Designing Individualised Virtual Reality Applications for Supporting Depression: A Feasibility Study

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Mental health conditions pose a major challenge for individuals, healthcare systems and society – and the COVID-19 pandemic has likely worsened this issue. According to the Mental Health Foundation of New Zealand, one in five people will develop a serious mood disorder, including depression, at some time in their life. Co-designed solutions to increase resilience and well-being in young people have specifically been recognised as part of the National Suicide Prevention Strategy and the New Zealand Health Strategy. Virtual Reality (VR) in mental health is an innovative field. Recent studies support the use of VR technology in the

treatment of anxiety, phobia, and pain management. However, there is little research on using VR for supporting, treating and preventing depression. There is also very little work done in offering an individualised VR experience to improve mental health. In our earlier work, we presented iVR, a novel individualised VR experience for enhancing peoples' self-compassion, and in the long run, their mental health, and described its design and architecture. In this paper, we outline the results of a feasibility study conducted recently. Most participants believed introducing elements of choice within iVR enhanced their user experience and that iVR had the potential to enhance people's self-compassion. We also approached seven mental health professionals for feedback, who felt that introducing elements of choice within iVR would increase their knowledge of clients. Our contribution can pave the way for large-scale efficacy testing, clinical use, and cost-effective delivery of intelligent individualised VR technology for mental health therapy in future.

CSS Concepts • Human-centered computing~Human computer interaction (HCI); Virtual reality; User models; User studies; • Applied computing~Life and medical sciences; Consumer health

Additional Keywords and Phrases: Virtual reality, individualisation, mental health, user models, user experience, feasibility study, self-compassion, depression.

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1 INTRODUCTION

Mental health conditions are a major challenge for society, healthcare providers, and health systems – and the COVID-19 pandemic has only worsened pre-existing conditions [56]. Mental health services are struggling to meet the needs of users and fail to reach large proportions of those in need of care in most countries [36, 59]. The World Health Organization predicts that by 2030 mental health conditions will be the leading contributor to the disease burden globally [37]. Early intervention can have a significant positive impact on a person's prognosis, particularly important in improving mental health outcomes and functioning for young people [38]. Co-designed solutions to improve resilience and well-being in young people have specifically been recognised as part of the National Suicide Prevention Strategy [20]. Innovative interventions that support long-term change for individuals are urgently needed [7].

Self-compassion/self-criticism constitutes a protective/risk factor with regard to improving mental well-being [12], particularly in young people [19, 23]. Self-criticism is one of the major psychological factors, identified as contributing to depressive and anxiety disorders and is defined as a dominant response style of negative evaluation and judgement of self to perceived failure [5]. It creates vulnerability and influences recovery and maintenance of depression [41, 42]. One effective method to increase self-compassion and reduction in depression may be to address self-criticism through compassion-focused therapy [11]. It is considered a form of Cognitive Behavioural Therapy (CBT) [24] that has been employed effectively in depression interventions [15,17]. While gaming approaches based on principles of CBT have been found to support adolescents experiencing low mood (e.g., SPARX) [2,3,9,16,25], with behaviour change as a key goal [6,8,19], self-compassion has not specifically been the focus of these efforts thus far.

Virtual Reality in mental health is an emerging and innovative field that holds potential for bridging gaps in the availability and quality of care, and for supporting those facing the challenges of mental illness. It is becoming more commonplace with the advent of affordable consumer head mounted displays (HMDs) and has potential for advancing the understanding, assessment and treatment of mental health problems. Recent studies support the effectiveness of VR in the treatment of anxiety disorders, phobias, stress, obesity and eating disorders, addiction, and pain management, where gains appear to generalise to real life scenarios [22, 26, 28, 30, 49, 50]. However, there is little evidence on the benefit of using VR for promoting self-compassion for the treatment of depression, and it is an emerging field of research [7, 27]. There is also very little work pertaining to personalising and/or individualising such VR environments to participants' preferences, interests, or mental health condition.

2 iVR: DESIGNING INDIVIDUALISED VR FOR MENTAL HEALTH

The focus of our initial project [19] was to design and implement a VR environment to improve self-compassion to influence recovery from depression. Inspired by earlier research conducted by Falconer et al [7], we proposed iVR [52], a novel design that would enable individual choices within a VR environment. There are a few VR platforms that have looked at offering personalised engagement with VR prototypes, e.g. use of VR for tobacco cessation [47] as well as sharing life stories (LifePathVR) [48], but, to the best of our knowledge, nothing for people with depression. We propose that offering choices to participants and allowing them to choose the avatar, therapy environment and behaviour exhibited by the avatar (as shown in Figure 1), may provide benefits to individuals with mental health issues as well as to their therapists.

Therapists could use an individual's choice of therapy environment (room, beach, forest, castle etc) and avatar's physical characteristics (e.g., skin colour, eyes, hair, gender and age) as a discussion point to drill down deeper into their underpinning psychological make-up in order to provide more effective and tailored therapeutic interventions and support. The VR system could potentially also support therapists who are engaging with individuals who do not seem to be either forthcoming with information and details about their situation or who simply may struggle to explain their current situation and any other concerns they may have about their past, present or future. In addition to choosing the therapy environment and avatar, iVR also provides the opportunity for participants to choose the behaviour exhibited by the selected avatar. This would further enhance the system by adding dimensions to a therapy session, which may be difficult for therapists to 'act out' within a session or as part of a therapeutic intervention. We hypothesise that this would enhance the therapy session and user experience.

The principle underpinning our thinking is that there is a trend to provide increasingly more individualised opportunities in several other domains, for example marketing, education and medicine through the application of other novel 21st century technologies. For example, Intelligent Tutoring Systems and Artificial Intelligence in Education fields are dedicated to tracking learners' progress and providing them with a personalised education experience [57, 58]. In marketing it is well-known that companies such as Facebook and Amazon track the behaviour of users to improve the options marketed to their customer base. Medicine is becoming more tailored to the individual, driven by new digital technology advancements; moving from one-size-fits-all to 'personalised medicine', where care delivery is tailored to the individual, thereby offering potential for higher cure rates and fewer side effects [46]. Even though the concept of individualised care in mental health has been discussed [51], it has not been applied to technology assisted mental health support.

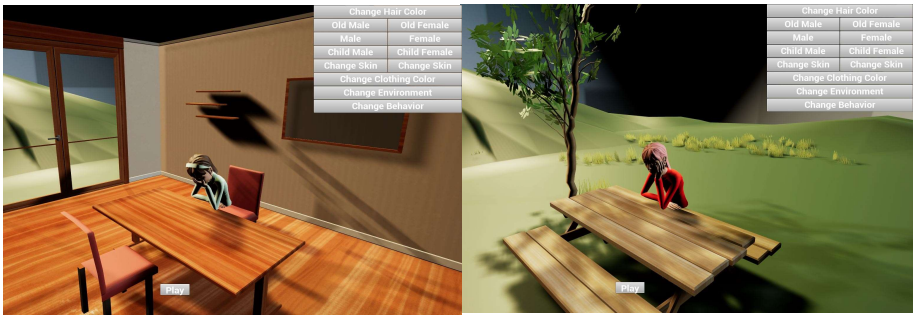

Figure 1: iVR prototype allowing participants to choose the characteristics of the avatar, behaviour and the environment

Our main research questions were*: RQ1)* Whether introducing elements of choice within iVR will enhance user experience, regardless of the level of self-reported depressive symptoms*; RQ2)* Whether introducing elements of choice within iVR will increase mental health professionals' knowledge of participants.

3 FEASIBILITY STUDY

We conducted a study recently with student sample size of 23 (18 self-identifying as male and 5 self-identifying as female, mean age: 24, SD: 7.36). The goal of the study was to see what participants thought about the iVR prototype, whether they enjoyed interacting with it, whether introducing elements of choice within iVR enhanced the user experience (*RQ1*), and if they found it potentially useful for increasing people's self-compassion and in the long run, their mental health. A prototype of iVR was implemented in Unreal Game Engine 4 (Figure 1). We used Oculus Rift headsets for the experiment.

iVR allows participants to choose the physical characteristics of the avatar they are going to interact with (age, gender, skin colour, eye colour, hair colour, colour of clothing), their behaviour (crying, sobbing, looking sad, looking angry, walking around the room) and the therapy environment (room, beach, jungle, castle etc). The participants have the option of making the choices themselves or ask their therapists for help, if they need it. They would then have to deliver compassionate words to the avatar (to which the avatar is programmed to respond positively), in an attempt to improve their own self-compassion.

We first asked the participants to fill out a Patient Health Questionnaire 9 (PHQ-9) [39]. PHQ-9 is a measure often used to assess and monitor depressive symptoms and the outcomes in psychological treatments for depression and is widely used in research settings [53]. The higher the score, the more chances of mild to moderate depressive symptoms [45]. The participants filled out a PHQ-9, interacted with the iVR prototype and filled out a subjective questionnaire at the end. They explored the system in an unconstrained manner with researchers present in the room to help, if needed.

3.1 Participants' Questionnaire

All participants were asked to complete a self-rated user experience questionnaire [63] at the end, indicating what they think about iVR on the scale of *1* to *5*, with *1* being "completely disagree" and *5* being "completely agree" for each question (SQ 1-7). Overall, *61%* of participants reported that iVR was easy to use (counting those who picked *4* or *5*), *65%* that it was enjoyable to use, *56%* said that they would recommend iVR to others and *30%* said

that 'maybe' they would recommend it, *52%* thought iVR was effective while *35%* responded with a 'maybe', *78%* that the individualisation features offered by iVR made it more engaging, and *91%* that iVR has potential to be used out in real world. We believe some of the lower percentages are due to the UI limitations to be improved in future iterations.

Table 1: iVR User Questionnaire & percentages of participants for each rating

Tell us what you think about iVR on the scale of 1 to 5, with 1 being completely disagree and 5 being completely agree	1	2	3	4	5
SQ_1: I think iVR is easy to use	*0.0%*	*13%*	*26.1%*	*30.4%*	*30.4%*
SQ_2: I think iVR is enjoyable to use	*0.0%*	*17.4%*	*17.4%*	*39.1%*	*26.1%*
SQ_3: I think iVR is fun to use	*0.0%*	*21.7%*	*26.1%*	*30.4%*	*21.7%*
SQ_4: I would recommend it to other people	*4.3%*	*4.3%*	*30.4%*	*34.8%*	*21.7%*
SQ_5: I think iVR is effective in doing what it is trying to do	*8.7%*	*8.7%*	*34.8%*	*34.8%*	*17.4%*
SQ_6: I think individuation features makes it more engaging	*0.0%*	*0.0%*	*21.7%*	*34.8%*	*43.5%*
SQ_7: I think iVR has potential to be used out in the real world	*4.3%*	*0.0%*	*4.3%*	*30.4%*	*60.9%*

Likert scale: 1= I completely disagree, 3= neutral, 5=I completely agree

We then divided our sample into two groups based on depression severity as assessed using PHQ-9 [53]: *Low* (PHQ-9 score between *0-4*, i.e. none-minimal group) and *High* (PHQ-9 score between *8-11*, i.e. mild-moderate group). The results show that those participants with lower PHQ-9 scores found iVR easier to use compared with others (SQ_1). The difference between the two groups (*High* vs *Low*) is statistically significant ($p = 0.021$). It is possible that the difficulty which participants with higher depression scores experienced, when it came to ease of use, were related to cognitive impairment, which can be a feature of depression [55, 60]. However, the ease of use is subjective and patients with depressive symptoms often express that they feel that they have cognitive impairment, even though this does not necessarily correlate with actual impairment [61]. There were, however, no statistically significant differences between the two groups, when it came to their responses to other questions ($p > 0.05$).

A majority of participants in both *High* and *Low* groups responded that they thought the individualisation features offered by iVR made it more engaging and that it had potential to be used in the real world. These were our two key questions in gathering user's perception and acceptability of the idea. The difference between the groups were not statistically significant.

3.2 Qualitative Feedback from Participants

We also asked participants to tell us what they thought about iVR and how they felt we could improve it going forward. Two researchers analysed the comments independently to find the main qualitative themes, using an established approach to qualitative data analysis [62]. No significant differences were noted between the themes. The top features that the participants liked included the ability to customise the avatar, behaviour of the avatar and the environment, clear audio, being immersed in VR, outdoor sceneries, ability to change avatar and scenery, realistic crying of avatar, interactivity, good form of escapism, the whole concept of the project, and enhanced immersion and personal connection with the avatar, as a result of allowing participants to pick the avatar's appearance.

Some suggestions were also made for further improvements. Several participants asked for the avatars to be made more realistic and interactive and for the graphics to be improved. Some asked for clearer instructions and

more customisation options, especially for selecting different environments and avatar behaviours. One participant requested for choices to be made available for changing the perspective that the participants viewed the avatar from - they preferred to be sitting next to the avatar as opposed to sitting in front of them. Another participant said they would have liked to be able to walk and explore the location with the avatar, if they had the option. A few participants suggested the possibility of adding intelligence to iVR, so the avatar can understand what the participant is saying and be able to respond. More robust and developed facial expressions and ambient audio for increased immersion were also suggested.

We also reviewed the comments to find the main qualitative themes among PHQ-9 *High* vs *Low* groups. The suggestions were similar across both groups, when it came to listing the top three features they liked or did not like about iVR. However, in response to how iVR could be improved in the future, we noticed that more participants in the *High* PHQ-9 group (suggesting depressive symptoms) requested more interaction with the avatar (e.g. basic communicative features), and more choices to be offered (especially for behaviour of the avatar and therapy environments) compared with participants in the *Low* group, who emphasised more on improved graphics and better visualisation. This is an interesting observation. The novel feature we have introduced in this project is individualism within a VR environment for people with depression and to see that those participants with higher PHQ-9 scores request more of this feature is encouraging.

3.3 Feedback from Mental Health Professionals

To answer *RQ2*, we approached and interviewed seven clinical psychologists (5 self-identifying as female, mean age: 45) to seek their feedback. A total of *86%* of our participants believed introducing elements of choice within iVR would increase their knowledge of clients, *86%* liked the individualisation offered by iVR and *100%* felt iVR had potential to be used in clinical setting. They found the idea behind iVR patient-centered, as it allowed people to take action by making several choices about the avatar, behaviour and the therapy environment. They felt the act of thinking about those choices can help the treatment process as well. Some thought that iVR addresses post-modern psychology, in that the client is actively involved in the process and that would enable the mental health professionals to extract information on how the client feels about themselves.

The participants also had some suggestions for improvement, including 1) giving mental health professionals full control over the situation in case they have to intervene immediately, 2) introducing levels of individualisation, so the mental health professional can increase or decrease the number of choices that are available to the client, based on their assessment of the client and how far they are into the treatment process, 3) gamifying the levels and introducing more or less choices depending on the assessment of mental health professional, 4) providing tutorials/training before or at the beginning of the first session for the mental health professionals and for the participants to make them feel more comfortable.

4 CONCLUSIONS AND FUTURE DIRECTIONS

We presented iVR, a novel individualised VR experience for enhancing peoples' self-compassion, and in the long run, their mental health. We described the architecture and design of iVR and uncovered several interesting observations in the feasibility study conducted recently. Our findings show that: (i) most participants (regardless of their PHQ-9 scores) believed that the individualisation features offered by iVR makes it more engaging and that it has potential to be used in real world; (ii) most mental health professionals we approached believed introducing elements of choice within iVR would increase their knowledge of clients, and all of them felt iVR had potential to be

used in clinical setting. This serves as an important and promising step for determining the effectiveness of using Individualised VR interventions for addressing and supporting depression and potentially other mental health challenges.

Going forward, we are enhancing the iVR prototype to build on the lessons learned from this study, with a main focus on *i)* improving the UI and making the avatars more realistic (early version of iVR prototype v2 is shown in Figure 2a-c), *ii)* making the avatars intelligent by enabling them to respond to the participants and have a conversation with them. The participants' speech will be analysed using Python Natural Language Toolkit library [64]. Based on the emotions detected (positive, negative or neutral), the avatar's facial expressions will also change to provide users with a more realistic VR experience.

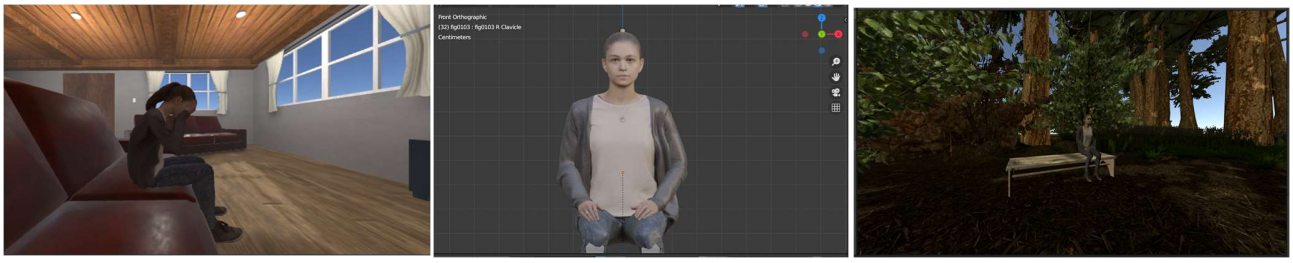

Figure 2a-c: iVR prototype v2 – the UI and avatar are enhanced following participants' feedback

We aim to conduct another study in future to investigate whether introducing elements of choice will improve therapeutic outcomes for patients. We will recruit an appropriate sample size and run a longer 3-week study. We will divide the participants into one control group (non-individualised VR) and one experimental group (iVR). The participants will be aged 18-40 years and they may or may not have a history of depression and/or mood changes. To determine if there are changes in self-compassion, we will collect pre-test and post-test measures of depression using the PHQ-9, anxiety symptoms using GAD-7 (Generalised Anxiety Disorder 7-item scale) [53] and self-compassion using the Self-Compassion and Self-Criticism Scale (SCCS) [40]. We will also collect outcomes (PHQ-9, GAD-7 and SCCS forms) after each session, and a post-test questionnaire at the end of the study, asking the participants and mental health professionals to describe their experience.

Based on our initial feasibility findings reported here, more studies need to be done to investigate the UX/UI design requirements for people with depression and cognitive impairment in order to improve their virtual reality experience. Our hypothesis is that individualised immersive VR will have a significant impact on increasing participants' mental well-being. We believe our contribution will pave the way for large-scale efficacy testing, clinical use and cost-effective delivery of individualised VR technology for mental health therapy in future research.

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