DESIGNING AND IMPLEMENTING INDIVIDUALIZED VIRTUAL REALITY FOR SUPPORTING THE TREATMENT OF MENTAL HEALTH

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Abstract

Depression is a prevalent mental health disorder with serious detrimental effects on individuals and society at large. Yet, it is largely untreated or underdiagnosed, often due to insufficient healthcare resources. Virtual Reality (VR) technology has the potential to be an effective treatment for mental health illnesses such as anxiety, eating disorders, and phobia, according to studies. However, little research has been conducted on the therapeutic application of VR to treat and prevent depression. Aside from this, little is known about how individualizations in virtual reality can alter user experience to improve mental health. In this thesis, we describe the design implementation process of iVR – an individualized VR application designed to promote self-compassion and support the treatment of depression. At present, there is little known about the effects of individualized VR on self-compassion and depressive symptoms.

This research aims to investigate if an individualized VR can potentially be used to increase self-compassion and reduce symptoms of depression, and also evaluate the usability and acceptability of the individualized VR among participants. A total of 36 participants were recruited in the pilot study. Participants attended two iVR sessions, at least two weeks apart. Findings reveal that individualized VR shows promise in increasing self-compassion and reducing symptoms of depression and that the iVR system was generally usable and acceptable among participants. This provides justification for a larger-scale clinical study in the future.

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Chapter 1: Introduction

1.1 Background

Depression is a major human blight, with an estimated 3.8% of the population affected, including 5.0% of adults and 5.7% of adults older than 60 (World Health Organization, 2021). Its symptoms can be incapacitating, and its effects are far-reaching, affecting not only the individual patient but also their families and society. Because of this, depression is the leading cause of functional disability worldwide and a significant contributor to the global disease burden (World Health Organization, 2021). According to the World Health Organization, prolonged moderate or severe depression can cause a person to suffer greatly, impacting their performance in their daily lives and might lead to suicide in the worst cases (2020). Currently, there are psychological and pharmacological treatments that are widely used to treat depression, such as cognitive behavioral therapy (CBT), interpersonal psychotherapy (IPT), and antidepressant medication (World Health Organization, 2020). Despite different treatment options, around 76% to 85% of people in low to middle-income countries do not receive appropriate care (Wang et al., 2007). This gap in healthcare for depression can be caused by a lack of resources and trained healthcare providers (World Health Organization, 2020). While measures have been taken to tackle these barriers (World Health Organization, 2020), more efficient and accessible care is still very much needed.

Research shows that self-compassion – or treating oneself with kindness and understanding during times of struggle – is a protective factor of depression. According to Gilbert (2009), self-compassion can be increased by training oneself in compassion-related skills. Increasing self-compassion is generally the goal of self-compassion focussed therapy (CFT), a form of CBT that focuses on increasing self-compassion (Gilbert, 2009). The efficacy of psychotherapies such as CBT has been proven in treating depression, and its positive effects might persist for longer when compared to antidepressant medications (Cuijpers & Gentili, 2017). However, the downside of CBT is that it often requires numerous components to interact with each other and can be resource-intensive.

The high level of immersion afforded by modern VR head-mounted display (HMD) and its ability to stimulate the user's sense of presence could improve the way skills are trained in several fields, including education and business (Grassini et al., 2020). VR technology could be more cost-effective than conventional training methods. It has an immense potential to be used as a therapeutic tool in mental health care (Emmelkamp & Meyerbröker, 2021).

The use of Virtual Reality in the treatment of mental health disorders, namely post-traumatic stress disorders (PTSD), specific phobias and social anxiety disorder (SAD), has been widely studied (Emmelkamp & Meyerbröker, 2021). VR has been used as a tool for exposure therapy in the treatment of post-traumatic stress disorder (PTSD), in which patients are exposed to a simulated scenario that triggers their trauma in conjunction with relaxation training to help them adapt to the stress and eventually decrease their anxiety in a stressful situation over time (Freeman et al., 2017). VR has also been used to provide exposure therapy for the treatment of phobia, in which individuals are exposed to a simulation of their cause of fear in a safe, controlled virtual environment. (Rothbaum et al., 2000). VR was proven to be effective in the treatment of phobias, including acrophobia, trypanophobia, panic disorder, claustrophobia, social phobia, agoraphobia, fear of driving, and arachnophobia (Giuseppe, 2003).

Despite the extensive amount of literature on the use of virtual reality for mental health, very little is known about the efficacy of virtual reality for the treatment of depression. Several studies, for instance, a study by Falconer et al. (2016) and a feasibility study by Shah et al. (2015), found that the use of virtual reality can decrease levels of depression over time.

Shah et al. (2015) investigated the effect of a VR-based stress management program on people with mood disorders. Upon completing the program, participants (n=22) reported lower levels of subjective stress, depression, and anxiety and higher measurements in skin temperature, perceived relaxation, and knowledge. However, due to the limited sample size and the lack of a control sample, further research might be needed to verify the findings of this experiment.

A study by Falconer et al. (2016) analyzed the impact of self-identification via virtual bodies within a virtual reality environment on self-compassion in patients with depression. The study's results demonstrated that virtual reality shows promise in improving depressive symptoms. Building on the results of the study by Falconer et al. (2016), Baghaei et al. (2020) explores the possible effect of individualization in VR on the self-compassion of people with depression. According to Baghaei et al. (2020), individualization of Virtual Reality mental health therapy can benefit patients and therapists by enhancing user experience and helping therapists gather knowledge about their patients that would otherwise be difficult to obtain. An early prototype of iVR was then designed and implemented to be used in a preliminary study (Baghaei et al., 2021). The participants were allowed to choose their preferred therapy environment, avatar, and scenario in this early prototype. The iVR can be a powerful tool to gather knowledge from patients who might not be as forthcoming in giving information about their mental health, as therapists could see the individual's choices from each session. Results from Baghaei et al.'s (2021) study suggest that individualization improved engagement on the prototype and could potentially be used in a clinical setting. However, some aspects of the prototype can be improved based on participants' feedback, mainly in terms of the graphics and user experience. The effects of individualized VR in a clinical setting were also largely unknown, as Baghaei et al.'s (2020) study did not investigate the impact of iVR on self-compassion levels and depressive symptoms.

1.2 Research Questions

Given the lack of research regarding the possible effects of individualized Virtual Reality on self-compassion and depression, this study will focus on designing and implementing elements of iVR, an individualized VR application for mental health, and investigating if the iVR can positively impact self-compassion and depressive symptoms in participants. This study will investigate the following research questions:

RQ1. Can Individualized VR potentially be used to increase self-compassion in participants?

RQ2. Can Individualized VR potentially be used to reduce symptoms of depression?

RQ3. Was the current implementation of iVR generally usable and acceptable?

1.3 Thesis Outline

Chapter 2 provides a background on depression and self-compassion, a protective factor against depression. It also reviews current literature on the use of Virtual Reality in mental health, including the use of VR in the treatment of depression. Chapter 3 outlines the design and development process of the iVR used in the evaluation, while chapter 4 details how the study was conducted in April 2022. The results of the study are presented in Chapter 5. Chapter 6 discusses the outcomes and limitations of the study. Finally, conclusions are given in Chapter 7.

In the course of the study, the author has prepared and presented two publications, which are listed in Appendix C.

Chapter 2: Literature Review

2.1 Depression

Depression is ubiquitous in the general population, affecting more than 264 million people worldwide (James et al., 2018). Depression is described as a mental illness where one experiences persistent low mood and feels sad and miserable most of the time (New Zealand Ministry of Health, 2020). Depression is the leading cause of functional disability worldwide and a significant contributor to the global disease burden (World Health Organization, 2021). This is due to the impairment of patients' ability to cope with daily stresses and perform daily activities independently (Astuti et al., 2020). During a depressive episode, a person experiences symptoms that could cause severe difficulties in their personal, familial, social, educational, occupational, and other vital areas of functioning (World Health Organization, 2021).

The eight neurovegetative symptoms of depression as specified by the Diagnostic and Statistical Manual of Mental Disorders-DSM-5 can be remembered with the mnemonic 'SIGECAPS' created by Dr Carey Gross at Massachusetts General Hospital (Kadiyala, 2020). The acronym refers to a prescription one might write for a depressed and anergic patient: SIG: Energy CAPSules (Carlat, 1998; Kadiyala, 2020). Each letter represents key diagnostic criteria for major depressive disorder: Sleep disorders (either increased or decreased sleep); Interest deficit (anhedonia); Guilt (worthlessness, hopelessness, regret); Energy deficit; Concentration deficit; Appetite disorder (either decreased or increased); Psychomotor retardation or agitation; and Suicidality (Flemming, 2021; Maurer et al., 2018). Anhedonia and depressed mood are the two primary signs of depression (New Zealand Ministry of Health, 2020). The presence of four SIGECAPS symptoms in addition to depressed mood or anhedonia for at least two weeks is suggestive of major depression (Carlat, 1998; Hong et al., 2019), and additional screening should be considered (Maurer et al., 2018).

Depression can become a chronic disorder if inadequately treated (National Collaborating Centre for Mental Health (UK), 2010). Prolonged moderate or severe depression can cause a person to suffer greatly, impacting their performance in their daily lives and might lead to suicide in the worst cases (World Health Organization, 2020). However, depression is widely undiagnosed and untreated (National Collaborating Centre for Mental Health (UK), 2010). This can be caused by a lack of trained healthcare providers, social stigma associated with mental disorders, and inadequate mental-health resources (World Health Organization, 2020). Almost half of the world's population lives in a country with only two psychiatrists per 100,000 people (World Health Organization, 2019). Around 76% to 85% of people in low to middle-income countries do not receive appropriate care (Wang et al., 2007). Therefore, more efficient and accessible care is still very much needed to bridge the gap in healthcare for depression.

2.2 Self-Compassion and Depression

Recently, self-compassion has emerged as a protective factor against the onset and maintenance of depression symptoms (Egan et al., 2022) (Pullmer, Chung, Samson, Balanji, & Zaitsoff, 2019). Positive self-compassion was described as treating oneself with kindness and understanding during times of struggle (Zhang et al., 2018), as opposed to self-criticism, which was characterized by negative self-judgement and self-evaluation in perceived failure (Ehret et al., 2015).

According to Neff (2003), self-compassion consists of three key characteristics exhibited at times of personal failure or hardship: (1) self-kindness, which refers to being kind to oneself as opposed to self-criticism and judgement, and (2) common humanity, which involves recognizing suffering as a shared human experience as opposed to something isolating and (3) mindfulness, which involves a willingness to approach difficult situations with acceptance and curiosity as opposed to over-identification.

Gilbert (2009) describes from a theoretical perspective how self-compassion activates affective regulation systems involved with feelings of contentment, safety, and connectedness, which help moderate increased threat-oriented emotions in people with high levels of shame and self-criticism. Chishima et al. (2018) demonstrate how self-compassion predicts adaptive coping following the recall of a stressful incident by decreasing threat perceptions. Similarly, higher levels of self-compassion mitigated the effects of a stress-inducing stimulus on physiological stress responses, according to Bluth et al. (2016). These findings give empirical support for the hypothesis that kindness and compassion directed inwards may guard against the harmful impacts of stressful experiences, hence promoting resilience against depression symptoms and related pathologies (Pullmer et al., 2019).

Studies suggest that compassion can be increased via training (Germer & Neff, 2019; Jazaieri et al., 2013). In the treatment of depression, this is commonly done with Cognitive Behavioral Therapy (CBT) and adaptations of CBT that specifically targets self-compassion, such as Mindfulness and Self-Compassion (MSC) protocol and Compassion-Focused Therapy (CFT).

2.3 Cognitive Behavioral Therapy (CBT)

Both psychological and pharmacological treatments are widely used to alleviate the symptoms of depression (World Health Organization, 2020). It has been demonstrated that the results of psychological treatments for depression in adults are comparable to those attained through pharmacological treatments and possibly more long-lasting (Cuijpers & Gentili, 2017).

Cognitive Behavioral Therapy (CBT) is a widespread and effective psychological treatment for depression (Hundt et al., 2013; Li et al., 2018; López-López et al., 2019). According to Li et al (2018), the effects of CBT are immediate and might endure for a considerable amount of time. It also offers a high efficacy in people with treatment-resistant depression (Li et al., 2018).

Cognitive-behavioral models examine the role of cognitions and behaviors in the development, management, and treatment of depression (Hundt et al., 2013). Beck, Rush, Shaw, and Emery's (1979) cognitive model suggests that dysfunctional ideas, core beliefs, and information processing biases are precursors to and increase the risk for depression, and CBT treats depression by addressing them. Behavioral components of CBT (Beck et al., 1979) and behavioral activation (Hundt et al., 2013) alleviate depression by increasing the probability that patients may meet natural reinforcers in their surroundings. Overall, the objective of cognitive behavioral therapy is to teach patients to establish a new or modified repertoire of behaviors and beliefs that they can employ to lessen depression and prevent recurrence (Hundt et al., 2013).

Among the different forms of CBT, studies show that interventions that focus on increasing self-compassion are effective in lowering depressive symptoms (Egan et al., 2022; Frostadottir & Dorjee, 2019). A study by Ferrari et al. (2019) supports the efficacy of self-compassion-based interventions across various outcomes and diverse populations. Ferrari et al. (2019) conducted a meta-analysis. They found that self-compassion interventions significantly improved across 11 diverse psychosocial outcomes, with moderate effects of interventions on anxiety and depression. Arimitsu (2016) examined a seven-session self-compassion intervention (including loving-kindness meditation, mindfulness training and compassionate mind training) with Japanese university students who had low self-compassion. Significant decreases were observed in depressive and anxious symptoms compared to controls, maintained at a three-month follow-up. In an open trial evaluating a four-session group self-compassion intervention with university students with elevated depressive symptoms in the UK, (Burke et al., 2020) found pre-post reductions in anxiety and depression.

The following section will discuss Mindfulness and Self-Compassion (MSC) and Compassion Focused Therapy (CFT) (Gilbert, 2009; Germer & Neff, 2019), some of the interventions that are widely used to explicitly increase self-compassion.

2.3.1 Mindfulness and Self-Compassion (MSC)

Mindfulness and Self-Compassion (MSC) is a mindfulness-based self-compassion training program developed by Chris Germer and Kristin Neff (2019). In the context of MSC, self-compassion is a form of self-to-self relationship characterized by a compassionate approach towards oneself in the face of personal suffering. At the same time, mindfulness is described as being aware of one’s present experience of suffering with clarity and poise, without becoming caught up in a dramatic narrative about negative parts of oneself or one’s life experience - a process known as “over-identification” (Neff K. D., 2003).

According to Germer and Neff (2019), there were several reasons why MSC was based on mindfulness:

1. Compassion has always been an implicit component of mindfulness training, in the sense that we can only be mindful when our awareness is warm and loving. We must be able to recognize pain in order to offer compassion to our environment and to ourselves.
2. Self-compassion training can trigger difficult emotions, at least during the beginning phases of practice; therefore, we require mindfulness to anchor and stabilize our awareness.
3. Mindfulness training fosters broader awareness and calmness as the foundation for compassionate action.

MSC combines training in personal growth and psychotherapy. When someone treats themself with compassion and understanding, they eventually unearth instances in their past in which they were not treated with compassion and understanding (Germer & Neff, 2019). MSC does not emphasize the healing of these old traumas like psychotherapy does. Instead, MSC trains individuals to approach them with mindfulness and self-compassion.

Studies suggest that MSC is effective at enhancing self-compassion and other aspects of psychological wellness. A randomized controlled trial was conducted by Friis et al. (2016) to evaluate the effects of self-compassion training on mood and metabolic outcomes among patients with diabetes. Measures of self-compassion, depressive symptoms, and diabetes-specific distress were taken at baseline (preintervention), week 8 (postintervention), and 3-month follow-up. Friis et al.'s (2016) study shows that MSC participants demonstrated a significantly greater increase in self-compassion and decrease in depression and diabetes distress compared to controls, suggesting that MSC may have both emotional and metabolic benefits among patients with diabetes. A study by Bluth et al. (2016) investigates the efficacy of an adaptation of MSC developed for adolescents called "Making Friends with Yourself" (MFY). Compared to the waitlist control, the intervention group had significantly greater self-compassion and life satisfaction and significantly lower depression than the waitlist control, with trends for greater mindfulness, greater social connectedness and lower anxiety, implying that Mindful Self-Compassion skills can be taught at a young age. A recent study by Pérez-Aranda et al. (2021) showed that mindfulness and self-compassion had significant direct effects on anxiety and depression symptoms.

A typical MSC therapy is usually delivered in a group setting for eight sessions (Germer & Neff, 2019). Participants learn mindfulness and self-compassion in these sessions through various modalities, including talks, exercises, meditations, informal practices, discussion, poetry and videos (Germer & Neff, 2019). However, because there was a very limited amount of Virtual Reality Head Mounted Devices (VR HMD) available at the time the research was conducted, it was not possible to provide the device to multiple participants simultaneously to perform a group session. Therefore, MSC as a group session was not included in the scope of this study.

2.3.2 Compassion-Focused Therapy (CFT)

Compassion-focused therapy (CFT) is a system of psychotherapy established by Paul Gilbert that employs self-soothing techniques to assist individuals in accessing and cultivating self-compassion to resolve shame and self-criticism concerns and develop supportive inner resources (Gilbert, 2009). The evolutionary model and psycho-education drive CFT techniques, aiming to depersonalize and de-shame the client by teaching them how their brain regulates emotion. The theoretical background of this approach is based on neuropsychology, attachment theory, evolutionary psychology, social psychology, and Buddhism, and it tries to help the individual self-soothe and acquire acceptance and compassion for their suffering (Gilbert, 2009). Once clients stop criticizing and blaming themselves for their symptoms, thoughts, and emotions, they can proceed toward accepting responsibility and learning to cope (Gilbert, 2014).

In the context of CFT, compassion is understood in terms of specific attributes and skills one can train in. According to Gilbert (2009), the attributes of compassion include:

1. Care for well-being, or the ability to utilise compassionate motivation to alleviate distress and promote the target's growth.
2. Sensitivity, where one is sensitive to distress and needs and can identify others' emotions and needs.
3. Sympathy, or the ability to be emotionally engaged with the feelings and suffering of others,
4. Distress tolerance, or the ability to contain high levels of emotion when one is in distress rather than avoid, deny, or divert from them.
5. Empathy, or making an effort to understand the meaning behind a person's feelings.
6. Non-Judgement, described as not condemning, shaming, criticising, or rejecting.

Whereas the skills of compassion included:

1. Compassionate attention: focusing our attention in a way that helps and supports us. For example, it may involve remembering times when we were kind to others or others were kind to us, or it might involve compassionate imagery.
2. Compassionate reasoning: involves how we reason about the world, ourselves and others. CFT teaches how to replace self-critical thinking with compassionate refocusing.
3. Compassionate behavior: behaviors that are focused on alleviating distress and facilitating development and growth. The therapist encourages the client to create an encouraging, warm tone in their minds when the individual has to engage in difficult or frightening behavior.
4. Compassionate imagery: the technique of using compassionate imagery involves a series of exercises that help the client generate compassionate feelings for themselves. The client imagines themselves as a highly compassionate person and explores their sense of age, facial expressions, body postures, voice tones and styles of thinking. Clients can be encouraged to

practise each day at becoming 'the compassionate self' with the appropriate facial expressions, voice tones and ways of thinking.

5. Compassionate feeling: relates to experiencing compassion from others, for others and the self. As noted throughout, compassionate feelings are generated in a number of ways, for example, via the therapeutic relationship and focused attention, thinking, behavior and imagery.
6. Compassionate sensation: therapist helps the client to explore feelings in their bodies when they focus on being compassionate, experiencing compassion from others and being self-compassionate.

In CFT sessions, the therapist uses the skills and expresses the attributes of compassion to instil them in the client (Gilbert, 2009). By working with and developing these skills, compassion-focused therapy tries to help the client create feelings of warmth, kindness and support within themselves. These sessions can be delivered one-on-one or in a group session (Craig et al., 2020; Judge et al., 2012).

A three-stage approach is used in CFT when dealing with emotional situations (Falconer et al., 2016):

1. Validation phase: The aim of this stage is to acknowledge that the other person is upset, that you do not judge them for this, and that it is perfectly acceptable for them to react in this way.
   Sample dialogue: *"It's not nice when things happen to us that we don't like. It's really upset you hasn't it?"*
2. Redirection of Attention: The aim of this stage is to direct the other person's attention towards something that is more positive, soothing, and comforting.
   Sample dialogue: *"Sometimes when we are sad it's helpful to think of someone who loves us or is kind to us."*
3. Memory Activation: The aim of this stage is to suggest that the person could try to recall a memory of a person who loves or is kind to them. This memory is supposed to instil more positive feelings of warmth, comfort, and safety.
   Sample dialogue: *"Can you think of someone who loves you or is kind to you? What might they say to you now that would make you feel better?"*

There is extensive literature supporting the efficacy of CFT in increasing self-compassion and improving mental well-being, including reducing symptoms of depression. A study by Collins et al. (2018) investigated the effectiveness of Compassion-Focused Therapy (CFT) in reducing anxiety, depression, and respiratory rate in people with dementia and their spouses. The study found that CFT effectively improves depression and the quality of life of people with dementia and their spouses. Further, in a randomized controlled trial conducted by Sommers-Spijkerman et al. (2018) to investigate the effects of CFT as guided self-help on well-being, it was found that participants in the CFT group (n=120) showed greater improvement on well-being post intervention compared to the control group (n=122), suggesting that CFT shows promise as a public mental health strategy for increasing well-being and decreasing psychological distress. These findings show that CFT is an effective intervention for increasing self-compassion and improving depressive symptoms.

2.4 Multimedia CBT Intervention

As discussed in the previous section, compassion-focused CBT interventions such as MSC and CFT are effective in increasing self-compassion and reducing the symptoms of depression. However, though effective, CBT interventions, in general, can prove to be challenging and resource demanding since they frequently consist of complex therapeutic components that are administered in numerous ways (Cujipers & Kleiboer, 2017). Therefore, there is a need for innovative interventions that are more sustainable and easily accessible (Falconer et al., 2015).

While CBT is often provided in a traditional face-to-face format (either individually or in groups), the use of multimedia platforms is on the rise (Button et al., 2012). According to Cujipers and Kleiboer (2017), multimedia CBT therapies can be given with varied levels of therapist interaction, among them "self-help" or "self-directed" approaches, which are characterized by a standardized treatment regimen that the patient follows without having to speak to the therapist directly. It is also possible to use hybrid CBT interventions that combine in-person sessions with multimedia components (López-López et al., 2019). Moreover, in a context where CBT is often not accessible for patients who could benefit from it (Shafran et al., 2009; Wiles et al., 2012) multimedia and hybrid interventions constitute promising alternatives to improve coverage for depressed adults (Cujipers & Kleiboer, 2017).

This study utilized the hybrid intervention approach, where CFT was delivered through a multimedia device, more specifically through a Virtual Reality Head Mounted Display (VR HMD), with the guidance of a therapist.

2.5 Virtual Reality

Virtual Reality (VR) is an emerging technology that enables the presentation of artificial settings that represent possible scenarios in a realistic and immersive way (Grassini et al., 2020). VR has the potential to excite the senses as effectively as a real-life stimulus can (Kritikos et al., 2020). The high level of immersion provided by modern head-mounted display (HMD) VR, and therefore its ability to stimulate the sense of presence for the user, could improve the way skills are trained in several fields, including education and business (Grassini et al., 2020). VR technology might also be more cost-effective than standard training methods. It has an immense potential to be used as a therapeutic tool in mental health care (Emmelkamp & Meyerbröker, 2021).

The basic technology of Virtual Reality, namely a computer that generates an image, a display system that displays the information to the user, and a tracker that communicates back the user’s location and orientation in order to update the image, has been around for more than 50 years. The hardware we recognize today debuted in the 1980s, though it has been primarily restricted to specialized facilities

(Freeman et al., 2017). Now, VR is moving out of specialist laboratories, and VR systems in various degrees of complexity and levels of immersion are available to the general public.

Virtual Reality systems can be categorized into three levels of immersion: low-immersive, semi-immersive, and fully immersive (Miller & Bugnariu, 2016). In the low-immersive VR experience, the platform does not entirely cover the user's field of view. Thus, the user does not feel like they are in the virtual environment. Low-immersive VR experiences are typically presented via desktop or laptop screens (Martirosov et al., 2022). The semi-immersive experience provides a virtual environment via a projector system and allows limited interaction with the environment (Miller & Bugnariu, 2016). An example is the Cave Automatic Virtual Environment (CAVE) system, where computer-generated images are projected to the walls of a room, and the user wears tracked shutter glasses to view the scene three-dimensionally. The fully immersive VR is a digital technology that enables users to experience simulated environments as if they were in the real world (Miller & Bugnariu, 2016). In other words, users perceive a computer-generated virtual environment through visual, auditory, and haptic cues, which are typically presented by wearable technology like head-mounted displays (HMD) and gloves. The new generation of Virtual Reality head-mounted displays (VR HMD) falls under this category (Martirosov et al., 2022).

The new generation of VR HMD and its accompanying technology is gaining traction in the market as global companies have invested in making them affordable and accessible for consumers (Freeman et al., 2017). Currently, there are numerous types of VR HMDs available, from simple and inexpensive HMDs that runs their VR software via smartphones such as Google Cardboard (Miller et al., 2020) and Gear VR (Hillmann, 2019) to more sophisticated VR HMD systems like the Oculus/Meta Quest 2 (Hillmann, 2019).

Though they vary in sophistication and affordability, VR HMDs share a common mechanism to provide a virtual scene. They display two different images, one for each eye, that interact to create a stereo scene (Freeman et al., 2017). Each image is independently computed and presented with an accurate perspective based on the position of each eye using a mathematical description of a three-dimensional (3D) virtual scene. The HMD captures the position and orientation of the user's head and head-based gaze direction. As users turn or move their heads to look around, the computer refreshes the displayed images at a high-speed frame rate, often 60 frames per second, creating an illusion of a surrounding 3D stereo scene that can change dynamically.

There is a growing interest in the study of the use of VR in various fields such as education, business, and medical, primarily due to the high level of immersion provided by modern VR HMD and its ability to stimulate the sense of "presence" (Grassini et al., 2020). In a study by Grassini et al. (2020), the use of VR alone does not promote training performance, but the sense of presence does. In this case, immersion reflects the system's technical capabilities, whereas "presence" refers to the subjective experience produced or the illusion of being present in a virtual environment (Jazaieri et al., 2013). According to Slater (2009), presence consists of two elements: place illusion (PI) and plausibility illusion (Psi). PI is the feeling of being in the real place. PI is constrained by the capability of the VR system to provide a natural sensorimotor experience based on the active vision paradigm (Noë 2004). The idea behind this paradigm is that we use our whole bodies to understand what is happening around us. We achieve this by doing movements such as turning our heads, leaning, reaching, looking around, and so on. The VR system should generate images in response to these movements. If what we see corresponds to our movements, the brain concludes that this is our environment. Psi is the feeling that the events experienced in Virtual Reality are really occurring (e.g., that people are walking around and a ball is flying in the air), despite the fact that individuals are consciously aware that they are not real (Slater, 2009). For Psi to occur, the virtual environment needs to respond to the actions of the user, create spontaneous actions towards them, and is ecologically valid when depicting actual events. For instance, if an environment contains virtual human characters, these avatars should react to the presence and actions of the players (e.g. by gaze or by maintaining appropriate interpersonal distances). Participants are likely to behave realistically in VR when both PI and Psi collaborate to create a sense of presence (Slater, 2009), adding to the appeal of the study of VR for education, business, and therapeutic purposes (Emmelkamp & Meyerbröker, 2021).

2.5.1 Virtual Reality in Mental Health

VR has great potential for assisting people in overcoming mental health issues because of its ability to achieve a high level of presence. One of the most common modes of VR application in mental health is virtual reality exposure therapy (VRET) (Emmelkamp & Meyerbröker, 2021). This method of exposure therapy takes advantage of the high level of presence generated in VR environments. Freeman et al. (2017) state that exposure to environmental distress or real-life scenarios can often be triggering or contributing factors to mental health disorders. For instance, the presence of spiders in the room can cause a high level of anxiety and fear in a person with arachnophobia (the fear of spiders), and the presence of alcohol might trigger the urge to start drinking in a person with alcohol abuse disorder. Therefore, healing requires different ways of thinking, reacting, and acting in these situations. Successful interventions can usually change or improve the patient's way of thinking, reactions, and behaviors in stressful real-life situations.

With virtual reality, patients can enter a simulation of problematic scenarios with guidance on appropriate responses from their therapist based on their specific disorder. Problematic scenarios that are difficult to encounter in real life can be generated with the flip of a switch. The difficulty of the simulation can be easily adjusted, and the experience could be repeated many times until learning is made. In addition to that, virtual reality also has the advantage of giving a sense of safety to patients as they are aware that they are in a simulated experience, although their minds and bodies act like they were in a real-life situation, so patients can go through the problematic scenarios with less difficulty and therefore are more open to trying new therapeutic strategies. The learning can then be applied to the real world. In a study by Morina et al. (2015), it was found that gains from virtual reality exposure therapy seem to apply in real-life situations, supporting the effectiveness of VR technology in the treatment of mental health disorders. For some disorders, it may be possible to eradicate the need for any therapist input, while for other disorders, the time required of skilled therapists could be greatly reduced. Thus, VR could help improve access to the most effective psychological treatments.

Studies support the efficacy of VRET in the treatment of mental health disorders such as post-traumatic stress disorders (PTSD), specific phobias and social anxiety disorder (SAD) (Emmelkamp & Meyerbröker, 2021). In treating post-traumatic stress disorder (PTSD), patients are typically exposed to a simulated source of their trauma in combination with relaxation training to decrease anxiety in triggering situations (Freeman D. , 2008). However, despite the fact that prolonged exposure involving emotional processing of traumatic situations and habituation of anxiety is an evidence-based treatment for PTSD, a number of patients are unwilling to undergo this treatment or are unable to visualize the traumatic stimuli due to anxiety avoidance; as a result, these patients may drop out of treatment (Emmelkamp & Meyerbröker, 2021). Because of this, therapists have devised alternate exposure tactics based on virtual reality environments to overcome barriers in activating the fear structure because of avoidance. Moreover, for PTSD patients, exposure to a controlled fictitious virtual environment might be more acceptable than exposure by imagination. Some randomized controlled trials have compared VRET to prolonged imaginal exposure in active-duty U.S. military personnel and veterans. These VR sessions included imaginal exposure to traumatic war memories as well as computer-generated viewing of virtual worlds of Iraq or Afghanistan with multisensory stimulus options tailored to the patient's description of the trauma. VRET was generally as effective as prolonged exposure (Rizzo & Shilling, 2017), although in a larger randomized controlled trial comparing prolonged imaginal exposure to VRET in active-duty troops, prolonged exposure was more effective than VRET at 3-and 6-month follow-up (Reger et al., 2016). Further analyses by Norr et al. (2018) found that both prolonged exposure and VRET were associated with a decreased incidence of suicidal thoughts following therapy, compared to the waiting list control, providing support for the use of VRET (and prolonged exposure) in addressing suicidal thoughts among soldiers with PTSD.

In the treatment of phobia, VRET can be considered a modern form of exposure therapy in which patients are exposed in virtual reality to their specific phobia and shown that their worst-case scenario does not happen (Emmelkamp & Meyerbröker, 2021). The VR technology also shows promise in the treatment of phobias, such as acrophobia (fear of heights) (Kritikos et al., 2020), agoraphobia (fear of being able to escape a situation) (Giuseppe, 2003), and dental phobia (Emmelkamp & Meyerbröker, 2021).

There has been extensive research on the use of VR for the treatment of acrophobia. In a randomized crossover design (n = 26) study, Krijn et al. (2007) investigated whether cognitive coping self-statements would have an additional value above VRET in patients with acrophobia. Participants were randomly assigned to receive either two sessions of VRET followed by two sessions of VRET plus coping self-statements or two sessions of VRET plus coping self-statements followed by two sessions of VRET. Results indicated that VRET reduced the anxiety about heights and avoidance behavior regardless of whether or not coping self-statements were added. In another study by Meyerbröker et al. (2018), VRET was used to treat individuals with acrophobia and fear of flying. Patients were randomly assigned to receive VRET with either yohimbine hydrochloride, propranolol, or a placebo. While all three regimens decreased anxiety symptoms, there were no significant differences between them, showing that VRET with a placebo is an effective treatment for acrophobia. A more recent study evaluated a smartphone application for VRET use (Donker et al., 2019). Individuals with acrophobia were randomly allocated to either a VR cognitive behavioral treatment (VR CBT) group using cardboard VR goggles or a waiting-list control group in a single-blind randomized controlled trial. 193 participants were randomly assigned to either the intervention (n = 96) or control (n = 97) group. Results of the study demonstrated a reduction in acrophobia symptoms after therapy and at the 3-month follow-up.

In dental phobia, VR interventions have been the subject of extensive research. In a recent study, Yamashita et al. (2020) investigated the effect of VR on relieving anxiety during a mandibular third molar extraction. Anxiety decreased among patients who received the VR intervention (n=51) relative to those who had not received VR (n=49). In another study, VR was used as exposure therapy prior to dental treatment (Gujjar et al., 2019). Patients with dental phobia (n=30) were randomly assigned to receive either VRET or an informational pamphlet in a single-blind RCT. Patients in the VRET condition experienced a significant reduction in anxiety levels over time, but patients in the control condition did not. In another recent trial, Lahti et al. (2020) investigated if a short-term virtual reality intervention reduced preoperative dental anxiety. A total of 255 patients were randomly assigned to either the VR intervention group or the treatment-as-usual group. The VR intervention consists of a 3.5-minute immersion in a tranquil virtual environment. In the VR group, total and anticipatory dental anxiety dropped more than in the control group, implying that even a brief VR application can alleviate dental anxiety. In conclusion, VRET can play a significant role in helping individuals with specific phobias overcome their avoidance behavior.

Apart from VRET, Virtual Reality has also been used to assess mental health disorders. For instance, VR has been used to assess substance use disorder to simulate scenarios where addiction behaviors are likely to occur to help therapists observe and plan appropriate therapy for the patient (Srivastava et al., 2014). It is believed that craving in response to alcohol- and drug-related cues contribute to the continuation of substance use disorders (Emmelkamp & Vedel, 2006). Exposure to VR cues (e.g., cigarettes, ashtrays, smokers at a bar) is linked to craving. There is some evidence that peer pressure by virtual avatars is particularly effective at inducing cravings (Emmelkamp & Meyerbröker, 2021). Social pressure by virtual avatars led to a greater craving for alcohol abuse than virtual alcohol (Ghiţă & Gutiérrez-Maldonado, 2018). The findings of these studies indicate that immersing individuals in virtual environments pertaining to their particular addiction can improve the reliability of craving assessment.

2.5.2 VR for Depression

Despite the extensive amount of literature on the use of virtual reality for mental health, very little is known about the efficacy of virtual reality for the treatment of depression. Several studies, for instance, a study by Falconer et al. (2016) and a feasibility study by Shah et al. (2015), found that the use of virtual reality can decrease levels of depression over time.

Shah et al. (2015) investigated the effect of a VR-based stress management program on people with mood disorders. 22 participants participated in a program comprising three daily 1-hour sessions incorporating psychoeducation and VR-based relaxation practice. Both self-reported questionnaires and physiological measurements were collected. Upon completing the program, participants reported lower levels of subjective stress, depression, and anxiety and higher measurements in skin temperature, perceived relaxation, and knowledge. However, further research might be needed to verify the findings of this experiment due to the limited sample size and the lack of a control sample.

Falconer et al. (2016) studied the impact of avatar embodiment within a virtual reality environment on self-compassion in patients with depression. In the study, 15 participants engaged in an 8-minute simulated scenario where they practiced delivering compassion in one virtual body and then experienced receiving compassion in another virtual body. This session was repeated three times. After each repetition, participants were asked to fill out a Patient Health Questionnaire 9 (PHQ-9) to assess and monitor their depressive symptoms. At the end of the study, 5 showed reliable improvement, and a further 4 showed clinically significant change. The study's results demonstrated that virtual reality could potentially be used to improve depressive symptoms.

In a more recent study, Li et al. (2021) evaluated the impact of a Virtual Reality based restorative environment on the emotional and cognitive recovery of people with mild-to-moderate depression and anxiety. A total of 195 participants with mild to moderate depression and anxiety were recruited for the study. The study used several VR restorative environments, including an urban environment and a park environment. Participants were randomly selected into different groups, and each interacted with a particular scene. From the study, it was found that VR based restorative environment can have a positive impact on the emotional improvement and cognitive recovery of individuals with mild-to-moderate anxiety and depression.

2.6 Individualized VR

In the previous section, we discussed how VR could act as a driver in treating various mental disorders by stimulating appropriate emotions, memories, and physical movements that underpin the treatment procedures. However, most VR therapies are predefined and predesigned, yielding a uniform and common approach for all participants that is based on an immersion/presence-specific setting (Wilson & Soranzo, 2015). They do not currently take into account the unique nature, character, and behavior of each individual, which are significant elements affecting the efficacy and the duration of the treatment (Kritikos et al., 2021).

Throughout their life, people encounter a range of experiences and memories, causing them to react differently to known and unknown stimuli and thus, consciously or unconsciously, perceive and interpret stressors in a manner that is unique to them (Newbutt et al., 2020). In particular, overt characteristics such as age, gender, ethnic and cultural differences (Andersson et al., 1993; Brenes et al., 2008; Kritikos et al., 2021), economic, marital, and educational status differences (Robards et al., 2012), individuals with an inclination to nausea and loss of spatial awareness (Mittelstaedt et al., 2018), or more complex circumstances, such as individuals who suffer from comorbidity of psychiatric, neurological or medical conditions (Plana-Ripoll et al., 2019) can have a significant impact on VR interventions and cause significant variability in patient outcomes even though they receive the same VR simulation treatment. Therefore, individualization is an important element in the VR treatment of mental health disorders.

Research shows that individualization can be beneficial in mental health interventions. In a recent pilot study, Minor et al. (2022) investigated if tailoring treatment to focus on clients' daily life issues in therapy could effectively target metacognitive capacity in clients with schizophrenia. Results of the study show that tailoring a metacognitive intervention to improve social functioning and symptoms is feasible and acceptable for schizophrenia. In a study conducted by Egan et al. (2022) to investigate the efficacy of self-compassion in the treatment and prevention of anxiety and depression in youth, it was implied that interventions that are tailored to address diversity, with particular consideration for family environment, culture, sexual identity and specific challenges faced, might improve engagement in self-compassion-based intervention for young people. This supports the use of individualization in the treatment of mental health. Because of this, some studies have started looking into offering personalized engagement with VR prototypes for mental health disorders. Kim et al. (2016) proposed the development of a personalized VR behavioral therapy prototype for tobacco cessation. In a more recent study, Kritikos et al. (2021) looked into the efficiency of personalized VR in treating anxiety disorders such as arachnophobia (the fear of spiders). A total of 36 participants were divided into two groups, the Experimental Group, which was exposed to the adaptive virtual simulation, and the Control Group, which was exposed to a pre-recorded static virtual simulation. Results show that participants in the experimental group managed to stay approximately two times longer in the session when compared to the control group, supporting the efficiency of personalized VR simulation for the treatment of anxiety disorders. Kritikos et al. (2021) proposed that personalization might also have a positive impact on the treatment of other mental health disorders, including depression. However, at present, very little is known about the effects of individualization in VR compassion-focused therapy for depression.

2.7 Prior Study

In a proof-of-concept study, Baghaei et al. (2020) proposed a conceptual design of iVR, an individualized Virtual Reality mental health therapy to enhance self-compassion. This conceptual design was largely based on the structure of Falconer et al.'s VR prototype (2016), with added elements of individualization, allowing participants to choose their preferred therapy environment, avatar, and scenario. The iVR was intended to be used in a clinical therapy setting, where therapists could see the individual's choices from each session (Baghaei et al., 2020). Baghaei et al. (2020) hypothesized that individualized VR could positively impact participants' self-compassion and mental well-being, enhance user experience, and increase therapists' knowledge of clients, which can be used to provide better interventions for clients. Building on this, Baghaei et al. (2021) implemented an early prototype of iVR and conducted a pilot study to gather data on whether participants enjoyed interacting with the app, whether the introduction of choices improves user experience, and if it can be potentially helpful in increasing people's self-compassion and improve their mental well-being in the long run.

A total of 23 participants (5 females and 18 males, mean age of 24) were recruited for the study (Baghaei et al., 2021). Participants were asked to fill out a Patient Health Questionnaire 9 (PHQ-9), a measure often used to assess and monitor depressive symptoms and the outcomes of psychological treatments for depression (Kroenke et al., 2001). The participants then interacted with the iVR prototype and filled out a subjective questionnaire at the end.

An analysis was performed on the main qualitative themes among PHQ-9 High vs Low groups (Baghaei et al., 2021). Both groups had similar recommendations when it came to listing the top three features they liked or did not like about iVR. The top features that participants liked were the ability to customize the avatar, the behavior of the avatar and the environment, clear audio, being immersed in VR, the ability to change avatar and scenery, the realistic crying of the avatar, interactivity, a sense of escapism, the concept of the project, and the enhanced immersion and personal connection with the avatar that resulted from allowing participants to choose the avatar's appearance.

In response to how iVR could be improved in the future, however, more participants in the High PHQ-9 group requested more interaction with the avatar and more options to be provided than participants in the Low group, who placed greater emphasis on improved graphics and better visualization (Baghaei et al., 2021). Several participants suggested that the avatars be made more engaging and realistic and that the graphics be enhanced. Some requested clearer instructions and more customization choices, particularly for picking various surroundings and avatar behaviors. One participant wanted the ability to change the perspective from which they observed the avatar; they preferred to be seated next to the avatar rather than in front of them. If given the opportunity, another participant would have liked to be able to walk around and explore the environment with the avatar. A few participants recommended adding intelligence to iVR so that the avatar can comprehend what the user is saying and respond accordingly. Additionally, more robust and refined facial expressions and ambient music were suggested for improved immersion.

To investigate if introducing elements of choice within iVR will increase mental health professionals' knowledge of participants, Baghaei et al. (2021) interviewed and gathered feedback from seven clinical psychologists. Most of the mental health professionals approached believed that the introduction of individualization on the iVR app would help them increase their knowledge of clients and that it has the potential to be used in a clinical setting. 86% of the psychologists agreed that including elements of choice into iVR would increase their knowledge of clients, 86% liked the individualization afforded by iVR, and 100% believed that iVR had the potential to be used in a clinical setting. Participants also gave additional suggestions for improvement, such as giving mental health professionals complete control over the situation so they can intervene immediately if necessary and providing a tutorial or training for participants to make them feel more at ease during the session.

From Baghaei et al.'s (2021) study, it was found that individualization improved engagement on the prototype and could potentially be used in a clinical setting. However, there were some aspects of the prototype that could be improved based on participants' feedback, mainly in terms of the graphics and user experience.

Chapter 3: IVR Design and Implementation

This chapter outlines the design and implementation of the iVR prototype, an individualized VR for mental health, and how findings from Baghaei et al.'s (2021) study were incorporated to improve it.

3.1 IVR Application Workflow

The structure of Baghaei et al.'s (2020) prototype follows the structure of a prototype by Falconer et al. (2016) that looked at whether practicing compassion skills (Gilbert, 2009) in an immersive virtual reality could increase sufferers' levels of self-compassion. In Falconer's study (2016), the VR application comprises two stages. First, participants were asked to show compassion for a weeping child in a virtual setting, which in turn helped them feel more compassion for themselves. This is then followed by the second stage, in which participants were given the opportunity to embody the weeping child and receive compassion. In the initial prototype (Baghaei et al., 2021), individualisation features were navigated via graphical user interface (GUI) panels added to the virtual environment throughout all stages, as illustrated in Figure 1.

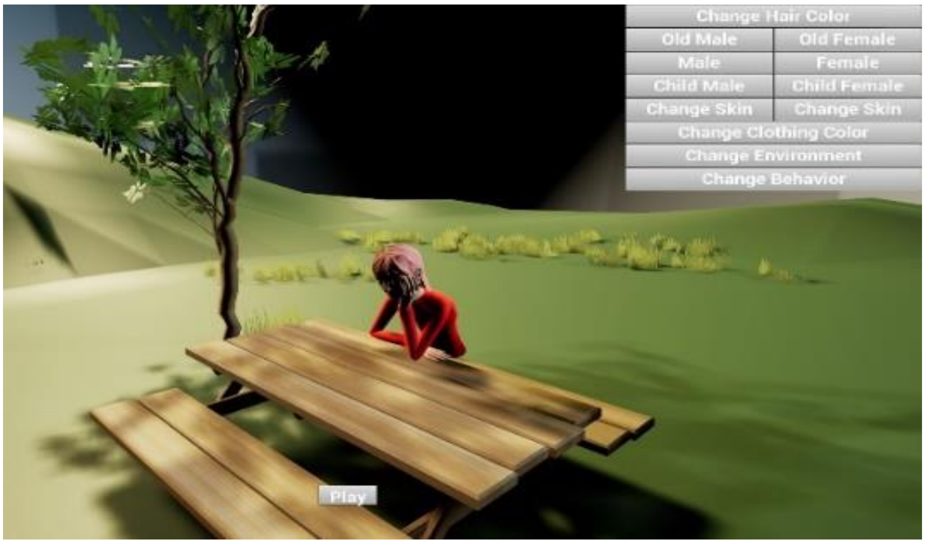

Figure 1 Graphical user interface (GUI) panels added to the virtual environment in early iVR prototype (Baghaei et al., 2021).

The structure of the VR application in this thesis mostly follows the initial iVR prototype (Baghaei et al., 2021), with the addition of a main menu/tutorial stage in the beginning to incorporate some of the qualitative feedback from Baghaei et al.'s (2021) preliminary study. The app included three different stages in total:

1. The main menu stage gives a brief outline of the application and enables them to customize their experience
2. Delivering compassion stage enables participants to practice delivering compassion
3. Receiving compassion stage presents the opportunity to experience compassion

The three stages in the iVR prototype will be outlined in the following sections.

3.1.1 Stage 1: Main Menu/Tutorial

One of the main recommendations from Baghai et al.'s (2020) earlier prototype was to provide clearer instructions and the inclusion of a tutorial or training for participants at the beginning of the experience to make them feel more at ease during the session. Therefore, the Main Menu stage was added to give an introduction to the application and give clear instructions to the participants. In the Main Menu, participants are presented with a brief explanation of how the VR application works and guided through the process of selecting their choice of avatar, environment, and scenario.

To maintain consistency, all menu options on the Main Menu follow the same template. The title of the menu section is displayed at the top of the menu options. All options are populated under the title banner. The contents of the menu options can vary between menu categories. Figure 2 is a screenshot of the Main Menu panel as viewed by the end user. Interactions with the main menu are done via hand-held controllers. When they are done selecting all available options, they can then proceed to the first stage, where they can practice delivering self-compassion.

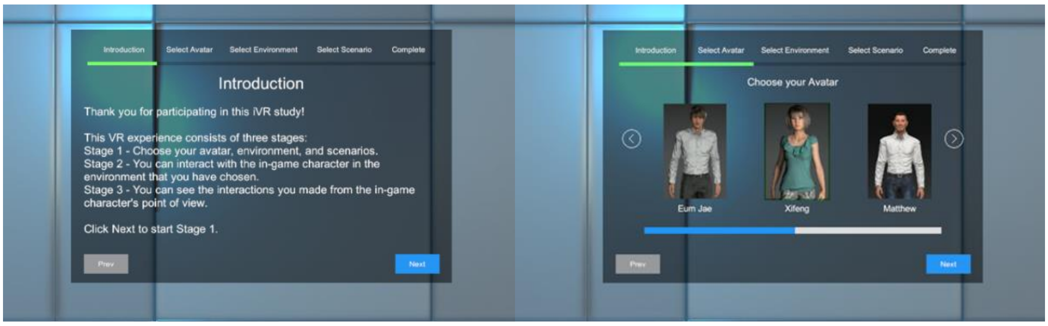

Figure 2 Main Menu stage in the current iVR prototype.

3.1.2 Stage 2: Delivering Compassion

In the second stage of the prototype, participants are given the opportunity to practice delivering compassion to a distressed in-game character. As in Falconer's study (2016), participants embody a virtual avatar when delivering compassion. The benefit of avatar embodiment is that when a life-sized virtual body replaces a person's actual body in immersive virtual reality, the illusion of body ownership, or the perceptual illusion that the body is one's own, is often created (Falconer et al., 2016). This enables participants to train participants in skills of compassion in line with the principles of CFT (Gilbert, 2009), namely the skills of compassionate imagery, compassionate behavior, compassionate feeling, and compassionate sensation. By embodying a virtual avatar of their choice to deliver compassion to a distressed in-game character, participants can utilize the Compassionate Imagery technique as they perceive themselves as a highly compassionate person (in this case, their avatar of choice) and practice at becoming their 'compassionate self' to improve compassion. Participants were encouraged to display compassionate behavior to alleviate distress in others and experience compassionate feelings and explore compassionate sensations when they focus on giving compassion to the distressed in-game character.

As in Baghaei et al.'s (2021) initial prototype, the scene is generated based on the participant's choices. Instead of a pre-determined virtual body, the appearance of the body is determined based on the chosen avatar from the Main Menu stage. The therapy environment, in-game character's appearance and behavior also reflect participant's choice. Taking the feedback for Baghaei et al.'s (2021) initial prototype into account, hints and clear instructions were added in the virtual environment to improve user experience.

When the stage is loaded, the speech of the participants is recorded automatically. After they have finished delivering compassion, they can go to stage by clicking the "Next Stage" button. Figure 3 illustrates a scene from stage 1, where a participant chose to engage with an upset young female character using an Asian woman avatar in the living room environment.

Figure 3 A screenshot of a participant delivering compassion.

3.1.3 Stage 3: Receiving Compassion

In the third stage, the participants will embody the in-game character's virtual body to experience receiving compassion. They will be able to see and hear the speech from the virtual body they chose on the first stage, as illustrated in Figure 4.

Figure 4 A screenshot of participant receiving compassion in current iVR.

This stage enables participants to train in skills of compassion, like the skills of compassionate attention, compassionate reasoning, compassionate feeling, and compassionate sensation (Gilbert, 2009). Participants can demonstrate compassionate attention and compassionate reasoning as they are prompted by the compassionate speech from the avatar to focus their attention to something positive, soothing, and comforting. Receiving compassion from others can also trigger compassionate feelings and compassionate sensations in participant.

Once they have experienced receiving compassion, the scenario ends. They can choose to go to the main menu or quit the application.

3.2 Individualized Elements

Like the initial prototype in Baghaei et al.'s study (2021), the iVR application provides individualization by giving participants an opportunity to personalize their avatar, therapy environment, and therapy scenario.

3.2.1 Avatar Customization

Avatars are prevalent across digital applications. Using avatars as representations of ourselves, we engage in social interaction, play, and conduct business. Researchers are becoming increasingly interested in avatar customization, that is, the ability to modify one's avatar (McArthur, 2017). Avatar customization has been shown to positively influence significant results in various fields. Players who customized their game character experienced higher identification with their avatars, which resulted in increased autonomy, invested effort, satisfaction, and immersion (Kao et al., 2022). A study by Waltemate et al. (2018) investigated the impact of the degree of personalization and individualization of users' avatars and the degree of immersion on typical psychophysical factors in embodied Virtual Environments. Results of the study show that in VR, personalized avatars were found to significantly increase body ownership, presence, and dominance compared to their generic counterparts with a similar degree of realism and graphical quality. These results substantiate the value of personalized avatars in VR applications that relies heavily on body ownership and presence. As the design of iVR relied heavily upon avatar embodiment (Baghaei et al., 2020; Falconer et al., 2016), it might benefit from avatar customization.

Avatar Customization was introduced in the earlier prototype (Baghaei et al., 2021). However, while it was well received, it was found that participants preferred to engage with more graphically realistic avatars. Therefore, improving the avatar's look and feel was one of the main goals in developing the iVR prototype.

For the scope of this project, pre-existing multi-layered humanoid assets were created on the Realussion software. These assets have a reasonably high degree of realism and graphical quality. However, although graphically realistic, these assets use single meshes for the skin layer, making it very technically challenging to programmatically change the avatar's personal attributes, such as clothes and skin colour, based on the participant's selection. For that reason, avatar customization in the prototype was limited to a selection of predefined virtual bodies. As this prototype was intended to be used in a study conducted in New Zealand, avatar choices were made available for major ethnic groups in the region: European/Pakeha, Māori/Pacific Peoples, and Asian (Stats NZ, 2020).

Available choices of virtual bodies are as follows:

- Pakeha male
- Pakeha female
- Māori/Pasifika male
- Māori/Pasifika female
- Asian male
- Asian female

3.2.2 Virtual Environments

In the initial prototype version of iVR (Baghaei et al., 2021), participants had a selection of therapeutic environments from which to choose. However, these environments were basic prototypes and did not provide a visually realistic portrayal of how the environment should seem. At the conclusion of the pilot project, it was observed from the qualitative data analysis of the participants' questionnaire responses that participants tend to prefer environments with a more realistic appearance since it can increase their sense of immersion in the therapy environment. (Baghaei et al., 2021).

The iVR design in this study focused on improving the graphical quality of the selectable environments to better reflect real life environments and make it more immersive for participants. Figure 5 shows the different art styles used in the pilot study in comparison with the current study.

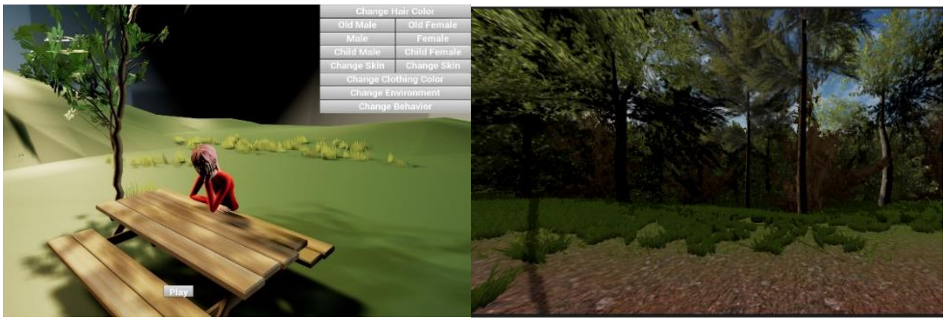

Figure 5 Stylized art style used in the pilot study (Baghaei et al., 2021) (left) and realistic art style used in the current prototype (right).

When designing the virtual environment, it is necessary to find the right balance between performance and the complexity of digital resources used. High-fidelity resources can create an environment with a more realistic appearance. However, this can be detrimental to the app's performance as it places a greater demand on the software and hardware of the VR HMD to load the digital models. This is one of the challenges that occurred during the development process of iVR environments. To prevent performance concerns, photorealistic 3D digital models that were not so sophisticated as to hamper the software's performance were used in the development of iVR. In addition, we employed occlusion culling to improve efficiency by avoiding drawing objects that are hidden from view. Figure 6 shows the improved assets in the outdoor and indoor environments from the iVR prototype.

Figure 6 Improved outdoor Virtual Environment (left) and indoor Virtual Environment (right) used in the iVR prototype.

From the pilot study (Baghaei et al., 2021), it was found that participants liked the inclusion of indoor and outdoor sceneries and the ability to change sceneries. Based on this feedback, we included both indoor and outdoor environments for the participants to choose from. Choices of therapy environment are as follows:

- Living room
- A study room in a Victorian house
- Park

3.2.3 Interaction Scenario

Other customizable elements in Baghaei et al.'s (2021) earlier prototype were in-game character customization and scenario selection.

Available in-game characters are as follows:

- Young female
- Young male

Available scenarios are as follows:

- Delivering compassion to a crying person
- Delivering compassion to an angry/upset person

One feedback from Baghaei et al.'s (2021) earlier prototype was that interaction with the in-game characters does not feel very natural and that the participants wanted to interact with avatars with more human-like behavior.

Creating a convincingly realistic humanoid model can be challenging as humans are graphically complex objects, and the human eye is very good at detecting subtle nuances of humanoid objects (Thalmann et al., 1994). There are three basic categories of techniques that can be used to animate human behaviors: 1) Keyframing, 2) Motion capture, and 3) Simulation (O'Brien & Hodgins, 2000). These techniques each have some advantages and disadvantages in terms of the level of control over motion details, cost of production, performance, and reusability (Vosinakis & Panayiotopoulos, 2005). The keyframing technique requires manually specifying key positions of objects in each timeline. With this technique, animators can control the subtle details of the object's motion. It also allows for a smoother transition between poses. However, the downside is that it can be time-consuming. In motion capture, the real object's movements are captured and recorded in a computer-usable form. However, while motion capture might be less time-consuming than the keyframe method, it does not give much control over the motion and does not necessarily have smooth transitions between scenarios, so in our case, this might not be ideal. The third technique is simulation, where motion is generated using the laws of physics. While this method can generate realistic movements, it might be very costly and time-consuming, thus not feasible at this stage. After weighing the pros and cons of each technique, the keyframing technique was selected to allow for more control and smoother transitions between scenarios.

3.3 Design Considerations for VR Application

Immersive virtual reality is fundamentally distinct from traditional digital products that target flat 2-dimensional screens in that, in contrast to a 2D screen, end users will get a fully immersive 3D experience comparable to the real world. Therefore, a number of factors must be considered while designing components for a Virtual Reality application.

3.3.1 Vision

The user's comfort was the initial consideration when building virtual components. According to guidelines by Facebook Technologies (2021), all menus and displays must be within a comfortable viewing distance from the user to prevent eye strain. It is advised that objects that could attract the attention of users be displayed at a minimum distance of 0.5 meters. For graphical user interfaces and menus, 1 meter is the optimal seeing distance for the majority of end users (Facebook Technologies, 2021). In accordance with this recommendation, the Main Menu and GUI panels were rendered roughly 1 meter from the user, as measured in real life environment.

Another important element to consider was the line of sight of the end users. Szauer (2020) suggested that crucial gameplay features be placed within the users' immediate line of sight, as elements placed outside the users' line of sight are frequently overlooked. Because of this, in-game characters and virtual bodies are placed directly in front of the camera, within its normal field of view. Figure 7 depicts a typical line of sight for virtual simulations.

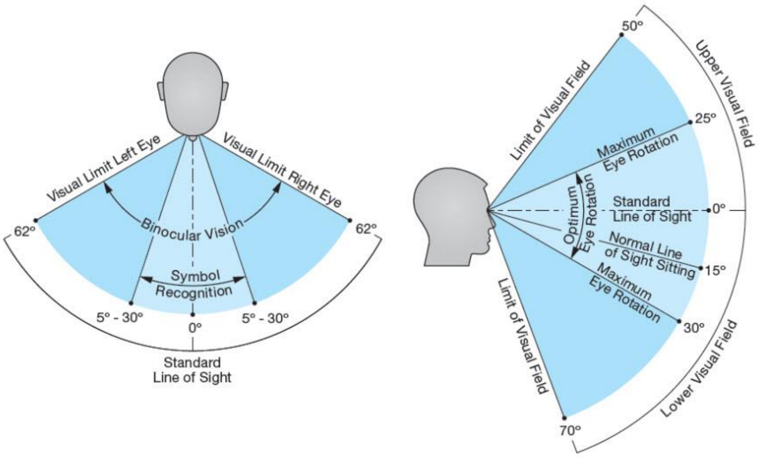

Figure 7 Standard line of sight for virtual simulations (Facebook Technologies, 2021).

GUIs and menus must be positioned relative to the camera and rendered in front of the user's eyes to ensure that they are always inside the user's field of view. All menu and user interface information must be visible without the user having to move their head (Szauer, 2020). As we have multiple customizable settings, presenting them all on a single panel was a challenge. In order to overcome this issue, the menu selections were separated into sections and displayed sequentially using a paginated panel. By clicking the Next/Back button, users can navigate through the menu. The primary menu panels conform to a template layout depicted in the low-fidelity prototype, as shown in Figure 8.

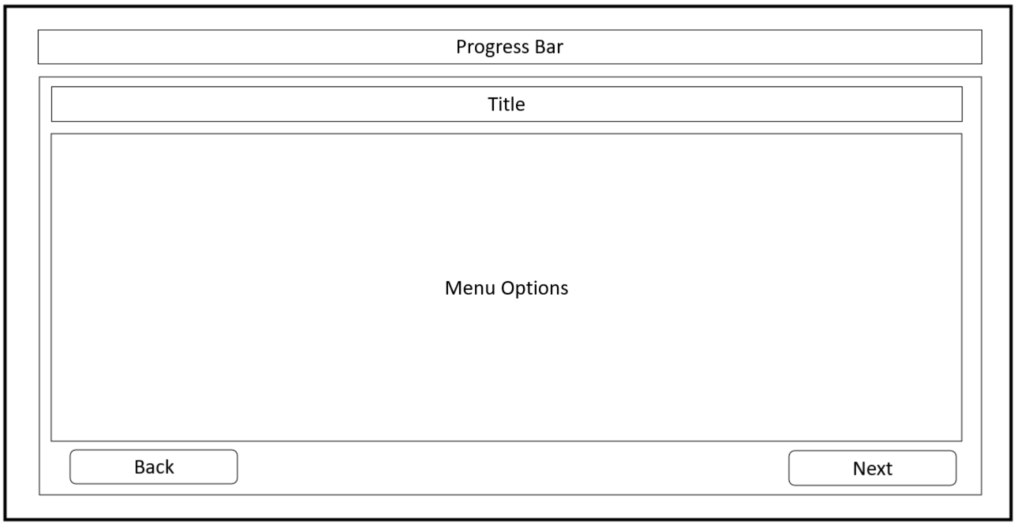

Figure 8 Low-fidelity prototype of the Main Menu panel

Figure 9-10 illustrates a low-fidelity and high-fidelity prototype of the Avatar Selection menu panel that follows the layout of the template.

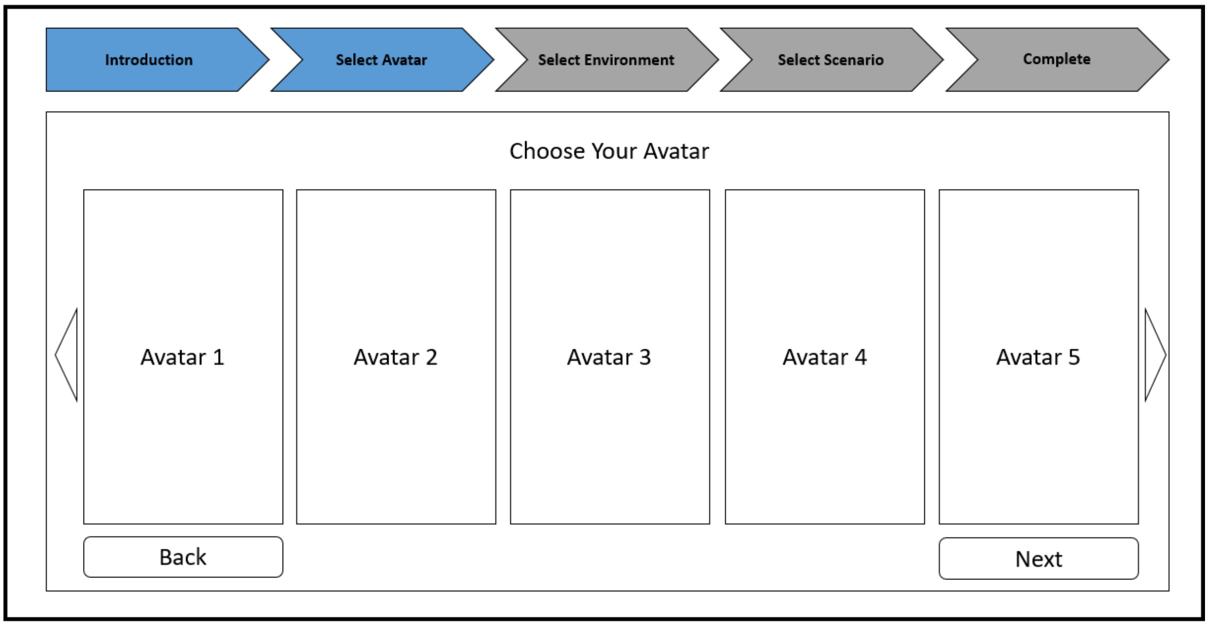

Figure 9 Low-fidelity prototype of the Avatar Selection menu panel.

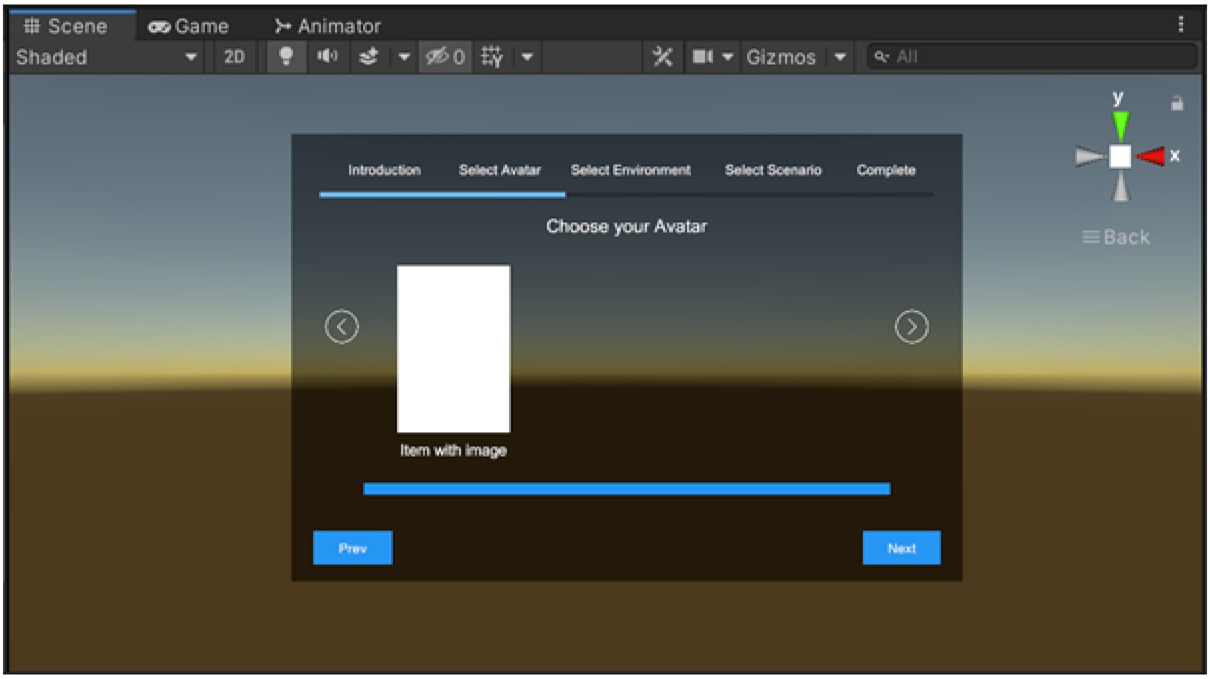

Figure 10 High-fidelity prototype of the Avatar Selection menu panel.

3.3.2 User Input

To create an immersive and engaging virtual experience, we need to consider how the application handles user input. Available user input methods vary between HMDs. For example, simpler headsets such as Google Cardboard might only support reticle or gaze-based input and single button clicks (Google, 2019). In contrast, a more sophisticated headset might support a controller or hand input. In this iVR prototype, the target device was Oculus/Meta Quest 2, which supports controller, hand, and gaze input. This project uses a controller input with laser pointers for GUI and menu interactions to provide a more engaging and interactive experience for the participants, as recommended by Facebook Technologies (2021), the manufacturer of the Oculus/Meta Quest 2 HMD.

3.3.3 Locomotive

Unlike 2D screens, end users can physically move in a virtual reality environment. In Virtual Reality development, users' movements in the virtual environment are commonly referred to as locomotive. Comfortable locomotion can have a direct and major impact on user experience, making it crucial for a successful Virtual Reality application (Bozgeyikli et al., 2019).

Physical locomotion and artificial locomotion are the two core types of locomotion in VR development (Facebook Technologies, 2021). Physical locomotion refers to when movements in the virtual world are in sync with the movements of the user in the physical world. The iVR for mental health application supports physical locomotion by allowing end users to navigate the virtual world via walking in the physical world. Artificial locomotion is when movements in the virtual world are controlled via external elements such as button clicks instead of moving in the physical world. While this can be useful to navigate the virtual world when there is limited physical space available, some artificial movements, such as smooth turning, can cause discomfort (Facebook Technologies, 2021). Therefore, one should exercise caution when designing an artificial locomotive in the virtual environment. A study by Bozgeyikli et. al. (2019) found that point & teleport, joystick, and redirected walking were suitable for an artificial locomotion. However, although teleport can be used to handle artificial locomotion in the virtual environment, it was not implemented in the iVR prototype as participants might not be familiar with the VR HMD and the feature was prone to user error.

3.4 Development Tools

3.4.1 Game Engine

The development of the iVR prototype was done using the Unity game engine. In the early stages of this project, Unity and Unreal game engines were considered. Both game engines provide the development tools to develop virtual reality applications. Both platforms have their own advantages and disadvantages. In terms of graphical fidelity, Unreal is arguably superior, although Unity can also produce realistic virtual environments (Buckley, 2020). Unity is superior in prototyping as it provides a simpler user interface with less learning curve. Unity also offers versatile VR plugins that can integrate well with Oculus/Metaquest Quest 2. For this project, Unity was chosen as the development platform as this project focuses on building a rapid prototype for evaluation. During the development process, an Oculus/Meta Quest 2 headset was used to test the application.

3.4.2 Animation Software

Mixamo and Blender software were used to animate all virtual avatars in the iVR prototype. First, generic movement patterns for the models were generated in Mixamo. When the animation process is done on Mixamo, it is edited on Blender software if it needs some finer animations (as shown in Figure 11), then exported to an FBX file so that it is ready to use in the Unity project. Afterwards, the animation transitions and pose orders were defined via animation controllers in Unity.

Figure 11 Keyframing animation process in Blender.

3.4.3 Facial Expression and Audio Recording

The iVR prototype records the Oculus/Meta Quest 2 headset's own mic input from stage 1 and uses the recording as the audio input for stage 2. Participants can hear and see their avatar re-enacting stage 1 from another point of view. To control the avatar's facial expressions, OVRLipSync was used. OVRLipSync is a Unity add-on plugin developed by Oculus that can be used to sync lip and facial movement of a digital asset to match audio input.

Chapter 4: Study Protocols and Methods

The pilot study was conducted from March – April 2022 to investigate if iVR can potentially be used to increase self-compassion in participants (RQ1) and reduce depressive symptoms (RQ2), and if the current implementation of iVR is generally usable and acceptable (RQ3).

Both quantitative and qualitative measures were used in the study. To investigate RQ1 and RQ2, Self-Compassion Scale (SCS) was used to measure quantitative data on participants' self-compassion (Neff K. D., 2003), while the Patient Health Questionnaire 8 (PHQ-8) was used to measure quantitative data on participant's depressive symptoms (Kroenke et al., 2009).

To assess the usability and acceptability of the VR application (RQ3), data was gathered on the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ). The SUS quantifies the end user's perceived usability (Brooke, 1995), while the UEQ quantifies a product's pragmatic and hedonic quality (Schrepp et al., 2014). Qualitative data was also gathered at the end of the study to determine subjective feedback from participants to be used for possible future iterations of iVR.

Sessions were conducted on a one-on-one basis for each participant, with a follow-up session conducted at least two weeks after the first. Participants were asked to interact with the iVR application in both sessions. Depressive symptoms and self-compassion were measured at baseline (pre-intervention) and once at the end of every session (post-intervention). Data on user experience and system usability was also gathered to measure the general user acceptability of the iVR application.

The study was approved by Massey University's Human Research Ethics Committee NOR 21/83.

4.1 Measures

4.1.1 Self-Compassion Scale (SCS) (Neff K. D., 2003)

The Self-Compassion Scale (SCS) was used to measure quantitative data on participants' self-compassion. The SCS a measure developed by Kristin Neff (2003) to assess self-compassion. It is widely used in research settings (Muris & Otgaar, 2020).

Self-compassion, as measured by the SCS, is robustly linked to psychological health (Neff K. , 2016). There are 26 items in the SCS questionnaire (see Appendix B), each belonging to one of the six subscales:

- Self-Kindness Items: 5, 12, 19, 23, 26
- Self-Judgment Items: 1, 8, 11, 16, 21
- Common Humanity Items: 3, 7, 10, 15
- Isolation Items: 4, 13, 18, 25
- Mindfulness Items: 9, 14, 17, 22
- Over-identified Items: 2, 6, 20, 24

For each item, participants indicate how often they behave in the stated manner on a 1-5 scale, with 1 being almost never and 5 being almost always (Neff K. D., 2003).

Subscale scores are computed by calculating the mean of subscale item responses (Neff K. D., 2003). When examining subscale scores, higher scores on the self-judgment, isolation and over-identification scale indicate less self-compassion before reverse coding and more self-compassion after reverse coding. These three negative subscales must be reverse coded before calculating a total self-compassion score (i.e., 1 = 5, 2 = 4, 3 = 3. 4 = 2, 5 = 1).

The total self-compassion score is computed by adding the reversed score of the negative subscale and to the score of other subscale items, then calculating a total mean (Neff K. D., 2003).

According to Neff (2003), there are no diagnostic norms or scores that indicate if a person's self-compassion is high or low. Instead, SCS scores are mostly used in a comparative manner to assess the outcomes of individuals. On an ad hoc basis, scores can be categorized as low (1.0-2.4), moderate (2.5-3.5), and high (3.51-5.0). Alternatively, a median split can be used to determine if compassion levels are high or low relative to a particular sample.

To investigate RQ1, SCS data was taken at three points of the study; once at the beginning of the study (baseline pre-intervention), once at the end of the first session (post-interaction with iVR), and once at the end of the follow-up session (post-interaction with iVR). The SCS scores post-intervention were then compared to the baseline score to investigate if the iVR session affected participants' self-compassion levels.

4.1.2 Patient Health Questionnaire 8 (PHQ-8) (Kroenke et al., 2009)

The nine-item PHQ-9 and PHQ-8, the eight-item subsets of the nine items in the PHQ-9 (Kroenke et al., 2009), are commonly recommended for depression screening in clinical and research settings (Thombs et al., 2014). The PHQ-9 incorporates DSM-V depression diagnostic criteria (American Psychiatric Association, 2013) with other leading major depressive symptoms into a brief self-report tool. The PHQ-8 omits item 9 in the Patient Health Questionnaire-9 (PHQ-9). The excluded item is the query about thoughts of death and self-harm that is sometimes used to assess suicide risk (Thombs et al., 2014). The PHQ-8 was found to be as useful as the PHQ-9 for major depressive disorder (MDD) screening (Shin et al., 2019). Sensitivity may be minimally reduced with the PHQ-8, but specificity is similar (Wu et al., 2020). This study did not look into assessing suicide risk in particular, therefore PHQ-8 was used to measure depressive symptoms instead of PHQ-9.

In PHQ-8, patients rate how often they were bothered by the following symptoms over the last two weeks from 0 to 1 day (not at all), 2 to 6 days (several days), 7 to 11 days (more than half the days) and 12 to 14 days (nearly every day) (Kroenke et al., 2009):

1. Little interest or pleasure in doing things

2. Feeling down, depressed, or hopeless
3. Trouble falling or staying asleep, or sleeping too much
4. Feeling tired or having little energy
5. Poor appetite or overeating
6. Feeling bad about yourself – or that you are a failure or have let yourself or your family down
7. Trouble concentrating on things, such as reading the newspaper or watching television
8. Moving or speaking so slowly that other people could not have noticed. Or the opposite – being fidgety or restless that you have been moving around a lot more than usual

To determine the PHQ-8 score, scores of 0, 1, 2, and 3 are assigned to each of the four rating categories and then added together (Kroenke et al., 2009). “Not at all” items are worth 0 points, “Several days” items are scored 1 point, “More than half the days” items are scored 2 points, and “Nearly every day” items are scored 3 points. The total score ranges from 0-24. A higher score indicates more severe depressive symptoms.

PHQ-8 scores were gathered at the beginning of the study (baseline pre-intervention), at the end of the first session (post-interaction with iVR), and at the end of the follow-up session (post-interaction with iVR). The PHQ-8 scores post-intervention were then compared to the baseline score to investigate if the iVR session impacted participants’ depressive symptoms, if any (RQ2).

4.1.3 System Usability Scale (SUS) (Brooke, 1995)

The System Usability Scale (SUS) was a scale to measure end users’ perceived usability. In the context of SUS, the usability of an artefact is defined by the context in which that artefact is used (Brooke, 1995). The SUS was developed by John Brooke (1995) as a low-cost measure that can be used for general assessments of systems usability across a range of contexts.

The SUS is widely used in the research field (Lewis, 2018), with references in over 4000 articles and publications. It has proven to be a robust tool, having been used to evaluate a wide range of interfaces, including Web sites, VR applications, GUI, and TV user interfaces (Bangor et al., 2009). Some of the benefits of using SUS were how easy it is to administer to participants, how it can be used on small sample sizes with reliable results and can effectively differentiate between usable and unusable systems (Bangor et al., 2009).

There are ten items in Brooke’s SUS (1995) (see Appendix B). Participants must rate each item from 1-5 (1 = strongly disagree, 5 = strongly agree). All items should be checked. If a respondent feels they cannot respond to a particular item, they should mark the centre point of the scale.

To calculate the SUS score, first get the total score contributions from each item (Brooke, 1995). Each item’s score will contribute a number of points ranging from 0 to 4. The score contribution is the scale position minus one for items 1, 3, 5, 7, and 9. The contribution is five minus the scale position for items

2, 4, 6, 8 and 10. Multiply the sum of the scores by 2.5 to obtain the overall value of system usability. SUS yields a single number representing a composite measure of the system's overall usability. Scores for individual items are not meaningful on their own. SUS scores have a range of 0 to 100. An adjective rating score can be used to interpret the SUS score (Bangor et al., 2009). According to Bangor et al. (2008), the SUS score can be categorized into seven adjective ratings: Worst Imaginable, Awful, Poor, OK, Good, Excellent, and Best Imaginable. Figure 12 shows a comparison of the adjective ratings, acceptability scores, and school grading scales in relation to the average SUS score according to (Bangor et al., 2009).

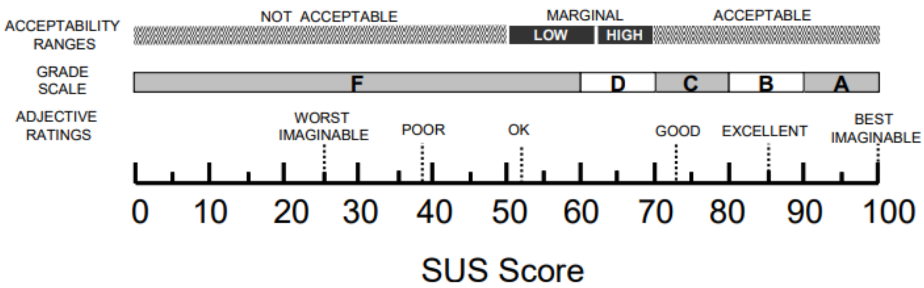

Figure 12 A comparison of the adjective ratings, acceptability scores, and school grading scales, in relation to the average SUS score (Bangor, Kortum, & Miller, 2009).

The SUS is generally used after the participant has had the opportunity to use the system but before any debriefing of the system takes place (Brooke, 1995). Therefore, to investigate the usability of the system (RQ3), SUS data was gathered at the end of the first session, right after participants finished interacting with the iVR system. SUS scores were then calculated and analysed using Bangor et al.'s (2009) adjective rating.

4.1.4 User Experience Questionnaire (UEQ) (Schrepp et al., 2014)

The User Experience Questionnaire (UEQ) is a commonly used tool to measure a product's user experience (Schrepp et al., 2014). Schrepp et al. (2014) defined user experience as a set of distinct quality criteria that includes classical usability criteria, like efficiency, controllability or learnability, and non-goal directed or hedonic quality criteria, like stimulation, fun-of-use, novelty, emotions or aesthetics. The UEQ considers aspects of pragmatic and hedonic quality (Schrepp et al., 2018). The questionnaire contains 26 items on 6 scales:

1. Attractiveness, or the overall impression of the product. Answers the question, "do users like or dislike it?" Items: annoying or enjoyable, good / bad, unlikable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly.
2. Perspicuity: Answers the question, "Is it easy to get familiar with the product?" Items: not understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear/confusing.

3. Efficiency: Answers the question, “Can users solve their tasks without unnecessary effort?” Items: fast / slow, inefficient / efficient, impractical /practical, organized / cluttered.
4. Dependability: Answers the question, “Does the user feel in control of the interaction?” Items: unpredictable/predictable, obstructive / supportive, secure / not secure, meets expectations / does not meet expectations.
5. Stimulation: Answers the question, “Is it exciting and motivating to use the product?” Items: valuable / inferior, boring / exciting, not interesting / interesting, motivating /demotivating.
6. Novelty: Answers the question, “Is the product innovative and creative?” Items: creative / dull, inventive / conventional, usual / leading edge, conservative / innovative.

Attractiveness is a pure valence dimension. Perspicuity, efficiency, and dependability are pragmatic (goal-directed) quality, while Stimulation and Novelty are hedonic quality aspects.

The UEQ does not produce an overall user experience score (Schrepp et al., 2014). Instead, it presents the total score for each of the six scales. The scales of the UEQ can also be presented by Attractiveness, pragmatic quality (Perspicuity, Efficiency, Dependability) and hedonic quality (Stimulation, Originality). Pragmatic quality describes task-related quality aspects, and hedonic quality refers to the non-task-related quality aspects. Scores ranges from -3 (horribly bad) to +3 (extremely good). The UEQ result of a new product can be compared with the results of a benchmark data set to determine if the user experience of a new product is sufficient (Schrepp et al., 2018). In addition, UEQ can also be used to provide a continuous measurement of different product versions by comparing results from various iterations of the product. This is especially useful as the current iVR is in its prototype stage, and the UEQ can be used for quality control for future versions of iVR. It is also possible to compare a product to its direct competitors to determine the product's relative position in the market. This study uses the questionnaire and an Excel-Tool for data analysis that is available for the public under www.ueq-online.org (Schrepp et al., 2014).

4.1.5 Qualitative Feedback

As in Baghaei et al.’s (2021) earlier pilot study, qualitative feedback was gathered on participants’ subjective preferences (what they like and dislike about the current version of iVR) and future recommendations at the end of the follow-up session.

The questions asked were:

1. What were the top three things that they liked about iVR?
2. What didn’t they like about iVR?
3. How do you think the next version can be improved? What other features would you like to see?

Thematic analysis (Braun & Clarke, 2006) was used to interpret the data gathered from participants. Data were analysed using the following process (Vaismoradi et al., 2013):

1. Familiarising with data: Transcribing data, reading and noting down initial ideas.
2. Generating Initial Codes: Interesting features of the data were systematically coded across the whole data set, collating relevant data for each code.
3. Searching for themes: The codes were collated into potential themes.
4. Reviewing Themes: Checking whether the themes are compatible with the coded extracts and the complete data set and producing a thematic map.
5. Defining and naming themes: Generate clear definitions and names for each theme by refining the particulars of each topic and the overall story that the analysis conveys.
6. Producing the report: Selection of vivid, engaging extract examples, the final analysis of selected extracts, linking the analysis back to the research topic and literature, and production of an analysis report.

4.2 Participants

A total of 36 participants consented to take part in the study. The sample includes 18 participants self-identifying as male and 19 participants self-identifying as female (mean age: 29, SD: 11.64). Because the study heavily involved mental health, which is sensitive in nature, only participants above the age of 18 were allowed to participate. As the experiment must be conducted in person at a set venue, participants must also reside in Auckland, New Zealand. Participants did not have to be diagnosed with depression to participate.

Participants were recruited through poster advertisement (see Appendix A), social media advertisement (see Appendix A), and "word of mouth". A copy of the information sheet was provided to potential participants who expressed interest via email (see Appendix A). A consent form was provided on the day of the actual experiment. Participants' written consent was obtained just before the individual experimental sessions (see Appendix A). Participants were given gift cards worth $20 at the end of the study to thank them for their time.

4.3 Procedures

Participants attended two iVR sessions, at least two weeks apart. The sessions were done in person in a one-on-one format, following local Covid-19 guidelines. Prior to the sessions, participants were given a Participant Information Form that gives a brief overview of the study (see Appendix A).

Session 1 consisted of four parts and took approximately 40-45 minutes. First, at the beginning of the session, participants complete the participant consent form and mental health questionnaires (SCS, PHQ-8). The SCS and PHQ-8 scores gathered will serve as a baseline value to be compared with scores post-intervention. Second, after completing the questionnaires, they are given the opportunity to familiarise themselves with the experimental set-up and the VR equipment. Participants can view a video demonstration of the experimental procedure and be given basic training on how to use the Oculus/Meta Quest 2 VR HMD if they are not familiar with VR HMDs. They are also given an Instruction Sheet to introduce them to the concept of Compassion Focused Therapy and relevant stages (validation, redirection of attention, memory activation). Then, when the participant is ready, they are given a chance to interact with the iVR application. They were allowed to explore the system without restriction, with a researcher present in the room to assist if necessary. The researcher will guide participants throughout the experience in VR:

Stage 1 (~ 2 minutes):

- Interaction with GUI panels to choose the virtual avatar, environment, and scenario

Stage 2 (~ 2 minutes):

- Visuomotor synchrony/embodiment with the chosen avatar through movement
- Interaction with crying/angry child/youth
- Instructions: "React to the child/youth by using the sentences you have learned just now."

Stage 3 (~ 2 minutes):

- Visuomotor synchrony/embodiment with crying/angry child/youth through movement
- Real-time playback of recorded interaction Part B from the perspective of crying/angry child/youth
- Instructions: "Stand/sit, look and listen."

After completing the iVR interaction, participants were asked to complete mental health questionnaires (SCS, PHQ-8) and acceptability questionnaires (SUS, UEQ).

Session 2 consists of two parts and takes approximately 20-30 minutes to complete. First, participants interact with the iVR application right at the start of the session. After completing the interaction with iVR, participants completed mental health questionnaires (SCS, PHQ-8), User Experience Questionnaire (UEQ) and were asked to give their qualitative feedback on the iVR prototype.

4.4 Research Setup

Research procedures followed the Covid-19 health and safety recommendations set by the New Zealand Government and Massey University. Social distancing was observed at all times, and surfaces were sanitized before and after use. Because the limited space available in the venue only allows two persons in the room at a time, sessions were done on a one-on-one basis.

The iVR system was run via an Oculus/Meta Quest 2 VR HMD. The Oculus/Meta Quest 2 is a VR HMD manufactured by Facebook technologies (Meta, 2022). One of the features of Oculus/Meta Quest

2 was its “Guardian” system, a safety measure built into the headset that allows users to define a safe play area in the real world and warns the user if they are approaching the edge of the play area. In this study, the researcher set up the boundaries of the “guardian” system prior to the sessions so that participants could safely explore the virtual world without running into potential physical hazards. The Oculus/Meta Quest 2 HMD is a standalone system that does not require any additional hardware to run, minimizing potential hazards such as wires and other peripherals that might get in the way of participants while navigating the virtual world.

Chapter 5: Results

5.1 Changes in Self Compassion Levels and Depressive Symptoms

SCS data was collected from 36 participants and at the beginning of session 1 (pre-intervention) and at the end of session 1 (post intervention). However, because of Covid-19 restrictions, some participants were not able to complete the follow up session and only data from 23 participants were gathered at the end of session 2 (post-intervention). This study will only consider SCS scores from the 23 participants who completed both sessions.

Table 1 shows the descriptive of SCS scores at baseline, session 1 post-intervention, and Session 2 post-intervention.

Table 1. SCS Descriptive Statistics

Descriptive Statistics

	Baseline	Session 1 (Post-Intervention)	Session 2 (Post-Intervention)
Mean	2.965	3.067	3.233
Std. Deviation	0.704	0.756	0.795
Minimum	1.577	1.731	1.385
Maximum	4.500	4.808	4.462

The skewness of all variables was between -0.400 to 0.600, which falls within the acceptable skewness for analysis (George & Mallery, 2010). A paired sample t-test was performed to examine the changes in participants' SCS score. There was a significant increase in SCS results at the end of session 2 ($M = 3.23$, $SD = 0.795$) compared to baseline results collected pre-intervention ($M = 2.965$, $SD = 0.704$), $t(22) = -2.372$, $p = .013$. A statistically significant increase in SCS result can be observed after the first session post-intervention ($M = 3.067$, $SD = 0.756$), $t(22) = -2.038$, $p = .027$. The SCS score increased further in the session 2 post-intervention compared to session 1, although the rise is not significant, $t(22) = -1.518$, $p = .072$. Figure 13 shows an upward trend in SCS score over time.

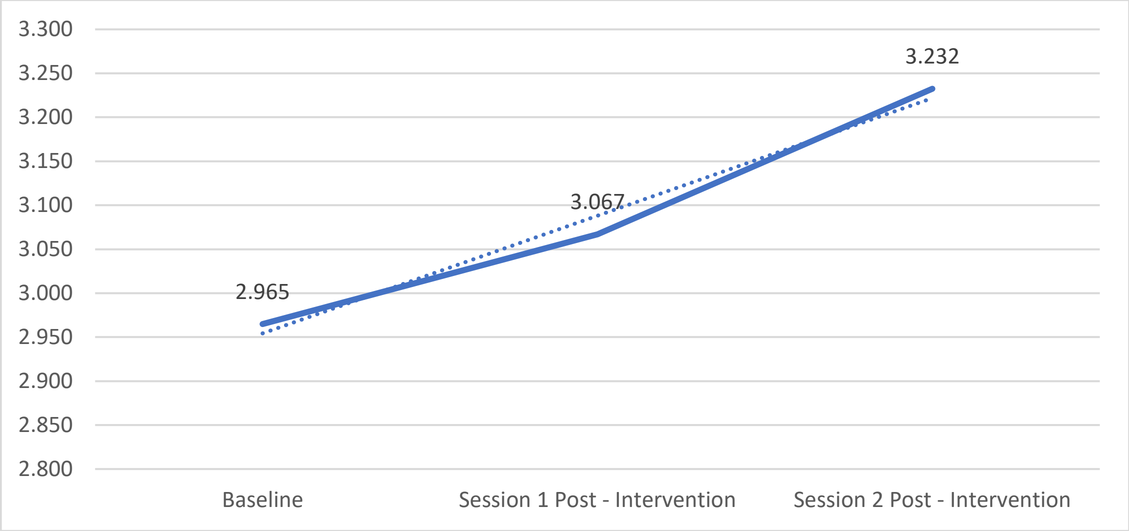

Figure 13 SCS Score Descriptive Trends.

PHQ-8 data was collected from 36 participants and at the beginning of session 1 (pre-intervention) and at the end of session 1 (post intervention). As with the SCS data, 13 participants were not able to complete the follow up session and only data from 23 participants were gathered at the end of session 2. This study only considered PHQ-8 data from participants who completed both sessions.

Table 2 shows the descriptive of PHQ-8 scores at baseline, session 1 post-intervention, and Session 2 post-intervention.

Table 2 Descriptive Statistics of PHQ-8 Scores.

Descriptive Statistics

	PHQ 8 (Baseline)	PHQ 8 (Session 1)	PHQ 8 (Session 2)
Mean	8.522	7.435	6.696
Std. Deviation	6.316	6.148	4.967
Minimum	1.000	0.000	0.000
Maximum	20.000	20.000	17.000

The skewness of all variable ranges from 0.300 to 0.700, which falls within the acceptable skewness for analysis (George & Mallery, 2010). A paired sample t-test was performed to examine the changes in participants' PHQ 8 score. There was a significant decrease in the overall PHQ-8 results from pre-intervention ($M = 8.522$, $SD = 6.316$) compared to the results at session 2 post-intervention at the end of the experiment ($M = 6.696$, $SD = 4.967$), $t(22) = 1.884$, $p = .036$. There was a decrease in PHQ-8 results from pre-intervention ($M = 8.522$, $SD = 6.316$) to session 1 post-intervention ($M = 7.435$, $SD = 6.148$), which indicates that the participants are less depressed after the first session post-intervention, although the difference is not significant yet at the first session, $t(22) = 2.772$, $p = .006$. The PHQ-8 results shown in Figure 14 shows a downward trend in PHQ-8 scores over time.

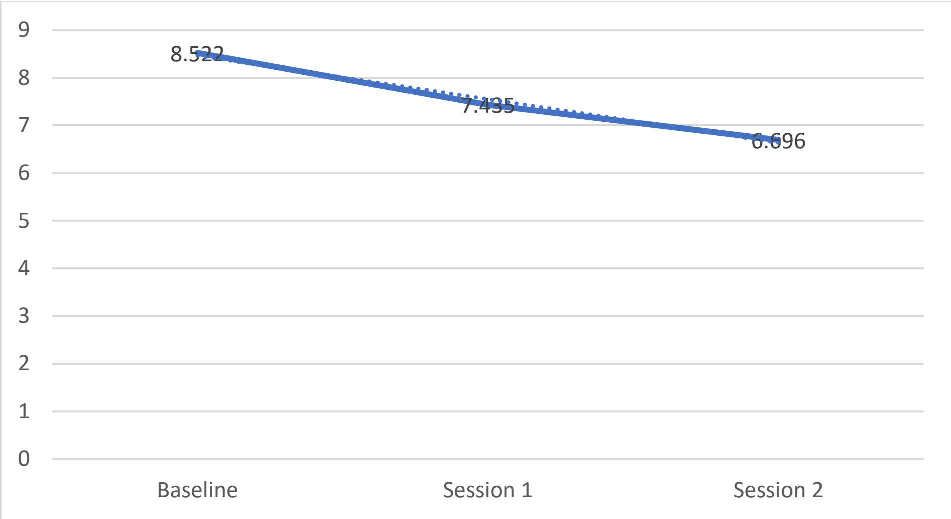

Figure 14 Descriptive trends of PHQ-8 scores.

The Pearson and Spearman correlations (Bonett & Wright, 2000) were calculated to measure the linear relationship between PHQ-8 and SCS scores. Results are as outlined in Appendix D. There were significant negative correlations between SCS score and PHQ-8 score at baseline, session 1, and session 2. An independent samples t-test was conducted to analyse differences in PHQ-8 and SCS scores between male and female participants. However, no significant difference was found between genders (see Appendix E).

5.2 System Usability and Acceptability

SUS data was gathered from 37 participants at the end of session 1. Table 3 outlines the descriptive data of the SUS score.

Table 3 Descriptive Statistics of the SUS score

Mean	**75.87**
Median	75
Mode	75
Standard Deviation	13.09

The overall SUS result for the iVR application was 75.87, which falls in the good to excellent category in the adjective rating scale developed by Bangor et al. (2009).

UEQ data was gathered from 36 participants at the end of session 1. Figure 15 presents the ratings for the six UEQ scales.

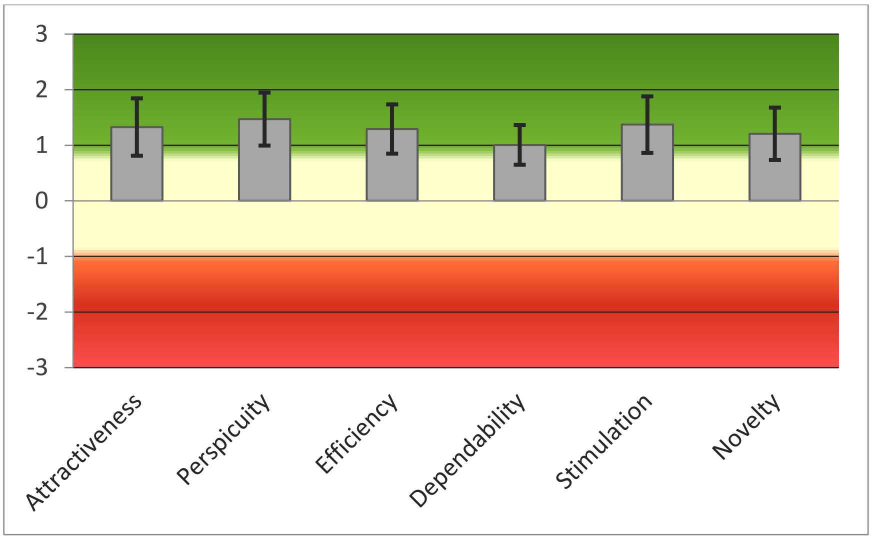

Figure 15 Results of UEQ Scales.

Figure 16 shows the mean of UEQ scales grouped by Attractiveness, pragmatic quality (Perspicuity, Efficiency, Dependability) and hedonic quality (Stimulation, Originality).

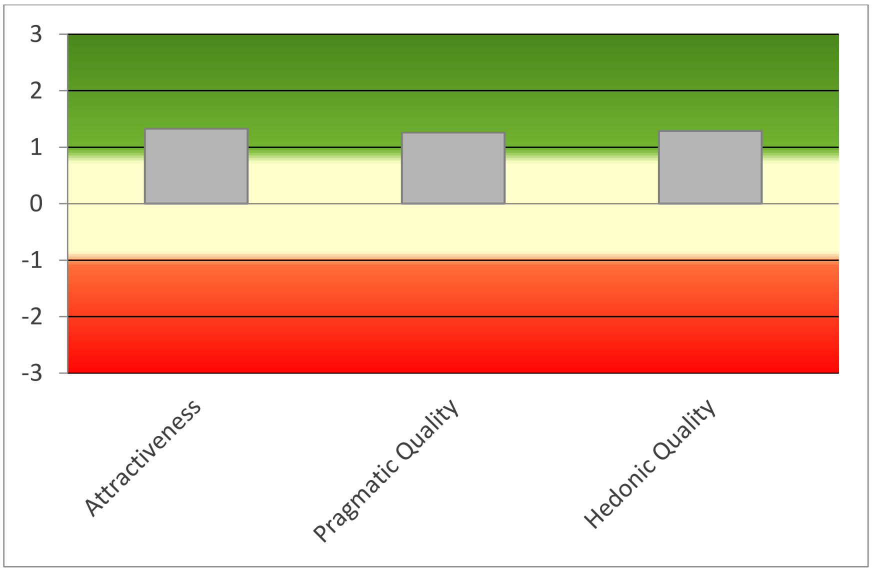

Figure 16 UEQ scales grouped by Attractiveness, pragmatic quality and hedonic quality.

The UEQ analysis tool (Schrepp et al., 2018) was used to compare the UEQ results with a benchmark data set containing data from 20190 individuals from 452 studies on different products. Figure 17 presents the results of the comparison.

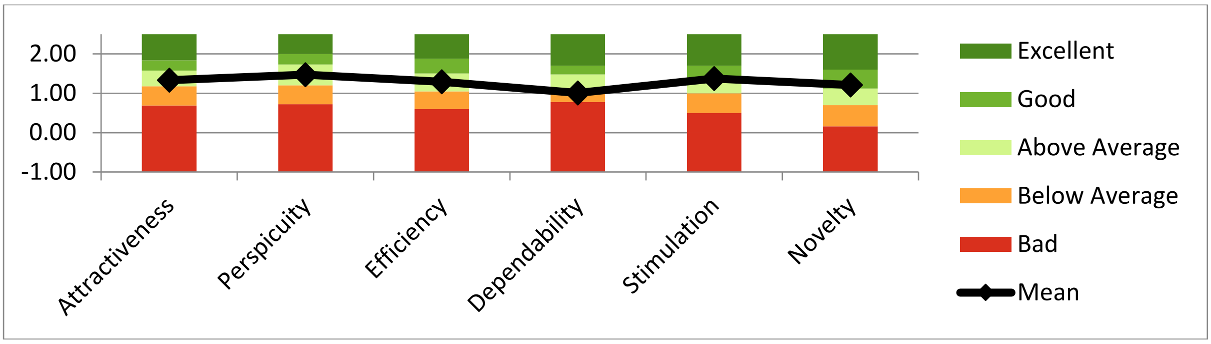

Figure 17 UEQ results in comparison to benchmark data (Schrepp, Thomaschewski, & Hinderks, 2018).

Among the UEQ scales, only Dependability falls in the "Below Average" category. Attractiveness and Efficiency scores for the iVR prototype falls in the "Above Average" range when compared to the benchmark data, and the Perspicuity, Novelty, and Stimulation scales falls in the "Good" range.

5.3 Qualitative Feedback

Qualitative feedback was gathered from 23 participants at the end of the study.

For the question "What were the top three things that they liked about iVR?", answers from participants can be coded into the following themes:

1. The top element that participants liked was that it is user-friendly. Almost half of the participants liked how the app was "easy to use". Some other quotes include "easy navigation", "easy instructions", and "easy to use and has a positive vibe".
2. Participants liked how they could customize their VR experience. Quotes from participants included the following: "Fun cool settings", "choose personal avatar", "how you got to choose your person and environment", "I enjoyed customising my situation", "choose-able characters", "Options to choose", "I like how you can choose the situation And I like how you could choose your person", "Choosing avatars and different settings", "I liked that you can pick different areas", "I liked that you can pick different scenarios".
3. Participants also liked how the experience feels real and immersive. Quotes include the following: "It feels like a person is there with you", "The immersive aspect really added an element of connection", "Illusion of real experience".
4. Participants liked the use of VR technology in the study. Quotes include: "VR is very immersive", "I just enjoy VR", "suitable for VR because other systems are just a single screen", "the ability to look around at your environment", "I like virtual reality", "Fun using a VR set".
5. Some participants liked the virtual environment. Quotes include: "The background was calming", "calming environment", "loved the scenery".
6. Some participants liked the UI design. Quotes include "Clean UI" and "I liked that the menu was simple".

For the question “What didn’t they like about iVR?”, answers from participants can be grouped into the following:

1. Participants disliked the limited interaction with the virtual avatars. Quotes include: "Maybe there can get more operation to do", "One way communication", "Very dull, nothing really happened", "I wished there had been more in stage 1, perhaps different situations", "a bit more interaction and maybe some more prompts".
2. Some participants found that the system could be a bit too slow. Quotes include: "has some lags", "Laggy, sometimes unresponsive", "I found the vr menu was a bit slow", "A little laggy going from one phase to the next".
3. Some participants felt that the scenarios were too simple. Quotes include: "The scenario could be more complex", "I wish it had more scenarios".

For the question “How do you think the next version can be improved? What other features would you like to see?”, answers from participants can be grouped into the following:

1. Participants suggested adding more robust scenarios to choose from. Quotes include: "You could create different scenarios and paths for users in the next version", "Maybe a more interesting scenario, like an argument", "I would like to see different situations to go through", "Perhaps expanding on the first stage to include more situations", "Maybe more situations", "More real world scenarios", "longer interactions with more scenarios", "Maybe add more situations so that people can learn how to approach different situations", "Add more scenarios".
2. Participants also would like to see more interactions with the virtual avatars and virtual environment. Quotes include: "more interaction with the environment", "More interaction, such as we can walk to gather, have a seat", "Better user interaction", "characters having more expression", "More complexity from the characters. More speaking instead of just crying, making noises.", "The ai reacting to the user", "Add in recognition for what people are saying. More dynamic characters".
3. Some participants wanted more avatar options to be added. Quotes include "More diverse ethnic avatars" and "more avatars and settings".
4. Some participants wanted to see improved graphics and more natural avatar, quoting "I’d like if the character models moved a bit more natural", "Better graphics".
5. Some participants said that they wanted to see improved performance of iVR. Quotes include "Improve load speed and fps".

Chapter 6: Discussion

The outcomes of this research have provided insight into the usability and acceptability of an individualized VR system and how it affected self-compassion and depressive symptoms in participants. However, the results should be interpreted with caution because of the limitations in the current research. This chapter provides a reflection on the research process. The limitations and potential consequences of the design are discussed, as well as the implications for the interpretation of the results. The chapter ends with recommendations for future research.

6.1 Changes in Self-Compassion Level and Depressive Symptoms

One of the most noteworthy findings was that participants' self-compassion increased after interacting with the individualized VR prototype over time. There was evidence of considerable increases in participants' SCS scores in as little as one interaction with the individualized VR, suggesting a significant increase in levels of self-compassion. The SCS score continued to increase after further interaction with the system in the follow-up session. This outcome show promise that individualized VR can potentially be used to increase self-compassion (RQ1).

Given that the individualized VR session heavily incorporates elements of the Compassion-Focused Therapy (CFT) by encouraging participants to train in compassionate behaviour and compassion-based skills, this finding provides further support to the literature that stated that compassion can be increased by training (Gilbert, 2009; Jazaieri et al., 2013).

Another notable finding was the observable decrease in participants' depressive symptoms after two interactions with the iVR system, implying that individualized VR can potentially be used to decrease depressive symptoms over time (RQ2). It was found there was a significant decrease in PHQ-8 scores at the end of the study when compared to the baseline measurements pre-intervention, suggesting a decrease in depressive symptoms over time, though, unlike self-compassion levels, the change in depressive symptoms was more gradual. A negative correlation was observed between depressive symptoms and self-compassion throughout the study, in line with the literature that self-compassion is established as a protective factor against depression (Ehret et al., 2015). This might contribute to the decrease in depressive symptoms despite the fact that the iVR design targets self-compassion instead of specifically targeting depressive symptoms.

Another interesting observation was that, although interactions with the iVR system in the sessions were done in short durations, there were notable outcomes in self-compassion after its first use. In a study by Lahti et al. (2020), it was found that even brief interaction with a VR system can improve outcomes in patients with dental anxiety. This implies that the effects of VR interventions might be felt even with minimal exposure.

In summary, findings from the study show promise that individualized VR can potentially be used to increase self-compassion (RQ1) and reduce symptoms over time (RQ2). This justifies conducting a large-scale study to further investigate the impact of individualized VR on self-compassion and depressive symptoms.

6.2 Usability and Acceptability of the Individualized VR Prototype

The overall SUS result for the iVR application was 75.87, which falls in the good to excellent category in the adjective rating scale developed by Bangor et al. (2009). This implies that participants mostly perceived that the system has good usability.

The UEQ ratings, compared to values in the benchmark data set, show a somewhat encouraging performance. Among the UEQ scales, Novelty and Stimulation scales fall in the "Good" range, performing better than 75% of systems in the benchmark. This implies that participants found that the iVR prototype was innovative and exciting to use.

The current iVR prototype addressed some of the concerns raised in the qualitative feedback from Baghaei et al.'s early prototype (2021). For instance, in the earlier prototype, it was found that participants would like clearer instructions, implying that participants struggle to learn how to use the system (Baghaei et al., 2021). Instructions and hints were added to the current iVR design to assist participants in learning how to use the current iVR system. Qualitative feedback from this study shows that users liked how easy it was to use. In the UEQ result, the Perspicuity scale falls in the "Above Average" range, implying that participants find it easy to get familiar with the product, further suggesting that participants felt like they were given ample instructions to successfully complete the iVR session.

However, the Dependability scale in UEQ falls in the "Below Average" category, implying that participants might not feel in control when interacting with the iVR system. Some participants also felt like the system was slow. This indicates that there might be some performance issues present in the current iVR prototype. It is recommended that the system performance and speed are optimized in future iterations of iVR to improve user experience.

All in all, it can be inferred that participants largely perceived that the system has good usability and that user experience was generally positive, providing some assurance that the current implementation of iVR is generally usable and well received by participants (RQ3), though there were some areas that could be improved in future iterations of the system.

6.3 Limitations and Future Directions

There were some Covid-19 restrictions placed by the New Zealand government during the time this study was conducted, such as travel restrictions, Covid-19 vaccine requirements, and social distancing rules. This limits participants to individuals who holds the Covid-19 vaccine pass and resided in or were able to travel to Auckland, New Zealand at the time of the study. In addition to that, some participants were unable to complete their follow-up session as they tested positive for Covid-19 or were in self-isolation. This significantly limited the sample data. The small sample data meant that the sample set might not represent the full population. Because of this, it was not possible to do a randomized controlled trial with a control group at the time of the study. A large-scale study with a control sample over a longer period might be needed to verify the findings in this study.

Because of the small sample size, it was not feasible to do data analysis based on characteristics such as culture and ethnicity in this study. This is another area to look into in future works on iVR, as overt characteristics such as ethnic and cultural differences (Brenes et al., 2008; Kritikos et al., 2021) can have a significant impact on VR interventions and cause significant variability in patient outcomes though they receive the same VR simulation treatment.

The study also did not include VR measures, such as presence and embodiment. The inclusion of these measures might give more value in future research on iVR, as presence in the virtual environment and sense of embodiment towards the avatar might have a moderating effect on different effects of VR interventions. Grassini et al. (2020) stated that presence might have an effect on training outcomes. Qualitative data showed that participants liked how the VR environment was immersive and how they felt like they were there in person. This raised a question on how presence might have affected outcomes in the level of self-compassion and depressive symptoms.

A few similar themes were observed when results of participants' qualitative feedback on their recommendations for future iterations of iVR were compared to results from an earlier prototype (Baghaei et al., 2021), identifying some areas of improvements that can be considered in future iterations of the individualized VR. For instance, more robust interaction with the avatar and more avatar choices can be introduced to the individualized VR to potentially improve user experience. It would also be interesting to investigate the correlation between UEQ scores and high vs low PHQ scores in a future study with more participants to determine if people with high depressive symptoms have a different user experience than other users.

Chapter 7: Conclusion

This study outlined the design and implementation of iVR, an individualized VR application for supporting mental health, and investigated if the individualized VR system can be used to enhance self-compassion and improve symptoms of depression.

The iVR system simulates a Compassion-Focused Therapy (CFT) session, a form of Cognitive Behavioral Therapy (CBT) that aims to increase self-compassion (Gilbert, 2009). It allows participants to practice delivering and receiving compassion to increase their self-compassion. Building on Baghaei et al.'s (2021) initial prototype, the design and implementation of the iVR prototype in this study incorporates individualized components, including various avatars, virtual environments, and interaction scenarios that can be personalized based on participants' individual preferences.

A pilot study was conducted in April 2022 to evaluate the impact of the individualized VR system on self-compassion and depressive symptoms and the general usability and acceptability of the system. The Self-Compassion Scale (SCS) (Neff, 2016) was used to measure quantitative data on participants' self-compassion, while the Patient Health Questionnaire 8 (PHQ-8) (Kroenke et al., 2009) was used to assess participant's depressive symptoms. The System Usability Scale (SUS) (Lewis, 2018) and the User Experience Questionnaire (UEQ) (Schrepp et al., 2018) were used to assess perceived usability and system acceptability, respectively. A total of 36 participants took part in the study. Participants attended two iVR sessions, at least two weeks apart. SCS and PHQ-8 data were taken at the beginning of session 1 (pre-intervention), at the end of session 1 (post-interaction with iVR), and at the end of the follow-up session, while acceptability questionnaires (SUS, UEQ) were taken at the end of session 1. Qualitative feedback was gathered on participants' subjective preferences and future recommendations at the end of the follow-up session.

7.1 Results

Results of the recently conducted study show promise that individualized VR can potentially be used to increase self-compassion and alleviate symptoms of depression over time, and the iVR system was generally usable and acceptable among participants:

1. There was a significant increase in SCS results at the end of the follow-up session at the end of the experiment compared to the pre-intervention baseline results. A statistically significant increase was observable from the first session post-intervention.
2. There was a gradual decline in PHQ-8 score over time after interacting with the iVR application. A statistically significant decrease can be observed in the PHQ-8 score at the end of the experiment compared to the baseline values collected pre-intervention. This implies that as the trial progressed, participants experienced a reduction in depressive symptoms.

3. The overall SUS score for the iVR application was 75.87, which according to the adjective rating system created by Bangor et al. (2009), falls into the “good” to “excellent” group, showing that the majority of users thought the product’s usability was good or excellent. Compared to values in the benchmark data set (Schrepp, Thomaschewski, & Hinderks, 2018), the UEQ ratings show encouraging performance, with five out of six scales scoring at least above average, implying that participants perceived their user experience as above average to good.
4. Some areas of improvement were identified from participants’ qualitative feedback. For instance, introducing more robust interaction with the environment, adding more avatar options, and optimizing system performance might improve the user experience for future iterations of iVR.

7.2 Future Directions

Some potential improvements to the iVR application can increase user engagement in a future iteration of the iVR system, such as integrating more robust participant-virtual environment interaction, with an emphasis on interactions with the avatars that are already present in the environment. We are considering including some interactive elements to boost user engagement. For instance, players can use the controller's hands to pick up and offer the avatar comforting virtual items like a tissue box or hot chocolate. Depending on the situation, the avatar will respond positively or adversely. Adding artificial intelligence to the avatar is another option that can be done to increase user engagement.

A large-scale study with a control sample over a longer period can be conducted using a future iteration of iVR to verify the findings in this study, as the current study uses a small sample size that might not represent a whole population. Another area to look into in the future is a data analysis based on characteristics such as culture and ethnicity using larger sample size, as such overt characteristics can have a significant impact on VR interventions and cause significant variability in patient outcomes (Brenes et al., 2008; Kritikos et al., 2021). Including VR measures, such as presence and embodiment, might also give more value in future research on iVR, as "presence" in the virtual environment and sense of embodiment towards the avatar might have an impact on different factors of VR interventions (Grassini et al., 2020).

References

Andersson, H. I., Ejlertsson, G., Leden, I., & Rosenberg, C. (1993). Chronic pain in a geographically defined general population: Studies of differences in age, gender, social class and pain localization. *The Clinical Journal of Pain*, *9*, 174–182.

Arimitsu, K. (2016). The effects of a program to enhance self-compassion in Japanese individuals: A randomized controlled pilot study. *The Journal of Positive Psychology*, *11*, 559–571.

Astuti, P., Kusnanto, K., & Novitasari, F. D. (2020). Depression and Functional Disability in Stroke Patients. *Journal of Public Health Research*.

Baghaei, N., Stemmet, L., Hlasnik, A., Emanov, K., Hach, S., Naslund, J. A., Billinghurst, M., Khaliq, I., & Liang, H.-N. (2020). *Time to Get Personal: Individualised Virtual Reality for Mental Health*.

Baghaei, N., Stemmet, L., Khaliq, I., Ahmadi, A., Halim, I., Liang, H.-N., Xu, W., Billinghurst, M., & Porter, R. (2021). Designing Individualised Virtual Reality Applications for Supporting Depression: A Feasibility Study. *2021 ACM SIGCHI Symposium on Engineering Interactive Computing Systems (EICS '21)*, 5–11.

Bangor, A., Kortum, P., & Miller, J. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, *24*, 574–594.

Bangor, A., Kortum, P., & Miller, J. (2009). Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale. *Journal of Usability Studies*, *4*, 114–123.

Beck, A. T., Rush, A. J., Shaw, B. F., & Emery, G. (1979). *Cognitive Therapy of Depression*. Guilford Press.

Bluth, K., Gaylord, S. A., Campo, R. A., Mullarkey, M. C., & Hobbs, L. (2016). Making Friends with Yourself: A Mixed Methods Pilot Study of a Mindful Self-Compassion Program for Adolescents. *Mindfulness*, *7*, 479–492.

Bonett, D. G., & Wright, T. A. (2000). Sample size requirements for estimating Pearson, Kendall and Spearman correlations. *Psychometrika*, *65*, 23–28.

Bozgeyikli, E., Raij, A., Katkoori, S., & Dubey, R. (2019). Locomotion in virtual reality for room scale tracked areas. *International Journal of Human-Computer Studies*, *122*, 38–49.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*, 77–101.

Brenes, G. A., Knudson, M., McCall, W. V., Williamson, J. D., Miller, M. E., & Stanley, M. A. (2008). Age and racial differences in the presentation and treatment of Generalized Anxiety Disorder in primary care. *Journal of Anxiety Disorders*, *22*, 1128–1136.

Brooke, J. (1995). SUS: A quick and dirty usability scale. *Usability Eval. Ind.*, *189*.

Burke, A. S., Shapero, B. G., Pelletier-Baldelli, A., Deng, W. Y., Nyer, M. B., Leathem, L., Namey, L., Landa, C., Cather, C., & Holt, D. J. (2020). Rationale, Methods, Feasibility, and Preliminary Outcomes of a Transdiagnostic Prevention Program for At-Risk College Students. *Frontiers in Psychiatry*, *10*.

Button, K. S., Wiles, N. J., Lewis, G., Peters, T. J., & Kessler, D. (2012). Factors associated with differential response to online cognitive behavioural therapy. *Social Psychiatry and Psychiatric Epidemiology*, *47*, 827–833.

Carlat, D. J. (1998). The Psychiatric Review of Symptoms: A Screening Tool for Family Physicians. *Am Fam Physician*, *58*, 1617–1624.

Chishima, Y., Mizuno, M., Sugawara, D., & Miyagawa, Y. (2018). The influence of self-compassion on cognitive appraisals and coping with stressful events. *Mindfulness*, *9*, 1907–1915.

Collins, R. N., Gilligan, L. J., & Poz, R. (2018). The Evaluation of a Compassion-Focused Therapy Group for Couples Experiencing a Dementia Diagnosis. *Clinical Gerontologist*, *41*, 474–486.

Craig, C., Hiskey, S., & Spector, A. (2020). Compassion focused therapy: A systematic review of its effectiveness and acceptability in clinical populations. *Expert Review of Neurotherapeutics*, *20*, 385–400.

Cuijpers, P., & Gentili, C. (2017). Psychological treatments are as effective as pharmacotherapies in the treatment of adult depression: A summary from Randomized Clinical Trials and neuroscience evidence. *Research in Psychotherapy*, *20*, 273.

Cujipers, P., & Kleiboer, A. M. (2017). Self-directed approaches to the treatment of depression. In *The Oxford Handbook of Mood Disorders* (pp. 469–477). Oxford University Press.

Depression: The Treatment and Management of Depression in Adults (Updated Edition). (2010). British Psychological Society.

Diagnostic And Statistical Manual Of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR). (2013).

Donker, T., Cornelisz, I., Klaveren, C. van, Straten, A. van, Carlbring, P., Cuijpers, P., & Gelder, J.-L. van. (2019). Effectiveness of Self-guided App-Based Virtual Reality Cognitive Behavior Therapy for Acrophobia: A Randomized Clinical Trial. *JAMA Psychiatry*, *76*, 682–690.

Egan, S. J., Rees, C. S., Delalande, J., Greene, D., Fitzallen, G., Brown, S., Webb, M., & Finlay-Jones, A. (2022). A Review of Self-Compassion as an Active Ingredient in the Prevention and Treatment of Anxiety and Depression in Young People. *Administration and Policy in Mental Health and Mental Health Services Research*, *49*, 385–403.

Ehret, A., Joormann, J., & Berking, M. (2015). Examining risk and resilience factors for depression: The role of self-criticism and self-compassion. *Cognition and Emotion*, 1496-1504. doi: 10.1080/02699931.2014.992394.

Emmelkamp, P. M. G., & Meyerbröker, K. (2021). Virtual Reality Therapy in Mental Health. *Annual Review of Clinical Psychology*, *17*, 495–519.

Emmelkamp, P., & Vedel, E. (2006). *Evidence-based treatments for alcohol and drug abuse: A practitioner's guide to theory, methods, and practice*. Routledge/Taylor & Francis.

Falconer, C. J., King, J. A., & Brewin, C. R. (2015). Demonstrating mood repair with a situation based measure of self compassion and self-criticism. *Psychol Psychother*, *88,* 351–365.

Falconer, C. J., Rovira, A., King, J. A., Gilbert, P., Antley, A., Fearon, P., & Brewin, C. R. (2016). Embodying self-compassion within virtual reality and its effects on patients with depression. *BJPsych Open, 2(1)*, 74-80. doi: 10.1192/bjpo.bp.115.002147.

Ferrari, M., Hunt, C., Harrysunker, A., Abbott, M. J., Beath, A. P., & Einstein, D. A. (2019). Self-Compassion Interventions and Psychosocial Outcomes: A Meta-Analysis of RCTs. *Mindfulness, 10*, 1455–1473.

Flemming, K. D. (2021). *Mayo Clinic Neurology Board Review*. Oxford University Press.

Freeman, D. (2008). Studying and treating schizophrenia using virtual reality: A new paradigm.

Schizophr Bull., *34*, 605–610.

Freeman, D., Reeve, S., Robinson, A., Ehlers, A., Clark, D., Spanlang, B., & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine*, *47*, 2393–2400.

Friis, A. M., Johnson, M. H., Cutfield, R. G., & Consedine, N. S. (2016). Kindness Matters: A Randomized Controlled Trial of a Mindful Self-Compassion Intervention Improves Depression, Distress, and HbA1c Among Patients With Diabetes. *Diabetes Care*, *39*, 1963–1971.

Frostadottir, A. D., & Dorjee, D. (2019). Effects of Mindfulness Based Cognitive Therapy (MBCT) and Compassion Focused Therapy (CFT) on Symptom Change, Mindfulness, Self-Compassion, and Rumination in Clients With Depression, Anxiety, and Stress. *Frontiers in Psychology*, *10*.

George, D., & Mallery, M. (2010). *Using SPSS for Windows step by step: A simple guide and reference*. Allyn & Bacon.

Germer, C., & Neff, K. (2019). Mindful Self-Compassion (MSC). In I. Ivtzan (Ed.), *The handbook of mindfulness-based programs: Every established intervention, from medicine to education* (pp. 357–367). Routledge.

Ghiţă, A., & Gutiérrez-Maldonado, J. (2018). Applications of virtual reality in individuals with alcohol misuse: A systematic review. *Addictive Behaviors*, *81*, 1–11.

Gilbert, P. (2009). Introducing compassion-focused therapy. *Advances in Psychiatric Treatment*, *15*, 199–208.

Gilbert, P. (2014). The origins and nature of compassion. *British Journal of Clinical Psychology*, *53*, 6–41.

Giuseppe, R. (2003a). Application of virtual environments in medicine. *Methods of Information in Medicine*, *42*, 524–534.

Giuseppe, R. (2003b). Application of virtual environments in medicine. *Methods Inf Med*, *42*, 524–534.

Grassini, S., Laumann, K., & Rasmussen, S. M. (2020). The Use of Virtual Reality Alone Does Not Promote Training Performance (but Sense of Presence Does). *Frontiers in Psychology*.

Gujjar, K. R., van Wijk, A., Kumar, R., & de Jongh, A. (2019). Efficacy of virtual reality exposure therapy for the treatment of dental phobia in adults: A randomized controlled trial. *Journal of Anxiety Disorders*, *62*, 100–108.

Halim, I., & Baghaei, N. (2020). *Designing, Implementing, and Evaluating Individualized Virtual Reality for Supporting Depression*.

Hillmann, C. (2019). *Comparing the Gear VR, Oculus Go, and Oculus Quest*. Apress.

Hong, C., Joseph, M., Kim, V. H., Lansang, P., & Lara-Corrales, I. (2019). Approach to the Assessment and Management of Pediatric Patients with Atopic Dermatitis: A Consensus Document. Section II: Comorbid Disease in Pediatric Atopic Dermatitis. *Journal of Cutaneous Medicine and Surgery*, *23*, 12S-18S.

Hundt, N. E., Mignogna, J., Underhill, C., & Cully, J. A. (2013). The Relationship Between Use of CBT Skills and Depression Treatment Outcome: A Theoretical and Methodological Review of the Literature. *Behavior Therapy*, *44*, 12–26.

James, S. L., Abate, D., & Abate, K. H. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *392*, 1789–1858.

Jazaieri, H., Jinpa, G. T., McGonigal, K., Rosenberg, E. L., Finkelstein, J., Simon-Thomas, E., Cullen, M., Doty, J. R., Gross, J. J., & R., G. P. (2013). Enhancing compassion: A randomized controlled trial of a compassion cultivation training program. *Journal of Happiness Studies*, *14*, 1113–1126.

Judge, L., Cleghorn, A., McEwan, K., & Gilbert, P. (2012). An Exploration of Group-Based Compassion Focused Therapy for a Heterogeneous Range of Clients Presenting to a Community Mental Health Team. *International Journal of Cognitive Therapy*, *5*, 420–429.

Kadiyala, P. K. (2020). Mnemonics for diagnostic criteria of DSM V mental disorders: A scoping review. *General Psychiatry*, *33*, e100109.

Kao, D., Ratan, R., Mousas, C., Joshi, A., & Melcer, E. F. (2022). *Audio Matters Too: How Audial Avatar Customization Enhances Visual Avatar Customization*. 1–27.

Kim, S., Schwartz, W., Catacora, D., & Vaughn-Cooke, M. (2016). *Virtual Reality Behavioral Therapy*.

356–360.

Körner, A., Coroiu, A., Copeland, L., Gomez-Garibello, C., Albani, C., Zenger, M., & Brähler, E. (2015). The Role of Self-Compassion in Buffering Symptoms of Depression in the General Population. *PLoS ONE 10(10): E0136598*, https://doi.org/10.1371/journal.pone.0136598.

Krijn, M., Emmelkamp, P. M. G., Ólafsson, R. P., Schuemie, M. J., & Mast, C. A. P. G. V. D. (2007). Do Self-Statements Enhance the Effectiveness of Virtual Reality Exposure Therapy? A Comparative Evaluation in Acrophobia. *CyberPsychology & Behavior*, *10*, 362–270.

Kritikos, J., Alevizopoulos, G., & Koutsouris, D. (2021). Personalized Virtual Reality Human-Computer Interaction for Psychiatric and Neurological Illnesses: A Dynamically Adaptive Virtual Reality Environment That Changes According to Real-Time Feedback From Electrophysiological Signal Responses. *Frontiers in Human Neuroscience*, *15*.

Kritikos, J., Zoitaki, C., Tzannetos, G., Mehmeti, A., Douloudi, M., Nikolaou, G., Alevizopoulos, G., & Koutsouris, D. (2020). Comparison between Full Body Motion Recognition Camera Interaction and Hand Controllers Interaction used in Virtual Reality Exposure Therapy for Acrophobia. *Sensors (Basel, Switzerland)*, *20*, 1244.

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9 – validity of a brief depression. *J Gen Intern Med*, *16*, 606–613.

Kroenke, K., Strine, T. W., Spitzer, R. L., Williams, J. B. W., Berry, J. T., & Mokdad, A. H. (2009). The PHQ-8 as a measure of current depression in the general population. *Journal of Affective Disorders*, *114*, 163–173.

Lahti, S., Suominen, A., Freeman, R., Lähteenoja, T., & Humphris, G. (2020). Virtual reality relaxation to decrease dental anxiety: Immediate effect randomized clinical trial. *JDR Clinical and Translational Research*, *5*, 312–318.

Lewis, J. R. (2018). The System Usability Scale: Past, Present, and Future. *International Journal of Human–Computer Interaction*, *34*, 577–590.

Li, H., Dong, W., Wang, Z., Chen, N., Wu, J., Wang, G., & Jiang, T. (2021). Effect of a Virtual Reality-Based Restorative Environment on the Emotional and Cognitive Recovery of Individuals with Mild-to-Moderate Anxiety and Depression. *International Journal of Environmental Research* *and Public Health*, *18*, 9053.

Li, J.-M., Zhang, Y., Su, W.-J., Liu, L.-L., Gong, H., Peng, W., & Jiang, C.-L. (2018). Cognitive behavioral therapy for treatment-resistant depression: A systematic review and meta-analysis. *Psychiatry Research*, *268*, 243–250.

López, A., Sanderman, R., & Schroevers, M. J. (2018). A Close Examination of the Relationship Between Self-Compassion and Depressive Symptoms. *Mindfulness*, 9(5), 1470-1478. https://doi.org/10.1007/s12671-018-0891–0896.

López-López, J. A., Davies, S. R., Caldwell, D. M., Churchill, R., Peters, T. J., Tallon, D., Dawson, S., Wu, Q., Li, J., & Taylor, A. (2019). *The process and delivery of CBT for depression in adults: A systematic review and network meta-analysis*. *49*, 1937–1947.

Marsh, I. C., Chan, S. W. Y., & MacBeth, A. (2018). Self-compassion and Psychological Distress in Adolescents—A Meta-analysis. *Mindfulness*, 1011–1027.

Martirosov, S., Bureš, M., & Zítka, T. (2022). Cyber sickness in low-immersive, semi-immersive, and fully immersive virtual reality. *Virtual Reality*, *26*, 15–32.

Maurer, D. M., Raymond, T. J., & Davis, B. N. (2018). Depression: Screening and Diagnosis. *Am Fam Physician*, *98*, 508–515.

McArthur, V. (2017). *The UX of Avatar Customization*. 5029–5033.

Metzinger, T. K. (2018). Why Is Virtual Reality Interesting for Philosophers? *Frontiers in Robotics and AI*.

Meyerbröker, K., Morina, N., & Emmelkamp, P. M. G. (2018). Enhancement of exposure therapy in participants with specific phobia: A randomized controlled trial comparing yohimbine, propranolol and placebo. *Journal of Anxiety Disorders*, *57*, 48–56.

Miller, H. L., & Bugnariu, N. L. (2016). Level of Immersion in Virtual Environments Impacts the Ability to Assess and Teach Social Skills in Autism Spectrum Disorder. *Cyberpsychology, Behavior, and Social Networking*, *19*, 246–256.

Miller, I. T., Miller, C. S., Wiederhold, M. D., & Wiederhold, B. K. (2020). Virtual Reality Air Travel Training Using Apple iPhone X and Google Cardboard: A Feasibility Report with Autistic Adolescents and Adults. *Autism in Adulthood*, *2*, 325–333.

Minor, K. S., Marggraf, M. P., Davis, B. J., Mickens, J. L., Abel, D. B., Robbins, M. L., Buck, K. D., Wiehe, S. E., & Lysaker, P. H. (2022). Personalizing interventions using real-world interactions: Improving symptoms and social functioning in schizophrenia with tailored metacognitive therapy. *Journal of Consulting and Clinical Psychology*, *90*, 18–28.

Mittelstaedt, J., Wacker, J., & Stelling, D. (2018). Effects of display type and motion control on cybersickness in a virtual bike simulator. *Displays*, *51*, 43–50.

Morina, N., Ijntema, H., Meyerbröker, K., & Emmelkamp, P. M. G. (2015). Can virtual reality exposure therapy gains be generalized to real-life? A meta-analysis of studies applying behavioral assessments. *Behaviour Research and Therapy*, 74:18-24.

Muris, P., & Otgaar, H. (2020). The process of science: A critical evaluation of more than 15 years of research on self-compassion with the Self-Compassion Scale. *Mindfulness*, *11*, 1469–1482.

Neff, K. D. (2003a). Development and validation of a scale to measure self-compassion. *Self and Identity*, *2*, 223–250.

Neff, K. D. (2003b). Self-Compassion: An Alternative Conceptualization of a Healthy Attitude Toward Oneself. *Self and Identity*, *2*, 85–101.

Neff, K. D. (2016). The Self-Compassion Scale is a Valid and Theoretically Coherent Measure of Self-Compassion. *Mindfulness*, *7*, 264–274.

Newbutt, N., Bradley, R., & Conley, I. (2020). Using Virtual Reality Head-Mounted Displays in Schools with Autistic Children: Views, Experiences, and Future Directions. *Cyberpsychology, Behavior and Social Networking*, *23*, 23–33.

Noë, A. (2004). *Action in Perception*. MIT Press.

Norr, A. M., Smolenski, D. J., & Reger, G. M. (2018). Effects of prolonged exposure and virtual reality exposure on suicidal ideation in active duty soldiers: An examination of potential mechanisms. *Journal of Psychiatric Research*, *103*, 69–74.

O'Brien, J. F., & Hodgins, J. K. (2000). Animating Fracture. *Communications of the ACM*, *43*, 68–75.

Pérez-Aranda, A., García-Campayo, J., Gude, F., Luciano, J. V., Feliu-Soler, A., González-Quintela, A., López-del-Hoyo, Y., & Montero-Marin, J. (2021). Impact of mindfulness and self-compassion on anxiety and depression: The mediating role of resilience. *International Journal* *of Clinical and Health Psychology*, *21*, 100229.

Plana-Ripoll, O., Pedersen, C. B., Holtz, Y., Benros, M. E., Dalsgaard, S., & de Jonge, P. (2019). Exploring comorbidity within mental disorders among a danish national population. *JAMA Psychiatry*, *76*, 259–270.

Pullmer, R., Chung, J., Samson, L., Balanji, S., & Zaitsoff, S. (2019). A systematic review of the relation between self-compassion and depressive symptoms in adolescents. *Journal of Adolescence*, *74*, 210–220.

Reger, G. M., Koenen-Woods, P., Zetocha, K., Smolenski, D. J., Holloway, K. M., Rothbaum, B. O., Difede, J., Rizzo, A. A., Edwards-Stewart, A., Skopp, N. A., Mishkind, M., Reger, M. A., & Gahm, G. A. (2016). Randomized controlled trial of prolonged exposure using imaginal exposure vs. Virtual reality exposure in active duty soldiers with deployment-related posttraumatic stress disorder (PTSD). *Journal of Consulting and Clinical Psychology*, *84*, 946–959.

Rizzo, A. 'Skip,' & Shilling, R. (2017). Clinical Virtual Reality tools to advance the prevention, assessment, and treatment of PTSD. *European Journal of Psychotraumatology*, *8*, 1414560.

Robards, J., Evandrou, M., Falkingham, J., & Vlachantoni, A. (2012). Marital status, health and mortality. *Maturitas*, *73*, 295–299.

Rothbaum, B. O., Hodges, L., Smith, S., Lee, J. H., & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. *Journal of Consulting & Clinical Psychology*, *68*, 1020–1026.

Schrepp, M., Hinderks, A., & Thomaschewski, J. (2014). Applying the User Experience Questionnaire (UEQ) in Different Evaluation Scenarios. In *Design, User Experience, and Usability. Theories, Methods, and Tools for Designing the User Experience* (pp. 383–392). Springer International Publishing.

Schrepp, M., Thomaschewski, J., & Hinderks, A. (2018). Construction of a Benchmark for the User Experience Questionnaire (UEQ). *International Journal of Interactive Multimedia and Artificial Intelligence*, *IV*, 40–44.

Shafran, R., Clark, D. M., Fairburn, C. G., Arntz, A., Barlow, D. H., Ehlers, A., Freeston, M., Garety,

P. A., Hollon, S. D., Ost, L. G., Salkovskis, P. M., Williams, J. M., & Wilson, G. T. (2009). Mind the gap: Improving the dissemination of CBT. *Behaviour Research and Therapy*, *47*, 902–909.

Shah, L. B., Torres, S., Kannusamy, P., Chng, C. M., He, H. G., & Klainin-Yobas, P. (2015). Efficacy of the Virtual Reality-Based Stress Management Program on Stress-Related Variables in People With Mood Disorders: The Feasibility Study. *Archives of Psychiatric Nursing*, *29*, 6–13.

Shin, C., Lee, S.-H., Han, K.-M., Yoon, H.-K., & Han, C. (2019). Comparison of the Usefulness of the PHQ-8 and PHQ-9 for Screening for Major Depressive Disorder: Analysis of Psychiatric Outpatient Data. *Psychiatry Investigation*, *16*, 300–305.

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 3549–3557.

Sommers-Spijkerman, M. P. J., Trompetter, H. R., Schreurs, K. M. G., & Bohlmeijer, E. T. (2018). Compassion-focused therapy as guided self-help for enhancing public mental health: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *86*, 101–115.

Srivastava, K., Das, R. C., & Chaudhury, S. (2014). Virtual reality applications in mental health: Challenges and perspectives. *Industrial Psychiatry Journal*, *23*, 83–85.

Thalmann, D., Shen, J., & Chauvineau, E. (1994). *Fast Human Body Deformations for Animation and VR Applications*.

Thombs, B. D., Benedetti, A., Kloda, L. A., Levis, B., Nicolau, I., Cuijpers, P., Gilbody, S., Ioannidis, J. P. A., McMillan, D., Patten, S. B., Shrier, I., Steele, R. J., & Ziegelstein, R. C. (2014). The diagnostic accuracy of the Patient Health Questionnaire-2 (PHQ-2), Patient Health Questionnaire-8 (PHQ-8), and Patient Health Questionnaire-9 (PHQ-9) for detecting major depression: Protocol for a systematic review and individual patient data meta-ana. *Systematic Reviews*, *3*, 124.

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & Health Sciences*, *15*, 398–405.

Vosinakis, S., & Panayiotopoulos, T. (2005). A Tool for Constructing 3D Environments with Virtual Agents. *Multimedia Tools and Applications*, *25*, 253–279.

Waltemate, T., Gall, D., Roth, D., Botsch, M., & Latoschik, M. E. (2018). The Impact of Avatar Personalization and Immersion on Virtual Body Ownership, Presence, and Emotional Response. *IEEE Transactions on Visualization and Computer Graphics*, *24*, 1643–1652.

Wang, P. S., Aguilar-Gaxiola, S., Alonso, J., Angermeyer, M. C., Borges, G., Bromet, E. J., Bruffaerts, R., de Girolamo, G., de Graaf, R., Gureje, O., Haro, J. M., Karam, E. G., Kessler, R. C., Kovess, V., Lane, M. C., Lee, S., Levinson, D., & Wells, J. E. (2007). Use of mental health services for anxiety, mood, and substance disorders in 17 countries in the WHO world mental health surveys. *Lancet*, *370*, 841–850.

Wiles, N., Thomas, L., Abel, A., Ridgway, N., Turner, N., Campbell, J., Garland, A., Hollinghurst, S., Jerrom, B., Kessler, D., Kuyken, W., Morrison, J., Turner, K., Williams, C., Peters, T., & Lewis, G. (2012). Cognitive behavioural therapy as an adjunct to pharmacotherapy for primary care based patients with treatment resistant depression: Results of the CoBalT randomised controlled trial. *Lancet*, *381*, 375–384.

Wilson, C. J., & Soranzo, A. (2015). The Use of Virtual Reality in Psychology: A Case Study in Visual Perception. *Computational and Mathematical Methods in Medicine*.

Wu, Y., Levis, B., Riehm, K., Saadat, N., Levis, A., Azar, M., Rice, D. B., Boruff, J., Cuijpers, P., & Gilbody, S. (2020). Equivalency of the diagnostic accuracy of the PHQ-8 and PHQ-9: A systematic review and individual participant data meta-analysis. *Psychological Medicine*, *50*, 1368–1380.

Yamashita, Y., Shimohira, D., Aijima, R., Mori, K., & Danjo, A. (2020). Clinical effect of virtual reality to relieve anxiety during impacted mandibular third molar extraction under local anesthesia. *Journal of Oral and Maxillofacial Surgery*, *78*, 545.E1-545.E6.

Zhang, H., Carr, E. R., Garcia-Williams, A. G., Siegelman, A. E., Berke, D., Niles-Carnes, L. V., & Kaslow, N. J. (2018). Shame and Depressive Symptoms: Self-compassion and Contingent Self-worth as Mediators? *Journal of Clinical Psychology in Medical Settings*, 408-419. doi:

10.1007/s10880-018-9548–9549.

Appendix A. Advertisements, Participant Information Sheet, Consent Forms.

Email Advertisement

Gmail Ilona Halim K. <[redacted]>

You are Invited to Participate in a Research Project - iVR for Mental Health

Ilona Halim K. <[redacted]> Thu, Mar 10, 2022 at 11:49 AM
To: Barbara <barbara@campusw.co.nz>

Dear Friends and Colleagues,

We are looking for participants to take part in a Virtual Reality research project experiment, conducted as part of my postgraduate qualification. We would like to know what you like about the VR application we have designed and implemented, what you dislike and what can be improved in future versions and if it can be used to increase people's self-compassion. You will be given a usercode, fill out a few forms, wear a VR headset we provide, interact with the application for 10-15 minutes and fill out some forms at the end. No personal information will be collected, and you will not be identified.

The study has been approved by Massey University Human Ethics committee (NOR 21/83).

If you have any questions about the study, please contact my supervisor, Dr Nilufar Baghaei (n.baghaei@massey.ac.nz).

You will be given a $20 Westfield voucher at the end, to thank you for your time and input.

If you are interested, please contact Ilona: [redacted]

Your help and support are much appreciated.

Kind Regards,
Ilona H. Kusnadi

Social Media Advertisement

Participant Information Form

Thank you for taking part in this study.

Project title - Designing, Implementing, and Evaluating Individualized Virtual Reality to Support Mental Health

Project type – Postgraduate Student Research.

This project is going to be used for a postgraduate thesis of Ilona Halim, who is completing a master's degree in information sciences.

General Introduction - Mental health conditions pose a major challenge to healthcare providers and society at large. Early intervention can have significant positive impact on a person's prognosis, particularly important in improving mental health outcomes and functioning for young people. Virtual Reality (VR) in mental health is an emerging and innovative field. Recent studies support the use of VR technology in the treatment of anxiety, phobia, eating disorders, addiction, and pain management. However, there is little research on using VR for supporting, treatment and prevention of depression – a field that is very much emerging. There is also very little work done in offering individualised VR experience to users with mental health issues. This project proposes iVR, a novel individualised VR for improving users' self-compassion, and in the long run, their positive mental health. We believe this contribution will pave the way for large-scale efficacy testing, clinical use, and potentially cost-effective delivery of VR technology for mental health therapy in future. We have recently published the initial idea and the VR architecture at the prestigious ACM International Conference on Human Factors in Computing Systems (CHI 2020).

What is the aim of the project? We would like to see if VR application can potentially be used as a tool to help support mental health conditions such as depression. We would also like to know what you like about the VR application we have designed and implemented, what you dislike and what can be improved in future versions and if there are any changes in your self-compassion levels as a result of interacting with the VR app.

What types of participants are being sought – adults over 18 years of age who are interested to take part in a VR study and provide feedback for improving the VR interface.

How will potential participants be identified and accessed? Through advertisement on social media. Potential participants can express their interest or request for more information via email provided on the advertisement.

What will my participation involve?

First, you will sign a consent form. Then, you will fill out a PHQ-8 form (Patient Health Questionnaire depression scale) and Self-Compassion Self-Criticism (SCSC) scale. The PHQ-8 is established as a valid diagnostic and severity measure for depressive disorders. After that is done, you will interact with a VR environment. After the interaction, you will be asked to fill out the SCSC scale, SUS (System Usability Scale) and UEQ (User Experience Questionnaire) to determine the usability and overall user experience of the VR application. You can also tell us what you think about iVR and how in your opinion we can improve it. We will do the session once more approx. 2 weeks after the first one was conducted.

How will confidentiality and/or anonymity be protected?

You will be given a usercode, which will be used during data analysis stage. Participants' real names will not be recorded on the forms. Only researchers have access to data. All raw data will be deleted after the analyse stage.

What data or information will be collected and how will it be used?

Data from completed questionnaires will be used for analysis. All data will be entered and will be further analysed using software packages such as Excel.

Data Storage

The data will be securely stored on a password protected computer and only the researchers will access to these information and data. Any information that can identify the participants will not be collected or entered into the system.

Can participants change their minds and withdraw from the project?

Yes, participants may withdraw from the study at any time, without giving reasons for their withdrawal. They also can withdraw any information that has already been supplied. We will allow participants 48 hours to withdraw their data, after the study is completed.

What if participants have any questions?

If the participants have any questions about the project, they can contact the senior researcher, Dr. Nilufar Baghaei (n.baghaei@massey.ac.nz) using the contact details given in the Consent Form.

Can participants request a copy of the findings?

Yes, please inform the researcher at the beginning of the session.

Ethics Committee Approval

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 21/83. If you have any concerns about the conduct of this research, please contact A/Prof Fiona Te Momo, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800, x 43347, email humanethicsnorth@massey.ac.nz

Consent Form

Project Title: Designing, Implementing, and Evaluating Individualized Virtual Reality to Support Mental Health

I have read the information sheet and understand what this project is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

- My participation in the project is entirely voluntary and I am free to refuse to answer any particular question
- I am free to stop participating at any time
- I can choose to withdraw information provided without giving reasons and without any disadvantage
- I cannot withdraw any information I have supplied after the data is analysed and participant identifying information is removed.
- My data will be destroyed at the conclusion of the project.
- The results of the project may be published and/or used at a presentation in an academic conference, but my anonymity and confidentiality will be preserved.
- I can ask to receive a copy of the research findings

Additional information given or conditions agreed to

____

____

☐ I want to receive a copy of the research findings (please tick if you want this to be provided to you).

I agree to take part in this project under the conditions set out in the Information Sheet.

.... (signature of participant)

.... (full name of participant – please PRINT)

.... (date)

Appendix B. SCS, PHQ-8, SUS, and UEQ questionnaires

PHQ-8 (*Patient Health Questionnaire-8)*

Please circle the answer that reflects your current experience.

Over the *last 2 weeks*, how often have you been bothered by any of the following problems?	**PHQ-8** **BFRSS conversion**	**Not at all** **0 - 1 day**	**Several days** **2 - 6 days**	**More than half the days** **7 - 11 days**	**Nearly every day** **12 - 14 days**
1. Little interest or pleasure in doing things		0	1	2	3
2. Feeling down, depressed, or hopeless		0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much		0	1	2	3
4. Feeling tired or having little energy		0	1	2	3
5. Poor appetite or overeating		0	1	2	3
6. Feeling bad about yourself—or that you are a failure or have let yourself or your family down		0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television		0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or the opposite—being so fidgety or restless that you have been moving around a lot more than usual		0	1	2	3

Self-Compassion Scale (SCS)

HOW I TYPICALLY ACT TOWARDS MYSELF IN DIFFICULT TIMES

Please read each statement carefully before answering. For each item, indicate how often you behave in the stated manner, using the following 1-5 scale. Please answer according to what really reflects your experience rather than what you think your experience should be.

Almost Never				Almost Always
1	2	3	4	5

1. I'm disapproving and judgmental about my own flaws and inadequacies.

   1 2 3 4 5

2. When I'm feeling down, I tend to obsess and fixate on everything that's wrong.

   1 2 3 4 5

3. When things are going badly for me, I see the difficulties as part of life that everyone goes through.

   1 2 3 4 5

4. When I think about my inadequacies, it tends to make me feel more separate and cut off from the rest of the world.

   1 2 3 4 5

5. I try to be loving towards myself when I'm feeling emotional pain.

   1 2 3 4 5

6. When I fail at something important to me, I become consumed by feelings of inadequacy.

   1 2 3 4 5

7. When I'm down, I remind myself that there are lots of other people in the world feeling like I am.

   1 2 3 4 5

8. When times are really difficult, I tend to be tough on myself.

1 2 3 4 5

9. When something upsets me I try to keep my emotions in balance.

1 2 3 4 5

10. When I feel inadequate in some way, I try to remind myself that feelings of inadequacy are shared by most people.

1 2 3 4 5

11. I'm intolerant and impatient towards those aspects of my personality I don't like.

1 2 3 4 5

12. When I'm going through a very hard time, I give myself the caring and tenderness I need.

1 2 3 4 5

13. When I'm feeling down, I tend to feel like most other people are probably happier than I am.

1 2 3 4 5

14. When something painful happens I try to take a balanced view of the situation.

1 2 3 4 5

15. I try to see my failings as part of the human condition

1 2 3 4 5

16. When I see aspects of myself that I don't like, I get down on myself.

1 2 3 4 5

17. When I fail at something important to me, I try to keep things in perspective.

1 2 3 4 5

18. When I'm really struggling, I tend to feel like other people must be having an easier time of it.

1 2 3 4 5

19. I'm kind to myself when I'm experiencing suffering.

1 2 3 4 5

20. When something upsets me I get carried away with my feelings.

1 2 3 4 5

21. I can be a bit cold-hearted towards myself when I'm experiencing suffering.

1 2 3 4 5

22. When I'm feeling down I try to approach my feelings with curiosity and openness.

1 2 3 4 5

23. I’m tolerant of my own flaws and inadequacies.

1 2 3 4 5

24. When something painful happens, I tend to blow the incident out of proportion.

1 2 3 4 5

25. When I fail at something that's important to me, I tend to feel alone in my failure.

1 2 3 4 5

26. I try to be understanding and patient towards those aspects of my personality I don't like.

1 2 3 4 5

SUS (System Usability Scale)

Please score the following items by circling one of five responses that range from Strongly Agree to Strongly disagree:

	Strongly Agree				Strongly disagree
I think that I would like to use this system frequently.	1	2	3	4	5
I found the system unnecessarily complex.	1	2	3	4	5
I thought the system was easy to use.	1	2	3	4	5
I think that I would need the support of a technical person to be able to use this system.	1	2	3	4	5
I found the various functions in this system were well integrated.	1	2	3	4	5
I thought there was too much inconsistency in this system.	1	2	3	4	5
I would imagine that most people would learn to use this system very quickly.	1	2	3	4	5
I found the system very cumbersome to use.	1	2	3	4	5
I felt very confident using the system.	1	2	3	4	5
I needed to learn a lot of things before I could get going with this system.	1	2	3	4	5

UEQ (User Experience Questionnaire)

Please assess the product now by ticking one circle per line.

	1	2	3	4	5	6	7		
annoying	○	○	○	○	○	○	○	enjoyable	1
not understandable	○	○	○	○	○	○	○	understandable	2
creative	○	○	○	○	○	○	○	dull	3
easy to learn	○	○	○	○	○	○	○	difficult to learn	4
valuable	○	○	○	○	○	○	○	inferior	5
boring	○	○	○	○	○	○	○	exciting	6
not interesting	○	○	○	○	○	○	○	interesting	7
unpredictable	○	○	○	○	○	○	○	predictable	8
fast	○	○	○	○	○	○	○	slow	9
inventive	○	○	○	○	○	○	○	conventional	10
obstructive	○	○	○	○	○	○	○	supportive	11
good	○	○	○	○	○	○	○	bad	12
complicated	○	○	○	○	○	○	○	easy	13
unlikable	○	○	○	○	○	○	○	pleasing	14
usual	○	○	○	○	○	○	○	leading edge	15
unpleasant	○	○	○	○	○	○	○	pleasant	16
secure	○	○	○	○	○	○	○	not secure	17
motivating	○	○	○	○	○	○	○	demotivating	18
meets expectations	○	○	○	○	○	○	○	does not meet expectations	19
inefficient	○	○	○	○	○	○	○	efficient	20
clear	○	○	○	○	○	○	○	confusing	21
impractical	○	○	○	○	○	○	○	practical	22
organized	○	○	○	○	○	○	○	cluttered	23
attractive	○	○	○	○	○	○	○	unattractive	24
friendly	○	○	○	○	○	○	○	unfriendly	25
conservative	○	○	○	○	○	○	○	innovative	26

Appendix C. Publications

Halim, I., Baghaei, N., Stemmet, L., Billinghurst, M., & Porter, R. (2022, March). Designing and Implementing Individualized VR for Supporting Depression. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)* (pp. 217-221). IEEE. (Halim & Baghaei, 2020)

Halim, I., & Baghaei, N. (2020). Designing, Implementing, and Evaluating Individualized Virtual Reality for Supporting Depression. *Massey University SNCS Postgraduate Conference. Best Poster Award.*

Appendix D. Pearson's Correlations of PHQ-8 and SCS Statistics.

Pearson's Correlations

Variable		SCS (Baseline)	SCS (Session 1)	SCS (Session 2)	PHQ 8 (Baseline)	PHQ 8 (Session 1)	PHQ 8 (Session 2)
1. SCS (Baseline)	Pearson's r	—					
	p-value	—					
2. SCS (Session 1)	Pearson's r	0.949 ***	—				
	p-value	< .001	—				
3. SCS (Session 2)	Pearson's r	0.747 ***	0.775 ***	—			
	p-value	< .001	< .001	—			
4. PHQ 8 (Baseline)	Pearson's r	-0.743 ***	-0.741 ***	-0.581 **	—		
	p-value	< .001	< .001	0.004	—		
5. PHQ 8 (Session 1)	Pearson's r	-0.699 ***	-0.694 ***	-0.531 **	0.955 ***	—	
	p-value	< .001	< .001	0.009	< .001	—	
6. PHQ 8 (Session 2)	Pearson's r	-0.76 ***	-0.727 ***	-0.735 ***	0.685 ***	0.64 **	—
	p-value	< .001	< .001	< .001	< .001	0.001	—

* p < .05, ** p < .01, *** p < .001

Appendix E. Independent Samples T-Test on SCS and PHQ-8 scores based on gender.

Independent Samples T-Test

	t	df	p	Cohen's d
SCS (Baseline)	1.603	21	0.124	0.669
SCS (Session 1)	1.084	21	0.291	0.452
SCS (Session 2)	1.018	21	0.32	0.425
PHQ 8 (Baseline)	-0.372	21	0.714	-0.155
PHQ 8 (Session 1)	-0.52	21	0.609	-0.217
PHQ 8 (Session 2)	-1.432	21	0.167	-0.598

Note. Student's t-test.