ARCADIA: A Gamified Mixed Reality System for Emotional Regulation and Self-Compassion

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Figure 1: Conceptual design of the ARCADIA mixed reality system.

ABSTRACT

Mental health and wellbeing have become one of the significant challenges in global society, for which emotional regulation strategies hold the potential to offer a transversal approach to addressing them. However, the persistently declining adherence of patients to therapeutic interventions, coupled with the limited applicability of current technological interventions across diverse individuals and diagnoses, underscores the need for innovative solutions. We present ARCADIA, a Mixed-Reality platform strategically co-designed with therapists to enhance emotional regulation and self-compassion. ARCADIA comprises several gamified therapeutic activities, with a strong emphasis on fostering patient motivation. Through a dual study involving therapists and mental health patients, we validate the fully functional prototype of ARCADIA. Encouraging results are observed in terms of system usability, user engagement, and therapeutic potential. These findings lead us to believe that the combination of Mixed Reality and gamified therapeutic activities could be a significant tool in the future of mental health.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; *User centered design*; *User studies*; • **Applied computing** → **Consumer health**.

KEYWORDS

mixed reality, mental health, emotional regulation, gamification

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1 INTRODUCTION

In recent years, mental health and wellbeing have been gaining increased acknowledgement on their vital role in global health, and its impact on socio-economic conditions and the global burden of disease [63]. Specially after the COVID pandemic and the toll it took on already prevalent mental health conditions such as anxiety or depression [95], major organisations and governments are raising awareness and creating international policies to support facilitate coping with mental health illnesses. Despite these efforts, there is a heightened demand of mental health care which current services are unable to cope with [44], and an increased interest towards improvement of general wellbeing in people without any additional mental health diagnosis.

Long before this recent uprising on mental health care demand, researchers were already exploring different technological interventions to provide more effective treatments as well as to reach more patients [74]. One of the most frequent applications of immersive technology for mental health has been the use of Virtual Reality

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(VR) and Augmented Reality (AR) as tools to support Exposure Therapy (ET) [27, 31, 33, 51]. Such technologies are ideal to replicate stressful conditions and scenarios within a virtual and controlled environment, allowing patients to gradually expose themselves to their fears before *in vivo* exposure.

However, often technological interventions are designed to target a specific mental health treatment strategy, in this case VR/AR for exposure therapy. This strategy might no be applicable to other mental health problems or therapeutic methodologies. Some researchers have tried to combine different simulated scenarios for exposure therapy into the same software [3, 69], or include additional configuration parameters [36], but the variety of patients' specific needs and personal backgrounds makes it difficult to generalise these interventions. Hence, Mental Health Professionals (MHPs) would need to invest time in learning how to use and configure different VR systems that might not adapt completely to what their patients require.

In addition, MHPs typically treat patients with various diagnoses, including conditions that are not as straightforward to simulate as phobias, such as major depression. These professionals, encompassing therapists such as psychologists, psychiatrists, or occupational therapists, also draw on a variety of techniques, not just ET, to treat their patients. For example, current third generation therapies include mindfulness and acceptance strategies, which are helpful not only in specific diagnostics such as anxiety or addictive behaviours, but also to improve general wellbeing and emotional intelligence. In this regard, emotional regulation (ER) strategies could be a powerful tool to address mental health and wellbeing in a comprehensive manner. ER is a crucial component of Cognitive Behavioral Therapy (CBT), a widely practiced and researched form of psychotherapy that focuses on helping individuals identify and change unhelpful thought patterns and behaviors that contribute to emotional distress and psychological problems [24]. Specifically, ER studies how individuals influence which emotions they have, when they have them, and how they experience and express them [32]. It involves recognising, understanding, and managing emotions in a way that promotes psychological well-being. There is consistent evidence showing the presence of ER difficulties in a wide range of mental disorders, suggesting that emotion dysregulation is an important factor to target in clinical interventions [21].

In recent years, there is a growing interest in applying XR technologies to support and practice ER strategies [54], but yet again, the majority of related works are based on immersive ET with VR. This lack of more creative, varied and easy to use technological resources might not be the best scenario if we aim to help increase patients' motivation. One of the key elements in assessing the quality of a mental health care system is treatment adherence, which is the rate at which a treatment prescribed by a mental health professional is followed by a patient. There are several patient-related factors that can affect adherence, such as social, economic, or biological causes. For example, having restricted access to services, or even genetic predisposition might affect patients' non-compliance. Other factors are related to behavioral changes [45, 70], the treatment itself, and the nature of the condition being treated [9, 62]. Among all these factors, the most common reason leading to the treatment's drop off is when patients lose motivation in their therapeutic process [1]. According to studies, 86% of patients drop out of behavioural health treatments within 17 months [88], and non-adherence to prescribed anti-psychotic medications is the leading cause of relapse in mental illness [94]. Aiming to increase users' motivation, researchers in many areas, from education to industrial training, have turned into gamification and its well-known benefits to increase users' engagement. Within mental health, some researchers have already developed VR games, successfully obtaining encouraging results in terms of patients' intrinsic motivation. However, in the realm of mental health, there is still a lack of gamified design strategies for other immersive technologies such as mixed reality experiences. Due to its novelty, there is not extensive evidence of using MR in the context of mental health treatment. MR, o a certain extent, represents the convergence of AR and VR. While VR creates a completely synthetic and interactive environment for users, AR overlays a graphic layer on the real world without interacting with it. In contrast, MR allows for the rendering of 3D objects over the real world in a way that interacts with it, enabling features such as dynamic occlusion and realistic physics (see Figure 2). This could certainly set the ground for developing creative solutions for therapies other than exposure, such as ER, facilitating that mental health professionals working in different disciplines and diagnosis could use them across the board to treat their patients.

Hence, our aim is to design and study how mixed reality technologies could better support different mental health therapies with more creative and motivating strategies. To address these challenges, we propose ARCADIA, a Mixed Reality platform comprised of interactive and gamified therapeutic activities focused on emotional regulation. We hypothesised that ARCADIA could provide a novel and engaging user experience in the domain of emotional regulation, which fosters patients' implication in their therapeutic process. We have evaluated ARCADIA with both mental health professionals and patients, and reported the study results, insights and design recommendations for gamified interactive systems for Mixed Reality.

More specifically, this paper makes the following contributions:

- A MR platform for Microsoft Hololens 2 based on gamified therapeutic activities to support emotional regulation for wellbeing and mental health treatment, which has been co-designed with mental health professionals.
- An evaluation of the platform by two different profiles of mental health professionals, focusing on user experience and the potential application of the MR experience in clinical practice.
- An evaluation of the platform by mental health patients, focusing on user experience and perceived benefits for emotional regulation and self-compassion.
- Implications and design considerations for gamified mental health experiences in MR.

2 RELATED WORK

2.1 Mixed Reality as an accessible immersive technology for mental health

Immersive technologies, particularly VR and AR, have been extensively used for mental health treatment, especially for ET in post-traumatic stress disorder (PTSD) [90], eating disorders [26, 33],

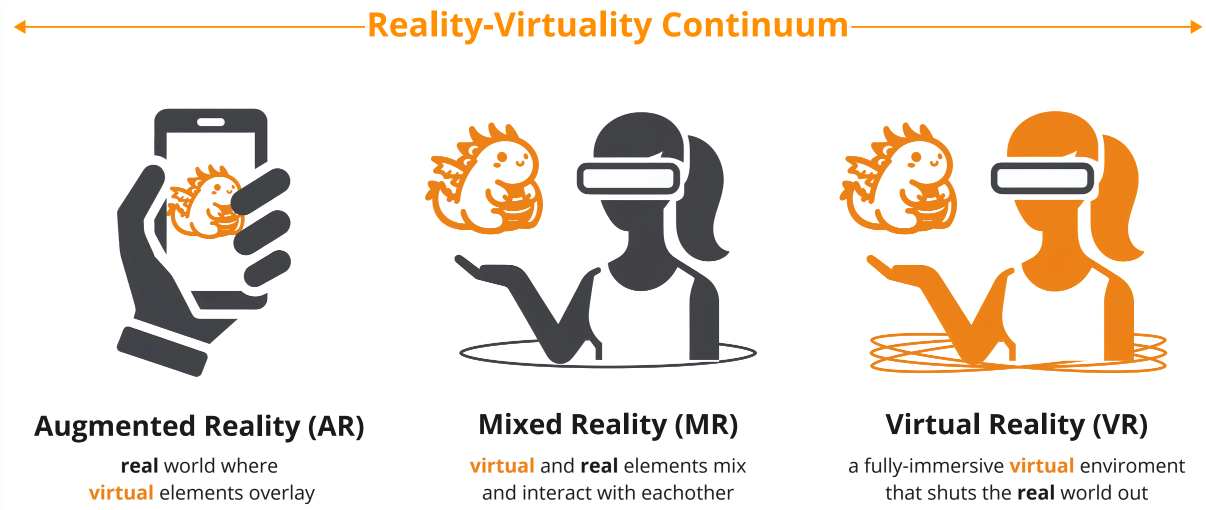


Figure 2: Extended Reality Continuum [61, 71]

phobias [27, 31, 51, 97], Obsessive Compulsive Disorder (OCD) [59], or practising social skills [20]. The potential of these technologies for mental health settings is explained by the concept of presence, i.e. the subjective sensation that a user of immersive technologies has of being "there," in the virtual environment [83, 91]. Presence is a cognitive multi-factor construct that results from the immersive capacity of the technology, interaction design, perceptual capabilities, and more [18, 82]. The stronger the sense of presence, the more natural the reactions and activated cognitive mechanisms become, thereby proportionally enhancing the effectiveness and transferability of therapies [19, 29, 53]. To a certain extent, it could be stated that VR and MR are the most immersive XR technologies, surpassing AR [7, 22], although both of them approach immersion from different perspectives. VR is typically considered the most immersive of the three technologies, as the complete immersion into a digital world allows for a high level of presence, making the user feel as though they are truly inside the virtual environment [84]. In MR, the immersion is less about complete sensory envelopment and more about the seamless integration of virtual and real-world elements. Blending real and digital elements can also lead to a strong sense of presence, as users interact with both physical and virtual objects in a cohesive space, being similar to VR levels [92]. However, the level of presence in MR can be influenced by the design of the system and how well the virtual and real elements are integrated, where a more seamless integration leads to a stronger sense of presence [35, 60]. In this regard, MR can be implemented on Optical See-Through Head-Mounted Displays (OST-HMDs) with transparent displays, such as Microsoft Hololens, or on Video See-Through Head-Mounted Displays (VST-HMDs) that use cameras, like the Meta Quest Pro or Quest 3 [73]. Hence, the kind of device used for MR might affect on how presence is perceived.

Although VR is the most common technology being used to support mental health scenarios, the devices used for the deployment of this type of applications might not be suitable in all cases when aimed towards mental health patients. VR present different challenges when it comes to scaling their usage in mental health patients, especially in terms of User Experience (UX). One of these issues is related to Visually Induced Motion Sickness (VIMS) [14], which arises from the perceptual dissonance between what is perceived through Head Mounted Displays (for example, camera movement linked to head movements) and what the proprioceptive system feels is actually happening (that the body is not moving). VIMS symptoms result in disorientation, distress [43], and consequently, reduced accessibility and a negative UX. Another aspect to consider is that some mental health patients might not tolerate well the use of a VR immersive headset covering a great part of their face. For example, patients with Autism Spectrum Disorder (ASD) who do not tolerate physical touch, or patients with OCD who do not find hygienic to wear such an enclosed device. In this case, lighter headsets with an open frame allowing for peripheral vision such as the Microsoft Hololens 2 might be more comfortable for such patients.

In addition, MR could allow for therapeutic activities to be grounded in the real world. On one hand, this seems highly relevant to provide an intermediate step between purely simulated VR environments for exposure therapy, and *in vivo* therapy. On the other hand, it allows MHPs to maintain eye contact with the patient, while integrating real world elements, which could facilitate knowledge transfer. In this regard, MR experience also helps to create a social and engaging environment among the participant and the observers [6], which might be relevant in scenario aimed to foster social relationships and avoid feelings of isolation and loneliness.

In contrast, the corpus of mental health interventions utilizing MR is still relatively small, even considering that it allows a significant degree of immersion, fostering local and co-presence, while avoiding VIMS problems. MR constitutes a very interesting intermediate point between VR and AR, as it offers a wide variety of possibilities for natural interaction and the combination of the physical and digital worlds [66]. Therefore, we consider essential to further investigate MR for therapeutic support, especially for therapeutic approaches other than ET, such as emotional regulation strategies.

2.2 XR and biofeedback for emotion regulation user studies

In the domain of Human-Computer Interaction (HCI) a significant paradigm shift is observed in the exploration of emotion regulation. This transition is marked by the advent of mobile applications like MoodHacker, which employ CBT techniques for emotional management [10]. Additionally, wearable sensors have revolutionized personal healthcare by providing real-time biofeedback, facilitating better emotional regulation through physiological awareness [38]. The role of social media has also been transformative, with platforms fostering supportive communities and positive interventions for emotional well-being [65]. Furthermore, ambient displays represent another innovative front, providing visual feedback on emotional states, aiding users in emotion regulation [48]. In the field of affective health, research has predominantly focused on developing technologies for automated diagnosis and self-tracking, with emerging innovations in tangible interfaces [72]. These advancements in HCI research demonstrate a critical shift towards more ethically sensitive and inclusive design practices, particularly for vulnerable populations dealing with mental health issues.

Particularly within XR research, there has been a growing interest in harnessing the benefits of immersive technologies for ER settings [54], as an intervention that can address the underlying factors of many other conditions, operating in both recovery and prevention scenarios. Immersive environments can elicit emotional responses in the person using them, allowing to identify their affective states based on physiological data [55]. The integration of biofeedback in these environments is specially relevant in order to give users more control over what is happening and helping them gain control over their physiological processes [74]. This biofeedback has to be presented in a way that does not evoke categorisations of behaviour as right or wrong, i.e., the user does not feel evaluated or judged [5].

Blum et al. [12] have explored the use of cardiac biofeedback to improve breathing patterns and enhance relaxation in a VR scenario that emulates nature. The VR implementation with biofeedback was more effective than the traditional approach, as it helped participants achieve a greater state of relaxation. Similarly, Mazgelytė et al. [57] have evaluated various scenarios in VR with biofeedback from different sources. In all cases, a decrease in the subjective sensation and physical response of stress was observed.

Immersive environments with biofeedback can also be a resource with great potential to practice meditation skills, mindfulness or attention to the present moment. In the case of VR environments, this is because they help to dissipate external stimuli, focusing the person's attention on what is happening in the immersive experience at each moment [80], and therefore facilitating introspection when combined with real-time biofeedback. Mindfulness practice through VR also produces positive effects on anxiety, mood, stress and attention levels [52]. However, MR experiences could also allow patients to practice meditative or introspective activities of a different kind. For example, by focusing on the real world while facilitating visualization of inner feelings or sensations, and perhaps sharing the space with the MHP. In this regard, ZenG [68] proposes a mixed reality application for kinesthetic meditation, i.e. body movement through activities such as walking or gardening, which uses the user's EEG signal as biofeedback.

Furthermore, employing immersive technologies for mindfulness practice helps to reduce the dropout rate of mindfulness therapy, increasing adherence to treatment versus conventional practice [52]. The abandonment of therapy in general, and of emotional regulation strategies in particular, entails short- and long-term problems. Therefore, it is essential to delve into the combination of immersive technologies along with other strategies to motivate the user and encourage habits that promote good mental health. Among these strategies is the use of gamification and serious games, whose application in immersive environments is described in the following section.

2.3 Games for mental health

Serious games typically refer to interactive computer-based experiences designed to serve specific objectives in areas such as education, training, simulation, health or public policy [87] but they also could include board games, card games or live-action role play games. In recent years, gamification has emerged as another strategy to exploit games mechanics and dynamics for other, not strictly playful purposes [23, 41]. Both terms, serious games and gamification, have recently been collected under the umbrella term "applied games" [76].

Using applied games for mental health care is supported by their intrinsic ability to modify users' behaviour [76] and their potential to increase patients' motivation. Thanks to game-based mechanics, therapeutic experiences can increase their engagement, attendance and adherence to treatment in comparison with traditional interventions [34]. Applied games have found applications in various healthcare contexts and could emerge as a novel and readily available choice for numerous mental health service users [42]. Traditionally, computer-based games designed to support mental health have addressed the most prevalent disorders: anxiety [75, 77, 78, 93], depression [4, 81] and ADHD [16, 17, 28]. VR games have also been developed to help people with depression [49], and to alleviate children's anxiety during an MRI scan [50]. Commercial games which have been primarily designed to be engaging and entertaining, can also serve therapeutic purposes [13, 46]. There are also several examples of commercial off-the-self 3D games [67] and VR games [64] aimed to support treatment with positive results. Gross et al. [85]'s framework provides new directions for HCI by focusing on designing technology to help emotional regulation. This framework contrasts the development of specialized games with commercial ones, favoring experiential learning methods that offer direct emotional regulation in real-time situations[96]. This approach, distinct from traditional didactic methods, positions the XR system as innovative for its on-the-spot application capabilities. Commercial games were excluded from our consideration due to the system's focus on customization and supporting a wider range of emotional strategies, beyond just response modulation.

Regarding immersive games for emotional regulation, several works have focused on serious games and game mechanics to offer alternative ways of approaching mental health. For example, InMind is a VR game explicitly designed to intervene in people's beliefs about the malleability of emotions [58]. The recently launched TRIPP [79] has gained some visibility offering customisable mindfulness experiences aiming to 'Pause the mind chatter, calm the mind, and fully immerse yourself in a state of deep relaxation'. These games could be benefited from the addition of physiological inputs as in-game controls. For example, Stressjam is a Virtual Reality (VR) game using biofeedback to train stress-mindset and to become better at regulating stress and lets you play in real-time with your own stress system on an exotic island in VR [39]. DEEP [89] is a VR game designed for children with anxiety, who are encouraged to explore an underwater fantasy world to practice diaphragmatic breathing, which is measured using a wearable sensor. In Bjørner's educative serious game [11], real-time EEG was used to adjust game difficulty based on players' affective state, aiming to achieve a stable flow state.

Considering the potential for appeal, engagement, and effectiveness that games offer when used as a means for mental health treatment, we contemplated creating a playful universe for working on one's mental health. The guiding principles were: simple, intuitive yet motivating mechanics, a "*kawaii*" and non-aggressive aesthetic, and a metaphorical narrative focused on inner flourishing. Additionally, by incorporating user biofeedback, we would be able to make the system react to the user's physiological data in real time, adding a layer of interactivity that would enhance the adaptability of the experience, while increasing attachment towards the therapeutic process. Based on this internal briefing, we initiated the system design.

3 ARCADIA: SYSTEM DESIGN

We present ARCADIA, a mixed reality system envisioned to improve emotional regulation through gamified therapeutic activities. The system's central metaphor is that of a garden, symbolizing the user's therapeutic journey. Currently, ARCADIA offers two therapeutic activities, but its modular design allows for the incorporation of additional activities in the future, extending beyond emotional regulation. We aim for ARCADIA to offer enough flexibility to empower mental health professionals to select a customized set of activities tailored to each patient's specific needs, offering a versatile tool for technology-driven interaction in mental health therapy.

3.1 Co-design process with mental health professionals

The design and development of the ARCADIA system was a collaborative endeavour that actively engaged mental health professionals, including occupational therapists and psychologists. By employing an opportunistic recruiting approach, we established a productive partnership with *Proceso Terapéutico*, a local mental health clinic specialised in CBT and third wave strategies such as mindfulness. This collaborative effort yielded a series of co-design sessions with psychologists who have expertise in a diverse range of mental health disorders. The experts from *Proceso Terapéutico* played a pivotal role in the co-design process by contributing their specialised knowledge to shape and guide the core aspects and design choices of the system. Their input extended beyond mere consultation, as they actively participated in the decision-making process, offering insights that directly influenced the system's functionalities and features. By leveraging their expertise, we were able to extract essential requisites for the system's functionality, ensuring that it aligns with real-world therapeutic needs and practices.

In total, five co-design sessions were conducted, with an approximate duration of 45 minutes each. The sessions were held both in-person and online, aiming to enhance inclusivity and accessibility, drawing on the strengths of each medium to engage a diverse participant group [86]. To ensure consistency across these formats, standardized protocols and materials were adopted [40]. Recognizing the inherent differences between face-to-face and virtual environments, such as in non-verbal communication [37], specific facilitation techniques were implemented to maintain engagement and effectiveness in both settings and to ensure that diverse perspectives were captured and meaningful collaboration fostered.

The first co-design sessions where focused on better understanding how psychologists usually tackle different mental health disorders during in-person consultation. Psychologists also explained the basis for emotional regulation, as well as different strategies based on mindfulness that could be relevant for a wide range of patients' needs. Researchers in HCI who participated in the co-design sessions provided background on how different technological devices and immersive technologies operate, in order to find a common ground for the extent of the system in terms of current needs and capabilities. From the psychologists' point of view, MR offered them an unparalleled context to share with the experience with their patients at the clinic without losing visual contact, while also providing an easy way to allow patients' to practice at home or in other suitable locations.

With that information in mind, both psychologists and researchers actively engaged in brainstorming sessions aimed to define therapeutic activities that could be supported and empowered by MR. After the sessions, we used thematic analysis in order to gather insights from the transcribed sessions and notes [15]. The underlying need was to offer support for the different steps of the beginning of a therapeutic process around emotional regulation, which are transversal to several disorders. First, identifying physiological manifestations of an emotion, mostly focusing on anxiety or fear, while understanding that the emotion cannot harm oneself. Second, providing strategies to be able to calm the emotion once it has been triggered, for example with mindfulness or breathing exercises. And finally, being capable of recognizing the ideas or underlying causes that triggered the emotion, and being able to let those thoughts go away. Another core aspect considered to be extremely relevant was the incorporation of biofeedback within the MR experience, which could help increase their engagement while allowing to reflect on their internal state. As mentioned previously, the therapeutic activities were designed having in mind patients' motivation, therefore gamified components and interactions were envisioned throughout the system. Taking into consideration the different activities proposed by the psychologists, HCI researchers reflected on how these could be intertwined within the same experience providing a cohesive story.

Once the functionality of the ARCADIA experience and therapeutic activities were defined, we followed an iterative development process. We conducted both follow-up sessions as well as specific email consultations with the psychologists in order to validate updates and implemented functionalities.

3.2 Emotional avatar

When a new patient arrives to consultation, one of the first steps in almost each mental health problem is to help the patient to acknowledge, identify and accept the physical symptoms that accompany its condition. For example, patients with anxiety might experience an increased heart rate and respiration pattern, leading to hyperventilation and dizziness. The patients might feel something with their physical health is wrong, before understanding that it is all a byproduct of anxiety and its physical manifestations. Understanding these physical symptoms and how anxiety works could therefore help patients to identify an anxiety attack earlier as well as treat themselves with more kindness when it happens. Within the co-design sessions, psychologists explained that patients are usually asked to visualize their inner state, e.g. their anxiety, as an external separated entity. Each patient selects the representation that they feel more compelled to, however this representation tends to be in the form an animal or imaginary creature.

Therefore, in ARCADIA we introduced a concept we termed the "emotional avatar" (Fig. 3a), a novel approach that aimed to externalise and represent the physiological and emotional state of the user. The emotional avatar was represented within the MR experience as a digital fictional animal, in this case a dragon, illustrating the inner state of the user. This emotional avatar served as a visual representation, intricately mimicking the user's emotional and physiological cues in real time. During the co-design sessions with mental health professionals, we engaged in discussions aimed at identifying the most beneficial biofeedback for our emotional avatar to replicate, as well as determining the optimal sensors in terms of comfort and portability for extracting this feedback. The consensus among mental health professionals was to prioritize two key physiological parameters: heart rate as the primary parameter and users' breathing patterns as a secondary parameter in terms of importance. With regard to the choice of sensors for capturing these physiological parameters, it was determined that utilizing a smartwatch for monitoring heart rate and a respiration band for monitoring breathing patterns would be most advantageous for our purpose, primarily due to its comfort and ability to provide precise and non-intrusive measurements. As the avatar was aimed to mimic the user's internal state, when users inhaled, the avatar mirrored this action, expanding in size, and conversely contracting as users exhaled. This dynamic visual feedback created a direct and immediate connection between the user's emotional state and the avatar's movements. This mechanism allowed users to gain awareness of their emotional fluctuations by observing the avatar's responses, thereby facilitating a heightened sense of emotional self-awareness.

Furthermore, the emotional avatar had an additional profound purpose: foster the development of self-compassion within users. By personifying their emotional experiences through the avatar, users were prompted to nurture a compassionate attitude toward this representation of themselves. This embodiment of their emotions allows for a transformative psychological process, aiming to encourage users to treat themselves with the same care and understanding they would extend to the avatar.

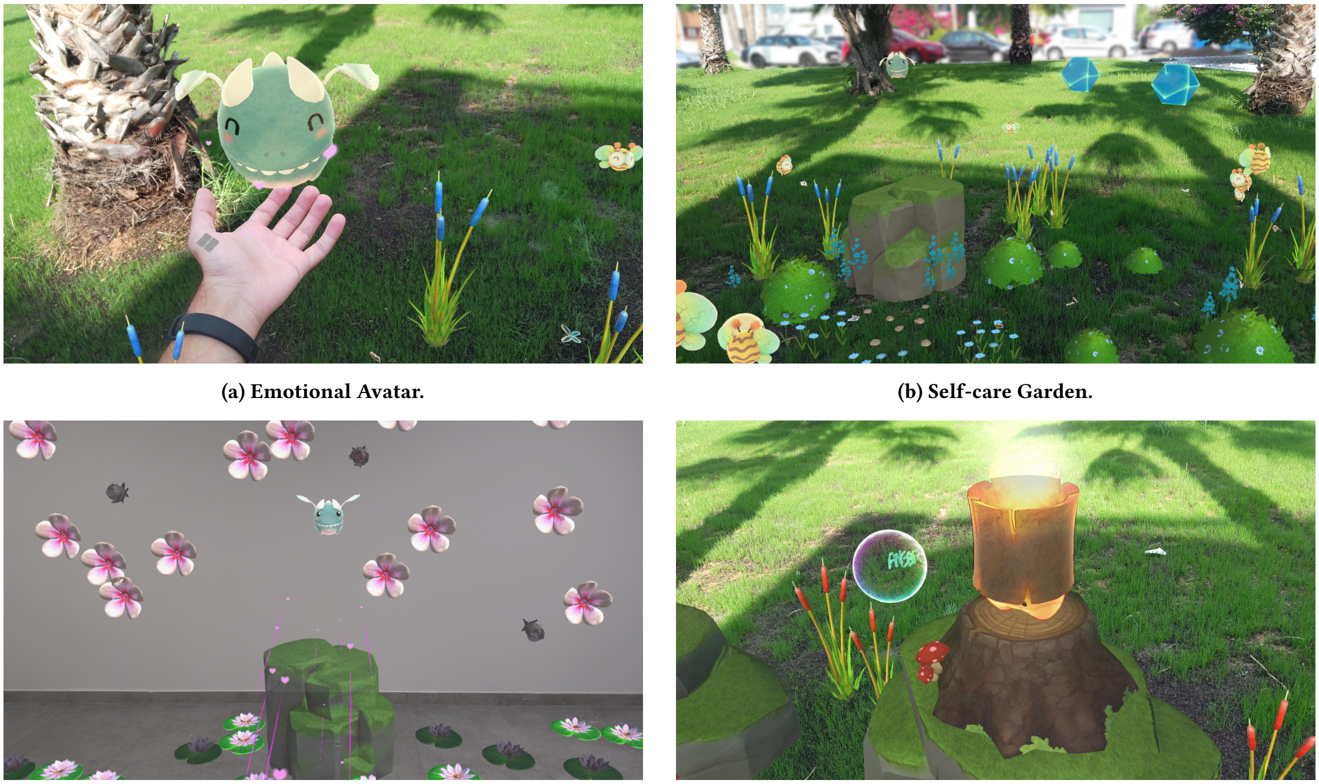
3.3 Self-care garden

As a fundamental component of the ARCADIA system, we encounter the concept of the "self-care garden" (Fig. 3b). We designed it to serve as the central hub of the entire system, acting as a dynamic space where users could interact with the emotional avatar and partake in various therapeutic activities. This decision also served a threefold purpose: 1) it allowed us to introduce the user into the ARCADIA world, presenting the emotional avatar which will accompany the user through the different activities, as well as other required elements such as the activity gems; 2) it serves as a "personal space" in which users can keep track of their progress with gamified metaphors, and 3) it allowed us to build the system in a modular fashion, facilitating the incorporation of future activities into the platform.

We designed the self-care garden in order to serve as more than a visual representation; but to act as a metaphor for the user's emotional well-being. Through engagement in therapeutic activities within the system, users will be rewarded with visual elements that progressively transform their virtual garden. This garden setting serves as an appropriate environment to provide users with a sense of progression through developmental dynamics such as exploration, evolution, or collection. Upon returning to the garden after each activity, they will observe changes resulting from their performance: new creatures, plants that change appearance or colour, and so on. This subtle mechanic fosters engagement for player profiles defined by Bartle [8] as explorers or achievers. The more the users participate in therapeutic exercises, the more their gardens flourish and evolves, becoming lush, colourful, and vibrant — an external reflection of their commitment to self-care and emotional growth.

This metaphor extends beyond rewarding the user and fostering a sense of progression. It was co-designed in order to symbolise the reciprocal relationship between engaging in therapeutic practices and nurturing one's emotional state. Just as tending to a garden requires consistent care, tending to one's emotional well-being demands ongoing attention and investment.

The ARCADIA system can be used at any location, as it harness from the spatial understanding capabilities present in modern Mixed Reality HMDs such as Hololens 2 or Meta Quest 3. ARCADIA considers the user physical space in order order to render the digital elements over the physical world (for example, enabling occlusion of the digital elements from the physical ones, or displaying floral elements in the floor or walls of the user). However, it is recommended that the user has a free area around them of at least 2 meters to be able to completely visualise all the digital elements. At the beginning of the ARCADIA experience users are welcome to the self-care garden, where they meet their emotional avatar, and are then free to walk around and explore the area as much time as they want. Once they feel ready, they can start exploring the available therapeutic activities.



(a) Emotional Avatar. **(b) Self-care Garden.**

(c) Breathing activity. **(d) Intrusive thoughts activity.**

Figure 3: Actual screenshots of the ARCADIA system running on the Hololens 2 HMD.

3.4 Therapeutic activities

The ARCADIA system currently features two distinct therapeutic activities, both with a keen focus on specifics aspects of emotional regulation. However, these activities were not intended to cover the entirety of emotional regulation skills, they served as a demonstration of how certain aspects of emotional regulation could be improved through the use of such systems. Users could initiate and engage with these activities seamlessly from within the system’s central hub, the "self-care garden".

3.4.1 Breathing activity. This activity (depicted in Figure 3c) was co-designed in order to guide users towards a heightened awareness of their own breath, a powerful tool for emotional regulation. It therefore requires the use of a wearable respiration sensor in order to capture the users’ breath movements. Importantly, we did not impose any specific breathing patterns; instead, users were encouraged to simply breathe naturally.

Mindfulness activities around breathing can draw from different visual metaphors to facilitate user’s concentration. For example, imagining breath as a way to channel positive energy into the body, sending compassive energy towards ourselves (when inhaling) and towards others (when exhaling), visualizing a brilliant light that grows and shrinks, etc. In fact, a common meditation exercise is visualizing the heart as a lotus flower, unfolding at the center of the chest. It is this metaphor in which we grounded the basis of our breathing activity for ARCADIA. In the breathing activity, users found themselves in a meadow adorned with closed and withered flowers. As users breathed, directing their attention to each inhalation and exhalation, we intended for them to foster a connection between breath, the flowers, and their emotions. With every exhale, users sent a burst of energy to their emotional avatar, and this energy had a visible effect. As users continued to breathe and channel their focus, the withered flowers in the meadow gradually blossomed, returning to life in a visual representation of emotional release and renewal. This subtle and deferred feedback serves as gamification mechanic in order to increase users’ agency feeling as they actions are able to change the MR environment while avoiding the sense of urgency to complete immediate feedback. Thus, we intended a balance between receiving feedback and it not being intrusive to the focus on breathing rather than changes in the environment. The completion of the activity was signalled when all the virtual flowers had fully blossomed.

3.4.2 Intrusive thoughts. This activity (depicted in Figure 3d) was designed to facilitate a meditative mental state, encouraging users to observe their thoughts attentively. The primary objective was to address intrusive thoughts when they arose. MHPs might use different visual metaphors to help patients avoid rumination, and instead let go of their intrusive thoughts: from imagining that the thought gets frozen into a block of ice, to writing it into paper and destroying it, are some examples.

Within this activity, users were prompted to focus on their stream of thoughts, awaiting the emergence of an intrusive one. Once such a thought surfaced, the user's task was to externalise it by writing it in the air with their hand. This writing gesture was recognised by the MR system, which painted the corresponding digital trails according to the user's hand movements. Once the user finished writing, the word remained floating in front of them. This act of materialisation served to make the intrusive thought tangible, allowing the user to confront it directly.

Following this, users were instructed to transfer the written intrusive thought into a soap bubble. To do so, they have to grasp the bubble directly with their hand, and approach it to the digital representation of their written thought. This transition symbolised the encapsulation of the intrusive thought, isolating it from their immediate consciousness. To conclude the process, users were encouraged to release the soap bubble into a virtual fireplace, effectively disposing of the intrusive thought.

When placing the bubble with the intrusive thought into the fireplace, a recognisable positive sound is received, creating a small reward to activate and reinforce the positive loop. There is no possibility of failure, as if the bubble falls to the ground, it remains there and can be picked up whenever desired. This ensures an accessible mechanic as it does not require skill, aim, or timing. Importantly, users had the autonomy to repeat this sequence as needed, determining when they felt ready to conclude the activity.

4 USER STUDY

To comprehensively evaluate the potential, user experience and suitability of ARCADIA, we also collaborated with *Asociación ACOVA*, a mental health day-care centre. Our study unfolded in two distinct phases, a first one with MHPs from *Proceso Terapéutico* and *Asociación ACOVA*, and the second one with the users of *Asociación ACOVA* mental-health service, each offering valuable insights into the system's feasibility and impact.

4.1 Study design

The goal of this study was to understand the perceptions, feelings and affordances that the ARCADIA system would arise on mental health patients, and its potential to be used as an additional tool for MHPs in their clinical practice regarding emotional regulation. The study was therefore organised in two phases: (1) first with MHPs, in order to gain insights on the feasibility of using the ARCADIA system with mental health patients, as well as to gather feedback about certain design aspects that could conflict with specific conditions of end users, and (2) second, with patients, so that we could have firsthand information about the user experience of using the ARCADIA environment for therapy in a quasi-real clinical setting.

The user study was designed in order to comply with appropriate ethical and legal standards, fulfilling the ACM Publications Policy on Research Involving Human Participants and Subjects and compliant with national and international standards such as The Declaration of Helsinki, The Belmont Report, and The Common Rule. Additionally, the experimental design was over sighted and approved by the direction of the *Asociación ACOVA* centre, falling upon them also the task of subsequently tracking the impact of the study on the centre's patients.

Table 1: MHPs' post-questionnaire

#	Value from 0 to 10 the following aspects:
TQ1	Therapeutic potential of ARCADIA's therapeutic activities
TQ2	Ease of use of self-care garden
TQ3	Ease of use of breathing activity
TQ4	Ease of use of intrusive thoughts activity
TQ5	Therapeutic usefulness of the breathing activity
TQ6	Therapeutic usefulness of intrusive thoughts activity

4.1.1 Methodology. In order to comprehensively capture participants' insights on their ARCADIA user experience, the choice was made to employ a mixed methods approach as it blends strengths from both qualitative and quantitative research, bridging the gap between positivist and non-positivist approaches. From the different mixed methods approaches, we decided to follow the Concurrent Triangulation Strategy [2] as it is a robust and flexible approach that operates on the simultaneous collection of data through qualitative and quantitative methods.

While the user study procedure remained mostly equal for both target groups, our aim for each group was different and therefore we administered each group with different questionnaires. In the case of the user study with MHPs, no pre-questionnaire was administered, and they were only required to complete an online post-questionnaire. This included a User Experience Questionnaire (UEQ) [47], and six questions with 10-base scoring regarding their experience and their perceptions about whether the proposed solution could be applied in their professional practice (see Table 1). Participants from the patients group required to complete a pre and post 5-points Self-Assessment Manikin (SAM) and a 5-point Likert-scale questionnaire regarding their experience. Regarding the qualitative data, during the sessions we recorded verbal feedback from the participants and observational notes from the researchers, which were later analyzed and contrasted with their quantitative results from the questionnaires. It should be noted that the study was conducted in Spanish, and the reported questionnaires and results in this manuscript have been translated to English.

4.1.2 Participants. In the initial phase, we recruited MPHs from two different entities and professional backgrounds. We engaged the psychologists from *Proceso Terapéutico* who had already been involved in the system design. In order to provide a more objective assessment of the system and also validate its suitability to different scenarios, we established contact with another entity, *Asociación ACOVA*. *Asociación ACOVA* is a local mental health day centre, and provides services to foster personal autonomy with people with functional diversity and mental health disorders. The professional qualifications of the mental health workers of *Proceso Terapéutico* was clinical psychology, while for *Asociación ACOVA* it was occupational therapy. In both scenarios, they introduce and practice emotional regulation activities among their patients. Our MHPs consisted on 21 participants (18 identified as woman, 3 as man), with an average age of 39 years old (SD: 10.84, range 20-58). Six of the MHPs worked at *Proceso Terapéutico* and 15 at *Asociación ACOVA*. Regarding their previous experience with VR, 14 MHPs had already used a VR HMD while 7 of them had no previous experience with immersive technologies at all. It has to be noted that only 2 MHPs from *Proceso Terapéutico* had tried a MR HMD before this study, while for the rest of the participants this was their first experience with MR.

For the second phase, we conducted the evaluation with patients from the day centre *Asociación ACOVA*. The recruitment of participants was made by the MHPs following a combination of purposive and convenience sampling [56], taking into account the everyday circumstances inherent to a day centre (users transitioning between guided activities, with established routines, schedules, etc.), and the personal characteristics of the patients Our patient participants consisted on 23 people (14 identified as man, 9 as woman) with an average age of 50 years old (SD: 7.22, range 35-60). The study included individuals with a wide range of capacities and cognitive abilities, reflecting the heterogeneous nature of the target population. All of the participants were regular patients of the day centre with different diagnostics, which consisted mostly of schizophrenia or personality disorders. All of the patients were stable at the time they participated in the study, and their participation was voluntary as it was offered as another activity of the day centre. The proposed study has been an initial validation of the ARCADIA system, focused on user experience and therapeutic potential. We aimed for it to be a motivating activity for the participants, allowing them to feel free to express their opinions as future ARCADIA users and not as current patients being evaluated as in clinical interventions. Hence, we preferred not to conduct further follow-up evaluations rather than the one conducted the day of the study.

4.1.3 Apparatus and material. The experimental set-up (depicted in Figure 4) consisted of a Mixed-Reality optical see-through head mounted display (OST-HMD), specifically the Microsoft Hololens 2, a Piezo-Electric Respiration (PZT)[1] wearable sensor connected to a BITalino Core[2] from PLUX Biosignals, and a ZMQ broker, running on the experimenter laptop, that centralises the data communication between the MR headset and the wearable sensors. The ARCADIA MR application was developed using Unity (2020.3.47f1), OpenXR (1.5.1) and MRTK (2.8.2).

4.1.4 Procedure. Prior to performing the MR therapeutic activities, the participant was given an brief introduction to the research project and their role within the user study by one of the researchers. All participants were asked to fill-in consent forms for their participation in the study, as well as GDPR and basic demographic information (full name, age, gender). Only in the case of the mental health patients, they were required to fill-in the SAM pre-questionnaire. For each participant, there were always two researchers in the room, one of them taking care of the explanations and guiding the participant through the activities, while the other researcher was taking annotations and guaranteeing the correct functioning of the MR streaming and wearable sensors.

The study sessions were conducted in a room with a cleared space of approximately four meters wide and five meters long, in which the participant was located in the centre at the beginning of the activity. The MR application allows to recognise the room

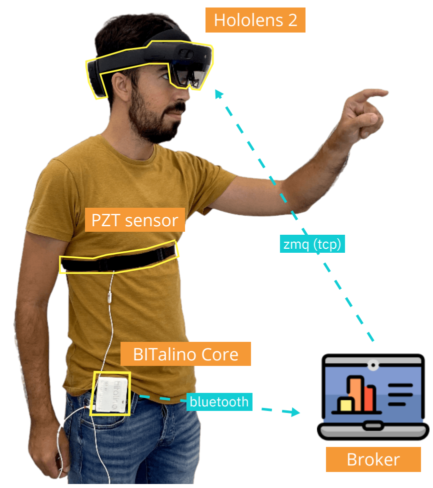


Figure 4: User study system setup.

(objects, floor and walls), and set-up the floor position to adapt the MR content to the current space. Before starting the activity, the respiration sensor was placed on the participant's chest, and the HMD was placed and adjusted to the participant's field of view and comfort. Once the devices were worn by the participant, they could then move freely around the room and explore the MR content. During the evaluation, each participant could explore three different scenes: the self-care garden, the breathing activity, and the intrusive thoughts activity. All participants started in the self-care garden to familiarise themselves with the MR technology and the emotional avatar, and once they were ready they could enter one of the proposed therapeutic activities. To counterbalance the effect, half of the participants started with the breathing activity followed by the intrusive thoughts one, while the other half did the opposite.

After the three activities were explored and the participants expressed they were contented about finishing the experience, the HMD and wearable sensors were turned off and removed. As a final stage, the MHPs were asked to fill the UEQ questionnaire while patients were asked to fill again the SAM post-questionnaire and the post-experience qualitative questions. In total, the average duration of each session including pre and post-questionnaires was 15-20 minutes.

4.2 Results

4.2.1 Mental health professionals. We analysed the results for each entity separately as *Proceso Terapéutico* participated in the co-design sessions and therefore their ratings might be more favourable. For the user experience questionnaire (UEQ), the items are scaled from -3 to +3, with values > 0,8 represent a positive evaluation and values < -0,8 represent a negative evaluation. As expected, *Proceso Terapéutico* results were slightly more positive than *Asociación ACOVA* (Figure 5) even when there is no significant statistical difference, as shown in Table 2.

The UEQ questionnaire results indicate no statistically significant differences between the two companies across all variables, as all p-values exceed .05. This suggests no evidence of perceptual

[1]https://www.pluxbiosignals.com/products/respiration-pzt
[2]https://www.pluxbiosignals.com/products/assembled-bitalino-core-ble-bt

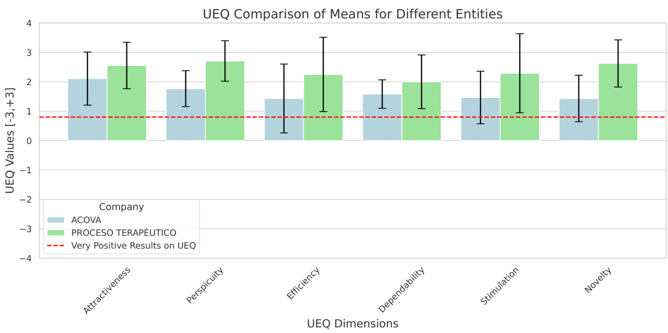


Figure 5: MHPs scores for the UEQ questionnaire.

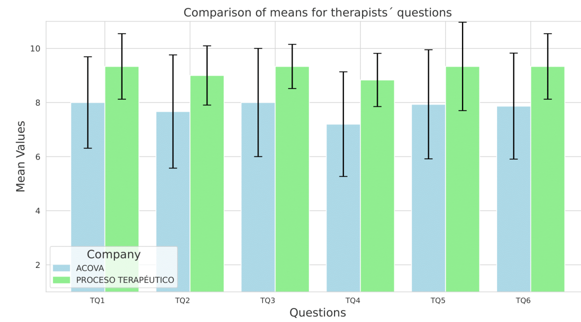


Figure 6: MHPs quantitative questions.

differences in Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty between the companies. However, Cohen's d effect sizes point to notable practical differences, with Dependability showing the largest effect size (.9510), indicating a significant difference despite the lack of statistical significance. A small sample size could limit the study's power to detect true differences, potentially explaining these findings.

Results for MHPs Quantitative Questions indicates no statistically significant differences across all variables, as reflected by p-values greater than .05. Nonetheless, Cohen's d values suggest substantial practical differences, particularly in TQ4 (.9510) and TQ1 (.8501), highlighting higher average scores for the *Proceso Terapéutico* group compared to the *Asociación ACOVA* group, despite statistical insignificance. This may be attributed to small sample sizes or high variability, emphasizing the importance of considering both statistical and practical significance in interpreting results.

All of the participants except 2 (1 from *Proceso Terapéutico* and 1 from *Asociación ACOVA*) stated that they would use ARCADIA in their professional activity with patients. In addition, all participants indicated that they would recommend the ARCADIA system to another colleague in their professional environment. Regarding comfort, only 2 participants from *Asociación ACOVA* indicated that the wearable sensors and cables might be uncomfortable for their patients.

4.2.2 Mental health patients. The results of the SAM questionnaires (see Figure 7 and Figure 8) indicate a slight increase in valence levels, from an initial average of 4.38 (SD=0.64) to a post-questionnaire average of 4.80 (SD=0.39). Arousal levels remained relatively stable, from a pre-questionnaire average of 2.96 (SD=1.20) to a post-questionnaire average of 3.34, but with a higher standard deviation (SD=1.42). Dominance ratings, on the other hand, showed a consistent increase, with pre-questionnaire averages at 3.80 (SD=1.07) and post-questionnaire averages at 4.57 (SD=0.58). As shown in Table 4, the psychological variables Valence and Dominance revealed significant changes before and after the experience, as indicated by their respective p-values of 0.0067 and 0.0099. In contrast, the variable Arousal did not exhibit a significant change, with a p-value of 0.1097.

The SAM questionnaire results reveal statistically significant changes in Valence and Dominance post-intervention, as indicated by p-values below .05. The effect sizes (Cohen's d) for Valence (.67) and Dominance (.61) suggest moderate practical differences. However, Arousal, despite showing a change, does not reach statistical significance (p-value .1097), with a smaller effect size (.33), suggesting a less pronounced difference.

The Likert-scale questions with mood scales were aimed towards understanding patients' experience in terms of attractiveness (PQ1), emotional impact (PQ2), willingness to use ARCADIA again (PQ3 and PQ4), stimulation (PQ5), efficiency (PQ6), and comfort (PQ7 and PQ8). Besides the Likert-scale questions, patients also answered several open-ended questions to better understand their ratings. Regarding the attractiveness, all participants rated their likeliness of the ARCADIA user experience as high (30%) or very high (70%), with participants reporting that "*It was an unforgettable experience*", "*It was an enriching experience*" or "*I had never seen anything similar when using the hand in the glasses' reality and I was surprised*".

In terms of how the experience affected their emotions and mood, 4% of the participants did not experience any changes in their mood, while only 9% of the participants indicated to be feeling a bit nervous. The great majority (86%) of the participants described feeling calmer after using ARCADIA, with quotes such as "*I felt calm*", "*Breathing with the puppet made me relax*", "*I felt relaxed*", "*I felt very good*". In fact, almost all participants (96%) reported that, to some degree, the experience might help them feel better when they are upset, even the participants who reported feeling a bit nervous after their first use. Concerning whether they would like to use ARCADIA again, 91% of the patients reported that they would, with comments such as "*I loved the experience. I would take it home*". Only 4% of participants did not want to use it again, while 4% were not sure about their answer.

The MR environment was considered to be fun (26%) or very fun (74%), and 70% of the participants found ARCADIA to be easy to use. Only 22% participants experienced a minor degree of difficulty during their usage of the system. There were no major problems regarding comfort, as most of the participants reported both the HMD (92%) and the wearable sensors (87%) to be comfortable. Only 4% of participants reported the HMD to be a bit uncomfortable, reporting "*The glasses were a bit tight and felt uncomfortable*" or "*The warmth of the helmet*".

Additionally, participants were invited to provide both positive and negative feedback, with an opportunity to include additional comments or suggestions. Among the prevalent positive comments,

Figure 7: Answers from SAM questionnaire.

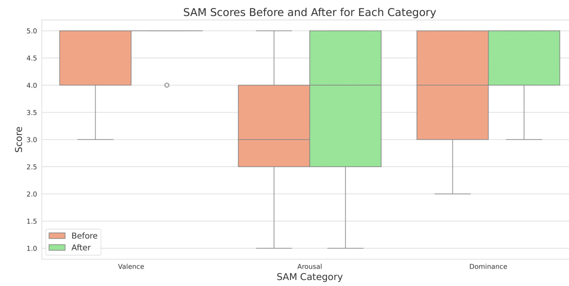


Figure 8: Data distribution for SAM questionnaire.

participants frequently expressed their appreciation for the Emotional Avatar and characterised the overall experience as profoundly relaxing. Some participants conveyed sentiments such as "*breathing with the dragon was relaxing*", or "*hearts appeared when you touched the dragon, that was very nice*". Conversely, common negative aspects mentioned by participants included challenges in accurately writing their intrusive thoughts in the air and a perception of the activity's brevity. Comments like "*I was writing very badly*", and "*I found the experience rather brief*" were recurrent. In the section for additional suggestions, a recurring theme emerged, with participants expressing a desire for greater diversity in elements within the system and more interactive possibilities with these elements.

5 DISCUSSION

Based on the aforementioned results, the overall user experience for both MHPs and patients can be described as very positive. Both target groups considered ARCADIA to be a novel and interesting tool. It is worth noticing that MHP from two different backgrounds and with patients with very different needs stated their willingness to use the proposed system, with no significant statistical differences, as shown in Figure 6 and Table 3. They considered that the two therapeutic activities as well as the overall ARCADIA experience have an appealing therapeutic potential, demonstrating the possibilities of MR for mental health treatment akin to VR [92]. On one hand, the self-care garden and the emotional avatar allow to create very different tasks by just changing the narrative and the context in which they use the system. On the other hand, the breathing activity and the intrusive thoughts activity were already known practices that MHPs from both entities currently use with some of their patients. In traditional non-technological interventions, the activity is adapted and explained differently depending on the target goal, the patients' needs, and cognitive abilities, but the core idea remains the same. Therefore, having a technological intervention that could support all those different activities while keeping the patients motivated would be a great addition to their professional practice. There are already related works with VR that allow MHPs to select between different simulated scenarios for exposure therapy depending on the patient's needs [57, 79]. Other works have rather focused on gamified experiences that might include biofeedback but follow the same narrative for every user [12]. With ARCADIA, we combined these two approaches: on one hand, ARCADIA provides a single platform in which the therapeutic activities that will be available can be selected for each patient. On the other hand, the activities are gamified and provide a personal experience for each user.

Regarding the effect of the experience on patients' emotions, the SAM might not have been as clarifying as intended for such a short and timely intervention. Patients came to the study already motivated, hence the high values on the prequestionnaire for arousal. Even thought they indicated to feel more calm and relaxed after using ARCADIA, arousal levels increased slightly. Overall, valence levels showed a slight increase, reflecting a positive emotional shift following the intervention. In addition, according to the quantitative results, patients felt more in control after using the system. This is a remarking result considering that mental health patients tend to blame themselves or underestimate their capabilities. It could be that they were a bit nervous before using a mixed reality system for the first time, not knowing whether they would enjoy it or be able to complete the activities successfully. The novelty effect might have also been a factor influencing the responses. Hence, it would be interesting to evaluate responses to the SAM questionnaire during a long-term study. This would help assess not only how the novelty effect develops over time, but also whether the gamification elements help to maintain the user's motivation as well as the perceived novelty of the system, as it was previously stated by Hadley (2019) when comparing game based with traditional interventions. Regarding motivation, while some participants had difficulties during the writing part of the intrusive thoughts activity, the gamified activities do not reward nor classify the performance and actions into positive or negative. Hence, patients' feelings of self-confidence and control might have increased over time, which can be also observed in their willingness to use the system another time.

Another aspect we considered very relevant to be able to reach a wider population was the ease of use of the system. Overall, the system was considered to be easy to use by both MHPs and patients, and observational results did not yield any major problems throughout the whole study. Mental health professionals from both collaborating entities rated the six categories from the UEQ above the threshold to be considered as very positive results. However, two minor issues were observed during the evaluation with MHPs that were corrected for the study with patients: starting and finishing a therapeutic activity, and starting the writing feature within the intrusive thoughts activity. In both cases, this was due to a poor accuracy in hand tracking recognition, which was solved either by simplifying the detected gesture or adding visual clues to notify the

Table 2: Results of the Statistical Tests for UEQ questionnaire

Variable	Normality Asociación ACOVA	Normality Proceso Terapéutico	Test Used	Statistic	P-Value	Cohen's d
Attractiveness	Not Normal	Normal	Mann-Whitney U	31.50	.3019	.8501
Perspicuity	Not Normal	Not Normal	Mann-Whitney U	24.00	.1025	.715
Efficiency	Normal	Normal	T-test	-1.95	.0663	.7638
Dependability	Normal	Normal	T-test	-1.13	.2728	.9510
Stimulation	Not Normal	Not Normal	Mann-Whitney U	31.50	.3066	.7311
Novelty	Not Normal	Not Normal	Mann-Whitney U	21.50	.0646	.8250

Note: P-values lower than 0.05 indicate significant differences.

Table 3: Results of the Statistical Tests for MHPs Quantitative Questions

Variable	Normality Asociación ACOVA	Normality Proceso Terapéutico	Test Used	Statistic	P-Value	Cohen's d
TQ1	Not Normal	Not Normal	Mann-Whitney U	24.0	.0963	.8501
TQ2	Normal	Not Normal	Mann-Whitney U	27.0	.1620	.7156
TQ3	Not Normal	Normal	Mann-Whitney U	26.0	.1368	.7638
TQ4	Normal	Not Normal	Mann-Whitney U	21.0	.0599	.9510
TQ5	Normal	Not Normal	Mann-Whitney U	24.5	.0985	.7311
TQ6	Normal	Not Normal	Mann-Whitney U	23.5	.0909	.8250

Note: P-values lower than 0.05 indicate significant differences.

Table 4: Results of the Statistical Tests for SAM questionnaire (Valence, Arousal, and Dominance)

Variable	Normality Before	Normality After	Test Used	Statistic	P-Value	Cohen's d
Valence	Not Normal	Not Normal	Wilcoxon Signed-Rank Test	0.0	.0067	.67
Arousal	Not Normal	Not Normal	Wilcoxon Signed-Rank Test	23.0	.1097	.33
Dominance	Not Normal	Not Normal	Wilcoxon Signed-Rank Test	10.0	.0099	.61

Note: P-values lower than 0.05 indicate significant differences.

user. After these changes, no users were observed to have difficulties with the hand detection in either case.

Based on the reported results, the intrusive thoughts activity was usually considered to be more difficult than the rest of the system. This might be due to the fact that it entailed different steps, including hand tracking recognition and interaction. For the HMD to be able to recognise the writing gesture, the hand should be perfectly visible within the device's Field of View (FOV), which might be limited and thus required users to make an additional effort. Users could also move freely around the space, hence objects such as the bubble or the hand written text might not be visible at some points, requiring the user to turn around and move their head in order to find the element within their FOV. Therefore, this therapeutic activity seems to have a more pronounced learning curve as it might required additional coordination.

One of the concerns of mental health professionals when they use additional elements within the therapeutic process, such as XR headsets, is that patients might get distracted or might not delve into the activity as much as they should. However, this was not our case when using a mixed reality headset and a lightweight sensor, as neither MHPs nor patients found the headset and wearable sensors to be interfering with their experience. MHPs were satisfied with the hardware, and only two mental health patients reported to be experiencing some discomfort with the headset which in turn did not seem to greatly affect their overall satisfaction. No participant reported nor showed any sign of VIMS during the sessions. In fact, the use of MR facilitated the experience for patients who typically wouldn't tolerate VR headsets, while offering an engaging experience [6].

Focusing on emotional regulation activities has demonstrated to be a promising strategy to provide technological platforms capable of catering to a wide range of professionals and patients. In our design process and user study, we had a very diverse pool of participants in terms of MHPs' backgrounds, patients' cognitive abilities and therapeutic needs. This diversity ensured a comprehensive representation of potential users and enriched the study's findings by accounting for varying cognitive responses and preferences within the context of the ARCADIA mixed reality system for emotional regulation. In this context, several common aspects emerged from the qualitative and observational results. The emotional avatar has been an essential feature within the system, with many patients reporting it as one of their most liked aspects. It evoked empathetic responses and self-compassion, as patients wanted to care, caress and interact with the avatar that was mimicking their breathing. This representation of one's own physiological activity aided users in their emotional regulation efforts, as previously stated in works by Li (2010) and Insel (2016): awareness through real-time biofeedback facilitates emotional regulation. Another common feature that several patients reported was their willingness to have more varied elements, and also personalised ones.

Figure 9: Likert scale questions were presented with a mood selector. Following recommendations from the W3C on working with users with cognitive and learning disabilities.

6 STUDY LIMITATIONS

In this section, we examine the limitations of our user study, shedding light on areas that could hinder the generalisation of our results and where our research may benefit from further investigation.

A crucial limitation of our study pertains to the scope and duration of the research. To comprehensively assess the impact of mixed reality systems like ARCADIA on mental health treatment adherence, a more exhaustive longitudinal study is needed. Our study provided valuable insights into the initial usability and engagement aspects, but the full extent of the system's effectiveness in fostering long-term treatment adherence and its impact on mental health outcomes requires a more extended examination over time.

Another limitation of our study lies in the homogeneous nature of our sample, mainly middle-aged Spanish mental health users diagnosed primarily with schizophrenia or personality disorders, lacking wide representation across various mental health conditions, age groups, or nationalities. This limits the applicability of our ARCADIA system findings to a broader audience. Additionally, selection bias from participants favorably predisposed to Mixed Reality (MR) technology might have skewed the results positively, with the novelty effect potentially inflating initial enthusiasm that may not indicate long-term engagement. Future studies should aim for a more diverse participant pool and examine enduring impacts beyond the initial exposure.

While we gathered valuable qualitative insights and user feedback based on self-reported evaluations, physical and physiological measurements would have provided a more objective and quantifiable assessment of the therapeutic benefits of our mixed reality interventions. These metrics could offer concrete evidence of the system's effectiveness in improving emotional regulation and mental health outcomes.

The MR device, Microsoft HoloLens 2, used in our study, has a smaller Field of View (FOV) compared to newer MR headsets like the Meta Quest 3. A limited FOV may reduce presence and hinder user experience by limiting visual engagement. Additionally, the smaller FOV can result in occasional loss of hand tracking recognition and challenges with intricate hand movements or gestures beyond the device's visual range. Therefore, comparing our study's results with newer devices with broader FOV would be relevant to understand the impact on overall experience.

In all cases, the effect of the intervention will be dependent on several factors. For example, current devices for MR might not be affordable for some end users or some mental health clinics. Additionally, it's essential to recognize that the effectiveness of CBT is not one-size-fits-all. For example, there is evidence that patients with comorbid severe personality disorders such as antisocial personality disorders or several cognitive impairments are difficult to manage through CBT [30]. Different therapeutic approaches can be effective for different individuals and conditions. Evidence-based practices like CBT are essential, but they are not the only valid option, and the choice of therapy should be made collaboratively between the MHP and their patient based on what is most likely to be effective and comfortable for the individual.

7 DESIGN IMPLICATIONS

Through ARCADIA's design and evaluation, we've gained insights benefiting future practitioners in developing mixed reality systems for mental health. These implications, from our practical experience, offer guidance for the enhancement of user engagement, therapeutic efficacy, and systems' impact on emotional well-being and treatment adherence.

7.1 Keep it simple, but not boring

While designing and testing ARCADIA we learned about the importance of incorporating multiple interactions while keeping them notably simple. In the realm of therapeutic gamified activities within a mixed reality context, striking this balance is pivotal for user engagement and effectiveness. Feedback based on bodily sensations is recommended to be represented in a subtle way [25], contextualised with the experience and in a non-distracting way [5]. However, when activities require users to adopt an overly passive role, such as the breathing activity, where interaction solely involved inhaling and exhaling, users may quickly succumb to boredom and disengagement if repeated over time. Hence, gamification in such a context is crucial to add motivating and arbitrary component that would keep the user interested. In our case, the emotional avatar and the flowers added a narrative layer in which the user has to focus on its breath with a clear purpose that each time will be achieved differently, while they can also interact with the avatar. Conversely, implementing highly intricate interactions, as seen in the intrusive thought activity, where users transition between drawing, interacting, manipulating objects, and navigating virtual spaces, could lead to frustration. This complexity is exacerbated by the current limitations of contemporary mixed reality devices. Hence, it is imperative achieving a delicate equilibrium between engagement and simplicity in interaction design. By offering a range of interactions that are intuitively graspable yet sufficiently engaging, we can enhance the user experience while accounting for the inherent constraints of present mixed reality technology while allowing for a more accessible experience.

7.2 Freedom in guidance

A further key aspect when designing therapeutic activities in MR involves striking a balance between facilitating free-will interaction (user autonomy / user agency) and guiding users through the intended experience. This balance is crucial in ensuring that users can

Table 5: Likert-scale post-questionnaire for mental health participants.

Item	Question	1	2	3	4	5
PQ1	How did you find the experience?	Didn't like at all	Didn't like	Neither like nor dislike	Liked it	Liked it a lot
PQ2	How do you feel after the experience?	Very nervous	A bit nervous	I feel the same	A bit calm	Very calm
PQ3	Do you think it could help you feel better when you feel upset?	Not at all	I don't	I don't know	I do	For sure
PQ4	Would you like to experience it again?	Not at all	I don't	I don't know	I do	For sure
PQ5	Did you find it fun?	Very boring	Boring	Neither too much nor too little	Fun	Very fun
PQ6	Did you find it difficult?	Very difficult	Difficult	Neither too much nor to little	Easy	Very easy
PQ7	How did you find the head mounted display?	Very uncomfortable	uncomfortable	Neither too much nor too little	Comfortable	Very comfortable
PQ8	How did you find the sensors and cables?	Very uncomfortable	uncomfortable	Neither too much nor too little	Comfortable	Very comfortable

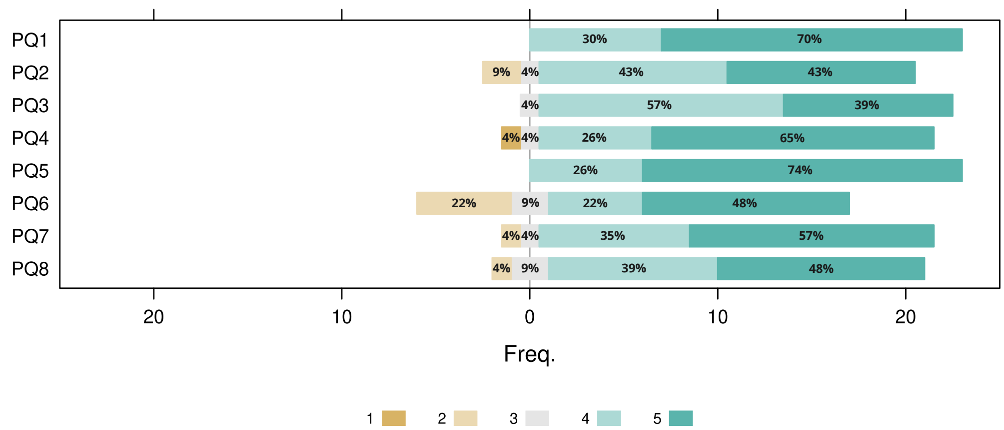


Figure 10: Results of the participants Likert-scale post-questionnaire regarding their experience.

engage meaningfully with the system while maintaining a sense of agency. In ARCADIA, users encountered spaces like the self-care garden that encouraged them to explore freely, fostering a sense of autonomy. However, in activities such as the intrusive thoughts exercise or the breathing activity, a structured sequence of steps was essential to achieve the therapeutic goals. Yet, we observed instances where users deviated from these prescribed steps, shifting their field of view away from the intended holographic MR elements, oblivious of them. To address this issue, practitioners should consider implementing strategies that gently guide users through key aspects of the experience, perhaps through narration or visual cues, without imposing rigid constraints. This approach allows users to remain active participants while ensuring they are aware of the significant elements within the activity. It strikes a harmonious balance, empowering users to navigate the experience in a way that feels meaningful and engaging while not compromising the therapeutic integrity of the MR activity.

7.3 Location is key

Another crucial design implication that our experience with the ARCADIA system has highlighted is the necessity of adapting MR content to the user's FOV by considering different layers of spatial placement. This multifaceted approach entails placing elements within the user's near space, medium space, and far space, while adjusting the elements' size and associated interactions accordingly. In the context of near space, elements should be positioned close to the user, within arm's reach or direct gaze. These elements typically involve immediate interactions that require minimal physical effort from the user. Due to current limitations of MR headsets, locating medium or large digital elements near the user might break the immersive sensation as the content cannot be fully visualised. Elements positioned in the far space are situated at a considerable distance from the user, hence they could be of greater size (e.g. high bushes or trees). Interactions with these elements usually necessitate locomotion, extended movements, gaze interaction or no direct interaction at all. Moreover, MR requires careful design of the digital environment taking into consideration that each physical location might be different, considering also occlusions and physical objects in the area. By structuring MR content in this layered manner and aligning interactions accordingly, designers can optimise the user experience.

8 CONCLUSION

In this paper, we investigated how MR technology could be used to successfully design and develop gamified therapeutic activities that could potentially improve mental health patients' adherence and motivation. We presented ARCADIA, a MR system based on gamified therapeutic activities to support emotional regulation for wellbeing and mental health treatment, which has been co-designed with mental health professionals. We reported on a double study: one involving mental health professionals to assess the user experience and therapeutic potential, and another with patients to evaluate the user experience and perceived benefits, specifically in terms of emotional regulation and self-compassion. Our study unveiled promising outcomes in terms of using MR systems for emotional regulation in a wide range of mental health patients. Overall, the system was motivating, innovative and easy to use. Our study revealed that mental health professionals considered ARCADIA to be a promising tool for their clinical practice, while patients showed interest in continuing using the application. Our reports on user experience from both mental health professionals and patients provided with deeper understanding on the capabilities and limitations of MR gamified systems. Additionally, we identified and discussed a series of limitations in our approach itself and in the current state of MR technology. This work constitutes a significant first step toward the integration of MR technology into mental health care, paving the way for innovative, personalised, and highly effective therapeutic interventions.

Additionally, we identified several promising directions for future research. The realm of personalisation stands as a key frontier within XR therapeutic experiences. As a diverse array of therapeutic activities continues to be developed, a compelling frontier lies in the potential of generating procedural activities in real-time, driven by user profiles and biofeedback, using generative AI technologies. Another promising avenue is the facilitation of collaborative scenarios, whether in remote or co-located settings. Allowing patients and MHPs to coexist within the same mixed reality space, engaging with the same virtual elements, could offer new dimensions to group therapy by enabling individuals from different geographical locations to participate seamlessly in shared experiences. Beyond traditional therapy, such MR collaborative systems have the potential to profoundly shape the future of the metaverse for mental health, revolutionising how individuals access and benefit from therapeutic interventions in an increasingly digital world.

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REFERENCES

[1] Sven Alfonsson, Karin Johansson, Jonas Uddling, and Timo Hursti. 2017. Differences in motivation and adherence to a prescribed assignment after face-to-face and online psychoeducation: an experimental study. *BMC Psychology* 5, 1 (dec 2017), 3. https://doi.org/10.1186/s40359-017-0172-5

[2] Fernando Almeida. 2018. Strategies to perform a mixed methods study. *European Journal of Education Studies* (2018).

[3] Amelia Virtual Care [n. d.]. *Virtual Reality for Mental Health Professionals*. Retrieved September 1, 2023 from https://ameliavirtualcare.com/

[4] Joaquin A Anguera, Faith M Gunning, and Patricia A Areán. 2017. Improving late life depression and cognitive control through the use of therapeutic video game technology: A proof-of-concept randomized trial. *Depression and anxiety* 34, 6 (2017), 508–517.

[5] Pasquale Arpaia, Giovanni D'Errico, Lucio Tommaso De Paolis, Nicola Moccaldi, and Fabiana Nuccetelli. 2022. A Narrative Review of Mindfulness-Based Interventions Using Virtual Reality. *Mindfulness* 13, 3 (2022), 556–571. https://doi.org/10.1007/s12671-021-01783-6

[6] Beatrice Aruanno and Franca Garzotto. 2019. MemHolo: mixed reality experiences for subjects with Alzheimer's disease. *Multimedia Tools and Applications* 78, 10 (2019), 13517–13537. https://doi.org/10.1007/s11042-018-7089-8

[7] Ronald T Azuma. 1997. A survey of augmented reality. *Presence: teleoperators & virtual environments* 6, 4 (1997), 355–385.

[8] Richard Bartle. 1996. Hearts, clubs, diamonds, spades: Players who suit MUDs. *Journal of MUD research* 1, 1 (1996), 19.

[9] L. Beatty and C. Binnion. 2016. A systematic review of predictors of, and reasons for, adherence to online psychological interventions. *International Journal of Behavioral Medicine* 23 (2016), 776–794. Issue 6. https://doi.org/10.1007/s12529-016-9556-9

[10] Amelia J Birney, Rebecca Gunn, Jeremy K Russell, and Dennis V Ary. 2016. MoodHacker mobile web app with email for adults to self-manage mild-to-moderate depression: randomized controlled trial. *JMIR mHealth and uHealth* 4, 1 (2016), e4231.

[11] Thomas Bjørner. 2023. Using EEG Data as Dynamic Difficulty Adjustment in a Serious Game about the Plastic Pollution in the Oceans. In *Proceedings of the 2023 ACM Conference on Information Technology for Social Good* (Lisbon, Portugal) *(GoodIT '23)*. Association for Computing Machinery, New York, NY, USA, 6–15. https://doi.org/10.1145/3582515.3609512

[12] Johannes Blum, Christoph Rockstroh, and Anja S. Göritz. 2019. Heart rate variability biofeedback based on slow-paced breathing with immersive virtual reality nature scenery. *Frontiers in Psychology* 10, SEP (2019). https://doi.org/10.3389/fpsyg.2019.02172

[13] Arianna Boldi and Amon Rapp. 2022. Commercial video games as a resource for mental health: A systematic literature review. *Behaviour & Information Technology* 41, 12 (2022), 2654–2690. https://doi.org/10.1080/0144929X.2021.1943524

[14] Jelte E Bos, Willem Bles, and Eric L Groen. 2008. A theory on visually induced motion sickness. *Displays* 29, 2 (2008), 47–57.

[15] Victoria. Braun and Victoria Clarke. 2021. Thematic analysis: a practical guide.

[16] Kim CM Bul, Lisa L Doove, Ingmar HA Franken, Saskia Van der Oord, Pamela M Kato, and Athanasios Maras. 2018. A serious game for children with Attention Deficit Hyperactivity Disorder: Who benefits the most? *PloS one* 13, 3 (2018), e0193681.

[17] Kim CM Bul, Pamela M Kato, Saskia Van der Oord, Marina Danckaerts, Leonie J Vreeke, Annik Willems, Helga Jj Van Oers, Ria Van Den Heuvel, Derk Birnie, Thérèse AMJ Van Amelsvoort, et al. 2016. Behavioral outcome effects of serious gaming as an adjunct to treatment for children with attention-deficit/hyperactivity disorder: a randomized controlled trial. *Journal of medical Internet research* 18, 2 (2016), e26.

[18] Karl-Erik Bystrom, Woodrow Barfield, and Claudia Hendrix. 1999. A conceptual model of the sense of presence in virtual environments. *Presence: Teleoperators & Virtual Environments* 8, 2 (1999), 241–244.

[19] Joanne Carroll, Louise Hopper, Aaron Mark Farrelly, Richard Lombard-Vance, Panagiotis D Bamidis, and Evdokimos I Konstantinidis. 2021. A scoping review of augmented/virtual reality health and wellbeing interventions for older adults: redefining immersive virtual reality. *Frontiers in Virtual Reality* 2 (2021), 655338.

[20] Ian Chard and Nejra van Zalk. 2022. Virtual Reality Exposure Therapy for Treating Social Anxiety: A Scoping Review of Treatment Designs and Adaptation to Stuttering. *Frontiers in Digital Health* 4, 1 (feb 2022), 464. https://doi.org/10.3389/fdgth.2022.842460

[21] Desirée Colombo, Amanda Díaz-García, Javier Fernandez-Álvarez, and Cristina Botella. 2021. Virtual reality for the enhancement of emotion regulation. *Clinical Psychology & Psychotherapy* 28 (2021), 519–537. https://doi.org/10.1002/cpp.2618

[22] Nele A.J. De Witte, Fien Buelens, Glen Debard, Bert Bonroy, Wout Standaert, Fernando Tarnogol, and Tom Van Daele. 2022. Handheld or head-mounted? An experimental comparison of the potential of augmented reality for animal phobia treatment using smartphone and HoloLens 2. *Frontiers in Virtual Reality* 3, December (2022), 1–9. https://doi.org/10.3389/frvir.2022.1066996

[23] Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke. 2011. From game design elements to gamefulness: defining" gamification". In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*. 9–15.

[24] Deborah Dobson and Keith S Dobson. 2018. *Evidence-based practice of cognitive-behavioral therapy*. Guilford publications.

[25] Nina Döllinger, Carolin Wienrich, and Marc Erich Latoschik. 2021. Challenges and Opportunities of Immersive Technologies for Mindfulness Meditation: A Systematic Review. *Frontiers in Virtual Reality* 2 (apr 2021). https://doi.org/10.3389/frvir.2021.644683

[26] Marta Ferrer-Garcia, Joana Pla-Sanjuanelo, Antonios Dakanalis, Ferran Vilalta-Abella, Giuseppe Riva, Fernando Fernandez-Aranda, Laura Forcano, Nadine Riesco, Isabel Sánchez, Massimo Clerici, Joan Ribas-Sabaté, Alexis Andreu-Gracia, Neli Escandón-Nagel, Osane Gomez-Tricio, Virginia Tena, and José Gutiérrez-Maldonado. 2019. A Randomized Trial of Virtual Reality-Based Cue Exposure Second-Level Therapy and Cognitive Behavior Second-Level Therapy for Bulimia Nervosa and Binge-Eating Disorder: Outcome at Six-Month Followup. *Cyberpsychology, Behavior, and Social Networking* 22, 1 (2019), 60–68. https://doi.org/10.1089/cyber.2017.0675

[27] Daniel Freeman, Sinéad Lambe, Thomas Kabir, Ariane Petit, Laina Rosebrock, Ly-Mee Yu, Robert Dudley, Kate Chapman, Anthony Morrison, Eileen O'Regan, Charlotte Aynsworth, Julia Jones, Elizabeth Murphy, Rosie Powling, Ushma Galal, Jenna Grabey, Aitor Rovira, Jennifer Martin, Chris Hollis, David M Clark, Felicity Waite, James Altunkaya, Humma Andleeb, Aislinn Bergin, Emily Bold, Jessica Bond, Kate Bransby-Adams, Susan Brown, Cindy Chan, Nisha Chauhan, Michael Craven, Jason Freeman, John Geddes, Andrew Goodsell, Lucy Jenner, Alex Kenny, José Leal, Joanna Mitchell, Heather Peel, Maryam Pervez, Eloise Prouten, Eva Roberts, Dan Robotham, Harry Walker, and Jonathan West. 2022. Automated virtual reality therapy to treat agoraphobic avoidance and distress in patients with psychosis (gameChange): a multicentre, parallel-group, single-blind, randomised, controlled trial in England with mediation and moderation analyses. *The Lancet Psychiatry* 9, 5 (may 2022), 375–388. https://doi.org/10.1016/S2215-0366(22)00060-8

[28] Alba García-Baos, D Tomas, Isadora Oliveira, Peter Collins, Carme Echevarria, Laura Pérez Zapata, Elizabeth Liddle, Hans Super, et al. 2019. Novel interactive eye-tracking game for training attention in children with attention-deficit/hyperactivity disorder. *The primary care companion for CNS disorders* 21, 4 (2019), 26348.

[29] Rebeca I García-Betances, María Teresa Arredondo Waldmeyer, Giuseppe Fico, and María Fernanda Cabrera-Umpiérrez. 2015. A succinct overview of virtual reality technology use in Alzheimer's disease. *Frontiers in aging neuroscience* 7 (2015), 80.

[30] Manaswi Gautam, Adarsh Tripathi, Deepanjali Deshmukh, and Manisha Gaur. 2020. Cognitive behavioral therapy for depression. *Indian journal of psychiatry* 62, Suppl 2 (2020), S223.

[31] David Jose Giraldy and Wilson Novaldo. 2022. A Systematic Literature Review: Acrophobia Treatment with Virtual Reality. *Engineering, MAthematics and Computer Science (EMACS) Journal* 4, 1 (feb 2022), 33–38. https://doi.org/10.21512/emacsjournal.v4i1.8077

[32] James J. Gross. 1998. The Emerging Field of Emotion Regulation: An Integrative Review. *Review of General Psychology* 2, 3 (sep 1998), 271–299. https://doi.org/10.1037/1089-2680.2.3.271

[33] Jose Gutierrez-Maldonado, Natalia Briseño, and Mariarca Ascione. 2023. Treatment of Anorexia Nervosa Through Virtual Reality-Based Body Exposure and Reduction of Attentional Bias. In *Lecture Notes in Computer Science*, Vol. 14027. Springer Nature Switzerland, 453–463. https://doi.org/10.1007/978-3-031-35634-6

[34] Wendy Hadley, Christopher Houck, Larry K. Brown, Josh S. Spitalnick, Mirtha Ferrer, and David Barker. 2019. Moving beyond Role-Play: Evaluating the Use of Virtual Reality to Teach Emotion Regulation for the Prevention of Adolescent Risk Behavior Within a Randomized Pilot Trial. *Journal of Pediatric Psychology* 44, 4 (2019), 425–435. https://doi.org/10.1093/jpepsy/jsy092

[35] Sogand Hasanzadeh, Nicholas F. Polys, and Jesus M. De La Garza. 2020. Presence, Mixed Reality, and Risk-Taking Behavior: A Study in Safety Interventions. *IEEE Transactions on Visualization and Computer Graphics* 26, 5 (2020), 2115–2125. https://doi.org/10.1109/TVCG.2020.2973055

[36] Joris Heyse, Barbara Depreeuw, Tom Van Daele, Tine Daeseleire, Femke Ongenae, Femke De Backere, and Filip De Turck. 2022. An adaptation algorithm for personalised virtual reality exposure therapy. *Computer Methods and Programs in Biomedicine* 225 (2022), 107077. https://doi.org/10.1016/j.cmpb.2022.107077

[37] Stefan Hrastinski. 2010. The potential of synchronous communication to enhance participation in online discussions: A case study of two e-learning courses. *Information & Management* 47, 7 (2010), 249–256.

[38] T. R. Insel. 2016. Digital phenotyping: a global tool for psychiatry. *World Psychiatry* 15, 3 (2016), 240–241.

[39] Petar Jerčić. 2019. *The Effects of Emotions and Their Regulation on Decision-making Performance in Affective Serious Games.* Ph. D. Dissertation. Blekinge Tekniska Högskola.

[40] Garett Johnson and Austin Henderson. 2012. *Conceptual models: Core to good design.* Synthesis Lectures on Human-Centered Informatics.

[41] Jesper Juul. 2011. Gamification backlash roundup. *The Ludologist* 2 (2011).

[42] Pamela M Kato. 2010. Video games in health care: Closing the gap. *Review of general psychology* 14, 2 (2010), 113–121.

[43] Robert S Kennedy, Julie Drexler, and Robert C Kennedy. 2010. Research in visually induced motion sickness. *Applied ergonomics* 41, 4 (2010), 494–503.

[44] Robert Kohn, Shekhar Saxena, Itzhak Levav, and Benedetto Saraceno. 2004. The treatment gap in mental health care. *Bulletin of the World Health Organization* 82, 11 (nov 2004), 858–66. https://doi.org//S0042-96862004001100011

[45] Geza Kovacs, Zhengxuan Wu, and Michael S. Bernstein. 2021. Not Now, Ask Later: Users Weaken Their Behavior Change Regimen Over Time, But Expect To Re-Strengthen It Imminently. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21).* Association for Computing Machinery, New York, NY, USA, Article 229, 14 pages. https://doi.org/10.1145/3411764.3445695

[46] Magdalena Kowal, Eoin Conroy, Niall Ramsbottom, Tim Smithies, Adam Toth, and Mark Campbell. 2021. Gaming Your Mental Health: A Narrative Review on Mitigating Symptoms of Depression and Anxiety Using Commercial Video Games. *JMIR Serious Games* 9, 2 (16 Jun 2021), e26575. https://doi.org/10.2196/26575

[47] Bettina Laugwitz, Theo Held, and Martin Schrepp. 2008. Construction and evaluation of a user experience questionnaire. In *HCI and Usability for Education and Work: 4th Symposium of the Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society, USAB 2008, Graz, Austria, November 20-21, 2008. Proceedings 4.* Springer, 63–76.

[48] I. Li, A. Dey, and J. Forlizzi. 2010. A stage-based model of personal informatics systems. (2010), 557–566.

[49] Alice J. Lin, Fuhua Frank Cheng, and Charles B. Chen. 2020. Use of virtual reality games in people with depression and anxiety. *ACM International Conference Proceeding Series* (2020), 169–174. https://doi.org/10.1145/3381271.3381299

[50] Stefan Liszio, Oliver Basu, and Maic Masuch. 2020. A Universe Inside the MRI Scanner: An In-Bore Virtual Reality Game for Children to Reduce Anxiety and Stress. *CHI PLAY 2020 - Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (2020), 46–57. https://doi.org/10.1145/3410404.3414263

[51] Johan Lundin, Anders Lundström, Jan Gulliksen, Joakim Blendulf, Kersti Ejeby, Hedda Nyman, Daniel Björkander, and Erik Hedman-Lagerlöf. 2022. Using 360-degree videos for virtual reality exposure in CBT for panic disorder with agoraphobia: a feasibility study. *Behavioural and Cognitive Psychotherapy* 50, 2 (mar 2022), 158–170. https://doi.org/10.1017/S1352465821000473

[52] Jingni Ma, Dongrong Zhao, Naihong Xu, and Jinmei Yang. 2023. The effectiveness of immersive virtual reality (VR) based mindfulness training on improvement mental-health in adults: A narrative systematic review. *Explore* 19, 3 (2023), 310–318. https://doi.org/10.1016/j.explore.2022.08.001

[53] Minhua Ma, Michael McNeill, Darryl Charles, Suzanne McDonough, Jacqui Crosbie, Louise Oliver, and Clare McGoldrick. 2007. Adaptive virtual reality games for rehabilitation of motor disorders. In *Universal Access in Human-Computer Interaction. Ambient Interaction: 4th International Conference on Universal Access in Human-Computer Interaction, UAHCI 2007 Held as Part of HCI International 2007 Beijing, China, July 22-27, 2007 Proceedings, Part II 4.* Springer, 681–690.

[54] Anna-Leena Macey, Joseph Macey, and Juho Hamari. 2022. Virtual reality in emotion regulation: A scoping review. In *6th International GamiFIN Conference.*

[55] Javier Marín-Morales, Juan Luis Higuera-Trujillo, Alberto Greco, Jaime Guixeres, Carmen Llinares, Enzo Pasquale Scilingo, Mariano Alcañiz, and Gaetano Valenza. 2018. Affective computing in virtual reality: emotion recognition from brain and heartbeat dynamics using wearable sensors. *Scientific Reports* 8, 1 (2018), 1–15. https://doi.org/10.1038/s41598-018-32063-4

[56] Martin N Marshall. 1996. Sampling for qualitative research. *Family practice* 13, 6 (1996), 522–526.

[57] Eglė Mazgelytė, Virginija Rekienė, Edita Dereškevičiūtė, Tomas Petrėnas, Jurgita Songailienė, Algirdas Utkus, Gintaras Chomentauskas, and Dovilė Karčiauskaitė. 2021. Effects of virtual reality-based relaxation techniques on psychological, physiological, and biochemical stress indicators. *Healthcare (Switzerland)* 9, 12 (2021). https://doi.org/10.3390/healthcare9121729

[58] Jane McLachlan, Mani Mehdikhani, Beth Larham, and Luna C.Muñoz Centifanti. 2022. Borderline Personality Traits and Emotion Regulation Strategies in Adolescents: The Role of Implicit Theories. *Child Psychiatry and Human Development* 53, 5 (2022), 899–907. https://doi.org/10.1007/s10578-021-01169-8

[59] Franziska Miegel, Lara Bücker, Simone Kühn, Fariba Mostajeran, Steffen Moritz, Anna Baumeister, Luzie Lohse, Jannik Blömer, Karsten Grzella, and Lena Jelinek. 2022. Exposure and Response Prevention in Virtual Reality for Patients with Contamination-Related Obsessive–Compulsive Disorder: a Case Series. *Psychiatric Quarterly* (jul 2022). https://doi.org/10.1007/s11126-022-09992-5

[60] Paul Milgram and Fumio Kishino. 1994. A taxonomy of mixed reality visual displays. *IEICE TRANSACTIONS on Information and Systems* 77, 12 (1994), 1321–1329.

[61] Paul Milgram, Haruo Takemura, Akira Utsumi, and Fumio Kishino. 1995. Augmented reality: A class of displays on the reality-virtuality continuum. In *Telemanipulator and telepresence technologies*, Vol. 2351. Spie, 282–292.

[62] M. Olfson, M. Guardino, E. L. Struening, F. R. Schneier, F. Hellman, and D. F. Klein. 2000. Barriers to the treatment of social anxiety. *American Journal of Psychiatry* 157 (2000), 521–527. Issue 4. https://doi.org/10.1176/appi.ajp.157.4.521

[63] World Health Organization. 2022. *World mental health report: Transforming mental health for all.* 296 pages.

[64] Federica Pallavicini and Alessandro Pepe. 2020. Virtual reality games and the role of body involvement in enhancing positive emotions and decreasing anxiety: Within-subjects pilot study. *JMIR Serious Games* 8, 2 (2020). https://doi.org/10.2196/15635

[65] M. Park, C. Cha, and M. Cha. 2018. Depressive moods of users portrayed in social media. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–12.

[66] Patricia Pons, Samuel Navas-Medrano, and Jose L. Soler-Dominguez. 2022. Extended reality for mental health: Current trends and future challenges. *Frontiers in Computer Science* 4 (nov 2022). https://doi.org/10.3389/fcomp.2022.1034307

[67] Marlou Poppelaars, Aniek Wols, Anna Lichtwarck-Aschoff, and Isabela Granic. 2018. Explicit mental health messaging promotes serious video game selection in youth with elevated mental health symptoms. *Frontiers in psychology* 9 (2018), 1837.

[68] Dominic Potts, Kate Loveys, Hyunyoung Ha, Shaoyan Huang, Mark Billinghurst, and Elizabeth Broadbent. 2019. ZenG: AR neurofeedback for meditative mixed reality. In *C and C 2019 - Proceedings of the 2019 Creativity and Cognition*. 583–590. https://doi.org/10.1145/3325480.3326584

[69] PsyTechVR [n. d.]. *VR Micro-training system for Mental Health*. Retrieved September 1, 2023 from https://www.psytechvr.com/

[70] Amon Rapp and Arianna Boldi. 2023. Exploring the Lived Experience of Behavior Change Technologies: Towards an Existential Model of Behavior Change for HCI. *ACM Trans. Comput.-Hum. Interact.* 30, 6, Article 81 (sep 2023), 50 pages. https://doi.org/10.1145/3603497

[71] Roberto Ribeiro, João Ramos, David Safadinho, Arsénio Reis, Carlos Rabadão, João Barroso, and António Pereira. 2021. Web AR solution for UAV pilot training and usability testing. *Sensors* 21, 4 (2021), 1456.

[72] Carine Rognon, Benjamin Stephens-Fripp, Jess Hartcher-O’Brien, Bob Rost, and Ali Israr. 2022. Linking haptic parameters to the emotional space for mediated social touch. *Frontiers in Computer Science* 4 (2022), 826545.

[73] Jannick P Rolland, Henry Fuchs, et al. 2001. Optical versus video see-through head-mounted displays. *Fundamentals of wearable computers and augmented reality* (2001), 113–156.

[74] Pedro Sanches, Axel Janson, Pavel Karpashevich, Camille Nadal, Chengcheng Qu, Claudia Daudén Roquet, Muhammad Umair, Charles Windlin, Gavin Doherty, Kristina Höök, et al. 2019. HCI and Affective Health: Taking stock of a decade of studies and charting future research directions. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–17.

[75] Rebecca Sanchez, Emily Brown, Kelly Kocher, and Melissa DeRosier. 2017. Improving children’s mental health with a digital social skills development game: a randomized controlled efficacy trial of adventures aboard the SS GRIN. *Games for health journal* 6, 1 (2017), 19–27.

[76] Ralf Schmidt, Katharina Emmerich, and Burkhard Schmidt. 2015. Applied games–in search of a new definition. In *Entertainment Computing-ICEC 2015: 14th International Conference, ICEC 2015, Trondheim, Norway, September 29-Ocotober 2, 2015, Proceedings 14*. Springer, 100–111.

[77] Elke A Schoneveld, Anna Lichtwarck-Aschoff, and Isabela Granic. 2018. Preventing childhood anxiety disorders: Is an applied game as effective as a cognitive behavioral therapy-based program? *Prevention Science* 19 (2018), 220–232.

[78] Elke A Schoneveld, Monique Malmberg, Anna Lichtwarck-Aschoff, Geert P Verheijen, Rutger CME Engels, and Isabela Granic. 2016. A neurofeedback video game (MindLight) to prevent anxiety in children: A randomized controlled trial. *Computers in Human Behavior* 63 (2016), 321–333.

[79] Matthias Christian Schrempf, Julian Quirin Petzold, Hugo Vachon, Morten Aagaard Petersen, Johanna Gutschon, Sebastian Wolf, Florian Sommer, Marcus Murnauer, and Matthias Anthuber. 2021. Virtual reality-based relaxation for enhancement of perioperative well-being and quality of life: protocol for a randomised pilot trial. *BMJ open* 11, 4 (2021), e044193.

[80] Elizabeth Seabrook, Ryan Kelly, Fiona Foley, Stephen Theiler, Neil Thomas, Greg Wadley, and Maja Nedeljkovic. 2020. Understanding how virtual reality can support mindfulness practice: Mixed methods study. *Journal of Medical Internet Research* 22, 3 (2020). https://doi.org/10.2196/16106

[81] Maria Semkovska and Elayne Ahern. 2017. Online neurocognitive remediation therapy to improve cognition in community-living individuals with a history of depression: A pilot study. *Internet Interventions* 9 (2017), 7–14.

[82] Mel Slater, Beau Lotto, Maria Marta Arnold, and Maria V Sanchez-Vives. 2009. How we experience immersive virtual environments: the concept of presence and its measurement. *Anuario de psicología* 40, 2 (2009), 193–210.

[83] Mel Slater, Martin Usoh, and Anthony Steed. 1994. Depth of presence in virtual environments. *Presence: Teleoperators & Virtual Environments* 3, 2 (1994), 130–144.

[84] Mel Slater and Sylvia Wilbur. 1997. A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators & Virtual Environments* 6, 6 (1997), 603–616.

[85] Petr Slovak, Alissa Antle, Nikki Theofanopoulou, Claudia Daudén Roquet, James Gross, and Katherine Isbister. 2023. Designing for emotion regulation interventions: an agenda for HCI theory and research. *ACM Transactions on Computer-Human Interaction* 30, 1 (2023), 1–51.

[86] John Smith and Jo Firth. 2011. Qualitative data analysis: the framework approach. *Nurse Researcher* 18, 2 (2011), 52–62.

[87] Tarja Susi, Mikael Johannesson, and Per Backlund. 2007. Serious games: An overview. (2007).

[88] Benjamin Tolchin, Barbara A. Dworetzky, Steve Martino, Hal Blumenfeld, Lawrence J. Hirsch, and Gaston Baslet. 2019. Adherence with psychotherapy and treatment outcomes for psychogenic nonepileptic seizures. *Neurology* 92, 7 (feb 2019), e675–e679. https://doi.org/10.1212/WNL.0000000000006848

[89] Marieke Van Rooij, Adam Lobel, Owen Harris, Niki Smit, and Isabela Granic. 2016. DEEP: A biofeedback virtual reality game for children at-risk for anxiety. *Conference on Human Factors in Computing Systems - Proceedings* 07-12-May-(2016), 1989–1997. https://doi.org/10.1145/2851581.2892452

[90] Ana Vianez, António Marques, and Raquel Simões de Almeida. 2022. Virtual Reality Exposure Therapy for Armed Forces Veterans with Post-Traumatic Stress Disorder: A Systematic Review and Focus Group. *International Journal of Environmental Research and Public Health* 19, 1 (jan 2022), 464. https://doi.org/10.3390/ijerph19010464

[91] Bob G Witmer and Michael J Singer. 1998. Measuring presence in virtual environments: A presence questionnaire. *Presence* 7, 3 (1998), 225–240.

[92] Erik Wolf, Marie Luisa Fiedler, Nina Döllinger, Carolin Wienrich, and Marc Erich Latoschik. 2022. Exploring presence, avatar embodiment, and body perception with a holographic augmented reality mirror. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*. IEEE, 350–359.

[93] Aniek Wols, Anna Lichtwarck-Aschoff, Elke A Schoneveld, and Isabela Granic. 2018. In-game play behaviours during an applied video game for anxiety prevention predict successful intervention outcomes. *Journal of psychopathology and behavioral assessment* 40 (2018), 655–668.

[94] Choochart Wong-Anuchit, Chutima Chantamit-o pas, Joanne Kraenzle Schneider, and Andrew C. Mills. 2019. Motivational Interviewing–Based Compliance/Adherence Therapy Interventions to Improve Psychiatric Symptoms of People With Severe Mental Illness: Meta-Analysis. *Journal of the American Psychiatric Nurses Association* 25, 2 (mar 2019), 122–133. https://doi.org/10.1177/1078390318761790

[95] World Health Organization 2022. *COVID-19 pandemic triggers 25% increase in prevalence of anxiety and depression worldwide*. Retrieved September 1, 2023 from https://www.who.int/news/item/02-03-2022-covid-19-pandemic-triggers-25-increase-in-prevalence-of-anxiety-and-depression-worldwide

[96] D. Zayeni, J. Raynaud, and A. Revet. 2020. Therapeutic and preventive use of video games in child and adolescent psychiatry: a systematic review. *Frontiers in Psychiatry* 11 (2020). https://doi.org/10.3389/fpsyt.2020.00036

[97] Anja Zimmer, Nan Wang, Merle K. Ibach, Bernhard Fehlmann, Nathalie S. Schicktanz, Dorothée Bentz, Tanja Michael, Andreas Papassotiropoulos, and Dominique J.F. de Quervain. 2021. Effectiveness of a smartphone-based, augmented reality exposure app to reduce fear of spiders in real-life: A randomized controlled trial. *Journal of Anxiety Disorders* 82 (aug 2021), 102442. https://doi.org/10.1016/j.janxdis.2021.102442