A Mixed-Methods Experimental Study of a Virtual Reality-Based Cognitive Defusion Application for Youth Depression and Anxiety

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Imogen Bell[1, 2]; Cassandra Li[1, 2]; Andrew Thompson[1, 2, 3]; Carli Ellinghaus[1, 2]; Shaunagh O'Sullivan[1, 2]; Kate Alexandra Reynolds[1, 2]; Greg Wadley[4]; Yang Liu[1]; Sarah Bendall[1, 2]; John Gleeson[5]; Lucia Valmaggia[1, 2]; Mario Alvarez-Jimenez[1, 2]

[1] Orygen Parkville AU
[2] Centre for Youth Mental Health The University of Melbourne Parkville AU
[3] Division of Mental Health and Wellbeing University of Warwick Warwick GB
[4] School of Computing and Information Systems The University of Melbourne Melbourne AU
[5] Healthy Brain and Mind Research Centre and School of Behavioural and Health Sciences Australian Catholic University Melbourne AU

Corresponding Author:
Imogen Bell

Orygen
35 Poplar Road
Parkville
AU

Abstract

Background: Third-wave psychological treatments, such as Acceptance and Commitment Therapy (ACT), can be effective for improving depression and anxiety in youth. However, third-wave therapeutic techniques such as cognitive defusion can be abstract, challenging to learn, and difficult to apply in real-world settings. Translating these techniques into virtual reality (VR) may provide interactive, enjoyable, and concrete learning opportunities, potentially enhancing engagement and effectiveness. This study evaluated a novel VR application ('app') that translates the technique of cognitive defusion into a brief, gamified VR experience.

Objective: The objectives of this study were to evaluate the feasibility, acceptability, usability, and safety of the VR cognitive defusion app, examine whether it could improve negative thinking and mood states, and understand how it compared to a non-VR cognitive defusion exercise.

Methods: In a mixed methods experimental study, 20 young people completed both a VR and audio cognitive defusion exercise in randomized order within a single session. Quantitative state-based measures were taken before and after each exercise, and a qualitative interview at the end focused on how the two experiences compared.

Results: It was feasible to recruit participants, and all participants completed both exercises and assessments. Both the VR and audio exercise were acceptable to participants, with qualitative themes highlighting a preference for VR due to the novel and engaging format, however there was a need for better guidance and more personalized environments. No severe adverse events were reported, though one participant experienced distress during the VR exercise. Pre-post effects showed improvements in thought discomfort, cognitive defusion, and state anger for both the VR and audio conditions, with the latter showing broader improvements, including thought negativity, rumination, tension, depression, anger, and confusion.

Conclusions: The VR cognitive defusion app was feasible, safe and acceptable for young people, with potential to enhance mental health treatment through an engaging and enjoyable approach to learning third-wave CBT techniques. While VR was preferred by participants, further refinements could improve effectiveness. Future research should focus on enhancing the VR app design based on user feedback, incorporating audio guidance, and conducting a larger trial in real-world settings to thoroughly evaluate its effectiveness and implementation.

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Original Paper

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Imogen H Bell1,2*, Cassandra Li1,2, Andrew Thompson1,2,3, Carli Ellinghaus1,2, Shaunagh O'Sullivan1,2, Kate A. Reynolds1,2, Greg Wadley4, Yang Liu1, Sarah Bendall1,2, John Gleeson5, Lucia Valmaggia1,2, Mario Alvarez-Jimenez1,2

1Orygen, Parkville, VIC, Australia
2Centre for Youth Mental Health, The University of Melbourne, Parkville, VIC, Australia
3Division of Mental Health and Wellbeing, University of Warwick, UK
4School of Computing and Information Systems, The University of Melbourne, Melbourne, VIC, Australia
5Healthy Brain and Mind Research Centre and School of Behavioural and Health Sciences, Australian Catholic University, Melbourne, Victoria, Australia

*Corresponding author. Address: 35 Poplar Rd, Parkville, VIC, Australia 3052
Telephone: + +61 3 99669177, Email: imogen.bell@orygen.org.au

Abstract

Background: Third-wave psychological treatments, such as Acceptance and Commitment Therapy (ACT), can be effective for improving depression and anxiety in youth. However, third-wave therapeutic techniques such as cognitive defusion can be abstract, challenging to learn, and difficult to apply in real-world settings. Translating these techniques into virtual reality (VR) may provide interactive, enjoyable, and concrete learning opportunities, potentially enhancing engagement and

effectiveness. This study evaluated a novel VR application ('app') that translates the technique of cognitive defusion into a brief, gamified VR experience.
Objective: The objectives of this study were to evaluate the feasibility, acceptability, usability, and safety of the VR cognitive defusion app, examine whether it could improve negative thinking and mood states, and understand how it compared to a non-VR cognitive defusion exercise.
Methods: In a mixed methods experimental study, 20 young people completed both a VR and audio cognitive defusion exercise in randomized order within a single session. Quantitative state-based measures were taken before and after each exercise, and a qualitative interview at the end focused on how the two experiences compared.
Results: It was feasible to recruit participants, and all participants completed both exercises and assessments. Both the VR and audio exercise were acceptable to participants, with qualitative themes highlighting a preference for VR due to the novel and engaging format, however there was a need for better guidance and more personalized environments. No severe adverse events were reported, though one participant experienced distress during the VR exercise. Pre-post effects showed improvements in thought discomfort, cognitive defusion, and state anger for both the VR and audio conditions ($P < .05$), with the latter showing broader improvements, including thought negativity, rumination, tension, depression, distress, and confusion ($P < .05$).
Conclusions: The VR cognitive defusion app was feasible, safe and acceptable for young people, with potential to enhance mental health treatment through an engaging and enjoyable approach to learning third-wave CBT techniques. While VR was preferred by participants, further refinements could improve effectiveness. Future research should focus on enhancing the VR app design based on user feedback, incorporating audio guidance, and conducting a larger trial in real-world settings to thoroughly evaluate its effectiveness and implementation.

Keywords: Virtual reality, depression, anxiety, third wave psychological treatment, mindfulness, cognitive defusion, youth mental health

Introduction

Virtual reality (VR) is an emerging technology with the potential to transform mental health treatment [1,2,3]. VR immerses users in a virtual environment through a headset, allowing real-time interaction with virtual objects via hand controllers or motion sensors. The ability to tailor and control experiences within VR offers a unique opportunity to enhance mental health interventions by delivering treatments in personalized, simulated real-world environments that provide strong ecological validity [2]. While meta-analyses have supported the efficacy of VR treatments for various mental disorders in adults [2,4], its application in youth mental health remains critically underexplored [5,6].

Seventy-five percent of mental disorders emerge before the age of 25 [7,8], representing a critical time for early intervention [9]. Anxiety and depression are the most prevalent disorders amongst youth, with one in four young people meeting diagnostic criteria [10]. Despite high rates of mental ill-health amongst young people, current treatments remain limited, with small treatment effect sizes, poor engagement, and high relapse [11, 12, 13]. VR offers innovative solutions to these challenges by providing a potentially engaging, effective, and accessible vehicle for treatment [1]. Young people widely use digital technologies in their day-to-day lives and have shown interest in VR for mental health support [14]. With consumer adoption of VR technology predicted to rise over the coming years [15], it is timely to expand the existing evidence base and explore the therapeutic potential of this technology for young people with mental ill-health.

The past decade has seen a rapid increase in the number of studies exploring the use of VR for the treatment of mental disorders [2, 16]. The majority of this research has focused on VR-based cognitive behavioral treatments (VR-CBT)[16]. VR-CBT typically involves exposure to anxiety-inducing stimuli in virtual environments, guided by a clinician (e.g., Pot-Kolder et al [17]). Randomized controlled trials (RCTs) have provided robust evidence supporting the efficacy of VR-CBT in improving outcomes in anxiety disorders, psychosis, eating disorders, and trauma-related conditions in adults (see Bell et al., 2024 for review)[2]. However, relatively limited research has explored the potential therapeutic applications of VR beyond exposure-based CBT approaches and research in youth is highly limited [2,5,6,16].

Third-wave psychological treatments, such as acceptance and commitment therapy (ACT), dialectical behavioral therapy (DBT), and mindfulness-based cognitive therapy (MBCT) [18], may be particularly well-suited to VR. While second-wave CBT focuses on modifying maladaptive thoughts which drive problematic behaviors, third-wave approaches focus on adapting the relationship between the individual and their mental processes, as well as targeting broader values and life goals [18]. Third-wave approaches typically employ experiential techniques to shift the dynamic between the individual and their mental experiences to foster more adaptive and flexible ways of responding to them. For example, cognitive defusion, a core technique within ACT [19-21], aims to help individuals separate themselves or ‘defuse’ from distressing thoughts and emotions, often using experiential and conceptual techniques such as metaphors and visualization. In the context of psychological treatment, cognitive defusion exercises typically involve a therapist guiding individuals to imagine negative thoughts in ways that are incongruent with their existing emotional relations with them (for example, singing the negative thought to the tune of "Happy Birthday"). By viewing and relating to these thoughts in non-literal and often paradoxical ways, individuals can shift the negative associations they have with these thoughts and ‘defuse’ or ‘decenter’ from them, viewing them as fleeting and non-threatening, rather than literal facts. The process of decentering has been highlighted as a core ‘active ingredient’ underpinning effective interventions for youth depression and anxiety [22,23], particularly in fostering objective and flexible ways of responding to negative thoughts and emotions.

Third-wave psychological treatments have demonstrated effectiveness in improving depression and anxiety in youth and adults [24-26]. However, while core techniques such as cognitive defusion can be highly effective for some individuals [19, 21,27], young people can find it challenging to conceptualize their internal experiences in abstract ways, limiting the effectiveness of the technique and engagement with treatment [28]. Recognizing this, Halliburton and Cooper [28] emphasize the importance of adapting ACT for the developmental needs of adolescent populations. To accommodate emerging cognitive development in adolescence, the authors recommend that techniques be brief, simple and concrete, highly interactive, and experiential. The use of creative tools and activities can also promote engagement. VR technology is highly suited to supporting these adaptations by transforming the way these techniques are taught and learned. Immersive environments enable individuals to directly observe and interact with their mental processes through virtual representations, bypassing the need for abstract thinking and visualization. This approach facilitates skill mastery through playful, low-risk encounters, and may boost the positive effects of techniques like cognitive defusion by translating them from abstract and conceptual into something more literal and concrete. Furthermore, by learning and practicing these skills within personally relevant virtual environments, young people may be more likely to apply these skills in everyday life. Harnessing gamification in VR environments to create a more motivating, fun, and low-risk learning experience could also enhance the goal of these techniques to change the nature of the relationship between the individual and their thoughts, while also addressing barriers to treatment engagement. When used as a blended tool [29], clinicians could use VR within sessions to guide young people to learn and practice third-wave skills in safe and controlled VR environments to facilitate their translation into real-world settings. Additionally, young people could use the intervention independently to manage and cope with mental health challenges as they arise. Such brief, flexible and engaging VR-based therapeutic tools have the potential to enhance engagement and treatment efficacy as well as increase access to on-demand support in daily life.

A study by Prudenzi et al. [30] investigated a VR-based cognitive defusion task in a non-clinical sample of young adults and found that the task reduced the believability and discomfort associated with negative thoughts. A small number of studies have also examined the use of VR for related techniques such as mindfulness [31-34], with preliminary evidence for positive outcomes. However, this research is at the very early stage with predominantly single case studies and typically involves populations of adults without a mental health condition. Further, while many claim that VR has advantages over and above standard face-to-face therapeutic approaches, limited research has been conducted to test this empirically. This research is critically needed to provide a strong foundation for ongoing development of VR-based interventions in youth mental health.

Study aims

To investigate the potential of VR for supporting third wave treatment of youth depression and anxiety, a prototype application ('app') was developed which translated the technique of cognitive defusion (the primary target mechanism) into a personalised, immersive, gamified VR experience. The aims of this mixed methods experimental study were to:

1. Evaluate the feasibility, acceptability, usability and safety of the VR cognitive defusion app;
2. Explore whether the VR cognitive defusion app could reduce negative thinking and improve mood states; and
3. Gather feedback from young people about how the VR cognitive defusion app experience compared to a non-VR audio guided cognitive defusion exercise.

Methods

Study Design

The study design was a cross-over, repeated-measures, mixed methods experimental study. This involved all participants being exposed to two forms of cognitive defusion exercises sequentially and in randomized order: one through a VR app and the other via a traditional audio exercise. Exposing all participants to both exercises in randomized order enabled examination of how the two compared.

Participants

Participants (N = 20) included young people who were recruited via *headspace* services across Metropolitan Melbourne. *headspace* is a nation-wide organisation delivering mental health treatment for youth aged 12-25 across Australia. Current and previous clients of four *headspace* centres in the metropolitan region of Northwest Melbourne were approached for the study. The sample size was deemed appropriate to meet the primary aim of assessing the acceptability, usability, and safety of the VR intervention, as well as exploring whether there were preliminary effects on state-based outcomes [58]. Informed consent was obtained from participants prior to their commencement, with additional parent/guardian consent obtained for participants below the age of 18. Participants were eligible to participate if the following inclusion criteria were met:

1. Between the ages of 16 – 25 years
2. Normal or corrected-to-normal vision and hearing
3. Experiencing clinical levels of depression and/or anxiety (score of 10 or more on PHQ-8 [35] or GAD-7 [36])
4. Experiencing high levels of repetitive negative thinking (RNT; score of 15 or more on the Brief PSWQ or 9 or more on the Brief RRS [37])
5. Sufficient command of the English language

Exclusion criteria were:

1. Unable to give informed consent
2. History of photosensitive epilepsy or previous experience of severe simulator sickness
3. Psychiatric inpatient or under the care of a mental health crisis team

Procedure

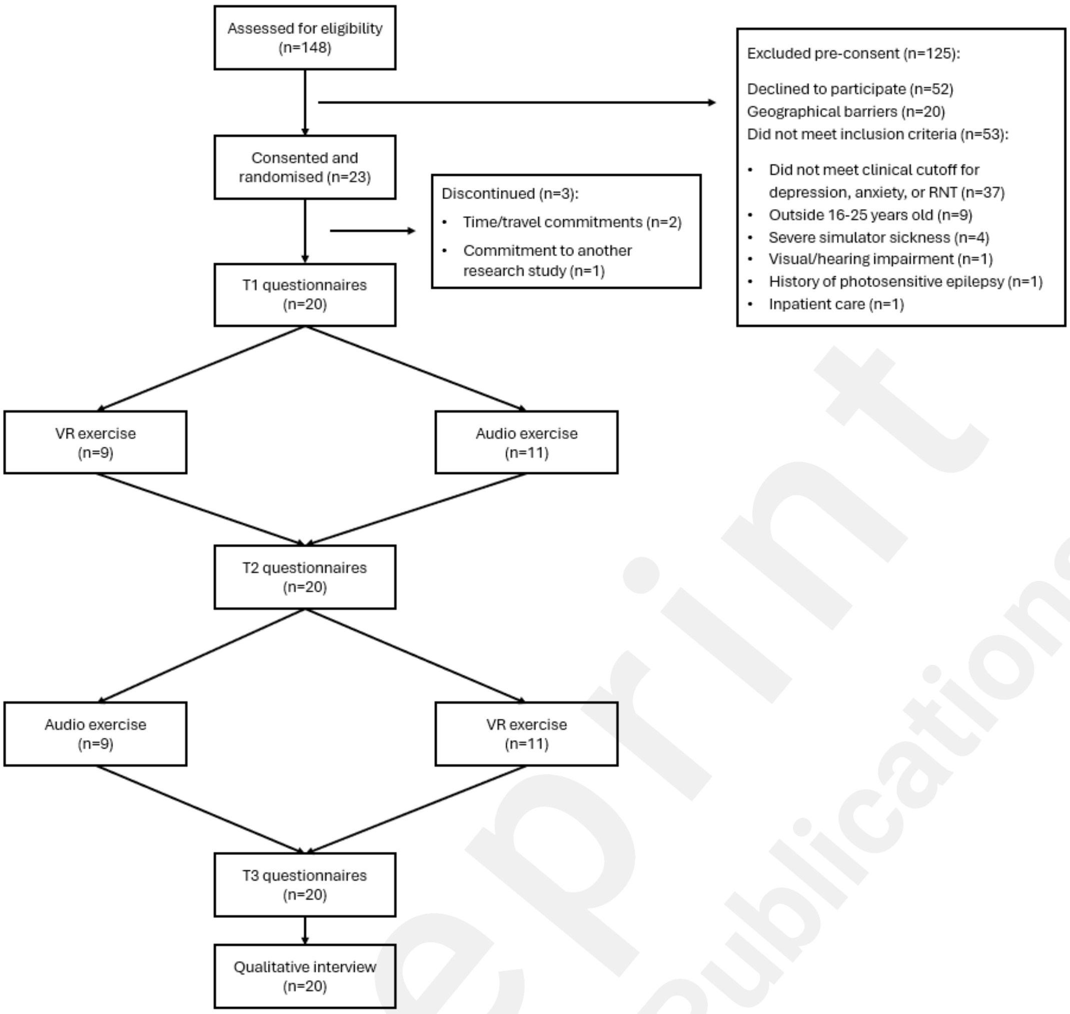
Participants were screened for eligibility over the phone, with those eligible then booked for the in-person consent and testing session. This 90-minute session involved informed consent and a baseline assessment, followed by the experimental procedure.

The experimental procedure involved being allocated to complete one of two possible intervention sequences via simple randomization: (1) VR defusion exercise followed by audio defusion exercise, or (2) audio defusion exercise followed by VR. Both exercises were matched for duration and took approximately 10 minutes each to complete. The session was conducted in a private clinical space with a researcher.

Pre-post assessments. Participants completed measures at baseline (T1), after they completed either the VR or audio first (T2) and again following their completion of the alternate exercise, VR or audio (T3). Following T3 questionnaires, participants completed a brief qualitative feedback interview of their experience with a research assistant, which lasted an average of 8 minutes (range 4-26 min).

Explanation of cognitive defusion. Regardless of which order the exercises were completed, participants were provided with a short explanation of cognitive defusion and how it can help people disconnect from their distressing thoughts prior to completing the first exercise (adapted from an ACT manual [38,39]). This was delivered by the researcher using a script (see supplementary materials).

Rumination induction. Following the protocol of Masuda et al. [21], prior to each exercise, a brief rumination induction procedure took place in which participants were prompted to choose and reflect on a negative thought that had been distressing them recently and keep this in mind during the exercises. This procedure was embedded within the Negative Thought Assessment [40-42] described under the Measures section.



Conditions

Two experimental conditions were designed for this study: the VR exercise and an audio exercise.

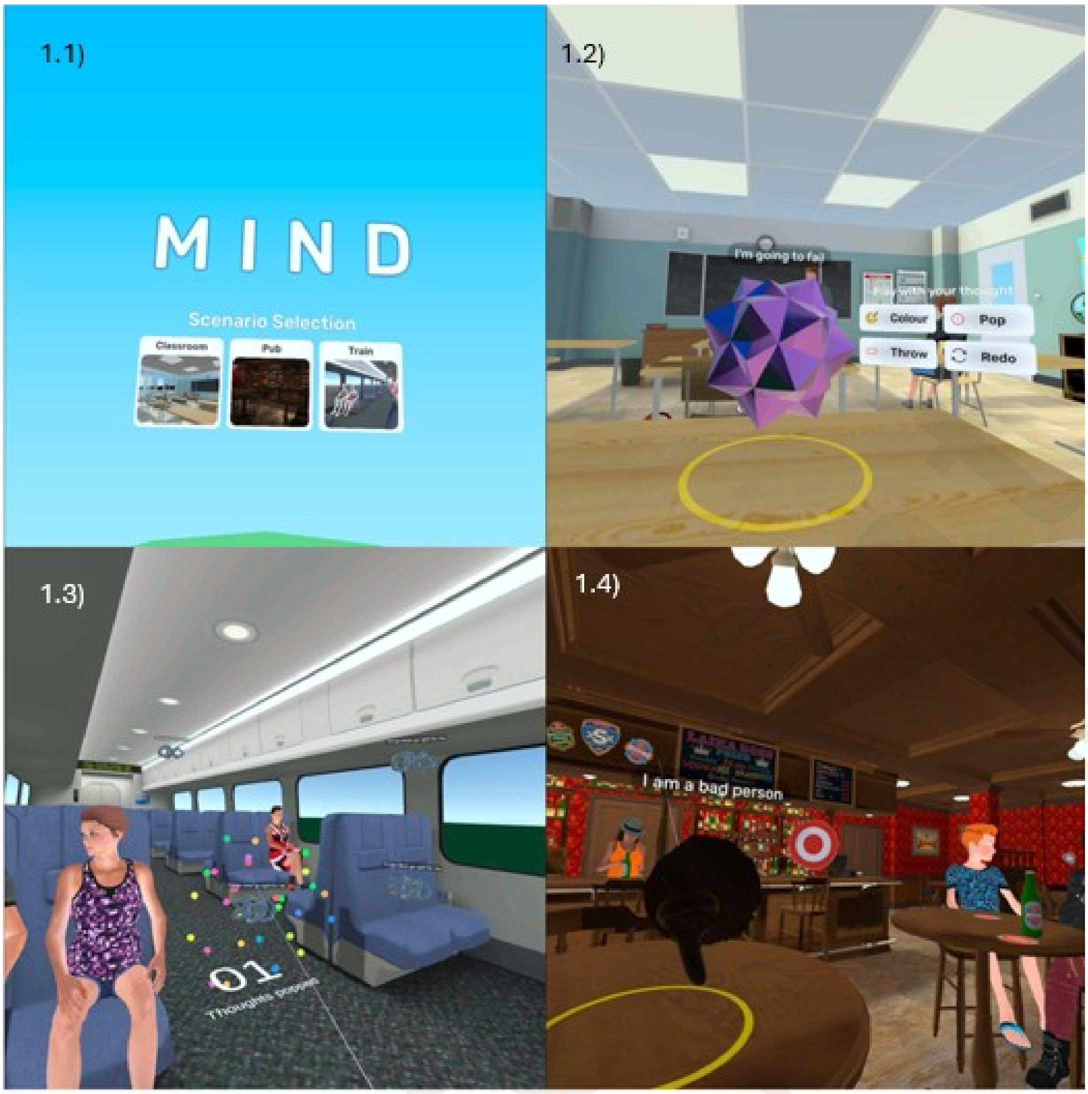
Both experimental conditions were designed to guide users through two different forms of cognitive defusion, as described in the introduction. The two conditions were informed by practices commonly used in Acceptance and Commitment Therapy (ACT); the approach from which defusion was developed [38,39].

VR condition

The VR app which was pre-loaded onto an Oculus Quest 2 VR headset for the purpose of this study. The research assistant conducting the session invited participants to wear the VR headset and explained how to use the hand controllers. Participants were informed at the start that they could stop the exercise at any time if they became distressed or uncomfortable. They were encouraged to complete the exercise from a standing position to allow for range of movement, but an option for completing the exercise in a seated position was also available. Prior to beginning the exercise, a verbal check of visual and audio clarity was conducted by the researcher.

When participants launched the VR app, they were presented with a menu screen showing three different environments to choose from: a classroom, a pub, and a train (see Figure 1.1). These environments were designed based on user consultations with young people with lived experience of mental health difficulties and clinicians which highlighted these as common environments where negative thoughts were experienced. Participants were encouraged to choose the environment in which they felt their negative thoughts were most likely to occur. When each participant entered the environment, they were faced with an animated object and instructed to imagine this as representing the thought they had been struggling with. They were then guided to use a keyboard to customize the thought by typing it in using a virtual keyboard presented to them within the scene, or selecting from pre-filled thought prompts (e.g., “I’m going to fail”, “I am being judged”, “I am a bad person”). The thought was then represented in the environment as text above the animated object (see Figure 1.2). Participants were then instructed to interact with their chosen thought and manipulate this in different ways using the hand controllers. These options included customising its shape and colour, picking it up and moving it around in the environment, and making the thought float upwards above them. Amongst the options were also two games that they could play with the thought object: 1) ‘popping’ the thought objects as they appear around them to receive points (see Figure 1.3), or 2) throwing the thought at targets which appear in the environment to receive points (see Figure 1.4).

Throughout the exercise, participants were guided by the researcher. The researcher followed a verbal script (see supplementary materials) supporting the participant to explore their negative thought in a visual form with curiosity and acceptance. The verbal script mirrored the audio defusion script with slight variations to accommodate the VR experience. The full experience lasted for 10 minutes. Once the exercise was finished, participants were prompted to remove the VR headset.


1.1)
MIND
Scenario Selection
Classroom
Pub
Train
1.2)
I'm going to fail
Colour
Pop
Throw
Redo
1.3)
01
Thoughts popped
1.4)
I am a bad person

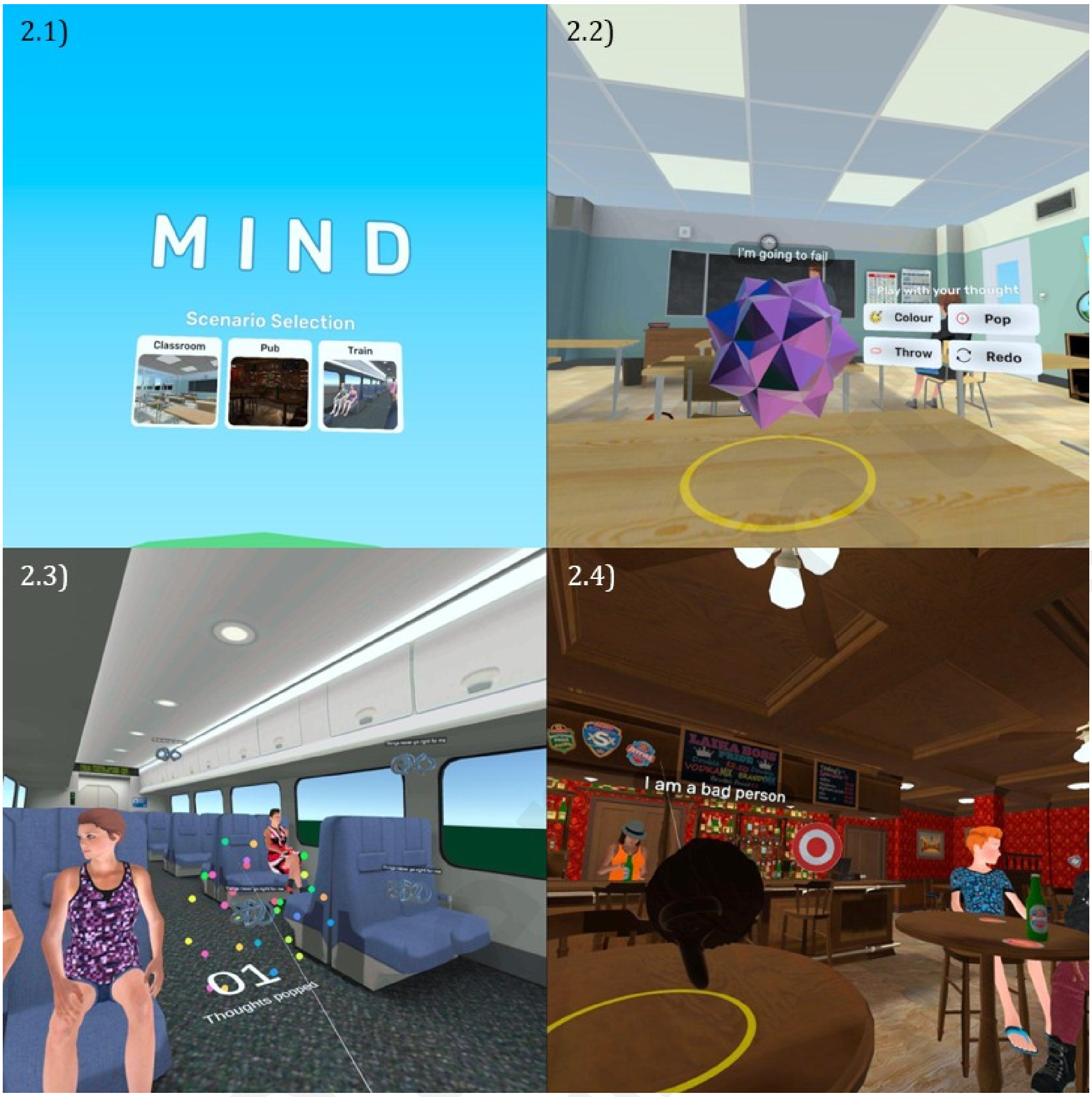


Figure 1. Scenes from the VR cognitive defusion app

Audio condition

The audio condition was designed to use the same defusion principles and identical instructions, but in a non-VR format using the participant's imagination. In a traditional psychological treatment setting, clinicians would typically guide the individual through the exercise following a verbal script spoken aloud in-session. For the purposes of this study, a standard pre-recorded guided audio exercise was used (see supplementary materials for script). In the exercise, the participant was guided by a single voice without any background noise or effects. The voice instructed the listener to identify a target negative thought and think about it in different ways, such as imagining their thought as having different colors, shapes, forms and contexts. These interactions were designed to match those of the VR exercise in that individuals were guided to think of environments where they were likely to experience negative thoughts and then instructed to visualize interacting with them in the same ways using their imagination. Participants listened to the audio exercise via headphones through an iPad device, remaining in a seated position, with the researcher remaining in the room to monitor for any signs of distress. The length of the audio exercise was 10 minutes to match the VR exercise.

Measures

The protocol for the current study was developed in collaboration with young people with lived experience of a mental health condition. Questionnaire completion at each timepoint took approximately 10 minutes, and no participants reported discomfort, fatigue or disengagement.

Demographics and Technology Use

Basic demographic information was collected, including age, gender, country of birth, Aboriginal and/or Torres Strait Islander origin, language(s) spoken at home, current living situation, and which *headspace* service they were a client of.

Questionnaires were used to collect experiences with technology use, including whether they owned a smartphone, laptop and/or desktop, and how many hours per day they use each owned device. Participants were asked about the ways they had sought or engaged with health support in the past (e.g., email, phone, online information, etc.). Previous experience with VR use was also collected. Those who reported previous use were prompted to complete additional items addressing the frequency of use (9-point scale ranging from '*Very rarely*' to '*Several times an hour*'), how comfortable they felt using VR (5-point scale ranging from '*Very uncomfortable*' to '*Very comfortable*'), as well as indicating whether they have used VR for therapeutic reasons (e.g., mindfulness, relaxation, exposure).

These measures were completed at baseline (T1).

Feasibility, acceptability, usability and safety

Feasibility: Measured via recruitment and retention rates, as well as completion of study assessments and procedures.

Acceptability and usability: A 14-item user experience questionnaire designed specifically for this study was used to evaluate and compare the usability and acceptability of both the VR and audio conditions. The questionnaire was designed to assess different aspects of the participant's experiences with the exercises. Respondents answer statements (e.g., "I found the experience enjoyable") by rating their experience on a 5-point Likert scale ranging from 1 ('*strongly disagree*') to 5 ('*strongly agree*'), with higher scores indicating better user experience and acceptability. This measure was completed after each defusion exercise (T2 and T3).

ITC-Sense of Presence Inventory (ITC-SOPO [43]): A 44-item scale measuring sense of presence within a virtual environment. The measure captures the degree to which the user feels physically present in the virtual environment, the level of engagement, and negative effects (e.g., motion sickness, eye strain). Respondents answer statements (e.g., "I felt sad that my experience was over") using a 5-point Likert scale ranging from 1 ('strongly disagree') to 5 ('strongly agree'), with higher scores indicating greater user experience and acceptability. The ITC-SOPO has been validated in adult populations and is commonly used within VR research [43]. This measure was completed following the VR condition only (T2 or T3, depending on the exercise order).

Safety: Safety was measured by monitoring potential adverse events during both exercises, responses to the negative effects questions within the user experience questionnaire and ITC-SOPO [43], and via questions within a qualitative interview described later in this section.

Clinical measures

Participant baseline characteristics were assessed using the following measures:

Patient Health Questionnaire – 8 item (PHQ-8 [35]): An 8-item scale commonly used to screen for depressive disorders. Respondents indicate the frequency of depressive symptoms experienced over the past two weeks on a 4-point Likert scale ranging from 0 ('not at all') to 3 ('nearly every day'), where higher scores indicate greater severity of depression. Scores are summed, with scores ≥ 10 indicating moderate to severe depressive symptoms. The PHQ-8 has demonstrated good reliability and validity with adolescent populations [44].

Generalised Anxiety Disorder Assessment (GAD-7[36]): A 7-item scale commonly used as a screener for anxiety disorders. Respondents indicate the frequency of symptoms of anxiety over the past two weeks on a 4-point Likert scale from 0 ('not at all') to 3 ('nearly every day'), where higher scores indicate greater severity of anxiety. Scores are summed, with scores ≥ 10 indicating moderate to severe levels of anxiety. The GAD-7 has good reliability and construct validity with adolescent populations [36].

Brief Penn State Worry Questionnaire (Brief PSWQ [37]): A 5-item scale measuring tendencies towards worry. Respondents rate statements (e.g., "Many situations make me worry") on a 5-point Likert scale from 1 ('not typical of me') to 5 ('very typical of me'), with higher scores indicative of greater trait worry. The scale has been validated in an adult population with good reliability and validity [37].

Brief Ruminative Response Scale (Brief RRS [37]): A 5-item scale measuring tendencies towards rumination. Respondents are asked to indicate how often they ruminate when they feel down, sad, or depressed. They indicate their response using a 4-point Likert scale ranging from 1 ('almost never') to 4 ('almost always'), with higher scores equating to higher degrees of ruminative symptoms. The measure has shown good reliability and validity [37].

Repetitive Thinking Questionnaire – 10 (RTQ-10 [45]): A 10-item scale used to measure tendencies towards repetitive negative thinking (RNT; a trait capturing the process of rumination and worry). Respondents rate statements capturing their tendency to engage in repetitive thinking when they feel distressed or upset using a 5-point Likert scale ranging from 1 ('not at all') to 5 ('very true'), with higher scores reflecting greater tendencies for RNT. The RTQ-10 has demonstrated robust internal consistency, convergent, and divergent validity [45].

These measures were completed at baseline (T1).

Therapeutic process measures

Negative Thought Assessment (NTA; [40-42]): This scale was completed as part of the rumination induction procedure to elicit rumination and capture state-based responses to this experience. The NTA has been used in prior experimental studies to elicit rumination and measure the immediate effects of cognitive defusion exercises [40-42]. The measure prompts respondents to generate and reflect on a particular negative thought that they identify as upsetting, find hard to stop thinking about, or that bothers them a lot. Respondents then rate the degree of discomfort (I.e., "How uncomfortable is the thought"), believability (I.e., "How accurate or true do you think the thought is?"), and the perceived importance of the thought ("How important is it to you not to have this thought?"). One additional item used in Prudenzi et al. [42] was added to measure the degree of negativity of the thought ("How negative is the thought?"). All items are rated on a 10-point visual analogue scale ranging from 0 ('not at all uncomfortable/accurate or true/important/negative) to 10 (very uncomfortable/accurate or true/important/negative). This measure was completed at baseline (T1) and following the first exercise (T2).

State Toronto Mindfulness Scale (TMS [46]): A 13-item scale measuring state mindfulness. Items are presented as statements referring to two constructs, decentering and curiosity, which are each scored as subscales. Decentering refers to psychological distance from thoughts, and curiosity refers to appreciation of thoughts with an accepting and curious attitude. Responses are scored on a 5-point Likert scale ranging from 0 ('not at all') to 4 ('very much'), with higher scores indicating greater state mindfulness. The scale has demonstrated good reliability and validity, with good sensitivity to change over time [47]. This measure was completed following the first exercise (T2).

State Cognitive Defusion Questionnaire (SCDQ [48]): A 7-item scale measuring states of cognitive defusion. Items include statements referring to the experience of struggling or being entangled with distressing thoughts in the present moment. Respondents indicate their response on a 7-point Likert scale from 1 ('not at all true') to 7 ('completely true'), with higher scores indicating greater levels of defusion. The SCFQ has demonstrated good internal consistency and construct validity in student samples [48]. This measure was completed at baseline (T1) and following the first exercise (T2).

Brief State Rumination Inventory (BSRI [49]): An 8-item scale measuring state depressive rumination. Respondents indicate the extent to which each statement describes their feelings and thoughts in the immediate moment (e.g., "Right now, I wonder why I react the way I do") on a 100-point visual analogue scale ranging from 0 ('completely disagree') to 100 ('completely agree'), where higher scores indicate greater state rumination. The scale has demonstrated good reliability and validity. This measure was completed at baseline (T1) and following the first exercise (T2).

Mood state measures

Profile of Mood States – Adolescent version (POMS-A [50]): A 24-item scale where respondents indicate how they feel in the moment across different mood items (e.g., sleepy, energetic, confused, etc.), using a 5-point Likert scale ranging from 1 ('not at all') to 5 ('extremely'). Higher scores indicate greater overall mood disturbance. The scale has demonstrated good reliability and criterion validity in the assessment of mood in adolescent populations [50,51]. This measure was completed at baseline (T1) and following the first exercise (T2).

Subjective Units of Distress Scale (SUDS [52]): A 1-item scale where respondents are asked to rate the level of anxiety that they are currently experiencing using a slider scale, with scores ranging from 0 ('no anxiety, calm') to 100 ('very severe anxiety, worst ever experienced'). The scale is commonly used to measure states of distress during therapeutic exercises, with a higher score indicating greater state distress. This measure was completed at baseline (T1) and following the first exercise (T2).

Qualitative interview

A brief semi-structured qualitative interview was conducted by the research assistant at the end of the experimental study which enquired about the following:

1. What was your experience of the VR exercise?
2. How did the VR experience compare to the audio exercise?
3. Which did you prefer out of the VR experience and audio exercise, and why?
4. Imagine the VR exercise was taught to you in therapy by a psychologist:
   a. Do you think there would be any benefits to using the VR exercise over the audio exercise? Can you explain your answer?
   b. Do you think there would be any downsides to using the VR exercise over the audio exercise? Can you explain your answer?
5. Would you recommend the VR experience to other young people with difficult thoughts, and why or why not?
6. Is there anything you would change about the VR experience to make it better?

Analysis

Quantitative data

Descriptive statistics were used to report the feasibility, acceptability, usability and safety of the VR and audio conditions. Independent t-tests and chi-square tests were conducted to test for differences between groups on baseline demographic and clinical characteristics. Repeated measures t-tests and within-group effect sizes (Cohen's *d*) were reported for changes in pre- to post-exercise scores on state-based measures for VR and audio groups. Only T1-T2 scores on state-based measures within groups were compared (i.e. pre-post changes before and after VR or audio exercises, depending on the order) to avoid carry-over effects into the second exercise. The primary measure of interest was the within group effect size and associated confidence intervals.. The sample size was not powered to detect statistically significant differences between conditions but instead was selected to provide sufficient data to evaluate feasibility and inform understanding of whether the approach could engage target mechanisms and influence mood states as a proof-of-concept. This is a critical step in intervention development and validation, particularly in emerging areas such as VR-based therapy and our study design reflects recommendations for pilot trials with small sample sizes [58].

Qualitative data

Qualitative data collected from interviews with participants were analysed using reflexive thematic analysis, guided by Braun and Clarke's approach [59, 60]. This method was chosen for its flexibility and suitability in exploring participants' subjective experiences. Two researchers (IHB and CL) independently read and coded an initial subset of four transcripts to familiarise themselves with the data and inductively generate initial codes. They then met to discuss their interpretations, reflexively exploring their assumptions and positionalities, and developed a shared, flexible coding framework. The remaining transcripts (n=16) were coded using this framework, with regular discussions to review coding decisions.

Themes were developed through an iterative process of data engagement, coding, and theme refinement, following the principles of reflexive thematic analysis. The final themes represent patterns of shared meaning relevant to the research question and were refined for coherence, internal consistency, and analytic depth. To enhance credibility and dependability, researcher triangulation, regular peer debriefing, and an audit trail of coding and theme development decisions was used. Reflexivity was maintained throughout via memos and ongoing discussion of interpretive lenses. Confirmability was supported by maintaining transparency in our analytic process and grounding themes in rich data extracts. While not aiming for statistical generalisability, sufficient contextual detail was extracted to support transferability to similar settings.

Ethical Considerations

The project was approved by The University of Melbourne Human Research Ethics Committee (ID# 2056403.1). Participants provided written informed consent. All participants received a full explanation of the study, in lay terms, relating to the aims of the study, study procedures, and potential risks and benefits in taking part before providing informed consent. The participants were reminded that they can withdraw from the study at any time without prejudice. Participants were provided with a copy of the participant information and consent form and were reimbursed $45 AUD for their participation in the study. All data was stored in a de-identified format within password protected electronic files only accessible by the research team.

Results

Feasibility and sample characteristics

Figure 21 displays a consort diagram of the recruitment and testing process. Of the 148 potential participants that were assessed for eligibility for the study, 95 were eligible (64%). Of the 95 eligible, 23 were interested and completed consent, representing a conversion rate of 24%. Three participants dropped out between the consent and baseline assessment, with a total of 20 being randomized (9 to VR first condition and 11 to audio first condition). The most common reason for non-participation was declining interest to participate, followed by difficulties attending the session due to travel or location issues, and not meeting inclusion criteria. Most did not meet inclusion criteria because they scored below the cutoffs for severity of repetitive negative thinking (RNT). Three participants who consented did not attend the session, two due to difficulties with travel and the other due to enrolment in another study which precluded their participation. All 20 participants who attended the session completed both the VR and audio exercises, assessment timepoints, and the interview, indicating a 100% retention rate.

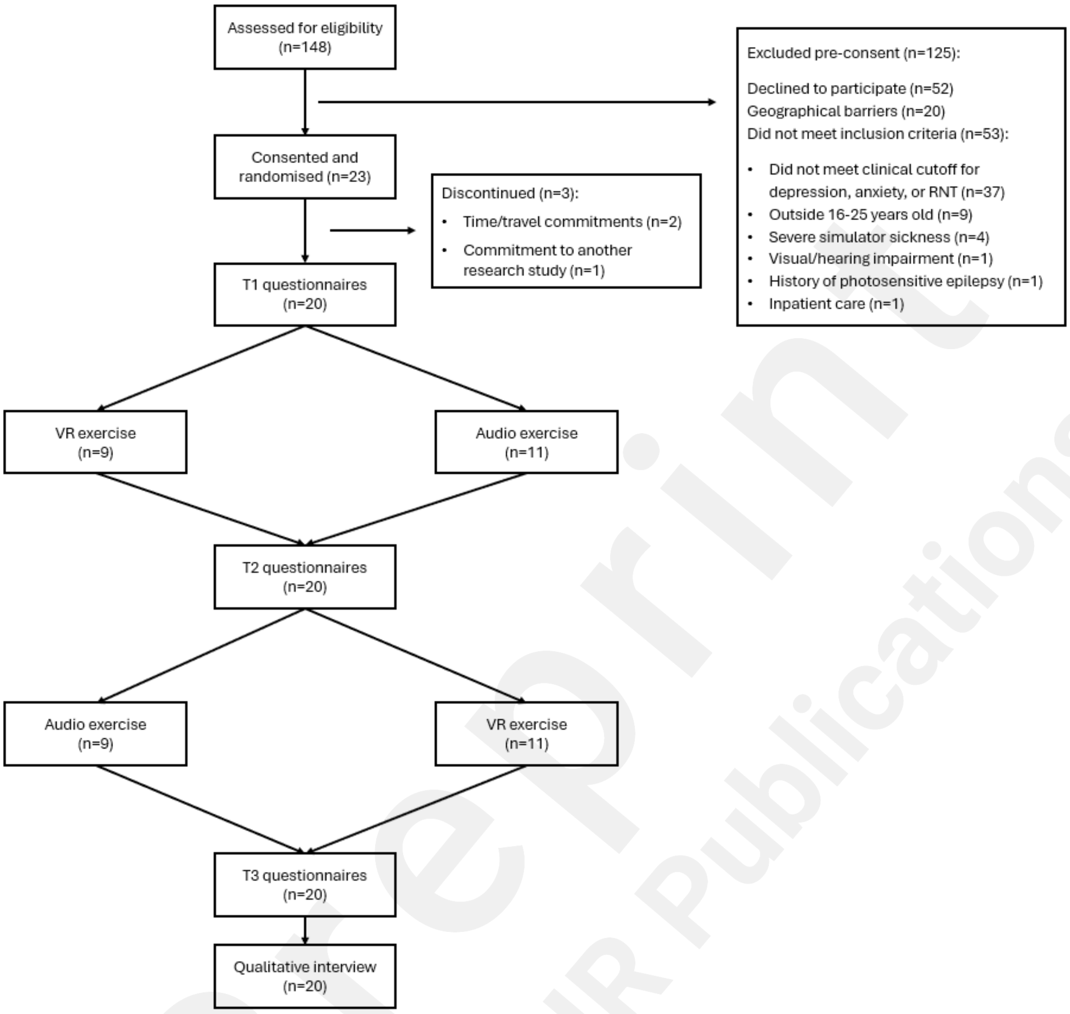


Figure 12. Study flow diagram illustrating participant recruitment to completion

Table 1 summarizes the demographic and clinical characteristics of the sample. The sample were mostly in their early 20s, relatively evenly split across male, female and transgender, born in Australia, with none identifying as Aboriginal or Torres Strait Islander. Around half the sample were receiving current mental health services and the other half were not. Clinical scores indicate that that sample was experiencing moderate to severe depression and anxiety, with high levels of RNT. There were no significant differences between groups on any baseline demographic or clinical variable (p>.05).

Table 1. Sample characteristics.

	VR first group[a] (n=9)	**Audio first group[b] (n=11)**	**Total sample (n=20)**
Age *Mean (SD)*	21.33 (2.96)	20.64 (2.66)	20.95 (2.74)
Gender *n (%)*			
Male	3 (33.3%)	2 (20.0%)	5 (26.3%)

Female	2 (22.2%)	6 (60.0%)	8 (42.1%)
Transgender	4 (44.4%)	1 (10.0%)	5 (26.3%)
Other	0 (0.0%)	1 (10.0%)	1 (5.3%)
Place of birth *n (%)*			
Australia	7 (77.8%)	6 (54.5%)	13 (65.0%)
Africa	0 (0.0%)	1 (9.1%)	1 (5.0%)
Asia	2 (22.2%)	2 (18.2%)	4 (20.0%)
Europe	0 (0.0%)	1 (9.1%)	1 (5.0%)
North America	0 (0.0%)	1 (9.1%)	1 (5.0%)
Aboriginal or Torres Strait Islander *n (%)*			
Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)
No	9 (100.0%)	11 (100.0%)	20 (100.0%)
Mental Health Service Usage *n (%)*			
Not current service user	5 (55.6%)	6 (60.0%)	11 (57.9%)
Current service user	4 (44.4%)	4 (40.0%)	8 (42.1%)
Clinical characteristics *Mean (SD)*			
PHQ8	18.33 (2.92)	16.91 (3.33)	17.55 (3.15)
GAD7	14.67 (2.65)	14.91 (4.25)	14.80 (3.53)
Brief-RRS	16.33 (2.35)	16.36 (2.46)	16.35 (2.35)
RTQ-10	45.00 (4.18)	44.00 (4.90)	44.45 (4.50)
Brief-PSWQ	21.89 (2.89)	22.09 (3.05)	22.00 (2.90)

[a]Refers to the group of participants that completed the VR exercise followed by the audio exercise; [b]Refers to the group of participants that completed the audio exercise followed by the VR exercise.

A summary of the use and familiarity of the sample with VR technology, and use of digital technologies for mental health support, is provided in the supplementary materials. These data indicated that the sample had previously used a range of digital technologies to support their mental health, however none had used VR for therapy previously. A third of the sample had used VR before and most were very comfortable, but average use was very infrequent.

Pre-post changes

A two-tailed repeated-measures t-test was used to explore changes in state-based variables before and after the VR and audio exercises. Note that as this study was not powered to detect effects, patterns of effect sizes across outcomes provide the most meaningful interpretation of changes in clinical measures. For the VR condition, there were large and statistically significant improvements in thought discomfort, cognitive defusion, and state anger. There were moderate but non-significant improvements in thought negativity, thought accuracy, thought importance, state rumination, and state tension, depression, fatigue, confusion and vigor, and subjective distress. For the audio condition, there were large and significant improvements in thought negativity, thought discomfort, cognitive defusion, state rumination, state tension, depression, anger and confusion, and subjective distress. There were moderate but non-significant improvements in thought accuracy, state fatigue, and very small improvements in state vigor. Levels of mindfulness were slightly higher on average in the audio condition than the VR condition, and this difference was more pronounced for the decentering relative to curiosity subscale.

Table 2. State based measures before (T1) and after (T2) the VR (*n* = 9) and audio (*n* = 11) exercises with associated statistics

	Pre (T1) *Mean (SD)*	**Post (T2)** *Mean (SD)*	**Repeated-Measures *t*-Test**	**Cohen *d* [95% CI]**
NTA – thought negativity				
VR	7.78 (1.39)	5.78 (2.22)	*t*(8) = 2.00, *P*=.08	0.67 [-0.08, 1.38]
Audio	9.18 (0.87)	6.64 (2.01)	*t*(10) = 5.37, *P*=<.001	1.62 [0.69, 2.52]
NTA – thought discomfort				
VR	8.56 (1.33)	6.11 (2.67)	*t*(8) = 2.72, *P*=.03	0.91 [0.10, 1.67]
Audio	9.00 (1.18)	5.36 (1.75)	*t*(10) = 6.90, *P*=<.001	2.08 [0.99, 3.14]
NTA – thought accuracy				
VR	7.33 (2.45)	5.78 (3.83)	*t*(8) = 1.90, *P*=.09	0.63 [-0.10, 1.34]
Audio	7.45 (2.30)	6.18 (2.09)	*t*(10) = 1.81, *P*=.10	0.55 [-0.10, 1.17]
NTA – thought importance				
VR	8.56 (1.88)	7.22 (2.28)	*t*(8) = 1.60, *P*=.15	0.53 [-0.18, 1.22]
Audio	8.45 (1.81)	7.09 (2.88)	*t*(10) = 2.01, *P*=.07	0.61 [-0.05, 1.24]
SCDQ - defusion				
VR	44.00 (4.72)	31.11 (12.41)	*t*(8) = 3.02, *P*=.02	1.01 [-0.23, 1.08]
Audio	43.27 (3.82)	26.09 (6.83)	*t*(10) = 10.31, *P*=<.001	3.11 [1.63, 4.56]
BSRI - rumination				
VR	479.67 (201.35)	366.44 (231.47)	*t*(8) = 1.19, *P*=.27	0.40 [-0.30, 1.07]
Audio	605.00 (106.57)	410.55 (133.94)	*t*(10) = 6.14, *P*=<.001	1.85 [0.84, 2.83]
POMS – tension				
VR	15.44 (2.30)	13.33 (3.84)	*t*(8) = 1.20, *P*=.27	0.40 [-0.29, 1.07]

Audio	15.18 (3.25)	10.09 (3.65)	*t*(10) = 7.08, *P*=<.001	2.13 [1.03, 3.21]
POMS – depression				
VR	15.33 (3.08)	12.33 (4.33)	*t*(8) = 2.11, *P*=.07	0.70 [-0.05, 1.42]
Audio	16.18 (3.28)	11.72 (2.83)	*t*(10) = 5.64, *P*=<.001	1.70 [0.74, 2.63]
POMS – anger				
VR	10.78 (1.86)	6.67 (1.66)	*t*(8) = 4.14, *P*=.003	1.38 [0.43, 2.29]
Audio	9.64 (4.11)	6.00 (2.28)	*t*(10) = 4.98, *P*=.001	1.50 [0.61, 2.36]
POMS – fatigue				
VR	13.22 (5.07)	12.33 (5.22)	*t*(8) = 1.40, *P*=.20	0.47 [-0.24, 1.15]
Audio	17.09 (2.21)	15.82 (3.57)	*t*(10) = 1.85, *P*=.09	0.56 [-0.09, 1.18]
POMS – confusion				
VR	13.44 (2.70)	11.33 (3.91)	*t*(8) = 1.51, *P*=.17	0.50 [-0.21, 1.19]
Audio	12.82 (3.71)	9.82 (2.14)	*t*(10) = 3.93, *P*=.003	1.19 [0.39, 1.95]
POMS – vigour				
VR	7.78 (3.49)	9.22 (3.70)	*t*(8) = -1.55, *P*=.16	-0.52 [-1.20, 0.20]
Audio	7.09 (2.26)	7.27 (3.17)	*t*(10) = -0.18, *P*=.86	-0.05 [-0.64, 0.54]
SUDS - distress				
VR	58.56 (30.00)	43.44 (25.58)	*t*(8) = 1.38, *P*=.20	0.46 [-0.24, 1.14]
Audio	59.36 (18.90)	35.09 (18.16)	*t*(10) = 4.96, *P*=.001	1.49 [0.60, 2.35]
TMQ[a] – state mindfulness – decentering subscale				
VR	NA	24.00 (6.67)	NA	NA
Audio	NA	26.27 (5.22)	NA	NA
TMQ[a] – state mindfulness – curiosity subscale				
VR	NA	21.44 (7.52)	NA	NA
Audio	NA	22.91 (3.94)	NA	NA

Positive effect sizes represent improvement; [a]Completed after each exercise, therefore no pre timepoint data for this measure.

User experience and satisfaction

Participant feedback on the user experience of VR and audio exercises is displayed in Table 3.

Individual item scores suggest that both VR and audio exercises were rated positively, however VR tended to be viewed as more fun and engaging, but less comfortable, more confusing and less of a learning experience compared to the audio condition.

Table 3. Participant feedback for the VR and audio exercises from the User Experience Questionnaire[a]

	VR exercise (n=20)	**Audio exercise (n=20)**
	Mean (SD)	*Mean (SD)*
1. I found the experience enjoyable	4.11 (1.05)	4.27 (0.65)
2. I found the experience fun	4.56 (0.53)	3.64 (0.93)
3. I found the experience comfortable	3.78 (1.09)	4.45 (0.82)
4. I found the experience interesting	4.56 (0.53)	4.73 (0.47)
5. I found the experience engaging	4.44 (0.73)	4.27 (0.65)
6. I found the experience easy to do	4.33 (0.87)	4.27 (1.01)
7. I learnt something from the experience	3.56 (1.42)	4.55 (0.52)
8. I would like this sort of experience to be a part of therapy	4.11 (1.05)	4.45 (0.69)
9. I would be likely to do this experience in my own time	4.22 (0.97)	4.36 (0.67)
10. I would be motivated to do this experience again	4.33 (0.71)	4.64 (0.67)
11. I would recommend the experience to other people with depression and/or anxiety	4.33 (0.87)	4.64 (0.67)
12. I found the experience confusing	2.44 (1.59)	1.45 (0.52)
13. I found the experience boring	1.11 (0.33)	1.55 (0.69)
14. I found the experience upsetting or distressing	2.22 (1.48)	2.00 (0.89)

[a]Scale range from 1 (strongly disagree) to 5 (strongly agree); ratings were pooled across the whole sample regardless of the order of the exercises.

Level of Presence in VR

Table 4 displays the subscale scores for the ITC-Sence of Presence Inventory. The pattern of scores supported a moderate to high level of spatial presence, indicating that participants felt a reasonable degree of “being there" in the virtual environment. The highest score was for engagement, indicating that participants felt moderately involved and interested in the VR experience. Ecological Validity/Naturalness was relatively low, suggesting that while the VR environment was somewhat convincing and behaved in a way that users expected, there could be improvements in making the environment and interactions feel more realistic. The low average score on negative effects suggests that participants generally did not experience significant discomfort, disorientation, or other adverse effects while using the VR application, supporting that it was well-tolerated.

Table 4. Subscale scores of the ITC-Sence of Presence Inventory

Subscale	Mean (SD)
Spatial Presence	3.32 (0.79)
Engagement	3.82 (0.55)
Ecological Validity/ Naturalness	3.07 (0.97)
Negative Effects	1.81 (0.72)

aScale range from 1 (strongly disagree) to 5 (strongly agree)

Qualitative feedback

All 20 participants provided feedback in a qualitative interview after they had completed both the VR and audio exercises. The themes arising from these interviews and representative quotes are described below.

VR is "new, different and engaging"

"I prefer the VR one mainly because…it's something I don't think I've ever really tried before and it's something new and different and engaging" (Participant #51, M, 19).

All 20 young people interviewed reported preferring VR over the audio exercise. Reasons for this preference centered on VR being perceived as a more engaging, novel and interesting way of learning psychological techniques. Young people were interested in the novelty of VR as "*something that I haven't really done before"* (Participant #91, M, 21), *"just a whole different perspective"* (Participant #91, M, 21), and a "*very interesting and new type of therapy"* (Participant #42, F, 25). This uniqueness was perceived as "*new and fresh*" (Participant #61, M, 21), "*fun*" (Participant #66, Non-binary, 20), "*cool"* (Participant #72, F, 19), and "*progressive*" (Participant #44, F, 21), relative to the audio which was seen as "*nothing new*" (Participant 61, M, 21). It was described as "*very important to attract young people's interest*" (Participant #42, F, 25) as a way of "*getting young people to engage with their mental health"* (Participant #91, M, 21). In addition to the novelty of VR, the "*fun*" (Participant #46, Other, 16) and "*enjoyable*" (Participant #66, Non-binary, 20) aspects of the experience were also seen as an important way of engaging young people: "*being able to do something fun as well as therapy, like it makes it a lot better in my opinion*" (Participant #85, F, 16).

VR facilitated cognitive defusion

"being able to have this distressing thought and then turn it into something that seemed really not important, and being able to interact with it in a way where I can really visualise it…I think it just sort of helps with that, compartmentalizing of thoughts." (Participant #64, F, 24).

Consistent with the aims of cognitive defusion, some young people described that the act of physically interacting with their thought made it easier to separate from them: "*It's kind of harder to see it as a fact when it when you can like so easily manipulate it"* (Participant #44, F, 21). Key to this was the interactive and visual element, where they could "*see and actually like interact, rather than just sit there and try to imagine."* (Participant #86, F, 17)
The process of physically acting out the technique was described as *"easier"* (Participant #71, F, 24) compared to "*mindfulness stuff where you're just listening, you're just like, I feel like it takes a lot of like activation energy to get yourself to do it. Whereas with the VR, like throwing for example like you're just throwing and the mindfulness comes like secondarily."* (Participant #61, M, 21). However,

many young people saw value in the audio exercise as well, with both offering different outcomes: "*I think the audio exercise was more relaxing and then the VR exercise was more engaging and, yeah so two different things, and they had two different outcomes.*" (Participant 91, M, 21).

Young people also described that the immersive environment helped them to focus more actively on the exercise with less distraction: "*I just had a fun time and wasn't distracted at all. I was paying a lot of attention*" (Participant #91, M, 21). Some found that this meant they "*could learn a lot more.*" (Participant 85, F, 16). Some felt that this greater focus meant that VR was "*probably a little bit more effective*" (Participant #44, F, 21) because it enabled them to be "*totally involved*" (Participant #44, F, 21), whereas "*during the audio, I still had like random thoughts coming to mind and you know, partly focusing on that, partly focusing on the audio, but in the VR I was like totally in the VR.*" (Participant #44, F, 21).

Gamification may create disconnection from technique

"*VR could potentially be distracting, that you're in a game and you're more like, oh, this is a game rather than doing therapy*" (Participant #46, Other, 16).

Some young people questioned whether the gamified element undermined the therapeutic intent of the VR experience. The opportunity for distraction from thoughts had appeal but risked not addressing the core issue: "*I do like to be distracted by my thoughts often and kind of like, yeah, even though it doesn't fix the problem*" (Participant #72, F, 19). The generalizability of the skill beyond the immediate experience into everyday situations was also questioned by two young people: "*how much crossover is there between when you do that with the VR headset…and being able to take that away and then still be get into that visualising sense without it*" (Participant #61, M, 21) and "*whenever I do get a negative thought, I just can't throw it or pop it*" (Participant #86, F, 17).

Implementation considerations

"*This is an experience that I'd want to do again in the future and in a therapeutic setting*" (Participant #91, M, 21)

Young people supported the idea of the VR app being used within therapy, describing it as "*something that would be very interesting to a lot of people, especially young people*" (Participant #91, M, 21). The appeal of using the VR app within treatment centred on the opportunity to "*get [young people] through the door*" (Participant #91, M, 21) and "*probably make them inclined to stay because of how interesting it is*" (Participant #91, M, 21). Some also mentioned the potential for the VR app to help strengthen the therapeutic relationship by creating "*common ground*" (Participant #61, M, 21) as the young person was able to talk through their interactions within the VR. However, the need for appropriate supports for both young people and clinicians was mentioned, including training and guidance on how to introduce and support young people to use VR more generally, such as a "*PDF that they have on hand*" (Participant #91, M, 21). Young people also warned that it would "*take some time to get familiar with it*" (Participant #42, F, 25).

The biggest perceived barrier to using the VR app was the cost of VR headsets and production of the software: "*The only downside that I can see is that it costs money to do. Yeah, since VR isn't very cheap*" (Participant #91, M, 21). Challenges accessing the equipment were mentioned both in terms of home use and clinical settings, with a need for "*centres and clinicians being able to get access to*

VR headsets and set them up and keep up with the IT and the maintenance." (Participant #61, M, 21).

A number of young people reported that the VR app may be particularly well suited to specific clinical populations, particularly those with attention difficulties or where abstract mental thought was challenging. They reiterated the appeal of the VR app for young people with depression and anxiety who might benefit from separation from thoughts: "*I think a lot of people like struggling with depression anxiety could sometimes be like yeah, angry at themselves or angry at other people, and it just was very like satisfying being able to like, let that go.*" (Participant #72, F, 19). The VR app was also seen as potentially beneficial for young people with attention difficulties as a way to facilitate focus without distraction: *"I think that VR could be a lot better for young people who suffer with ADHD and other types of attention deficits, especially since sitting there for 10-15 minutes might be hard for people who are a bit restless." (Participant #91*, M, 21*).*

Future changes to VR app

When asked directly what changes they would make to the VR app, most young people reported minor suggestions. This included expanding the range of exercises, including "*visualisation activities…could really be awesome, like the classic, like, you have a negative thought and just stick it on a cloud. And see it go away. You can literally make that.*" (Participant #61, M, 21). Several young people also suggested combining the audio and VR exercises to gain the added benefit of both: *"the headset itself like provides that sort of like audio guidance would be nice"* (Participant #64, F, 24).

Improvements to the user interface were mentioned as a priority, including clearer instructions for controls and interactions. Many young people suggested expanded options for personalisation. As there were only three options for environments to choose from, some young people suggested "*there might be like some people that like don't really resonate with any three of them"* (Participant #72, F, 19) and that the environments could be "*a little more realistic to my situation*" (Participant #44, F, 21), with suggestions to add *"more options"* (Participant #71, F, 24) such as "*a university classroom rather than like a school*" (Participant #44, F, 21). One young person suggested non-realistic environments may also be appealing which draw on traditional visualisations, such as representing thoughts as clouds.

Some commented that the characters and environments could appear more realistic, with some avatars described as "*a little bit creepy looking"* (Participant #61, M, 21) which could break immersion: "*I just found the people really weird and just sort of took me out of it because they were doing very stiff or weird sort of motions."* (Participant #51, M, 19). However, most young people found the graphic style acceptable.

Safety and adverse events

One young person experienced some distress during the VR exercise and requested to stop. This participant found the experience of manifesting a distressing thought in VR confronting, however, was able to continue and complete the post assessment and interview at their request following a break and some reassurance. They were contacted the following day and reported no persisting discomfort or distress. No other participants reported adverse events during the study. Within the qualitative interview, negative experiences of the VR app were mentioned by two young people. One described feeling "*a bit panicky and anxious in the VR experience, but it was OK to like kind of push* *through*" (Participant #67, non-binary, 22). Another young person described that "*thinking about the thought was quite distressing, but it was also helpful with the interactive bit*" (Participant #94, M, 24). No participants reported experiencing any cybersickness.

Discussion

Principal Results

This study explored the potential of using virtual reality (VR) to support third wave cognitive behavioural therapy (CBT [18]) for young people with depression and anxiety. To achieve this, a prototype VR app was developed, which involved a brief, interactive cognitive defusion exercise within personalised virtual environments. Using a mixed methods experimental approach, the current study sought to investigate the feasibility, acceptability, usability and safety of the VR app, explore whether it could improve negative thinking and mood states, and understand young people's experiences of this new VR treatment approach. Participants in this study completed both the VR and audio defusion exercises within a single session in randomised order, to understand how these experiences compared. Key results indicated the VR app was feasible, safe and acceptable to use. However, the pattern of effects across the two conditions suggested that the audio exercise may have led to greater immediate improvements in certain mood states, despite qualitative themes indicating that VR was preferred by participants.

Whilst the small sample precludes generalisable interpretations, results from the current study suggest that a single session of VR cognitive defusion can lead to reduced discomfort with negative thoughts and state anger, and increases in cognitive defusion. This provides proof-of-concept evidence that the app can engage the target mechanism of cognitive defusion (pre-post effect size = 1.01). Acceptability ratings indicated that the intervention was perceived to be enjoyable, and the environment was immersive and engaging, with the experience well tolerated with minimal adverse effects. Qualitative themes supported these quantitative results, with young people reporting that the physical interaction and visualisation of VR provided a more concrete and interactive learning experience that helped them separate from their negative thoughts, and that it was more fun and interesting compared to the audio exercise. Young people reported that these benefits may be particularly important for those who struggle with understanding abstract therapeutic concepts, such as autism spectrum disorders, or those who have attention and concentration difficulties, such as ADHD. These perspectives align with literature emphasising the need to tailor third-wave therapy approaches to the cognitive developmental stage of adolescents [28]. This is also consistent with the perspectives of clinicians and individuals with lived experience of developmental disorders, who advocate for novel therapeutic strategies that better accommodate sensory needs and learning styles, including VR [34]. This includes adapting exercises to be interactive, experiential, creative, interesting, and behaviourally focused. Both qualitative themes and acceptability survey responses suggest that VR can be used to support these adaptations, and that this is valued by young people.

Despite the preference among young people and the positive effects of the VR app on some outcomes, effect sizes were larger in the audio condition. While the small sample size prevented between-group comparisons and overall the interpretation of results must be approached with caution, this finding suggests that the defusion exercise delivered via audio may have led to greater improvements in mental states compared to VR. Previous research on VR-based cognitive defusion is limited, with only one study to the authors knowledge by Prudenzi et al. [30] finding that a VR defusion task reduced thought believability and discomfort compared to a non-defusion VR control. The current study also showed improvements in these domains for the VR defusion task, however the audio showed more favourable effects. One explanation for this difference is the choice of comparator. In the current study, the control condition was a non-VR, audio-based defusion task, which produced stronger effects, suggesting that audio guidance may be more effective in facilitating cognitive defusion. Other relevant studies have examined VR-guided meditation, finding that users tend to prefer VR over non-immersive formats (e.g., audio, video, or text) due to its novelty, immersion, and engagement [60-62]. However, unlike the current findings, VR-guided meditation has generally been associated with greater improvements in positive mood states compared to non-VR meditation, with less consistent effects on negative mood states. One possible explanation is that VR's sensory richness may support mood regulation in meditation by enhancing absorption and presence in the environment, whereas it may increase cognitive load and interfere with techniques like cognitive defusion that require more cognitive effort to achieve abstract mentalization. Indeed, previous research [63] has found that the novelty of VR can hinder learning by increasing cognitive load, as users adjust to the unfamiliar interface and immersive experience, potentially diverting attention from the intended task. Future research should explore ways to optimise VR-based defusion, such as simplifying visuals, adjusting interactivity, and selecting or tailoring virtual environments and scenes.

Another possible explanation for these findings is that the way the exercises were delivered influenced how participants engaged with their thoughts, particularly in terms of cognitive focus and mental manipulation. Cognitive defusion and related third-wave CBT techniques typically encourage individuals to sit with uncomfortable thoughts and view them as separate to the self [19-21]. This is a highly reflective process that requires individuals to focus and mentally manipulate their thoughts using their imagination. The audio exercise may have been more effective at achieving this due to the lack of external distractions, forcing participants to focus their attention on the thought. In contrast, the VR exercise involved creating a visual object to externalise the thought within a virtual environment and interacting with it in gamified ways. By externalizing the thought so directly, individuals may have lost the connection between the internal representation of their thought and instead related to the object as an external entity, thus losing the level of focus and mental manipulation required for successful cognitive defusion. Furthermore, the gamification element may have counterproductively enabled participants to experientially avoid their negative thoughts and further sever the connection between the object and their internal representation. This theory is supported by qualitative interview themes, in which some participants described the VR exercise as potentially being a fun distraction which may have undermined therapeutic learning, as well as by the description of the audio requiring "more energy." This explanation suggests that for the VR cognitive defusion exercise to be effective, individuals must maintain a connection between the symbolic thought in the virtual environment and their internal representations in order for them to effectively internalise the experience.

Another explanation for the findings is that the level of guidance and explanation within the VR exercise was insufficient to support young people to apply the skill of cognitive defusion in the moment. Ratings on the acceptability measure suggest that the audio condition provided a better learning experience compared to the VR condition. Given VR is a highly engaging visual medium, participants may have become either too distracted or potentially overwhelmed by the exercise in a way that reduced their focus on the core exercise and thus undermining their learning. This aligns with aforementioned research indicating that the novelty of VR can hinder learning, suggesting the need for a pre-learning phase to help users acclimate to the environment before therapy or a structured approach to gradually build toward more complex tasks [63]. Indeed, a small number of young people did report becoming distressed by the experience in VR. Whilst this did not appear to have a lasting effect, this may have undermined their ability to engage with the exercise. Other factors which may explain these effects could be the dosage, in which a single session may be insufficient to induce effects in VR, as well as a potential 'delayed' response in which effects might be observed in a longer time period compared to the audio. Indeed, participants described VR as being more fun and exciting, compared to the audio which was more relaxing. It might be that the audio achieved its therapeutic benefits by lowering arousal, leading to more immediate improvements in mood states. In contrast, given the level of immersion and engagement from the VR experience, participants may have been left feeling more activated. This is supported by the effect of the VR app on increasing vigour, whereas the audio did not show such effects on this outcome. In contrast, the audio had a much stronger effect on reducing tension. Thus, the immediate aftereffects of the VR might not be the ideal timeframe to uncover beneficial outcomes.

Despite these findings, young people in this study clearly endorsed the VR app as a valuable clinical tool, with all young people reporting that they preferred it over the audio experience. A central theme to this preference was the novelty of VR, and the opportunity to engage young people in treatment using a new and interesting approach. This is consistent with a prior study examining the addition of VR within a mindfulness intervention for generalised anxiety in adults, which found that those who received the addition of VR were more likely to complete the intervention compared to those that did not [31]. Given engagement with treatment is a key challenge in youth mental health care [11], this opportunity is significant. However, in considering the contrasting findings indicating that the audio condition yielded greater effects despite VR being preferred by participants, it is important to recognise the potential novelty effect of VR. The initial appeal of VR may contribute to a ‘digital placebo’ effect [57], where therapeutic effects and engagement benefits stem from the technology itself rather than the therapeutic content. Moreover, while novelty may drive short-term engagement, its impact may diminish over time, potentially reducing sustained effectiveness. Such novelty may have a greater impact on those with less VR experience and could be examined by comparing engagement across varying levels of prior VR exposure. Although we did not examine differences in engagement between participants with prior VR experience and those new to VR given sample size limitations, future research should investigate how prior exposure influences engagement and therapeutic outcomes. Studies incorporating non-active VR comparators (e.g. VR games) will also help disentangle the effects of novelty from the core therapeutic mechanisms, informing strategies to sustain engagement beyond the initial novelty phase.

Young people reported being particularly interested in using the VR app within a therapy session delivered by a clinician, however they also reported a need for clear guidance and clinical protocols. This is consistent with qualitative studies [53,54] of clinician attitudes towards VR which emphasize the need to address implementation barriers, as well as broader literature on the importance of working with end users to ensure technologies are fit-for-purpose and appropriately designed for the implementation context [2,55]. In addition to opinions about the use of the VR app within clinical settings, young people also called for improvements to the user experience. This included an expansion to the range of activities and environments, improvements to the graphics and user interface, and more options for personalisation. The current findings also suggest that there should be improvements to the guidance offered within the experience to better support therapeutic learning. For example, several young people reported enjoying both VR and the audio exercises and suggested a combination of both would be optimal.

In considering future iterations of the VR app, there may also be benefit in refining the therapeutic target. Specifically, the app may be better positioned as a treatment targeting decentering as a core underlying mechanism, rather than an adaptation of cognitive defusion. Decentering is a broader concept that includes cognitive defusion and refers to the process of mentally separating oneself from one's thoughts and emotions, becoming aware of underlying thinking processes, and reducing emotional reactivity to mental events [22,23]. Decentering has been identified as a core component of psychological interventions for anxiety and depression by reducing the negative emotional impact of stressors, including inner events like thoughts, feelings and memories. Indeed, interventions which improve decentering-related processes have been shown to decrease depression and anxiety severity [22]. Decentering techniques typically rely on experiential exercises drawn from third wave approaches, which includes cognitive defusion as well as mindfulness and acceptance and commitment therapy. This collection of techniques share an experiential learning focus that may be well suited to VR due to the ability to physically separate and visually manipulate mental processes in an immersive way. Broadening the VR treatment package to include a wider range of techniques to achieve decentering may provide a clearer theoretical model for the intervention whilst offering additional learning opportunities that can be tailored to the specific needs and preferences of young people.

Limitations

Future research would benefit from addressing the limitations of the current study design. Specifically, a larger trial with a bigger sample size and a more established intervention protocol over a longer period of time is needed to thoroughly evaluate effectiveness. This may include increasing the number of sessions and incorporating follow-up assessments to examine long-term effects. Additionally, the protocol could involve delivering the VR intervention in a blended format, aligning with the perspectives of young people in this study, and exploring how the intervention might be implemented in routine clinical practice. A hybrid implementation-effectiveness trial [56], which simultaneously tests both implementation and effectiveness outcomes, would be ideal for establishing evidence and fast-tracking implementation in real-world settings. Notably, the conversion rate suggests that only a proportion of young people who are eligible may be interested in the VR app, suggesting a clearer understanding of who the approach is best suited for is needed. This may involve expanding the age range of the VR offering from 16-25 to 12-25, in line many with youth mental health services in Australia, to understand if this type of intervention would be more appealing to a younger demographic. Another factor to consider in future trials is the selection of a control group. The active comparison of an audio cognitive defusion exercise with a repeated measures design in this study was a strength, providing insights into how VR compares to traditional methods. However, carry-over effects from the first condition to the second prevented direct comparisons, and the chosen control group did not isolate specific VR-related effects. Further, as previously mentioned, it is important that future research address the potential ‘digital placebo’ effect [57] involved in VR by including control groups with a therapeutically inactive VR experience to better isolate the intervention's effects. Other comparison groups of interest would include a passive control group, or an alternative non-VR based intervention, to further clarify the distinct effects of VR-based therapy. Lastly, limitations should be noted around the measures collected in the current study. We created a specific measure of acceptability based on the need to capture more nuanced aspects of user experience relevant to this VR intervention. However future research should incorporate validated measures of acceptability of digital mental health platforms alongside study-specific measures where possible. Further, it possible that participants experienced fatigue effects from the number of questionnaires completed in a single session. Whilst no participant reported such fatigue, future research should examine this by analysing consistency in responses.

Conclusions

In conclusion, the findings of the current study indicate that the VR cognitive defusion app is feasible, safe and acceptable to young people, and shows potential for supporting mental health treatment by increasing engagement and offering a novel, enjoyable approach to skill development within third-wave CBT approaches. The greater immediate improvements seen in the audio condition compared to the VR condition suggests that the app needs to be refined to optimise the learning experience. Future research should focus on improving the overall experience based on young people's feedback, and conducting a larger trial with an established intervention protocol conducted within a real-world implementation setting.

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Author contributions

IHB, AT, GW, SB, JG, and MAJ played key roles in the conceptualisation of the VR intervention. GW, MAJ and AT supervised the development of the first prototype and GW conducted initial user testing. IHB subsequently continued testing, refining and overseeing the development of enhancements to the final intervention which were completed by YL. IHB designed and oversaw the conduct of the study, with input from AT and MAJ. CL led the recruitment and testing, with oversight from IHB and CE. SO conducted the quantitative analysis, and IHB and CL conducted the qualitative analysis. IHB wrote the manuscript with contributions from CL and KAR. AT, MAJ, GW, SB and JG obtained funding for the study. All authors reviewed and provided feedback on the manuscript.

Data Availability

The data sets generated and analyzed in this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

None declared.

Abbreviations

ACT: Acceptance and Commitment Therapy
CBT: Cognitive Behavioral Therapy
JMIR: Journal of Medical Internet Research
RCT: randomized controlled trial
RNT: repetitive negative thinking

VR: virtual reality

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Supplementary Files

Multimedia Appendixes

Supplementary material.
URL: http://asset.jmir.pub/assets/5c6ce9ec28244d494f720669ffaeb3cb.docx