The Impact of Virtual Reality Mindfulness Training on Anxiety and Affect

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Abstract

Mindfulness is an attention-based, cognitive technique, which roots us within the present moment. Attention serves as the basis to many cognitive processes such as memory, learning, and social bonding. Psychological research suggests that not being able to pay attention may be an antecedent to many affective disorders. Mindfulness-based interventions, within a therapeutic setting, have been efficacious in abating negative affective disorders but now there is a need for a more convenient way to deliver mindfulness training. Virtual environments may offer the answer due to the experience of immersion which has shown to increase attention and promote wellbeing. In this study we investigate whether using VR-based mindfulness interventions can promote wellbeing along with looking at if mindfulness training in VR differs, if at all from traditional training (i.e., audio-based, guided training).

Author Keywords:

Virtual reality; VR; Mindfulness; Attention; Affect; Anxiety; Presence

Introduction

In our current society, it is common for individuals to encounter a number of different distractions, stressors, and other things that may negatively impact their emotions. While these interactions are common, there are cases where certain individuals may experience increased effects that may alter their cognitive state.

The question: “What is it to be well?”, can be objectively viewed as an individual’s genuine state of happiness. Does an individual experience life positively? Do they often feel in control and focused? It is

well documented that humans need mediation in their life to perform successfully and "feel" happy. People need breaks, they need effective coping strategies and daily relief through healthy practices. One way to help sustain a 'good' state of well-being is by facilitating mindfulness. Achieving such a state can be reached through practices that focus on breathing, meditation or physically-relieving exercises. However, it can be difficult to effectively deliver such practices.

Technology's prevalence today can be deterring for some individuals. However, with the intention of meditative interventions being relief and focus, technology may be here to help. Research on mindfulness has gained traction within the realm of technological platforms largely due to their manipulatable ability on sense of presence. That is, there is a great push for the interaction between mindfulness-based interventions (MBI) through technologically-supported platforms. However, the efficacy of such interactions remains widely unknown and continues to be researched. Another large component of understanding the direct effect of MBI is through computer-generated affective feedback. Such feedback is advantageous toward understanding what and why particular occurrences elicit positive or negative affect. By isolating what an individual cognitively experiences as negative or positive can further help researchers develop designs oriented around effectively delivering MBIs. What's more, the conversion of immersion-related technology, such as Virtual Reality (VR), and such mindfulness-based practices have begun to interact (Riva et al., 2007). That is, Virtual Reality and MBIs are coming together variably, in research, to assess the interaction between VR's capability to elicit a state of high-presence while the MBI's elicit states of positive cognition. The interaction between VR and MBI's could ensure a more effective medium of mediation for individuals seeking to increase their state of wellbeing.

Mindfulness

Mindfulness is rooted in ancient meditation tradition and is used as a tool to abate negative human emotions and bolster positive affect (Bhayee et al., 2016; Lim, Condon & DeSteno, 2015; Dickenson, Berkman, Arch & Liberman, 2013). The goal of mindfulness is to offer liberation from suffering and is popular now because contemporary life demands our constant attention and thus requires a significant portion of our cognitive resources. Mindfulness has been generally defined as the conscious direction of attention toward the present moment and is seen as both, a state of being and a process (Boettcher et al., 2013; Cavanagh et al., 2013). Attending to the present moment invites awareness of sensation, thought, and environment and can afford the practitioner a moment to rid themselves of tension. Further, paying attention and the ability to sustain attention is thought to be at the root of mindfulness, and therefore provides the foundation for increased wellbeing. Through practice and

mindfulness training (MT), increased acceptance grows and a desire to change the present, decreases; one learns to be content with life.

In the United States, statistics suggest that one in every four individuals will experience symptoms of anxiety disorder throughout their lifespan (Boettcher et al., 2013). Psychological research shows that many affective disorders are caused by increased distractions and a lack of attention span during daily tasks (Bhayee et al., 2016). Further, many individuals feel they cannot find time to access psychological programs to obtain the help they need or may have fear of stigmatization for receiving intervention (Cikajlo et al., 2017). MT creates a much-needed moment of acceptance because the practitioner learns to view emotions and physical sensations as temporary and this can be beneficial for those with clinical affective disorders (Cikajlo et al., 2017; Bhayee et al., 2016; Dickenson, Berkman, Arch & Lieberman, 2013). Previous psychological research posits that the ability to monitor and control one's thoughts, through repeated MT, can reduce negative affect and increase well-being (Freeman, J., Lessiter, J., Keogh, E., Bond, F., & Chapman, K.,

2004).

What is more, MT has already been established as an efficacious technique for clinical-populations (Cavanagh et al., 2013; Dickenson et al., 2013; Cikajlo et al., 2017). Two of the most widely used interventions are mindfulness-based cognitive therapy (MBCT) and mindfulness-based stress reduction (MBSR). These trainings expand over several days, are typically group-based interventions led by experienced mindfulness practitioners, and are faculty-led (Bhayee et al., 2016). Although the preponderance of evidence provided by prior studies supports the efficacy of these interventions to improve overall well being (Freeman et al., 2004; Boettcher et al., 2014; Lim et al., 2015), barriers to seeking out psychological services exist; including stigmatization from being diagnosed and treated with a disorder, lack of health insurance, lack of awareness that programs are available, inconsistent transportation or availability (Lim et al., 2016; Cikajli et al., 2017). Clinical as well as non-clinical populations would benefit from MT if it were more readily available and accessible. As a result of this need, MT interventions have emerged (Cavanagh et al., 2013) which extend beyond the treatment settings and into the homes of individuals with “self-help gurus”, audio-books, e-health programs, VR and cloud-based mindfulness technologies (Morgan & Mahali, 2013; Marks & Cavanagh, 2009; Nhayee et al., 2016).

Research using accessible MT has shown to be efficacious in some aspects. Freeman (2004) and team found a significant decrease in the ratings of negative emotions within the narrative-based virtual environment (VE) condition when compared to just the narrative with no VE. This suggests that the ability to experience immersion due to the VE, coupled with MT, plays a role in abating negative emotions. Boettcher et al. (2013) measured participants diagnosed with

social anxiety disorder, panic disorder, and generalized anxiety disorder and randomized participants into either an Internet-based mindfulness intervention program or a control group (CG). Participants in the Internet-based, mindfulness treatment group (MTG), showed a greater decrease in trait anxiety and depression symptoms when compared to the CG. This study highlights the advantage of technology-based MT as an efficacious tool for abating clinical psychological conditions. Further, meta-analyses of 15 mindfulness intervention programs showed significant benefits for mindfulness skills, trait anxiety, and depression, compared to control groups (Cavanagh et al., 2013). These programs utilized book-based or audio-based trainings. This evidence supports research that mindfulness interventions are effective for reducing trait anxiety/depression and for increasing attention, both of which benefit the individual and, more globally, society in general.

MT research has shown to be beneficial not only within the medical and psychological worlds, but in computer science and technology as well. Research in these camps looks at mindfulness as a mediator of increased attention and affective regulation (Lim et al., 2015; Navarro-Haro et al., 2017). Most of the current research has been centered around group-facilitated MT which is conducted at length and in the context of a supportive group setting. Little research has been conducted on individualized, or solo-MT through the use of VR and VE (Bhayee et al., 2016). VR and VE afford the user the experience of immersion which has been shown to be efficacious in ameliorating affective disorders (Boettcher et al., 2013). By suspending users' beliefs about their physical reality and transporting them into the VE, VR technology affords a greater sense of presence, which in turn could lead to better engagement in mindfulness practice. In light of this, there is a need to research individualized, technology-supported MT (tsMT) and its role in subjective well-being and attention. On account of the growing VR technology sales and mindfulness-based applications, there is an opportunity to reach more people who may have a desire to learn mindfulness skills and value convenience, both of which VR technology can provide.

There is evidence that MT influences cortical tissue within practitioners (Lim et al., 2015; Heeter & Allbritton, 2015). Research shows that one-time, mindfulness interactions, result in augmented control of emotions and cognitive functions (Dickenson et al., 2013). Specifically, because mindfulness requires the use of and strengthening of areas dealing with stress, communication, memory and focus. Since mindfulness can be used as a tool for managing stress it is assumed that certain cortical structures, such as the amygdala, nucleus accumbens (NA) and the Anterior Cingulate Cortex (ACC) are affected. fMRI research shows significant increase in grey matter within areas of concentration and memory as a function of mindfulness-based training (Cikajlo et al., 2017). Alberts & Thewissen (2011) found that those who

underwent MT remembered far fewer negative valanced words then those in the control condition. This suggests that there are neural connections between the valence of stimuli and our subjective sense of well-being.

This current study builds upon previous research by investigating MT as a possible catalyst for improved attention and well-being. As mentioned previously, the interaction between attention and well-being is supported in various group-facilitated MT programs but little is known about the effects of individual, tsMT (Bhayee et al., 2016). The intention of this study is twofold: firstly, we conducted a randomized control trial to assess the efficacy of a VR-based mindfulness intervention to promote wellbeing. Secondly, we investigated how MT in virtual reality differs, if at all, from a traditional training intervention (i.e., audio-based, guided training) in fostering mindfulness and promoting wellbeing.

With the use of affective computing, researchers work towards creating computer systems that are able to meet human-like capabilities. The aim of this practice is to allow these systems to observe, interpret, and generate affect features. The goal is for these processes to be completed in ways that can increase the quality of human computer communication, and also improve the intelligence of the system itself. While research on this topic is becoming increasingly active, studies on this topic date back to the 19th century.

With the help of affective computing and other technologies, there arises the question of how these can be used together to promote well-being within individuals through the use of MT. It has been seen that using VR as an effective medium for delivering MT, researchers are able to manipulate an individual's state of mind and give the user a type of cognitive therapy.

Implementing Mindfulness-Based Interventions in Virtual Environments

What makes natural phenomena so appealing? Not everyone enjoys the same scenery but, there are many consistencies oriented around preferable environments. What in these environments elicits such relaxation and such a feeling of presence? Within the mind, we capture these environmental sensations through schematic categorization of affective details associated with particular elements of an environment.

While remaining virtual, such natural environments can be replicated into a ‘simulative-environment’, by which factors such as an individual's sense of presence are able to be effectively replicated (Depledge et al., 2011). The combination of hardware and software afford programmers with the ability to have full control and manipulation of the VE individuals will encounter. This is especially useful for MBIs within VR because the manipulation within the environments are flexible, what works can stay. The sensorial forces of stimuli occur in a multimodal process by which our minds receive, perceive and conceive instantaneously, simultaneously. Replicating

an environment that can give us the same sensorial experience, the same 'sense of presence', is effectively the objective. VEs can heighten an individual's experience through immersion and an increased sense of presence (Banos et al., 2004).
When an individual engages in such environments, we see that their state of being can be effectively relaxed by decreasing negative affect and increasing positive affect (Freeman et al., 2004; Villiani & Riva, 2008). While it is evident that VE's support a more immersive, integrative and restorative experience (Heeter & Allbritton, 2015), some of the meta-analytic literature on MBI's reports that VE's are not yet as effective, as face to face interventions (Abbott et al., 2014; Khoury et al., 2015).

The literature surrounding meditative practices, such as MT, within the confinement of a VE, needs to be further researched to understand how effective and how much more 'efficient' this medium could be. Little empirical evidence supports technology supported mindfulness training specific to anxiety and affect and needs to be further researched. The purpose of this study was to investigate the question: Are VR-based interventions a sufficient means for delivering MT and increasing one's sense of well being. That is, when compared to a group of individuals who receive a guided-audio meditation and a control group, would a VR-based guided meditation yield more positive cognitive results? The effectiveness of VR-based interventions was supported by three hypotheses:

· There will be significantly greater reductions in trait anxiety levels in the VR and audio conditions when compared to the listening condition (control) and a significantly greater reduction in trait anxiety within the VR condition when compared to the guided audio condition will be observed.

· There will be significantly greater increases in positive affect levels in the VR and audio conditions when compared to the listening condition and a significant increase in positive affect in the Virtual Reality condition when compared to the guided audio condition.

· There will be significantly greater reductions in negative affect levels in the VR and audio conditions when compared to the listening condition and a significant reduction in negative affect within the Virtual Reality condition when compared to the guided audio condition.

METHOD

Design

The experiment conducted was a mixed design experiment. Participants were randomly assigned to one of the following conditions: VR, audio, or control. All participants attended the lab twice and completed a 10-day trial differentiated by condition. Both the VR and audio conditions are also known as the mindfulness conditions because over their 10-day trial they engage in a guided meditation. Participants in the control group, also labeled as the "Listening" condition, were given a random podcast. Three factors were measured twice per condition; pre-intervention and post-intervention. The first two measurements (positive and negative affect level) were both assessed using the Positive and Negative Affect Scale. The third factor, trait anxiety level, was measured using the State-Trait Anxiety Inventory.

Participants

Forty-five students were recruited from the university's undergraduate student population. The participants were divided into 3 groups, consisting of 15 participants per group. There were 24 males and 21 females with ages ranging from 18 to 33 (M=21.93, SD=3.06). Participants received course credit and were given $5 gift cards as an incentive.

Materials

Oculus Go

The Oculus Go was used as the virtual medium for the virtual reality condition in which participants engaged in the virtual mindfulness training exercise.

Positive and Negative Affect Schedule (PANAS)

The PANAS provides a way to measure both positive and negative affect in a person and maintain reliability and validity. When filling this out, participants are asked to rate on a likert-type scale how they are feeling. There a variety of different times that this scale can be used for, for the purposes of this study, participants were asked to answer as they felt in the moment. A shortened version was used, containing ten of the original twenty items that were found to have the strongest validity.

State-Trait Anxiety Inventory (STAI)

The STAI provides a way to measure the amount of anxiety present in a person at the given time. The original STAI consisted of 40 statements where participants would circle a number correlating to a likert-type scale about how much they felt the statement described. For the purposes of this study, the shortened version was used that consisted of six items that were found to be the most anxiety-present and anxiety-absent.

Procedure

Upon arrival in the lab, participants were presented with the informed consent form. Having signed the consent form, participants were asked to step into the room located inside the lab. When in there participants were placed at a computer where they completed part 1, series of questions. In Part 2, participants were given a run-through practice before completing a 5-minute, focus-attention task. Lastly, part 3 consisted of a 10-minute session (the first of their 10-day trial) which was then followed by another series of questions.

RESULTS

To test the hypotheses that guided the current study, we conducted several descriptive and inferential statistics tests. Table 1 presents a summary descriptive statistics for each of the dependent variables before and after the breathing exercise.

Table 1. Summary of Descriptive Statistics

	Before	**After**
	M (*SD*)	*M* (*SD*)
State Anxiety		
Listening	50.87 (12.83)	50.14 (15.25)
Guided Audio	48.27 (9.92)	42.74 6.16)
VR-Based	46.22 (7.81)	44.08 (11.56)
Positive Affect		
Listening	2.79 (.886)	3.07 (.934)
Guided Audio	3.11 (.580)	3.23 (.453)
VR-Based	2.85 (.761)	3.01 (1.02)
Negative Affect		
Listening	2.17 (.922)	2.52 (.973)
Guided Audio	2.44 (.660)	2.0 (.571)
VR-Based	2.25 (.873)	1.91 (.595)

Hypothesis 1a predicted reductions in trait anxiety levels in the two mindfulness conditions when compared to the listening condition and Hypothesis 1b predicted the reductions observed in the VR-based group would be greater than those obtained in the audio-based group. An ANCOVA was run to determine the effect of the interventions on post-intervention trait anxiety levels after controlling for pre-intervention trait anxiety levels. As seen in figure 1, after adjustment for pre-intervention trait anxiety levels, there was no statistically significant difference in post-intervention trait anxiety levels across the three groups, $F(2, 41) = .095$, $MSE = .664$, $p = .909$, indicating there were no significant changes in trait anxiety levels compared to the baseline measurements.

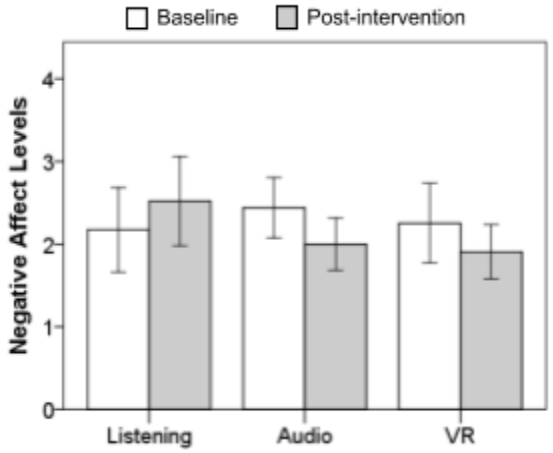

Figure 1. Negative Affect

Hypothesis 2a predicted greater increases in positive affect levels in the two mindfulness conditions when compared to the listening condition and Hypothesis 2b predicted the increases observed in the VR-based group would be greater than those obtained in the audio-based group. An ANCOVA was run to determine the effect of the interventions on post-intervention positive affect levels after controlling for pre-intervention positive affect levels. As seen in figure 2, after adjustment for pre-intervention positive affect levels, there was no statistically significant difference in post-intervention positive affect levels across the three groups, $F(2, 41) = .095$, $MSE = .664$, $p = .909$, indicating there were no significant changes in positive affect levels compared to the baseline measurements.

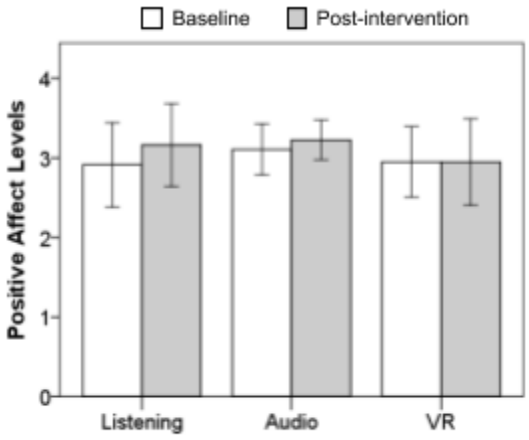

Figure 2. Positive Affect

Hypothesis 3a predicted reductions in negative affect levels in the breathing exercise conditions when compared to the listening condition and Hypothesis 3b predicted the reductions observed in the VR-based group would be greater than those obtained in the guided audio group. Results of ANCOVA revealed a significant difference in post-intervention negative affect levels, after controlling for

pre-intervention negative affect levels, $F(2, 41) = 4.40$, $MSE = .452$, $p = .019$.

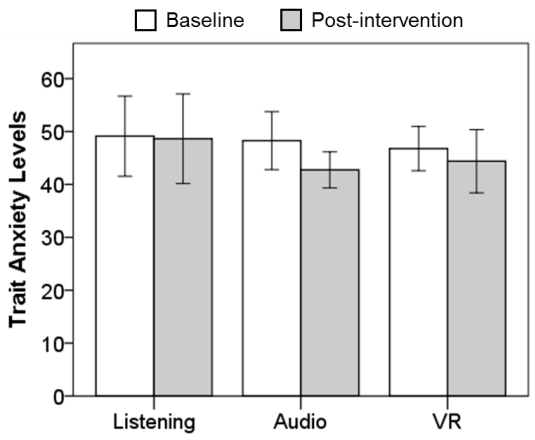

Figure 3. Trait Anxiety

As seen in figure 3, planned contrasts revealed that post-intervention negative affect levels were significantly lower in the VR-based mindfulness group vs. the listening group (*Mdiff* = -.644, *SE* = .246, $p < .05$) and in the audio-based mindfulness group vs. the listening group (*Mdiff* = -.623, *SE* = .248, $p < .05$). There were no significant differences between the VR-based and audio-based groups in post-intervention negative affect levels (*Mdiff* = -.021, *SE* = .247, $p > .05$). See Figure 1.

Discussion

Analysis of trait anxiety between the VR and audio groups when compared to the listening group revealed no significant difference in trait anxiety reduction. This suggests that the present MBI and VE used are not any more effective at decreasing trait anxiety than any other MT. Furthermore, trait anxiety level was also compared between just the VR and audio groups which indicated no significant difference. This finding was particularly evident based on the previous observation that the mindfulness conditions did not significantly differ from the listening condition. Overall analysis of pre-intervention trait anxiety compared to post-intervention trait anxiety across all three conditions revealed no significant differences.

In the analysis of positive affect, when comparing the VR and audio groups to just the listening group, results indicated no significant difference. Although the mindfulness groups did not significantly differ from the listening group, we still compared the two mindfulness groups. The analytic comparison between the two mindfulness groups indicated no significant difference, suggesting that the virtual medium did not effectively increase positive affect. Moreover, when comparing pre-intervention positive affect to post-intervention positive affect across all three conditions, no significant difference was accounted for.

The final analysis calculated the change in negative affect from pre-intervention to post-intervention, across all three conditions. The results indicated that there was a significant reduction in negative affect in both mindfulness conditions when compared to the listening group. To examine the extent to which the virtual medium effectively reduced negative affect, both mindfulness groups were compared. There was no significant difference observed, indicating that the VR-based intervention did not

produce a more beneficial effect than the audio-based intervention.

We found that participants experienced a decrease in negative affect in the VR and audio conditions. These results match with Freeman at al. (2004) and Navarro-Haro et al. (2017), who predicted that immersion within a VE coupled with MT will decrease negative emotional rating while increasing relaxation. The data supported research that the experience of VE creates the experience of presence which in turn can increase the feeling of relaxation. Moreover, Bhayee et al. (2016) suggests that repeated MT can reduce negative emotions and bolster a fair increase in subjective well being. The increase in attention may direct cognitive resources toward the creation of a sense of well being within the practitioner, but more results are needed to establish a stronger relationship. Astrom et al. (2013) found that MT was significantly efficacious at decreasing depression and anxiety within the internet-based condition. This suggests that using a remote option for MT, such as the internet or cloud-based applications, can deliver similar mood enhancing results as in-person MT.

While the findings show that VE are no more effective than other MT practices, there are limitations to the current study. With a small sample size of 45 total participants, each condition that was tested only contained 15 participants. With a bigger sample size, the current findings may have been able to uncover additional differences that may be present when using VE for MT. Also, while this study was completed over a 10 day trial period, participants were asked to complete their MT exercises on their own outside of a controlled lab setting. This made it so there was no way to ensure participants were receiving each MT trial at the appropriate time. Additional limitations include the use of the STAI as the data relies strictly on self-reported measures, which may leave room for participant responses to be biased.

Based on these ideas, physiological measures could help to increase the reliability of findings. Doing so could help uncover differences in brain activity that may be present before and after participants complete any MT interventions within a VE. Another implication of this study is that the VE that participants interacted with were all the same. It could be worth analyzing differences when individuals are placed within different virtual environments to see if this has any impact on the effect of the intervention they are completing.

It is also true that participants only given meditation trials to complete only involving focus. Participants who completed the meditation tasks within this experiment also only were given meditation trials pertaining to focus. It could be beneficial to see if there is a difference in effect for different types of meditation trials within a VE. While the current findings were only significant when testing for negative affect, this may have been due to the short amount of time that participants completed each task. It's possible that increasing the amount of time of these tasks could help to show more

significant results with positive affect. This would more closely replicate longer periods of mindfulness based cognitive therapies.

The hope of this study is to shed light on the use of VR-based mindfulness interventions to promote wellbeing. VR holds the possibility of delivering MT interventions in a more convenient way then traditional training (i.e., audio-based, guided training). While there is still more information to uncover, these findings help elucidate the effects of of VEs on subjective well being and negative affective states.

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