LUPINE PUBLISHERS

Scholarly Journal of Psychology and Behavioral Sciences

DOI: 10.32474/SJPBS.2022.06.000245

ISSN: 2641-1768

Research Article

More Than Just a Distraction: The Impact of Augmented Reality Meditation on Stress, Anxiety, and Mood

Ray Jackson[1,2]*, Jeff Tarrant[1] and Kayla Fromdahl[2]

[1]*Neuro Meditation Institute, Eugene, OR, USA*

[2]*University of Oregon, Eugene, OR, USA*

***Corresponding author:** Ray Jackson, Neuro Meditation Institute, Eugene, OR, USA

Received: August 30, 2022 **Published:** September 19, 2022

Abstract

In the face of a mental health crisis in the United States, stress and anxiety management strategies that are accessible, engaging, user-friendly, and effective may be more important than ever. In this study, 37 participants between the ages of 22 and 73 from across the U.S. were randomly assigned to two different phone-based interventions: either an Augmented Reality (AR) meditation-based app intervention or a dot to dot interactive distraction technique. Participants downloaded their assigned apps to their personal smartphones and engaged in the app for 4 minutes each day for 5 consecutive days. Measurements included daily pre- and post- mood questionnaires as well as pre- and post- intervention questionnaires measuring perceived stress and anxiety. Both groups exhibited a decrease in anxiety over the 5 days, with those scoring higher in anxiety levels seeing stronger effects with the AR intervention. The AR group also demonstrated reductions in perceived stress while the distraction group showed increases. Significant differences occurred in mood subscales favoring AR. These findings suggest that a brief AR mobile meditation application practice can reduce aspects of negative mental health. In addition, the results obtained from the Healium AR group appear to be related to something greater than distraction. Further research is needed to examine the long-term impact of these types of applications.

Keywords: Augmented Reality; Mindfulness; Anxiety; GAD; Perceived Stress; Nature

Introduction

Anxiety disorders are the most common mental health concerns identified in population-based surveys. In fact, it has previously been estimated that nearly 34% of the U.S. population will experience an anxiety disorder during their lifetime [1]. In addition, some estimates suggest that there may be twice that number suffering with undiagnosed anxiety [2]. In the face of the Covid-19 pandemic, these numbers appear to be on the rise, potentially leading to a mental health crisis. A Kaiser Family Foundation Health Tracking Poll conducted in April 2020 revealed that 56% of the 1,202 adults surveyed indicated that worry or stress related to the coronavirus has negatively affected them. The most common concerns included sleep problems (40%), poor appetite or overeating (33%), frequent headaches or stomach aches (18%), difficulty controlling their temper (15%), increased use of alcohol or drugs (13%), and worsening chronic health conditions (9%;) [3].

This is consistent with previous research showing that chronic stress contributes to the development of insomnia, panic attacks, substance abuse, depression, high blood pressure, and increased risk for cardiovascular disease [4-6]. Given the number of people affected, and the potential health impacts, researchers are increasingly calling for a "digital mental health revolution" [7]. It is noted that fewer than half of those with significant mental health concerns receive the care they need, with underserved populations being disproportionately affected [8,9]. Consequently, it is critical

that we identify stress-management tools that are accessible, and user-friendly, such as smart-phone based applications [7]. While there are more than 10,000 apps dedicated to addressing mental health concerns, almost none of them have been evaluated scientifically [10], and certainly none have been evaluated during a prolonged global health crisis.

Mindfulness-based exercises are one of the most common approaches used in phone-based stress management apps [11]. This is not surprising as even brief meditative experiences have been shown to reduce state stress and anxiety [12,13]. More recently, it has been shown that virtual technologies, such as Augmented and Virtual Reality (AR and VR), also have the potential for supporting personal and clinical change [14]. Several studies have now demonstrated that AR and VR can be used to positively impact anxiety and mood. For example, two recent studies have shown that a brief meditation-based experience in VR can be an effective tool to reduce anxiety and increase positive mood states in subjects with moderate to high levels of anxiety [15] and just prior to a stressful experience [16]. The positive effects from these interventions may be partly due to the novelty of the experience as well as the immersive nature of VR/AR. In essence, virtual technologies provide a level of presence that may aid the user in becoming more engaged and motivated, allowing them to more easily distance themselves from ruminative or negative thoughts [17]. In addition, there is evidence that some clients prefer VR based therapy approaches to more traditional approaches [17].

Augmented reality, in comparison to virtual reality, is defined as a real time direct or indirect view of the physical (real world) environment that has been enhanced by adding virtual computer-generated information [18]. AR creates a novel environment that helps distract the mind from internal thoughts, but does not require a complete break with physical reality. While not as immersive as VR, AR apps may be more accessible and user-friendly given that many can be accessed through a smart phone and do not require additional equipment. To date, there are only two known studies examining a meditation-based experience in AR. Researchers at the Shibara Institute of Technology compared an AR stress management application to traditional teaching methods, focused on slow, methodical breathing. Their results indicated that the AR condition resulted in greater feelings of comfort and relaxation. In addition, subjects rated the more traditional experience as significantly more "boring" and resulting in tiredness [19]. Viczko, et al. [20] demonstrated that a brief phone-based AR meditation could significantly decrease negative mood states while significantly increasing positive mood states in 4 minutes. These studies provide preliminary evidence that virtual meditative experiences may be an effective alternative to traditional meditation approaches in decreasing state stress and anxiety levels. However, it is possible that these positive results are the result of novelty or distraction rather than the meditation experience itself. As noted previously, one of the most powerful elements of virtual technologies is their ability to immerse the user in a different environment.

Distraction techniques that involve offering an alternative focus for attention have been used in a variety of studies as a successful intervention to reduce pain and stress [21,22]. Because virtual technologies are more immersive and have more presence, it makes sense that they may have an enhanced ability to provide effective distraction from pain and discomfort [23,24]. A review of studies examining the use of VR distraction for pain management concluded that VR is effective at reducing experimentally induced pain as well as pain related to care for burn injuries [25]. A more recent study found that VR can be considered an effective distraction technique for children and adolescents' pain management during venipuncture. Moreover, it was found that the VR intervention resulted in more positive emotions than traditional distraction techniques [26].

The current study was designed, first and foremost, to determine if a phone-based AR meditation experience could be used successfully to reduce stress and anxiety. The authors also wanted to know if such an intervention would continue to have a positive impact beyond the initial exposure. In essence, would the intervention be effective if used repeatedly over several days after the initial novelty has worn off? In addition, it seemed important to determine if any observed positive effects were due to distraction or something more specific to the meditation AR experience. Would the AR condition have positive effects above and beyond simple distraction? It was hypothesized that both groups would report stress relief in response to the intervention. However, these researchers predicted that the AR group would demonstrate significantly greater impacts on daily mood as well as after repeated use for a 5 day period. To address these questions, subjects were asked to complete either a phone-based AR meditation experience or a phone-based game (distraction) each day over a 5-day period. The researchers examined pre (day 1) - post (day 5) responses to measures of generalized anxiety and stress as well as daily pre-post changes in mood. The study was performed remotely through the NeuroMeditation Institute, LLC in Eugene, Oregon and was approved by the Solutions IRB LLC (Yarnel, Arizona).

Material and Methods

Participants

Participants were recruited through social media posts and marketing on Facebook®. Interested participants emailed the researcher and completed an online pre-screening survey. To be included in the study, participants had to be aged 18 or older, legally competent to independently provide consent, and have reliable access to a smartphone and internet connection. Of the 50 participants who responded, eight were removed due to attrition. Of the 42 total participants completing all steps of the study, five participants' data were removed due to time inconsistencies. Specifically, the intervention should have taken a minimum of 4 minutes to complete. Each pre and post questionnaire should have taken a minimum of 1 minute to complete. If a subject took less than 6 minutes to complete the daily procedure (as measured

by the Qualtrics software), their data was removed. For the final analyses, only the subjects with full data sets, meeting acceptable time criterion were included. A total of 37 participants were ultimately included (male= 8, female= 29), ranging in age from 22-73 years of age (*M*= 40.76, *SD*=11.60). For further demographic information see Table 1. The final sample was ultimately comprised of 19 participants in the AR group and 18 participants in the control group. An independent t-test of unequal variances indicated no differences between groups in age t (33) = -.541, p= .296, ethnicity t (33) = -1.17, p= .125, or gender t (33) = -.865, p= .197.

Table 1: Participant demographics by group.

		Group Assignment	
	Total (*n* = 37)	**Active (*n* = 19)**	**Control (*n* = 18)**
Gender (%)			
Female	29 (78.38)	16 (84.21)	13 (72.22)
Male	8 (21.62)	3 (15.79)	5 (27.78)
Race (%)			
Asian	1 (2.70)	0 (0)	1 (5.56)
Hawaiian/Pacific Islander	1 (2.70)	0 (0)	1 (5.56)
White/Caucasian	32 (86.49)	18 (94.74)	14 (77.78)
Other	3 (8.11)	1(5.26)	2 (11.11)
Age in years			
M ± *SD*	40.76 ± 11.60	39.74 ± 10.46	41.83 ± 12.91

Measures

Demographic Questionnaire

This questionnaire asked subjects to identify information related to their sex, age, and ethnic background.

Generalized Anxiety Disorder Assessment (GAD-7)

This 7-item self-report scale asks subjects to identify how much they were bothered by each of 7 symptoms. The original instructions asked subjects to respond based on their experience during the previous 2 weeks. This timeline was modified in the current study to only 1 week. This was done to make the responses more consistent with the time frame of the study. Response options include, "not at all," "several days," "more than half the days," and "nearly every day," scored 0,1,2, and 3, respectively. Total scores ranged from 0 to 21 with higher scores indicating higher anxiety and a higher likelihood of meeting criterion for GAD. A score of 8 has been shown to have a 92% sensitivity and a 76% specificity in relation to a diagnosis of GAD [27]. This was the cut-off utilized in the current study. In addition, the GAD-7 has previously demonstrated an internal consistency of .92 and test-retest reliability of .83 [27].

Perceived Stress Scale (PSS)

The Perceived Stress Scale [28] was used to measure participant stress. The PSS consists of 10 items that ask respondents how often they experienced various symptoms of stress (e.g. "How often have you felt that you were unable to control the important things in your life?"). Similar to the GAD-7, the original instructions were modified to ask subjects to respond to the items in relation to their experience in the past week. Responses ranged from "0 - Never" to "4 - Often." For this study we asked participants to place an emphasis on the week leading up to both the pre and post questionnaires.

Brunel Mood Scale

BRUMS; Soos, et al. [29]. The BRUMS consists of 32 mood descriptors that are categorized into 8 unipolar dimensions: anger, tension, depression, vigor, fatigue, confusion, happiness, and calmness. Using a response frame of "how do you feel right now?" subjects indicated the extent of their experience of the mood descriptors on a 5-point scale (0= not at all, 1= a little, 2= moderately, 3= quite a bit, 4= extremely).

Interventions

Healium AR (Google, 2020). The free version of this application is available on both iOS and Android platforms and served as the meditation task for this study. A 4-minute guided experience encouraged the user to activate feelings of calm and positivity to hatch virtual butterflies from a virtual chrysalis. The AR images viewed on the phone are superimposed on the environment viewed by the phone's camera, giving the impression that the experience is happening in the physical environment. As the experience progresses, the user is coached into recalling times they felt happiness and appreciation which gradually results in the hatching of 21 butterflies. The top of the screen has a counter to keep track of the number of butterflies hatched, and as the butterfly's hatch, they "fly around the room" and can be tracked by moving the phone, providing an interactive element (Figure 1). DOTS (Google, 2020). This is a free standard mobile phone application available on both iOS and Android platforms and served as the distraction task for this study. The game consists of multiple colored dots in a grid pattern. The player swipes to connect like-colored dots. Once a line of dots is connected, they disappear and the game continues. After 4 minutes, the application automatically stops (Figure 2).

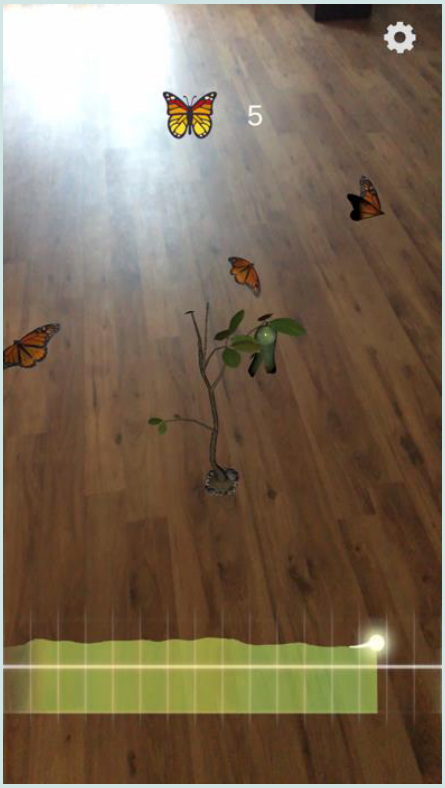

Figure 1: Healium Butterflies phone app as seen through a smartphone.

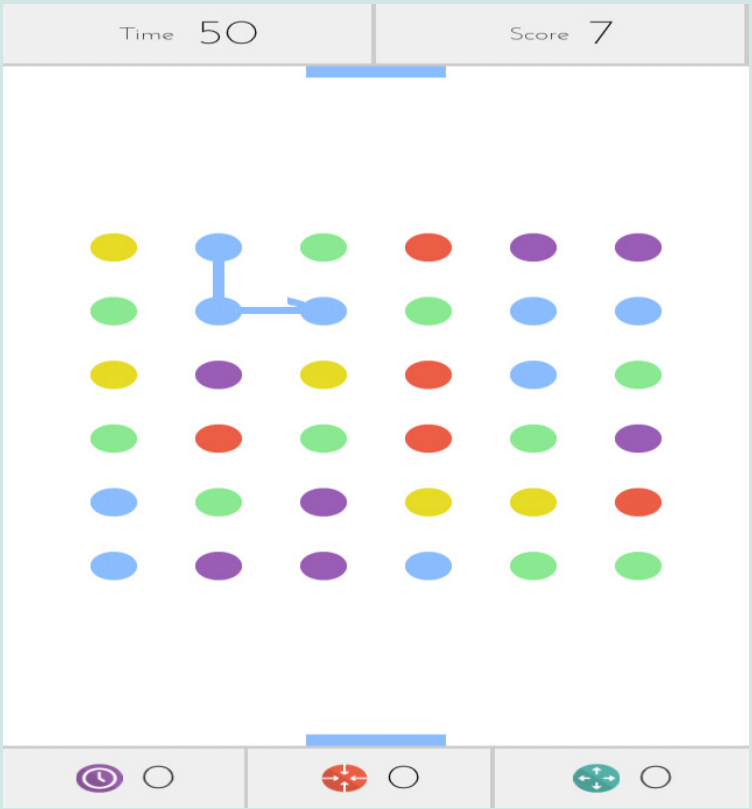

Figure 2: DOTS phone app as seen through a smartphone.

Procedures

Due to the safety limitations of the mandatory Covid-19 quarantine procedures, the entirety of this study took place virtually. When a potential subject contacted the study administrator and met criteria to participate, they were briefed on the purpose and expectations of the study and sent a digital consent form through Qualtrics software. Once this was completed, subjects were alternately assigned to either the distraction or meditation group by order of signed consent form. Every odd numbered participant was assigned to the meditation group, and every even number was assigned to the distraction group. Subjects were informed that they were being assigned to one of two comparison groups looking at phone applications and their subjective mental health effects. Subjects were blind to which group they had been assigned. Once assigned, participants were provided with a link and instructions to download the designated application to their phone.

For each of the 5 days of the study, subjects were sent email reminders with links to the questionnaires and instructions for that day. On day 1, subjects completed a demographic questionnaire, the GAD-7, the PSS, and BRUMS. Upon completion of these questionnaires, the participant engaged in the assigned mobile application (DOTS or Healium). Both applications were set to automatically end after 4 minutes. Upon completion of the app experience, the participants filled out a second BRUMS questionnaire. Qualtrics software automatically contacted the researcher when a subject completed all of the questionnaires for a particular day. When such notification was received, the researcher sent instructions and questionnaire links to be repeated and used the next day. For days 2-5, subjects received a daily reminder and link to the BRUMS scale. They were asked to complete the pre-BRUMS questionnaire, engage with the assigned phone application, and then complete the post-BRUMS questionnaire. On day 5, following the post-engagement BRUMS questionnaire, the participants were instructed to fill out the GAD-7, and Perceived Stress Scale. Upon completion of all questionnaires on day 5, the researcher sent a debriefing letter to the participant with an invitation to inquire with any questions about the study. They were also provided with information regarding the incentive drawing. If their name was selected, they were informed through email and given a $50 VISA gift card.

Data Analysis

Statistical analyses were performed with Jamovi software [30]. A series of mixed model repeated measure Analysis of Variances (ANOVAs) were computed for both the GAD-7 questionnaire and Perceived Stress Scale, as well as for each mood (Tension, Depression, Confusion, Happiness, Calmness) in the BRUMS. Assumptions of normality and equality of variance were evaluated with Levene's test (p <.05), and sphericity tests were analyzed across all ANOVAs with no violations detected. The threshold for evaluating significance was set to α = 0.05. Additionally, a Bonferroni-Holm method was utilized to correct for alpha inflation due to multiple comparisons.

Results

GAD-7

Generalized anxiety changes as measured by the GAD-7 were assessed before and after the 5-day intervention. A 2X2 repeated measures mixed ANOVA (Group: AR, distraction; Time: pre, post) was utilized to show a main effect for time $F_{1,35}$= 4.24, p = .047, indicating that anxiety went down from pre to post (pre: M= 7.48, post M= 6.41, SE= .079). No significant main effect was found for group ($F_{1,35}$= 2.66, p= .112) or interaction for group and time ($F_{2,35}$= 1.19, p=.282). However, when subjects were divided into subgroups based on their pre-intervention anxiety levels, there were additional significant findings. Subjects were categorized into levels of anxiety based on the GAD-7 scoring key (low= 0-4, mild= 5-9, moderate= 10-14, severe= 15-21; Spencer et al., 2006). Using these groups, the researchers conducted an exploratory 2X4X2 mixed factorial ANOVA (group: meditation, AR; GAD-level: low, mild, moderate, severe; time: pre, post). A significant main effect for time ($F_{1,35}$=10.34, p=.003), demonstrated a decrease in reported anxiety symptoms from pre to post regardless of group, and an effect for group ($F_{1,35}$= 10.20, p=.003), such that the distraction group rated themselves as overall more anxious at pre-testing. Additionally, GAD-level showed a main effect for both groups ($F_{3,29}$= 38.29, p< .001), such that there was a greater number of moderate to severe anxiety level participants than low to mild. Time and GAD level showed a significant interaction ($F_{3,29}$= 3.62, p=.025), as those with low anxiety levels at pre-testing saw a slight increase in feelings of anxiety, while mild and moderate participants saw a slight decrease, and participants with severe levels of anxiety saw the steepest decrease in anxiety levels. Additionally, there was a 3-way interaction for time point, group, and GAD level ($F_{3,35}$= 1.36, p=.027), as the more severe the anxiety levels at pre, the greater the reported relief at post, with a greater effect for the AR group than the distraction group.

(Figure 3) For both the distraction and AR groups, those with low anxiety levels at pre saw a slight increase in feelings of anxiety, while mild and moderate participants saw a slight decrease, and participants with severe levels of anxiety saw the steepest decrease in anxiety levels.

(Figure 4) The more severe the anxiety levels at pre, the greater the reported relief at post, with a greater effect for the AR group than for the distraction group.

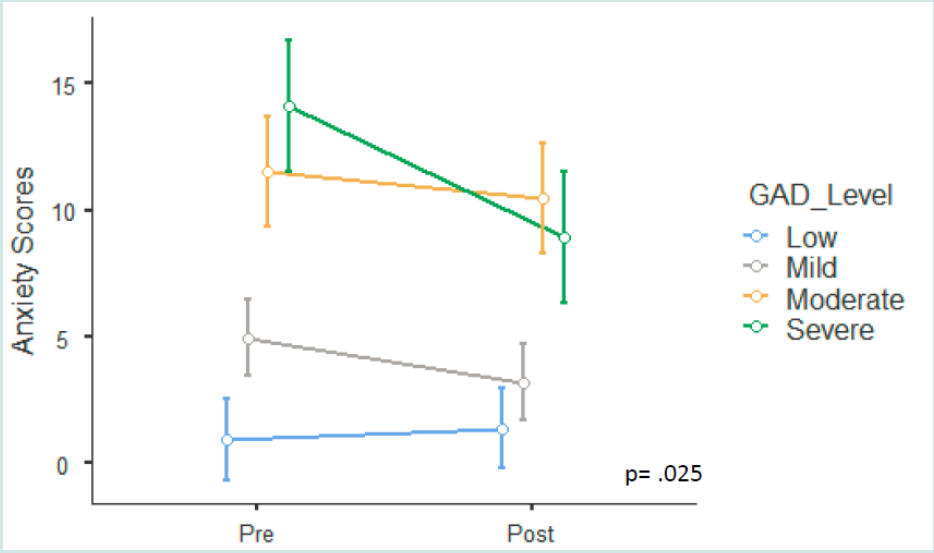

Figure 3: Interaction of GAD-7 group levels and Time (Pre, Post).

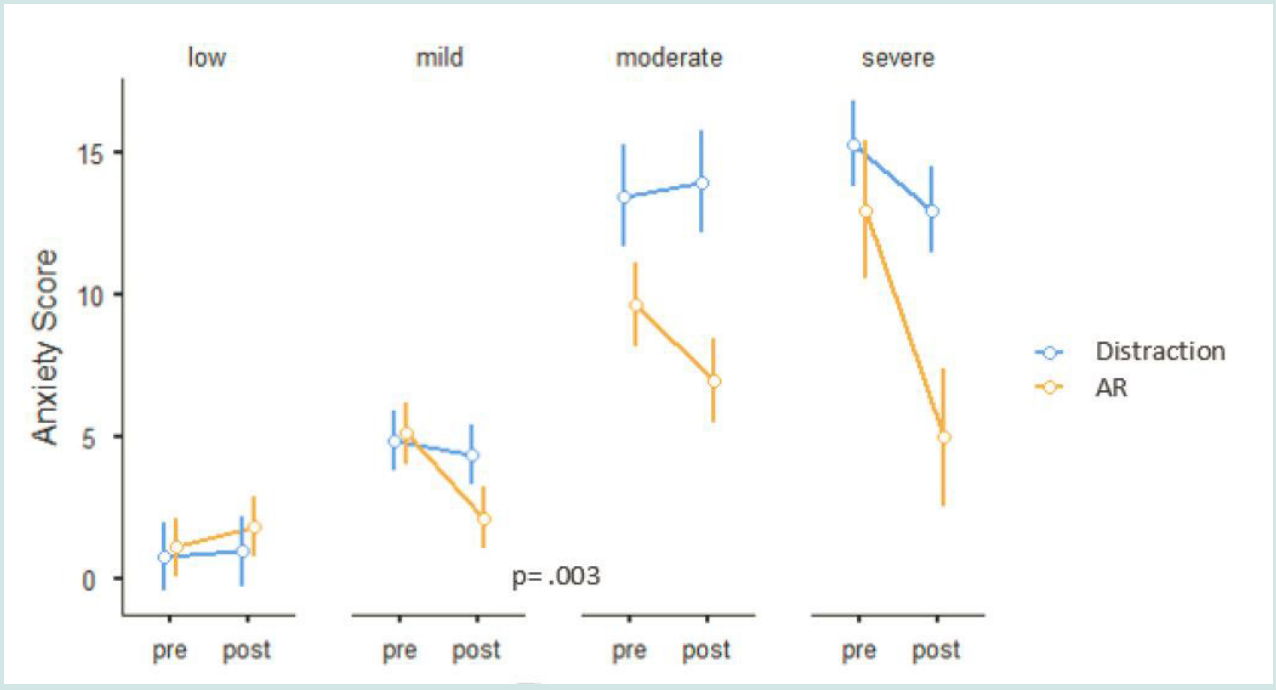

Figure 4: Interaction of GAD-7 group levels, Time, and Intervention Group.

Perceived Stress

A 2X2 mixed factorial ANOVA (group: AR, distraction; time point: pre, post) was used to analyze perceived stress. No main effects were found for group or time; however, there was a significant interaction for group and time ($F_{1,35}$= 7.92, p=.008), as the distraction group saw an increase in perceived stress, while the AR group saw a decrease in stress (Figure 5). The distraction group saw an increase in stress on day 5 compared to day 1, while the AR group saw a decrease in perceived stress.

Brunel Mood Scale

To analyze mood effects as measured by the Brunel Mood Scale, a 2X2X5 (Group: AR, distraction; Time: pre, post; Day: 1,2,3,4,5) repeated measures ANOVA was utilized for each of the 5 subscales (depression, tension, calmness, happiness, confusion) separately. All means and standard deviations are reported in Tables 2-6. Across all BRUMS subscales, both the AR and distraction groups saw increases in positive mood states and decreases in negative mood states from pre to post, however after corrections

for multiple comparisons only the following subscales retained significance: Tension ($F_{1,34}$=30.17, p <0.001), Happiness ($F_{1,34}$=6.41, p=0.016), and Confusion ($F_{1,34}$=6.41, p=0.016). For both conditions, on average, Happiness increased, while Tension, and Confusion decreased. Figure 5 displays the average individual change in scores after the interventions for each group by day. There were additional significant main effects for the three way interactions of day, group, and time.

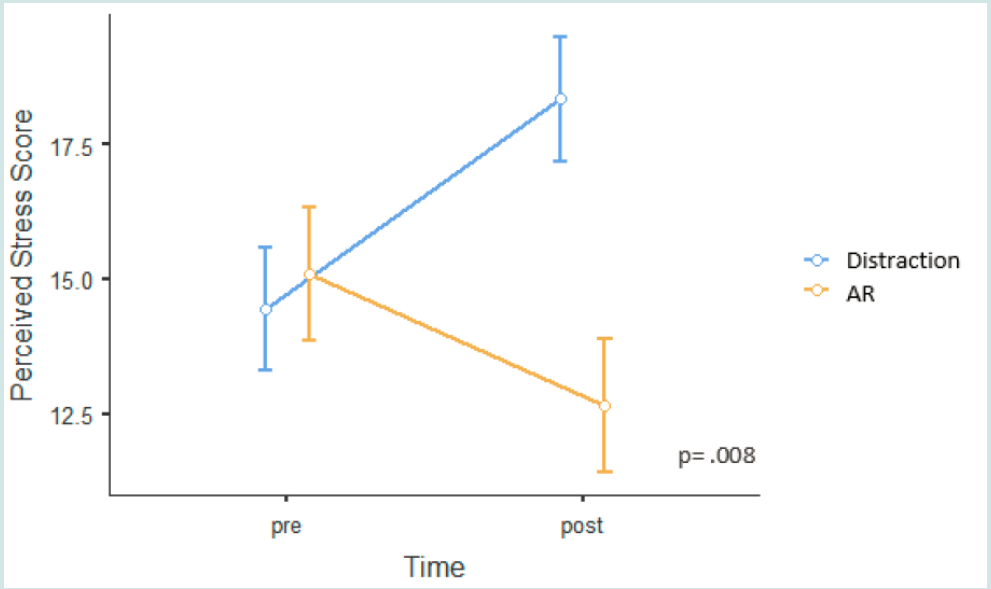

Figure 5: Changes in Perceived Stress scores from Day 1 to Day 5.

Table 2: Pre and post group means for Brunel Depression ratings.

Brunel Depression				
AR Distraction	**Day**	**Time**	**Mean**	**SE**
Distraction	1	pre	3.71	0.727
		post	2.53	0.727
	2	pre	3.83	0.727
		post	2.88	0.727
	3	pre	3.94	0.727
		post	4.35	0.727
	4	pre	2.77	0.727
		post	4.41	0.727
	5	pre	3.18	0.727
		post	2.88	0.727
AR	1	pre	2.27	0.716
		post	1.63	0.716
	2	pre	1.63	0.716
		post	0.73	0.716
	3	pre	1.10	0.716
		post	0.84	0.716
	4	pre	1.94	0.716
		post	1.21	0.716
	5	pre	1.36	0.716
		post	0.68	0.716

Table 3: Pre and post group means for Brunel Tension ratings.

Brunel Tension				
AR Distraction	**Day**	**Time**	**Mean**	**SE**
Distraction	1	pre	6.06	0.782
		post	3.53	0.782
	2	pre	4.30	0.782
		post	3.53	0.782
	3	pre	4.95	0.782
		post	3.83	0.782
	4	pre	3.77	0.782
		post	3.18	0.782
	5	pre	3.83	0.782
		post	3.71	0.782
AR	1	pre	3.63	0.767
		post	1.53	0.767
	2	pre	2.84	0.767
		post	1.79	0.767
	3	pre	2.00	0.767
		post	1.05	0.767
	4	pre	3.16	0.767
		post	2.00	0.767
	5	pre	2.21	0.767
		post	1.16	0.767

Table 4: Pre and post group means for Brunel Calm ratings.

Brunel Calmness				
AR Distraction	**Day**	**Time**	**Mean**	**SE**
Distraction	1	pre	5.39	0.679
		post	7.74	0.679
	2	pre	6.45	0.679
		post	6.56	0.679
	3	pre	5.27	0.679
		post	3.92	0.679
	4	pre	6.62	0.679
		post	4.45	0.679
	5	pre	5.62	0.679
		post	6.21	0.679
AR	1	pre	8.73	0.659
		post	10.30	0.659
	2	pre	9.09	0.659
		post	10.30	0.659
	3	pre	8.88	0.659
		post	10.04	0.659
	4	pre	7.78	0.659
		post	8.99	0.659

	5	pre	7.99	0.659
		post	9.88	0.659

Table 5: Pre and post group means for Brunel Happiness ratings.

Brunel Happiness				
AR Distraction	**Day**	**Time**	**Mean**	**SE**
Distraction	1	pre	5.14	0.738
		post	7.73	0.738
	2	pre	5.32	0.738
		post	6.61	0.738
	3	pre	4.38	0.738
		post	4.43	0.738
	4	pre	5.43	0.738
		post	4.79	0.738
	5	pre	5.02	0.738
		post	5.96	0.738
AR	1	pre	8.19	0.716
		post	8.66	0.716
	2	pre	9.08	0.716
		post	9.34	0.716
	3	pre	8.5	0.716
		post	8.45	0.716
	4	pre	7.71	0.716
		post	7.98	0.716
	5	pre	7.61	0.716
		post	8.71	0.716

Table 6: Pre and post group means for Brunel Confusion ratings.

Brunel Confusion				
AR Distraction	**Day**	**Time**	**Mean**	**SE**
Distraction	1	pre	5.14	0.738
		post	7.73	0.738
	2	pre	5.32	0.738
		post	6.61	0.738
	3	pre	4.38	0.738
		post	4.43	0.738
	4	pre	5.43	0.738
		post	4.79	0.738
	5	pre	5.02	0.738
		post	5.96	0.738
AR	1	pre	8.19	0.716
		post	8.66	0.716
	2	pre	9.08	0.716
		post	9.34	0.716
	3	pre	8.50	0.716

		post	8.45	0.716
	4	pre	7.71	0.716
		post	7.98	0.716
	5	pre	7.61	0.716
		post	8.71	0.716

After correcting for multiple comparisons Depression ($F_{4,34}$=2.90, p=0.024), Calmness ($F_{4,34}$=5.61, p < .001), Happiness ($F_{4,34}$=3.17, p=0.016), and Confusion ($F_{4,34}$=3.17, p=0.016) retained significance. For the Happiness and Calmness subscales, the distraction group showed an increase on day 1, no change on day 2, a decrease of Calmness and Happiness on days 3 and 4, then increased again on day 5, while the AR group saw increases across the 5 days. For Depression, the distraction group showed a decrease in Depression on days 1 and 2, while day 3 showed no change, day 4 showed an increase in Depression, then a decrease on day 5. The AR group remained consistent across the 5 days. For Confusion, the distraction group saw a decrease in Confusion on days 1 and 2, an increase on days 3-4, and a drop on day 5, while the AR group showed consistent decreases across the 5 days (Figure 6).

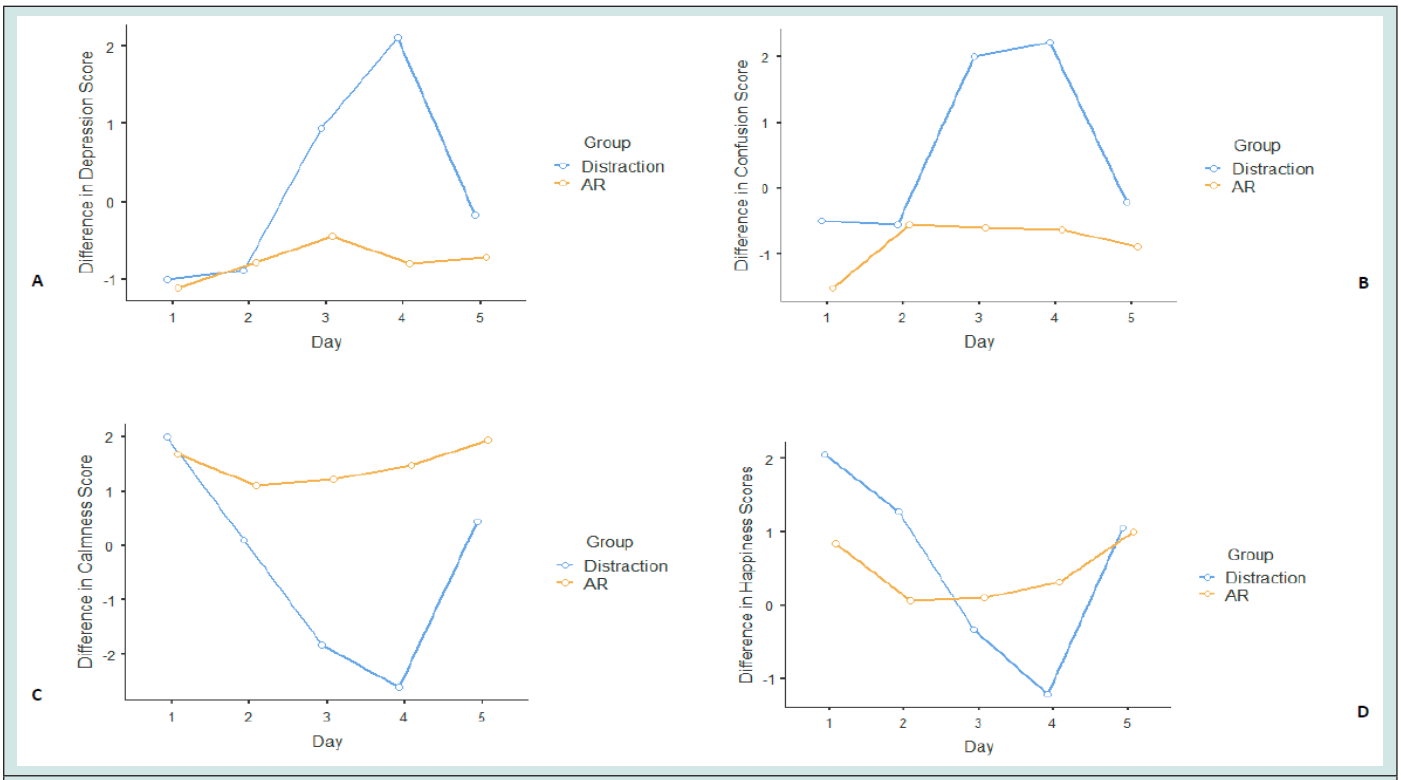

Figure 6: Mean difference of rating on Brunel questionnaire subscales post to pre- for AR and Distraction groups. (A) Depression (B) Confusion (C) Calmness (D) Happiness.

Discussion

This study was designed to determine whether a phone-based AR meditation app could be successfully used to reduce anxiety and stress as well as shift mood states. In an effort to control for the impact of participation expectations and social desirability, a control group was included. Importantly, the subjects in the study were not aware if they were enrolled in the active or control condition, having been randomly assigned and instructed that the study was designed to examine the impact of phone-based apps on stress and anxiety. The control condition was a standard mobile application game and involved connecting same-colored dots in a variety of patterns allowing the user to gain points for successful trials. This technique was not intended to have any kind of effect beyond distracting the user from their current circumstances. Because distraction techniques have been used in a variety of studies to manage pain and anxiety [31-33], this form of control condition also allowed us to consider if the AR meditation intervention had any additional benefit beyond that of a distraction technique.

While the overall results suggest that both the AR and distraction interventions had a positive impact on anxiety and stress levels, exploratory analyses revealed a more nuanced story. Specifically, higher anxiety subjects reported significantly better results with the AR app. In fact, the AR intervention outperformed the distraction intervention for subjects with mild, moderate, and

severe pre-intervention anxiety. These results were most dramatic with the moderate and severe groups (Figure 2). This is consistent with other research demonstrating that meditation based interventions are more effective than distraction techniques for a variety of concerns including decreasing pain [12] and reducing dysphoria [34]. In addition, changes on the perceived stress scale indicated that there was a significant difference between groups. While the AR group showed significant decreases in perceived stress, the distraction group showed increased levels of stress (Figure 3).

Beyond simply examining pre-post intervention changes, it also seemed important to consider the impact of each daily session. While the results of the BRUMS indicated that both groups showed positive changes during the 5 days, this overall statistic is somewhat misleading. An examination of the average daily change scores demonstrates that the distraction intervention was highly variable in its effects. While there were positive changes noted on some days on some scales, other days noted no change or even a negative shift. For example, on both the Happiness and Calmness subscales, the distraction group showed a positive change on day 1, no change on day 2, a decrease of calmness/happiness on days 3 and 4, and another increase on day 5 (Figure 4). A subsequent examination of changes in Depression across each of the 5 days reveals some important trends as well. Specifically, the distraction group showed a positive response only on days 1 and 2. Days 3-5 showed either no change or a negative response to the intervention. In contrast, the AR group appeared to have consistent results across all days for each of the scales in the expected direction across all 5 sessions.

Interestingly, both groups demonstrated their strongest effects on the first day of the intervention. The authors suspect that the strong positive initial impact for both interventions was due, in part, to the novelty of the interventions. That the AR group maintained relatively consistent impacts suggests that it was more engaging or motivating than the distraction technique. This interpretation is limited by the lack of specific data related to subject engagement or motivation. Future studies should directly inquire about these elements after each exposure to better determine their impact.

Taken together, these findings provide further support for the notion that a phone-based AR meditation app can be used to manage symptoms of anxiety and stress. This confirms the findings of another recent study using the same AR application. In that study, Viczko, et al. [20] demonstrated that a single exposure to the Healium meditation app resulted in increased positive mood and reduced negative mood states in a sample of anxious and/or depressed subjects. The current study adds to these results by demonstrating that the Healium app outperformed a phone-based distraction technique and is not limited to a single exposure, or novelty effect. This suggests that the impact of the Healium app may be related to the content or format of the AR meditation intervention. The Healium instructions ask the user to activate feelings of positivity by recalling a time they felt gratitude or appreciation for something in their life. These instructions are similar to a variety of positive psychology interventions that focus on the experience of gratitude. In general, gratitude as defined in the positive psychology literature, refers to the process of acknowledging that something good happened to you.

Typically this recognition is accompanied by a felt understanding that the positive experience was caused by an external source, such as another person, nature, or spiritual connection [35,36]. Research on gratitude practices has consistently demonstrated positive outcomes, including an increase of positive mood states [37], decreased stress [38], and reduced feelings of depression [39]. Positive psychology interventions have also been shown to be superior to a distraction technique, with significant benefit to those subjects with the highest levels of rumination [40]. Brief meditative practices emphasizing positive emotional states have also been shown to be effective in the reduction of pain, anxiety, anger, and mood concerns. In fact, Open Heart style meditations have been shown to increase feelings of positivity in as little as 7 minutes [41].

It is also possible that the AR intervention produced greater effects due to the level of engagement provided by this type of virtual technology. This interpretation is consistent with research indicating that the presence involved in virtual and augmented technologies may add to their beneficial impact [42,43]. For example, in a study comparing traditional textbook learning, a control condition of watching a video, and a virtual reality learning condition, subjects in the VR condition demonstrated better memory recall, increases in positive mood outcomes, and higher subjective engagement than either of the other groups [44]. With this in mind, it seems that virtual and augmented environments may provide a powerful method to facilitate the experience of meditation, particularly for those new to the practice. Speaking to this idea, Seabrook, et al. [45] reported that a VR-based meditation experience could help reduce a number of difficulties traditionally associated with meditation.

Specifically, they noted that the immersive nature of the experience can facilitate a meditative state by reducing the amount of information connected to the user's mind-wandering or by providing a more conducive meditative environment. In fact, this type of assisted meditation approach may be even more relevant during the COVID19 pandemic, whereby stressors associated with reduced social engagement, fear of infection, and economic consequences continue to impact millions of individuals. As noted previously, the current study did not include any assessments directly examining user engagement. Future studies should be sure to include this type of assessment to help clarify which elements of the experience are most related to positive outcomes. It is possible that the benefit from the Healium experience was due to the meditation rather than the format as other studies have demonstrated that non-AR mobile meditation apps are also effective. For example, Flett, et al. [46], compared two mobile phone-based meditation apps against a control group. Subjects used the apps for 10 consecutive days resulting in significant improvements in depressive symptoms, college adjustment, resilience, and mindfulness.

It should be noted, that due to the shorter time frame of this study (5 days) it may be more difficult to extricate "in the moment" mood changes in Tension and measures of stress or anxiety. Typically, measures of stress and anxiety take place over longer periods of time. A longitudinal study of 2 or more weeks would be beneficial to more accurately disentangle the impacts of the intervention between mood states and anxiety or stress. Another limitation, and perhaps benefit of this study, lies in the environment in which the interventions took place. In accordance with national COVID-19 health and safety social distancing measures, the participants were in their own homes, engaging with the study remotely. While this leaves the results vulnerable to various environmental effects, it bestows the benefit of reduced susceptibility to demand characteristics, and gives insight into how such applications might fare in a real world environment.

Launching this study at the height of the COVID-19 quarantine in the United States allowed a glimpse of a shared stressor across many different geographical regions. This allowed access to a broader perspective on the efficacy of such interventions. The study was limited in that it took place exclusively in the United States and was comprised of participants who were disproportionately Caucasian, female, and middle aged or older. It will be important for future studies to include a more ethnically and gender diverse sample. In addition, it would be helpful to study the impact of such interventions over a longer period of time, including a qualitative assessment of users' engagement and motivation for use.

Conclusion

Overall, the results of the current study suggest that both a brief phone-based AR meditation and a phone-based distraction were successful in reducing stress and anxiety, as well as improving mood states. However, the AR intervention produced more efficacious and consistent results on all measures, particularly for those with moderate to severe generalized anxiety. These findings set the stage for future studies to examine the mechanism of action of AR meditations and the potential use of this technology for longer-term interventions for mood, stress, and anxiety management.

Declaration of Interests

Jeff Tarrant, Ph.D. is contracted by Healium to assist in product development and assessment. PI for this study, Rachel Jackson, who has no affiliation with Healium, conducted statistical analyses and the interpretation of this data to reduce potential conflicts of interest.

Author Contributions

RJ contributed to study conception, design, data collection and manuscript writing. JT contributed to design and manuscript writing. KF assisted with data collection and manuscript writing. All authors contributed to manuscript revisions.

Datasets are available on request

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher. Given the small sample size and exploratory nature of the correlational findings all interpretations should be made with a high degree of caution and require replication in higher powered studies.

References

1. Bandelow B, Michaelis S (2015) Epidemiology of anxiety disorders in the 21st century. Dialogues Clin Neurosci 17(3): 327-335.
2. Haller H, Cramer H, Lauche R, Gass F, Dobos G (2014) The prevalence and burden of subthreshold generalized anxiety disorder: a systematic review. BMC Psychiatry 14: 128.
3. Kirzinger A, Hamel L, Muñana C, Kearney A, Brodie M (2020) KFF Health Tracking Poll-Late April 2020: Coronavirus, Social Distancing, and Contact Tracing. Kaiser Family Foundation.
4. Cool J, Zappetti D (2019) The physiology of stress. Medical Student Well-Being p. 1-15.
5. Brosschot JF, Gerin W, Thayer JF (2006) The perseverative cognition hypothesis: A review of worry, prolonged stress-related physiological activation, and health. Journal of Psychosomatic Research 60(2): 113-124.
6. Strine TW, Chapman DP, Kobau R, Balluz L (2005) Associations of self-reported anxiety symptoms with health-related quality of life and health behaviors. Social Psychiatry and Psychiatric Epidemiology 40(6): 432-438.
7. Figueroa CA, Aguilera A (2020) The Need for a Mental Health Technology Revolution in the COVID-19 Pandemic. Frontiers in Psychiatry 11: 523.
8. Mental Health America (2019) The state of mental health in America. Author Alexandria, VA: Mental Health America, Inc.
9. Clancy C, Munier W, Brady J, Moy E, Chaves K, et al. (2012) National Healthcare Quality & Disparities Report. Rockville, AHRQ Publications, Washington, DC, USA.
10. Torous J, Andersson G, Bertagnoli A, Christensen H, Cuijpers P, et al. (2019) Towards a consensus around standards for smartphone apps and digital mental health. World Psychiatry 18(1): 97-98.
11. Coulon SM, Monroe CM, West DS (2016) A systematic, multi-domain review of mobile smartphone apps for evidence-based stress management. Am J Prev Med 51(1): 95-105.
12. Zeidan F, Gordon NS, Merchant J, Goolkasian P (2010) The effects of brief mindfulness meditation training on experimentally induced pain. The Journal of Pain 11(3): 199-209.
13. Banks JB, Welhaf MS, Srour A (2015) The protective effects of brief mindfulness meditation training. Consciousness and Cognition 33: 277-285.
14. Riva G, Baños RM, Botella C, Mantovani F, Gaggioli A (2016) Transforming experience: the potential of augmented reality and virtual reality for enhancing personal and clinical change. Frontiers in Psychiatry 7: 164.
15. Tarrant J, Viczko J, Cope H (2018) Virtual Reality for Anxiety Reduction Demonstrated by Quantitative EEG: A Pilot Study. Frontiers in Psychology 9: 1280.
16. Tarrant J, Abrams JS, Jackson R (2019) The Impact of virtual reality on mood states prior to blood donation. Scholarly Journal of Psychology & Behavior Science 2(5)-2019.
17. Maples-Keller JL, Bunnell BE, Kim SJ, Rothbaum BO (2017) The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. Harvard Review of Psychiatry 25(3): 103.
18. Carmigniani J, Furht B (2011) Augmented reality: an overview. In Handbook of augmented reality. Springer, New York, USA pp. 3-46.

19. Tivatansakul S, Ohkura M (2014) Healthcare system focusing on emotional aspect using augmented reality. Transactions of Japan Society of Kansei Engineering 13(1): 191-201.

20. Viczko J, Tarrant J, Jackson R (2021) Effects on Mood and EEG States After Meditation in Augmented Reality With and Without Adjunctive Neurofeedback. Frontiers in Virtual Reality p. 9.

21. Haw J, Dickerson M (1998) The effects of distraction on desensitization and reprocessing. Behaviour Research and Therapy, 36: 765-769.

22. Isaacs JS (2004) Numerical distraction therapy: Initial assessment of a treatment for posttraumatic stress disorder. Traumatology 10(1): 39-54.

23. Pourmand A, Davis S, Marchak A, Whiteside T, Sikka N (2018) Virtual reality as a clinical tool for pain management. Current pain and headache reports 22(8): 53.

24. Koller D, Goldman RD (2012) Distraction techniques for children undergoing procedures: a critical review of pediatric research. Journal of Pediatric Nursing 27(6): 652-681.

25. Malloy K, Milling L (2010) The effectiveness of virtual reality distraction for pain reduction: A systematic review. Clinical Psychology Review 30(8): 1011-1018.

26. Atzori B, Hoffman HG, Vagnoli L, Patterson DR, Alhalabi W, et al. (2018) Virtual Reality Analgesia during Venipuncture in Pediatric Patients With Onco-Hematological Diseases. Frontiers in Psychology 9: 2508.

27. Spitzer RL, Kroenke K, Williams JB, Löwe B (2006) A brief measure for assessing generalized anxiety disorder: the GAD-7. Archives of Internal Medicine 166(10): 1092-1097.

28. Cohen S, Kamarck T, Mermelstein R (1994) Perceived stress scale. Measuring Stress: A Guide for Health and Social Scientists 10: 1-2.

29. Soos I, Lane AM, Leibinger E, Karsai I, Hamar P (2007) Validity of the Brunel Mood Scale for use with UK, Italian and Hungarian athletes pp. 119-130.

30. Jamovi Project (2017) Jamovi (Version 0.8).

31. Wiederhold MD, Gao K, Wiederhold BK (2014) Clinical use of virtual reality distraction system to reduce anxiety and pain in dental procedures. Cyberpsychology, Behavior, and Social Networking 17(6): 359-365.

32. Hudson BF, Ogden J, Whiteley MS (2015) Randomized controlled trial to compare the effect of simple distraction interventions on pain and anxiety experienced during conscious surgery. European Journal of Pain 19(10): 1447-1455.

33. Mohammad EB, Ahmad M (2019) Virtual reality as a distraction technique for pain and anxiety among patients with breast cancer: A randomized control trial. Palliative & Supportive Care 17(1): 29-34.

34. Broderick PC (2005) Mindfulness and Coping with Dysphoric Mood: Contrasts with Rumination and Distraction. Cogn Ther Res 29: 501-510.

35. Emmons RA, Shelton CM (2002) Gratitude and the science of positive psychology in Handbook of Positive Psychology CR Snyder and SJ Lopez (Eds), New York, NY: Oxford University Press, USA pp. 459-471.

36. Watkins PC, Van Gelder M, Frias A (2009) Furthering the science of gratitude in Oxford Handbook of Positive Psychology, eds SJ Lopez and CR Snyder, Oxford University Press, New York, NY, USA pp. 437-445.

37. Martínez-Martí ML, Avia MD, Hernández-Lloreda MJ (2010) The effects of counting blessings on subjective well-being: a gratitude intervention in a Spanish sample. Span J Psychol 13: 886-896.

38. Kerr SL, O'Donovan A, Pepping CA (2015) Can gratitude and kindness interventions enhance well-being in a clinical sample? J Happiness Stud 16: 17-36.

39. Southwell S (2012) Gratitude: A Basis for Positive Psychology Interventions with a Clinical Population. Master's thesis, Deakin University, Melbourne, VIC.

40. Odou N, Brinker J (2015) Self-compassion, a better alternative to rumination than distraction as a response to negative mood. The Journal of Positive Psychology 10(5): 447-457.

41. Hutcherson CA, Seppala EM, Gross JJ (2008) Loving-kindness meditation increases social connectedness. Emotion 8(5): 720.

42. Flavián C, Ibáñez-Sánchez S, Orús C (2020) Impacts of technological embodiment through virtual reality on potential guests' emotions and engagement. Journal of Hospitality Marketing & Management p. 1-20.

43. Graffigna G, Barello S, Riva G (2013) How to make health information technology effective: the challenge of patient engagement. Archives of Physical Medicine and Rehabilitation 94(10): 2034-2035.

44. Allcoat D, Von Mühlenen A (2018) Learning in virtual reality: Effects on performance, emotion and engagement. Research in Learning Technology pp. 26.

45. Seabrook E, Kelly R, Foley F, Theiler S, Thomas N, et al. (2020) Understanding How Virtual Reality Can Support Mindfulness Practice: Mixed Methods Study. Journal of Medical Internet Research 22(3): e16106.

46. Flett JA, Hayne H, Riordan BC, Thompson LM, Conner TS (2019) Mobile mindfulness meditation: a randomised controlled trial of the effect of two popular apps on mental health. Mindfulness 10(5): 863-876.

DOI: 10.32474/SJPBS.2022.06.000245