institute for Creative Technologies. The treatment environment consists of 14 virtual scenarios that represent relevant contexts for U.S. OIF/OEF service members and veterans. Figure 1 shows a Danish soldier in front of one of the visual scenarios. In addition to the visual stimuli, directional 3D audio, vibrotactile, and olfactory stimuli of relevance can be delivered by the therapist through a "Wizard of Oz" control panel. Figure 2 shows the vibrotactile floor used in this study. A detailed description of the BraveMind system can be found in Rizzo et al.<sup>25</sup>

### Treatment

The BraveMind VRET procedure follows the standard evidence-based protocol for imaginal PE<sup>26</sup> and consists of weekly, 90-minute individualized sessions over 10 weeks. In place of traditional imaginal exposure, during BraveMind VRET, the patient recalls the traumatic event aloud while the therapist matches the context and sensory details of the event in the virtual environment (e.g., location, sites, and sounds). The therapist in the current project was a licensed clinical psychologist, certified in PE. The therapist had completed a training workshop in VRET and participated in monthly supervision to ensure fidelity and effective implementation of treatment.



**FIG. 1.** A Danish soldier (not a participant in the present study, but volunteering to be photographed) in front of 1 of the 14 virtual scenarios of the BraveMind VR system. VR, virtual reality.



**FIG. 2.** Directional 3D audio, vibrotactile, and olfactory stimuli of relevance can be delivered by the therapist using a "Wizard of Oz" control panel.

## Results

### Feasibility outcomes

Of the nine participants, three discontinued treatment early (i.e., fewer than five sessions), and six completed treatment, resulting in a total dropout rate of 33 percent. One participant dropped out due to the Covid-19 shutdown in Denmark, one because of hospital admission for physical illness, and one due to not liking VRET. The participant stating the he did not like VRET completed imaginal PE, with the same therapist, instead of VRET. Table 1 shows demographic information, and Table 2 shows means and standard deviations for all outcome measures for the intent-to-treat sample ( $n=9$ ).

### VRE treatment outcomes

As shown in Table 3, paired sample  $t$  tests were conducted for the intent-to-treat sample ( $n=9$ ) to examine (a) the average change in symptoms of PTSD, depression, and quality of life between pre- and post-treatment assessments and (b) the maintenance of treatment gains between post-treatment and 3-month followup assessments. As depicted in Table 3, post-treatment assessments were only conducted with the six treatment completers, and 3-month followup assessments were only conducted with four of the treatment completers.

For treatment completers, there was a significant improvement in pre-treatment and post-treatment self-reported PTSD symptoms [PCL-C:  $t(5)=3.81$ ,  $p=0.013$ ] and self-reported quality of life [WHO-5;  $t(5)=-4.15$ ,  $p=0.009$ ]. No

TABLE 1. PARTICIPANTS DEMOGRAPHIC INFORMATION

	<i>Intent to treat, N = 9</i>
Education	
Completed vocational education	5 (50)
Completed high school	3 (37.5)
Completed public school	1 (12.5)
Employment status	
On sick leave	3 (37.5)
Unemployed	1 (12.5)
Part-time	1 (12.5)
Full-time	4 (50)
Military branch	
Army	9 (100)
Military rank	
Private	9 (100)
Deployment (index trauma)	
Afghanistan	9 (100)
Comorbid diagnoses	
Major depressive disorder	8 (87.5)
Generalized anxiety disorder	2 (25)
Panic disorder	3 (37.5)
Social anxiety disorder	2 (25)
Agoraphobia	4 (37.5)
Binge eating disorder	2 (25)
Alcohol abuse—early remission	2 (25)
Drug abuse—early remission	1 (12.5)
Suicide disorder—early remission	2 (25)

Values presented as *n* (percentage).

significant differences were observed between post-treatment and the 3-month followup regarding clinician-assessed PTSD, self-reported PTSD, and quality of life, indicating maintenance of treatment gains from post-treatment to the 3-month followup. Pre- to post-treatment

TABLE 2. MEANS AND STANDARD DEVIATIONS FOR ASSESSMENTS OF POST-TRAUMATIC STRESS DISORDER, DEPRESSION, AND QUALITY OF LIFE

	<i>Intent to treat, n, M (SD)</i>
CAPS	
Pre	9, 34.33 (8.44)
Post	6, 29.50 (5.51)
3 months	4, 22.50 (7.94)
PCL	
Pre	7, 62.86 (10.48)
Post	7, 52.71 (7.20)
3 months	4, 51.75 (15.77)
BDI	
Pre	7, 34.71 (13.40)
Post	7, 26.26 (5.44)
3 months	4, 29.25 (6.90)
WHO-5	
Pre	7, 12.57 (9.64)
Post	7, 28.00 (9.80)
3 months	3, 21.33 (4.62)

BDI, Beck Depression Inventory; CAPS, Clinician-Administered PTSD Scale; PCL, Post-traumatic Stress Disorder Checklist; PTSD, post-traumatic stress disorder; *SD*, standard deviation; WHO-5, WHO-Five Well-being Index.

Cohen's *d* effect sizes were large for self-reported PTSD (PCL-C: *d* = 1.55). Using established criteria for clinically significant pre- to post-treatment score differences, 67 percent (*n* = 4) of study completers demonstrated a clinically significant reduction in PCL-C scores (i.e., 10<sup>+</sup> reduction<sup>6</sup>).

#### *Qualitative method and analysis*

All treatment completers (*n* = 6) participated in the "Client Experience of VRET Interview" post-treatment. All the interviews were audiotaped and transcribed verbatim. The interviews were then analyzed using thematic analyses.<sup>27</sup>

Thematic analysis is essentially independent of theory and epistemology and can be viewed as a useful tool for identifying, analyzing, and reporting patterns or themes within data.<sup>27</sup> The thematic analysis was done with a semantic approach, where the identified themes were identical to the surface meanings of the data and not interpreted beyond these explicit meanings. Thus, all main themes represented data organized to show patterns in semantic context and summarized as a patterned response within the dataset relevant to the question of how Danish veterans react and respond to VRE and the BraveMind system.

The thematic analysis followed five steps. First, we familiarized ourselves with the data to obtain an overview and generated a list of what initially could be interesting to investigate further. Second, we manually coded the interviews and gathered statements in codes that identified specific data features. Third, different codes were sorted into potential themes. Fourth, we reviewed the themes to ascertain that they accurately reflected the meanings evident in the dataset and ensured that relevant additional data were coded within the themes. The final step was to define and name the themes.

#### *Qualitative results: Danish veterans' experience of VRET*

The thematic analyses resulted in five main themes, with each theme having two to five subcategories. The main themes were (a) *VR technology*, (b) *Active treatment components*, (c) *Therapeutic alliance and therapeutic guidance*, (d) *Experienced outcomes of VRET*, and (e) *Experience of VRET compared to imaginal PE*.

**VR technology.** All participants were critical of the virtual scenarios of the BraveMind VR system, underscoring that the graphics were not very believable or realistic. However, they all added that this did not influence the immersion effect or the overall emotional experience.

Regarding the acceptance of the BraveMind VR system, developed specifically for U.S. OIF/OEF service members and veterans, participants widely accepted the BraveMind system even though they reported that the visual content differed from the reality for Danish soldiers in Afghanistan (e.g., location, sites, military vehicles, uniforms, and, of course, language). However, the differences were not reported to be a problem for the immersion effect and emotional engagement in treatment.

**Active treatment components.** All participants highlighted tactile and auditory stimuli from the VR setup (e.g., vibrating floor making vibrations according to explosions and heavy gunfire) as particularly effective regarding

TABLE 3. PAIRED *t* TEST EXAMINING CHANGE IN POST-TRAUMATIC STRESS DISORDER, DEPRESSION, AND QUALITY OF LIFE

Outcome	n	M	SD	M difference	SD Difference	t Test	Cohen's d
CAPS							
Pre/post	6	36.50/29.50	9.77/5.50	7.00	8.65	1.98	0.81
Post/3 months	4	30.25/22.50	6.13/7.94	7.75	9.74	1.59	
PCL-C							
Pre/post	6	64.83/51.83	9.95/7.47	13.00	8.37	3.81*	1.55
Post/3 months	4	54.25/51.75	8.18/15.78	2.50	14.88	0.34	
BDI							
Pre/post	6	35.33/27.67	14.57/4.41	7.67	13.97	1.35	0.55
Post/3 months	4	29.25/29.25	4.57/6.90	0.00	19.42	0.00	
WHO							
Pre/post	6	12.00/25.33	10.42/7.45	-13.33	7.87	-4.15*	1.69
Post/3 months	3	21.33/21.33	2.30/4.61	0.00	6.93	0.00	

\* $p < 0.05$ .

PCL-C, PTSD Checklist–Civilian Version.

participants' emotional engagement in the trauma memory. Participants described how these vibrations made them feel more immersed in the scenarios and made their bodies respond in ways that vividly reminded them of their traumatic experience. In particular, sound effects (such as helicopters and explosions) were mentioned as vital treatment components, where most participants underscored the importance of this component in triggering memories and emotions.

**Therapeutic alliance and therapeutic guidance.** All participants highlighted a strong therapeutic alliance as important, especially the perception of the therapist as someone who provided clear guidance through VRET. Furthermore, therapeutic guidance was described as both practical guidance (with the use of VR technology), emotional guidance (with support and validation through the process), and, most importantly, guidance with moving the trauma narrative forward and therapeutic guidance in the subsequent processing of the trauma narrative. Furthermore, the participants highlighted the importance of feeling safe and secure with the therapist who delivered the VRET protocol and used the scenarios in a flexible and individually adjusted manner.

**Experienced outcomes of VRET.** All participants stated that they had gained something from therapy. The experienced outcomes of VRET can be divided into the following areas.

**Greater awareness and insight into trauma experiences.** Participants described how VRET gave access to new emotions associated with the trauma memory, giving them a richer and more complex understanding of how and why trauma had an impact on them.

**PTSD symptoms.** None of the participants claimed that their PTSD was a thing of the past. However, they all reported positive changes in PTSD symptoms, in terms of fewer nightmares, less anxiety, and decreased hyperarousal and vigilance.

**Personality and interpersonal functioning.** All participants explicitly expressed that they became better at dealing

with difficult emotions through therapy, in addition to expressing their thoughts and feelings toward significant others without falling apart.

Experience of VRET compared to "imagination-only" exposure therapy. Five of the six treatment completers had previous experiences with trauma-focused therapy, and two had specific experiences with imaginal PE. These participants found VRET to be more emotionally straining than imaginal PE and described how it gave more access to emotions, traumatic memories, and therapeutic reflections. Several participants described how VRET differs from regular therapy by providing a setting where "you can't get away or hide" from your emotions and memories, underscoring the very confrontational nature of the VRE treatment program.

## Discussion

This initial feasibility study examined the feasibility of the United States-developed BraveMind VRET procedure for non-U.S. military veterans. Moreover, the study sought to explore participants' experiences with BraveMind VRET in more depth.

The findings indicated that BraveMind VRET is an acceptable, safe, and effective treatment for Danish veterans with PTSD. Participants reported significant positive changes from pre- to post-treatment regarding self-reported PTSD symptoms and QoL. These treatment effects are consistent with similar studies of exposure-based treatments for PTSD.<sup>6,7</sup> Treatment gains were maintained at 3-months followup. The dropout rate (33 percent) was consistent with other PE treatment studies (30–40 percent) reported in PE for PTSD.<sup>6</sup>

The qualitative findings support the quantitative findings as treatment completers reported positive changes in PTSD symptoms in terms of fewer nightmares, less anxiety, and decreased hyperarousal and vigilance after BraveMind VRET. Moreover, participants reported that VRET made them better capable of dealing with their negative emotions, expressing thoughts and feelings, and sharing details of their trauma narrative with others.

All treatment completers stated that the virtual scenarios (designed to represent relevant contexts for U.S. OIF/OEF service members and veterans) did not entirely map the contexts for Danish veterans in Afghanistan. However, they all stated that this did not significantly influence the immersion effect. This is an interesting finding, since it indicates that VR, when used as a tool to deliver exposure therapy, does not require a set of stimuli identical to the original contexts of the trauma to activate the fear structure and enhance processing of the traumatic memories.

Treatment completers described VRET as more emotionally straining than previous experiences with imaginal PE and trauma-focused therapy and that it gave more access to emotions, traumatic memories, and therapeutic reflections. This finding is interesting, as it supports the anticipations of the BraveMind VR system as a method to immerse the user within the controlled stimulus environments, believed to help support user engagement with typically avoided trauma-relevant experiences, required to activate the emotions needed for therapeutic exposure to occur.<sup>25</sup>

In fact, early research of imaginal PE has shown that inability to engage emotionally (in imagination) is a predictor for negative treatment outcomes.<sup>28</sup> Thus, the qualitative results of the present study suggest that VRET offers a way to circumvent the natural avoidance tendency by directly delivering multisensory and context-relevant cues that aid the confrontation and processing of traumatic memories.

A randomized controlled trial study with active-duty U.S. military soldiers with PTSD compared the relative effectiveness of VRET, PE, and a waitlist control.<sup>14</sup> The study found no significant differences between VRET and PE post-treatment. However, greater improvement in PTSD symptoms was found at the 3- and 6-month followups with PE. A possible explanation for the followup results is that this study used a more limited 4-scenario Virtual Iraq/Afghanistan system and not the most recent and updated BraveMind system consisting of 14 diverse scenarios (used in the present study).

Results should be interpreted based on the limitations of the study, particularly the small sample size. Another important limitation is that medication (for conditions such as anxiety, depression, and PTSD) was not accounted for in pre- or post-screening. Further studies of psychotherapy interventions should control for potential effects of medication. Finally, the study lacks long-term followup assessments. Future research should replicate the current study with larger samples to examine the feasibility of the BraveMind VRET procedure with non-U.S. soldiers and veterans.

## Conclusions

In conclusion, this initial feasibility study suggests that BraveMind VRET is an acceptable, safe, and effective treatment for Danish veterans with PTSD after deployment in Afghanistan. The participants reported significant effects in clinical outcomes and dropout ranges that correspond to traditional exposure therapy for PTSD.<sup>6</sup> Qualitative results emphasize the importance of the therapeutic alliance and the adaptation of the VR scenarios to the individual client's trauma memory.

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## Ethical Approval

Before commencing the study, ethical approval was obtained from the Regional Research Ethics Committee of Denmark (ID No. SJ-760). All participants provided their written informed consent. Data were handled confidentially and according to GDPR.

## Data Access Statement

Due to privacy and data protection regulations of the Danish Defense, data from the current study cannot be shared.

## Authors' Contributions

S.F. and N.R. conceptualized the study. All authors contributed to the methods and study design and to the writing of the article. All authors are responsible for and accountable for the results.

## Author Disclosure Statement

No competing financial interests exist.

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