Translating Cognitive Behavioural Therapy Strategies Through VR Interactions to Tackle Anxiety Symptoms in University Students

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***Abstract*—Rising anxiety amongst university students not only adversely affects their academic performance but contributes towards a troubling decline in overall mental well-being. Existing psychotherapy such as Cognitive Behavioural Therapy (CBT) can work towards improving this, yet many barriers prevent CBT from being accessed, particularly from a student perspective. Our research proposes a modern solution utilising a Virtual Reality (VR) headset to deliver digital CBT strategies, investigating their suitability and effectiveness, across a 30 student study alongside the guidance of psychiatrists. Participants found that gamified VR interactions contributed towards greater visualisations of core CBT principles as well as overall engagement, but 3D environments and elements such as avatars must be believable to maintain a sense of realism. Feedback showed a keen interest towards the educational side of such applications, prompting further investigation.**

***Index Terms*—VR, CBT, Anxiety, Virtual Reality, Gamification**

I. Introduction

The growing pursuit of higher education has brought forth increased concerns about mental health issues such as anxiety among university students [1], [2], affecting their academic performance and overall well-being [3]–[5]. Globally as many as one-fifth of university students have been reported experiencing a mental health disorder each year [6]. When seeking traditional therapies, students often encounter barriers such as affordability, accessibility, awareness, stigma, and dependency, hindering their access and benefits. One such therapy is Cognitive Behavioural Therapy (CBT), a form of psychological treatment that has a long history of effectiveness towards a range of problems, including mental illnesses [7]. Treatment via CBT involves changing one's thinking and behavioural patterns, developing coping mechanisms to better manage difficult emotions. Following the COVID-19 pandemic there has been increasing attention on internet-based CBT solutions [8], and already studies have highlighted advantages compared to face-to-face CBT [9], [10], reducing said barriers. Virtual Reality (VR) headsets, continually evolving devices, hold the potential to offer therapeutic experiences with its 3D immersive and interactive nature. VR, when adapted for therapeutic purposes, can replace traditional CBT [11] and could even be a more engaging and effective experience for students, however it is crucial to investigate its effectiveness as a transformative tool to deliver therapies and evaluate its acceptability as a self-help tool among university students.

II. Research Aim

The rapid advancement of VR in the medical field [12], bridging the gap between games and health [13], has prompted further investigation into possible applications and adoptions towards mental health. The present research aimed to critically analyse the effectiveness of VR-based CBT, known as VR-CBT, in reducing anxiety symptoms in university students. Extensive review of existing studies in the field of VR adapted for mental wellness therapies acted as a foundation for the study. Furthermore, the hypothesis suggesting that university students experience anxiety at various times, affecting their overall well-being, was supported by quantitative data gathered during a preliminary study. The present research also explored the efficacy of VR as a platform to reduce anxiety and promote relaxation in students. The study integrated CBT-based cognitive restructuring exercises into a virtual environment developed using Unity. This therapeutic experience was aimed to assist students in dealing with anxiety. Additionally, VR-based meditation was employed to evaluate its effects in inducing relaxation among students. Data gathered during VR-CBT interactions and VR-based meditation was analysed to determine if interactions performed within a virtual environment can act as a self-help tool to aid anxiety, foster relaxation, and promote overall well-being in students' mental health.

III. Virtual Reality & Therapy

Despite VR platforms being predominantly focused around gaming for entertainment, there has been increasing attention towards VR healthcare applications with noticeable growth within the last 6 years and predictions of further acceleration to follow [14]. There have been many attempts to utilise these newer technologies to assist in areas such as phobias [15], [16], rehabilitation [17], [18], and even health education

[19], yet even older studies discussed the benefits of systems incorporating VR elements before dedicated headsets were available [20], [21].

VR-CBT Although CBT has been proven effective towards treating anxiety disorders [22], [23], and thus university students [24], typical treatment is not without criticism. A systematic review [25] highlights some of the weaknesses of traditional CBT in published work, namely the importance of exposure, the difficulty of controlling natural exposure [26], and the limitations of a person's imagination and cognitive function [27]. VR devices can compensate for some of these shortcomings through their ability to deliver immersive curated experiences that can simulate realistic exposure that may be otherwise challenging, such as simulating public speaking with an audience [28]. Already some of these works utilise and or report on the effectiveness of VR-CBT [25], although a weakness is the lack of distinction between older VR concepts (e.g. 2D virtual environments) compared to modern VR headsets, which may significantly contribute towards levels of immersion. A common sentiment shared amongst literature investigating VR health applications is the limited quality and quantity across published works [29].

These investigations demonstrate the need for further exploration into VR-CBT strategies and solutions and act as a foundation for the prototype focusing on combining virtual interactions with traditional CBT mindfulness approaches.

IV. Methodology

A. Preliminary study

As a part of a preliminary quantitative study, an online survey was conducted with 57 post-graduate university students (50.8% male), ranging in age from 22 to 37, to better understand potential triggers and symptoms of anxiety faced. Among respondents, 45.6% indicated experiencing occasional anxiety, with 22.8% experiencing constant anxiety and 19.3% facing anxiety quite often. The majority of respondents (86%) were postgraduate international students. The 3 leading symptoms of anxiety were reported as excessive worry (65%), feeling overwhelmed (58%), and difficulty focusing (54%). The top 3 triggering factors leading to anxiety symptoms were noted as submission deadlines (65%), academic pressure (60%), and time management issues (58%).

B. Artefact

A VR artefact was developed using Unity, a game development platform that supports the creation of 3D interactive virtual environments, and deployed onto a Meta Quest 2 headset with 2 motion controllers. A 3D animated female avatar portrayed the role of a virtual therapist introduced and named "Doctor Anna" (Fig. 1).

Fig. 1: Doctor Anna's onboarding brief.

A 2D animation, crafted with vector illustrations, subtitles, and narrated by Doctor Anna, was presented before the interaction, demonstrating what CBT is. 3D objects like thought bubbles, panels, and a button, were positioned to suit the user's seated interaction (Fig. 2).

Fig. 2: An animation representing CBT learning.

The text presented within the thought bubbles was essential for comprehending the task, hence it was sized consciously to ensure optimal legibility and comfortable reading.

Fig. 3: The cognitive restructuring task with destructible thoughts.

A 3D gun was created to be interactable, allowing targets to be shot and destroyed (Fig. 3). This gun was scripted (using C#) to be held and fired by the user upon trigger activation. The firing interaction produced necessary auditory feedback upon the triggering and hitting the target, simulating the destruction of negative thoughts.

C. Data collection

This research employed a total of 4 questionnaires to collect data. A Igroup Presence Questionnaire (IPQ) was used to measure the feeling of being present in the virtual world. A Game Experience Questionnaire (GEQ) - Post Game Module was chosen to assess the participants' feelings after the interaction, with 9 questions modified to fit therapeutic terminology. To measure usability, a User Satisfaction Evaluation Questionnaire (USEQ) was employed with updated terminology towards anxiety. Lastly a Cybersickness in Virtual Reality Questionnaire (CSQ-VR) was chosen as it offers better psychometric properties in detecting a temporary decline in performance caused by cybersickness.

D. Participants

The full-scale study involved 30 postgraduate students, comprising 18 males and 12 females, all aged between 21 to 37 years old, recruited from the preliminary study. While reporting proficiency in VR, 2 identified themselves as advanced users, 3 as intermediate, and the remaining 25 as novices. This data was collected to evaluate the ease of use of the interaction for different levels of proficiencies. Similarly proficiency in meditation practice was captured where 4 labelled themselves as advanced practitioners, 5 as intermediate and 21 as novice. This data aimed to analyse the acceptance of VR-based mediation and its effects. Usability testing sessions were conducted within the premises of Birmingham City University.

E. VR-CBT Cognitive Restructuring

The core interaction model was based on one of the fundamental concepts of CBT, known as "Cognitive Restructuring", with its foundation being formulated via consultations with a clinical psychologist. Cognitive restructuring commonly involves consciously interrupting a negative thought or belief, generating fresh alternatives, and transforming the original negative thought or belief into a more rational and constructive perspective [30]. A VR head-mounted display (HMD) platform was chosen due to their ability to deliver enhanced immersive and realistic experiences, showing greater promise for treating anxiety when the user is fully immersed in an environment [19], [31]. The interaction addressed various anxieties experienced by students, including exam anxiety, presentation anxiety, and social anxiety as identified in a study on university anxiety sources [32]. The occurrence of these anxieties was further substantiated by responses from the preliminary study.

The experience gamified the process of cognitive restructuring by presenting students with 10 scenarios, depicting common challenges encountered by students that may potentially evoke anxious thoughts or behaviours. Every scenario was accompanied by 3D thought bubbles representing a number of automatic thoughts based on the common cognitive distortions. The thought bubbles incorporated a blend of negative, positive, neutral thoughts.

The task was to identify the negative or irrational thoughts and eliminate them using a virtual gun attached to the right touch controller. Positive thoughts were supposed to be retained, representing an example of restructured thinking in a given scenario.

After eliminating all potential negative thoughts from each scenario, participants could proceed to the next scenario by hitting the 'next' button. The level of difficulty escalated from 3 to 9 thought bubbles, randomly allocated across 10 scenarios, aiming to mitigate potential response biases arising from a learning effect in the experiment design [33].

The interaction consciously avoided time constraints, ensuring participants sufficient time for reflective thinking. Furthermore, VR-CBT interactions deliberately avoided presenting the user with feedback post-performance, following guidance from the clinical psychologist. This precautionary measure was implemented to prevent the possibilities of causing stress or worry by disclosing sensitive information through the presentation of results. This approach was aligned with the "Primum non nocere" principle, also known as "Do no harm" which advises to exercise a proper degree of scientific caution when designing serious games for mental health [34].

F. Procedure

The study was conducted in a controlled laboratory environment with a duration of 45 minutes. Participants were assisted in wearing the HMD with their inter-pupillary distance calibrated. Participants were primarily engaged in 2 sessions, the first an onboarding tutorial demonstrating the meaning of CBT and following instructions given by a virtual therapist to interact with thought bubbles in a virtual garden using the right touch controller. On average, participants spent 8:43 seconds completing the first task. The second interaction required participants to engage in a 5-minute VR-based motion meditation using Guided Meditation VR, an existing VR meditation application. Both experiences involved sitting and required minimal physical movement. Post-test, they were asked to fill 4 questionnaires and participate in an in-depth user interview.

V. Results

A. Igroup Presence Questionnaire - IPQ

A IPQ questionnaire was utilised to record the sense of presence within our virtual environment.

Category	Mean	Standard Deviation
Involvement	4.11	1.85
Spatial Presence	4.86	1.9
Experienced Realism	3.68	1.64
Sense of being there	5.57	1.1
Overall	4.36	1.86

TABLE I: Results from IPQ

Involvement, the subscale which measures the attention devoted to the virtual environment, showed a slightly positive inclination towards involvement (M = 4.11, SD = 1.85). Data captured for spatial presence implied a sense of being physically present in the virtual world. (M = 4.86, SD = 1.9). Additionally, participants indicated they had a sense of presence in the virtual world (M = 5.57, SD = 1.1) (Table I).

While reporting the experienced realism, scores fell in the mid-range of the scale (M = 3.68, SD = 1.64). Finally, the overall presence score was reported slightly above the mid-point. (M = 4.36, SD = 1.86). This indicated that participants experienced a moderate level of sense of presence.

B. Game Experience Questionnaire (GEQ)

Due to the gamified nature of both the interaction and the medium, a GEQ (Post-game module) was utilised to gain perspectives.

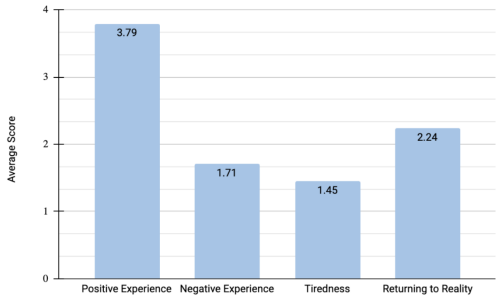

Fig. 4: Results of the Game Experience Questionnaire

The first module, Positive Experience, was given the highest rating (3.79). Returning to Reality was rated second highest (2.24). Negative Experience (1.71) and Tiredness (1.45) had similar results which scored lower (Fig. 4).

C. User Satisfaction Evaluation Questionnaire (USEQ)

A USEQ was utilised to gather participant satisfaction. Following table shows the overall scores given by participants:

QNo.	Type	Questions	Rating
1.	Positive	Did you enjoy your experience with the system?	4.5
2.		Were you successful using the system?	4.63
3.		Were you able to control the system?	4.53
4.		Is the information provided by the system clear?	4.73
5.	Negative	Did you feel discomfort during your experience with the system?	1.97
6.	Positive	Do you think that this system will be helpful to reduce anxiety? (Adapted)	4.3

TABLE II: Results from USEQ

Ratings given for positive questions (1 to 4) that measured attributes such as enjoyment, success, control, clarity of information, effectiveness for reducing anxiety, noted similarity (Average - 4.53). A negative question (5) that measured if participants felt any discomfort during the experience with the system recorded a low score (Average - 1.97). Participant's overall score given for USEQ was 26.73, close to the highest range of 30. This affirmed the higher satisfaction experienced by participants of using the system (Table II).

D. Cyber Sickness in Virtual Reality Questionnaire (CSQ-VR)

A CSQ-VR was utilised to measure cyber sickness, something that is common with VR applications. Symptom intensities were measured from scores provided by participants.

Category	Symptom	Symptom Intensity	Score
Nausea	Nausea (Nausea A)	1.07	2.47
	Dizziness (Nausea B)	1.4	
Vestibular	Disorientation (Vestibular A)	1.27	2.5
	Imbalance (Vestibular B)	1.23	
Oculomotor	Fatigue (Oculomotor A)	1.67	3.57
	Discomfort (Oculomotor B)	1.9	
CSQ-VR Score	**8.54**		

TABLE III: Results from CSQ-VR

The subscores measured for nausea and vestibular reported the low intensity of symptoms (Average - 2.5). The subscore for oculomotor was higher compared to the other 2 (Average - 3.57). The overall score (8.54) reported that participants faced cybersickness with mild intensity (Table III).

VI. Discussions

The data collected from each study highlight several key themes:

A. Immersiveness

All participants reported that the immersiveness of VR enhanced their overall therapeutic experience. However, 4 participants mentioned feeling more immersed during VR-based mediation (using a dedicated visual application) noting their preference towards natural calming environments, such as the beach and forests. 8 participants suggested improving the quality of graphics to achieve higher levels of realism that could enhance overall immersiveness, consistent with "Experienced Realism" reporting (M = 3.68), and may explain its lower scoring comparatively. One of the participant's remark is as follows: P5 - "In an open environment, I felt better compared to concrete walls." 11 participants experienced some amount of discomfort caused by the HMD, limiting their immersion which was also reported in CSQ-VR with mild symptoms of nausea and visually induced discomfort.

B. Onboarding approach

During the onboarding process, 70% (21) of the participants could not form a link between the briefing and the task they were intended to perform, instead relying on self-learning. Onboarding focused on simple language to explain CBT, yet was insufficient in task memorisation. Several factors may have influenced this. 11 participants reported that they found the avatar's gestures a bit repetitive and disengaging, distracting their attention to other elements in the virtual environment. 25 participants self-reported as novices to VR, possibly distracting them during their early adjustment of

experiencing a VR 3D environment. 5 participants reported that, English not being their first language, created a language barrier, making it challenging for them to fully comprehend the initial briefing. From gathered feedback, an improved onboarding approach should prioritise user freedom to explore and absorb VR environments and utilise the interactive nature of VR to train users in onboarding, rather than using one-way narration or instructional animation.

C. Acceptance of VR as self-help tool

22/30 participants showcased a keen interest in using VR as a self-help tool to ease their anxiety. Convenience of use, a preparatory tool to face challenging situations, calming virtual environments, overcoming social anxiety, were the major reasons noted behind this interest. One participant noted: P7 - "I can use it per my convenience. For example, before a big presentation to give, I can have a quick relaxation and go to that task." The remaining 8 participants showed a lower level of acceptance, along with some concerning factors including fear of addiction to VR and cybersickness.

D. Learning tool

6 participants commented that the prototype was powerful as a learning tool towards CBT, noting the strength of gamified elements increasing engagement. This coincides learning-by-doing methods commonly observed in serious games, focusing on hands-on experiences [35]. The proposed tool's suitability for education was not initially hypothesised, yet is noteworthy as participants suggested they did not fully understand CBT until concepts were interactive and visualised.

E. Cognitive Restructuring

The core objective of the cognitive restructuring session was to guide participants to restructure the negative thoughts. Participants reported that the cognitive restructuring session was highly engaging and effective in addressing negative or anxious thoughts. Interacting with a gun to destroy thoughts was overall reported as an easy, empowering, and fun experience. P17 commented: "It was fun. I like how you shoot the negative thoughts down literally." The prototype covered commonly faced scenarios by students that can trigger anxiety, although 2 participants could not relate with certain thoughts displayed, citing irrelevance. This commonly faced issues approach did generate a 'sense of empathy' towards reflections and others, as commented by participants. One participant remarked: P15 - "It was good. It gave me a perspective, like a new way of thinking of people or situations, coping with things.". 2 participants conveyed that automatic thoughts containing the word "should" felt motivating rather than pressuring. Overall feedback affirmed that this experience gave them various perspectives about dealing with negative thoughts.

F. VR-based meditation

Responses suggested that participants felt calm and refreshed after VR meditation. Immersion was assisted with natural surroundings and subtle music. The overall meditation was described with adjectives such as "interesting", "engaging", and "peaceful". Participants commented preferring VR-based meditation due to its ability to transport the user from the comfort of their homes without additional costs. However, the concept of integrating motion into meditation did not meet the expectations of 3 participants. This caused them some level of discomfort, leading to lack of focus which is fundamental to meditation practice. Further study is required to compare the advantages and drawbacks of both still and motion meditation to propose the ideal approach for VR-based mediation.

G. Conventional vs. VR-based therapy

Participants' gave mixed responses between conventional and VR-based therapy. 4 participants with prior experience in traditional therapy expressed a preference for VR-based therapy. A concern associated with traditional therapy settings is articulating problems or channelling your thoughts to a therapist, and experiencing mental zoning due to a lack of a clear discussion point. In contrast VR was perceived as helpful in addressing this issue. Another concern was related to trust and insecurity in traditional therapy. While it allows for venting and receiving feedback, it can create fear of information leakage. Therefore VR-based therapy was a preferred choice as it presents a judgement-free space for expressing freely. 6 participants showcased a strong preference for conventional therapy as it is perceived as deep, personalised, and natural, involving human presence and inputs. 20 participants saw VR-based therapy as more helpful to gain convenience and facilitate communication over traditional therapy.

VII. Conclusion & recommendations

This research contributes a novel application and further foundation into VR-CBT strategies towards a broader spectrum of psychotherapy applications. The prototype was effective as a tool that helped manage thoughts, educate users on CBT practices, and assist on dealing with irrational thoughts. Participants who expressed hesitation in opting to choose traditional therapy showcased a positive inclination towards VR-based therapy. These findings provide further justifications towards VR alternatives, particularly for universities, where mental health solutions are of crucial importance. VR can be considered as an initial or complementary tool during the preliminary phases before access to a professional is available. Overall participants demonstrated a notable acceptance of utilising VR-CBT as a self-guided tool to reduce anxiety.

The feedback and data collected also serves as recommendations for future works, informing researchers and designers on best practices surrounding VR-CBT anxiety solutions. Emulating natural calming environments, such as a forest/beach, is effective towards maintaining relaxation. VR has the potential to elucidate the concepts of therapy with its interactive nature hence learning with interaction can be leveraged. A human-like avatar was desired mimicking real-world therapists but only if their realism matches natural expectations. Gamification can be further enhanced through personalisation and additional haptic feedback for increased

immersion. Cognitive restructuring could be customised to cater specific student groups such as domestic along with developing anxiety-specific scenarios, such as social anxiety to achieve specific outcomes. The complexity and duration of tasks, legibility of the content, appropriate placement of 3D objects within the user's field of view, avoidance choice overload, and minimal body movements, are important for success. If a specific therapy necessitates revealing of feedback, the structure, information and delivery format of feedback should only be determined after an expert's consultation. A limitation of this tool is the lack of a longitudinal analysis, prompting further investigation into its effectiveness following more traditional CBT study expectations.

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