Time to Get Personal: Individualised Virtual Reality for Mental Health

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Abstract
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 paper proposes **iVR**, a novel individualised VR for improving users' self-compassion, and in the long run, their positive mental health. We describe the concept, design, architecture and implementation of **iVR** and outline future work. 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.

Author Keywords
Virtual reality; individualisation; user models; user experience; mental health; self-compassion; depression.

CSS Concepts

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

Introduction

Mental health conditions are a major challenge for society, healthcare providers, and health systems. The World Health Organization predicts that by 2030 mental health conditions will be the leading contributor to disease burden globally [37]. Mental health services are struggling to meet the needs of users and fail to reach large proportions of those in need in most countries.

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 [36]. 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 and risk factor with regard to improving mental well-being [12], particularly in young people [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. During compassion-focused therapy, the patient is exposed to a situation that causes distress. The main purpose is for therapists to then assist the patient to access and foster care-focused motives and emotions to reduce self-criticism and move towards mentally healthy behaviours. To create such situations in the real world is resource demanding, and innovative interventions that support long-term change for individuals are urgently needed [7]. To make this treatment feasible and timely to everyone who needs it, Virtual Reality (VR) technology may be a potentially useful and appealing approach.

VR in mental health is an emerging and innovative field. It is becoming more commonplace with the advent of affordable consumer head mounted devices (HMDs) and has a lot of potential for advancing the understanding, assessment and treatment of mental health problems. VR can provide a non-threatening, low-risk environment, which allows for free exploring of different coping strategies and techniques for managing and overcoming symptoms. Real environments can be replaced with virtual ones, thereby allowing a transformation of our external experience. When a life-sized virtual body substitutes a person's real body in

immersive VR, it typically generates an illusion of body ownership over the virtual body [31, 32]. Recent evidence shows that embodiment has a variety of physiological and psychological consequences that indicate that the person has identified with or taken on attributes of the virtual body, including changes in size perception after embodiment in a child body, and changes in implicit racial attitudes after embodiment in a body with a different skin colour [7, 34]. A high level of personal efficacy and self-reflectiveness is typically generated in VR by an increased sense of presence and emotional engagement. Moreover, VR can modify our inner experience by structuring, altering, and/or replacing our bodily self-consciousness [29, 43].

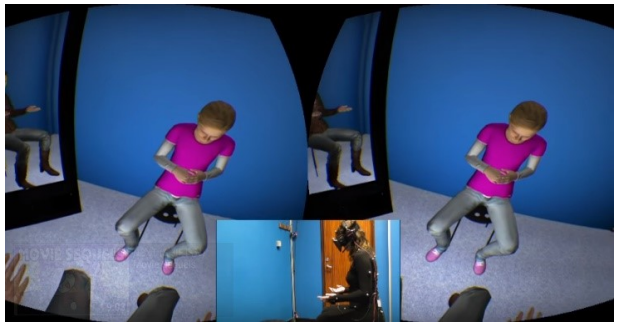

Figure 1: Participant delivers compassion to a crying child [7]

Recent studies support the effectiveness of VR in the treatment of anxiety diso rders, 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 for or against using VR for promoting self-compassion and/or the treatment of depression, and it is an emerging field of research [7, 10, 27]. There is also very little work pertaining to personalising and/or individualising such VR environments to participants' preferences, interests, or mental health condition.

iVR: Designing Individualised VR for Mental Health

The main focus of our initial project [19] was to design and implement a VR environment to improve self-compassion to influence recovery from depression. Building on earlier research conducted by Falconer et al [7], our research question was whether the effects of calming down virtual characters in different social settings could be exploited to increase self-compassion in young people with depression. In Falconer's experiment, the virtual character is a crying girl (see Figure 1) and the participant has to demonstrate compassion towards the child, in an attempt to improve their own self-compassion. Her study with 15 participants showed a significant improvement in participants' self-compassion as a result of exposure to VR compassion focused/mental health therapy. Our project is to replicate the same experiment with a younger population (aged 18-25), given that in most countries mental healthcare services for young people do not satisfactorily meet the care needs of this demographic group [44]. We build on the work that has been done with the addition of new social settings: 1) receiving a bad grade; 2) upset about having to give talk/job interview; 3) falling out of love; 4) bullying.

In this paper, we take this approach further by proposing iVR, a novel design that would enable individual choices within a VR environment. There are a few recently developed 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]. We propose that offering choices to participants and allowing them to choose the avatar, therapy environment and behavior exhibited by the avatar, may provide benefits to individuals with mental health issues as well as to their therapists.

Our three research questions are: *RQ1*) whether introducing elements of choice within iVR will enhance user experience; *RQ2*) whether introducing elements of choice within iVR will increase therapists' knowledge of participants; and *RQ3*) whether introducing elements of choice will improve therapeutic outcomes for patients.

Therapists could use an individual's choice of therapy environment and avatar's physical characteristics (e.g., skin colour, eyes, hair and gender) as a discussion point to drill down deeper into their underpinning psychological make-up in order to provide more effective therapeutic interventions and support. It could potentially also support therapists who are engaging with individuals who do not seem to be either very 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 behavior exhibited by the chosen 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. In marketing it is well-known that companies such as Facebook and Amazon track the behavior of users to improve the options marketed to their customer base. Medicine is becoming more tailored to the individual; 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.

iVR Architecture

The **iVR** architecture defines an application prototype, with the aim of making it as user-friendly and maintainable as possible. We believe giving participants options to choose from (i.e., avatar, therapy environment and avatar's behavior) will enhance the user experience. This is one of the key research questions that will be investigated (*RQ1*). The non-functional requirements have the highest priority; thus, the architecture is divided into two modules: 1) Application (front-end) module; 2) VR module (see Figure 2).

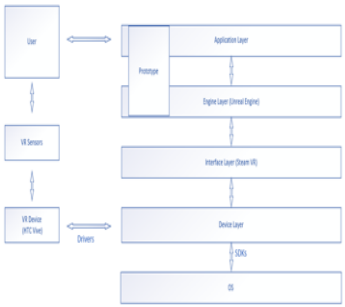

Figure 3: Overall high-level architecture

Figure 4: n-tier architecture

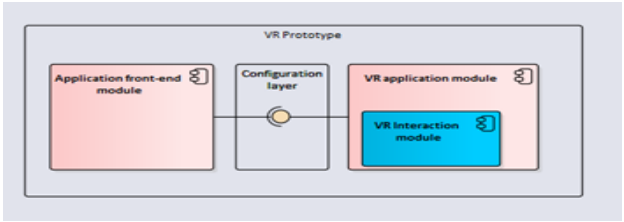

Figure 2: The **iVR** Prototype Architecture

Most of the application-related functionalities are implemented in the application module. All requirements related to personal data, business logic, voice and video recordings, timestamp information, session metadata as well as project and participant master data are part of the application front-end module business logic. This allows us to add the necessary customisation functionality and flexibility as well as provide the appropriate level of user experience (UX) for the application user. The VR module is then responsible for the VR session itself (i.e., execution of the VR environment with proper resources). The overall high-level architecture is illustrated in Figure 3.

Application Module

The application module is developed as a separate atomic unit and deployed as a single executable Java ARchive (JAR) file. The application is responsible for maintaining all business data and information relevant to the VR project. It is also responsible for preparing the input data for the VR session (i.e. interacts with the configuration files and resources in the configuration layer of the application). The module is based on the layered (n-tier) architecture following a Model-View-Controller design pattern: 1) Presentation layer (UI layer objects); 2) Business object layer (domain); 3) Data layer (repository objects).

The business logic is completely separated from the repository objects and front-end layers. It is, therefore, possible to modify the presentation layer based on the requirements (web-based client-server etc.). The source of the data is not known to the upper layers; thus, the application could be enhanced to use a different type of data source, database, file, external data source or cloud-based no-SQL database, making it flexible and maintainable.

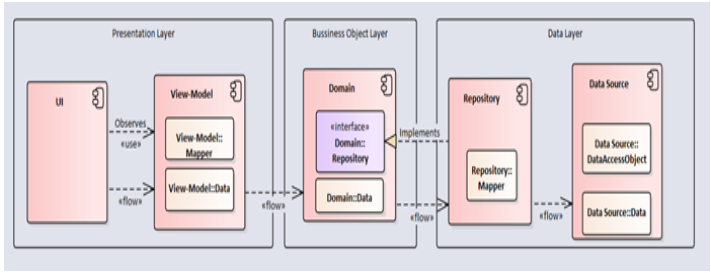

Figure 5: Three separate layers

VR Module

The VR module is built on the Unreal Engine 4, developed as a separate executable VR application file, allowing the participant to experience the VR session with resources and assets of their choice. The interaction features enable the therapists and/or researchers to interact in real-time with the currently running VR session. All resources must be compiled and added in the application before they could be used in the front-end module as available data. The VR module has no special architecture layers (UE architecture), and the only enhancement is the loading sequence. Before the session is executed, the configuration files are modified based on the application front-end module properties, which allows performing specific session type with proper resources.

Methodology, Conclusion and Future Work

To answer our research questions, we aim to recruit 60 participants divided into one control group (*VR*) and one experimental group (**iVR**). 30 people will be randomly allocated to each group. The participants will be aged 18-25 years and they may or may not have a history of depression and/or mood changes. We will have six VR sessions over three weeks.

To determine if there are changes in response to the **iVR** environment relative to the control group, 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) and self-compassion using the SCCS form (to answer *RQ3*). We will also collect outcomes (PHQ-9, GAD-7 and SCCS forms) after each session, and a post-test questionnaire at the end of three weeks, asking the participants and therapists to describe their experience (to answer *RQ1 & RQ2*). This will be supplemented with a focus group discussion with potential VR users and participants' mental health professionals to further elicit participant feedback regarding VR feasibility/acceptability and to inform further refinements. As part of the focus group discussion with participants' mental health professionals, we will gather perspectives regarding the potential for *individualised* VR to enhance therapists' knowledge of their patients and improve delivery of mental health services.

The primary outcome measure will be the Patient Health Questionnaire-9 (PHQ-9) [39], a measure often used to assess outcomes in psychological treatments for depression. This assesses symptoms of depression over the previous two weeks and has nine items scored 0 ('not at all'), 1 ('several days'), 2 ('more than half the days') or 3 ('nearly every day'). A score of 10 or greater on the PHQ-9 suggests mild to moderate depressive symptoms [45]. A reduction of at least five points will indicate reliable change [7] and whether there have been any therapeutic improvements.

The Self-Compassion and Self-Criticism Scale (SCCS) [40] will also be used, which consists of five scenarios that are potentially self-threatening and can elicit varying degrees of self-criticism or self-compassion (e.g. '*You arrive home to find that you have left your keys at work'*). Participants are asked to imagine that these scenarios are happening to them now and rate on 7-point scales from 1 ('not at all') to 7 ('highly') the extent to which they would react to themselves in a harsh, critical, soothing, reassuring, and compassionate manner [7]. The positive ratings are summed to generate the Self Compassion Scale (range 15–105) and the negative ratings generate the Self-Criticism Scale (range 15–105).

Our hypothesis is that individualised immersive **iVR** will have significant impact on increasing participants' mental well-being, enhancing user experience and increasing therapist's knowledge of participants that would have been challenging to gather otherwise.

This proof-of-concept study serves as an important step for determining the feasibility and acceptability of using Individualised VR (iVR) interventions for addressing depressive symptoms and other mental health challenges among young people. We believe this project will pave the way for clinical use and cost-effective delivery of individualised VR technology for mental health therapy in the future.

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