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FACULDADE DE CIÊNCIAS
DEPARTAMENTO DE INFORMÁTICA

Supporting Therapists in Authoring Virtual Reality Exposure Therapy for Children

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Mestrado em Engenharia Informática

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2024

Acknowledgements

To my parents and family, thank you for your unwavering support and encouragement throughout my academic and personal journey, as well as for providing me with an environment that allowed me success.

To my girlfriend Marta, I want to express my gratitude for always being there for me, even when we're physically apart. Thank you for patiently listening to my frustrations and for the care and love you've given me. You are my rock and my daily source of motivation. I appreciate you and everything that you do.

I want to express my gratitude to Professors Doctor Tiago Guerreiro and Doctor João Guerreiro for their professionalism, experience, guidance, and availability throughout my academic journey. I also want to thank Doctor Filipa Brito for her help from the very beginning of the process. My colleagues Beatriz Nogueira, Daniel Reis, and Madalena Vieira deserve a special mention for their valuable contributions to the success of each step of this journey.

I would like to express my sincere gratitude to the DI-LaSIGE team for welcoming me into their family with open arms. Their gatherings and social events were truly inspiring and helped me immensely.

Thank you to FCT and LASIGE for providing me with a scholarship that allowed me to pursue my goals during this thesis more comfortably.

I also want to extend my heartfelt appreciation to the therapists who were present during the informal meetings, as well as those who participated in our user study. Without their invaluable help, this thesis would not have been possible.

Additionally, I would like to thank all my friends and colleagues whom I met during my Masters for the wonderful times we shared and the camaraderie we built.

To everyone who has supported me throughout this journey, my deepest thanks.

To my family and girlfriend

Resumo

À medida que a sociedade evolui, a saúde mental das crianças tem vindo a deteriorar-se [36]. Embora existam opções terapêuticas, estas não são geralmente as mais adequadas para as crianças, estando a ser deixadas para trás.

A tecnologia está cada vez mais ubíqua nos dias de hoje devido a avanços e novos dispositivos que emergem. Desde carros a smartphones, até aos nossos eletrodomésticos e televisões, evidenciando o gradual aumento da tecnologia nas nossas vidas.

Recentemente, a realidade virtual (VR) tem vindo a ganhar cada vez mais prevalência na indústria da saúde, especialmente em terapia de exposição, onde tem demonstrado bastante potencial a tratar diversos distúrbios de ansiedade [3, 7, 29]. Esta vem a resolver alguns dos problemas associados aos métodos de exposição mais estabelecidos e comuns como a exposição *in vivo* e a exposição por imaginação. A primeira, é por muitos considerada a mais robusta e requer que o paciente enfrente os estímulos problemáticos cara-a-cara, o que pode levar a problemas éticos (especialmente em crianças), assim como quebras de confidencialidade, custos altos e problemas de logística [50]. A segunda, por outro lado, é mais simples de realizar, visto que requer apenas a imaginação do paciente, mas isto torna-se um problema com crianças devido à falta de maturidade e capacidade de imaginação. Em ambas as abordagens, o terapeuta tem pouco ou nenhum controlo sobre a situação, e/ou é desafiante conduzir a sessão num ambiente seguro.

Todavia, são levantados desafios para terapeutas que interagem com esta tecnologia. Sistemas de realidade virtual quase nunca atendem às necessidades dos terapeutas, visto que não são desenvolvidos com os mesmos em mente [33, 11]. Além disso, a maioria das soluções que existem são de ”tamanho único”e não são desenvolvidas para crianças [34].

Concomitantemente aliado ao facto de que os terapeutas muitas vezes encontram pacientes com distúrbios únicos e específicos, fazendo com que seja difícil providenciar uma terapia customizada [33], evidencia a necessidade de que sistemas de realidade virtual para terapia de exposição (VRET) tenham de ser co-desenhados com terapeutas, de modo a que estes mesmos sistemas consigam atender às suas necessidades tanto de controlo como de customização dos ambientes, assim como entender as necessidades únicas e particularidades das crianças.

Por isso, o nosso principal objetivo é democratizar VRET ao incluir os terapeutas no processo de desenho, dar-lhes mais controlo e capacidade de autoria, assim como providenciar uma plataforma que pode ser usada para VRET em crianças de forma facilitada.

A nossa metodologia durante todo este processo de desenho focou-se em várias reuniões informais; onde foram trabalhados protótipos tanto para uma aplicação de realidade virtual, assim

como uma de controlo para o computador.

Assim, o nosso sistema – *VRTherapist* – consiste em duas componentes: uma aplicação VR e uma aplicação de computador. A aplicação VR proporciona aos pacientes a imersão em diversos ambientes virtuais, assim como a possibilidade de interagir com o seu redor. Por outro lado, o terapeuta consegue controlar diretamente estes ambientes virtuais em tempo real, dando uso à aplicação de computador, permitindo um acompanhamento do paciente e a orientação por parte do terapeuta em tempo real ao longo da sessão

É importante notar que realizar estudos com usuários na nossa área é muito importante. Ajuda-nos a perceber melhor a nossa plataforma, receber feedback mas, também, possibilitar ainda mais o seu desenvolvimento. Por isso, conduzimos um estudo com o objetivo de 1) compreender as práticas correntes que são usadas por terapeutas nos dias de hoje, 2) ganhar conhecimento em relação ao possível impacto de VR no futuro da terapia, e 3) determinar como é que terapeutas iriam responder a uma plataforma que os empodera de maneira a controlarem o ambiente virtual.

Com estes objetivos, desenhámos uma entrevista semiestruturada que incluía questões relacionadas com as práticas correntes e o uso da tecnologia no contexto terapêutico. Foram imaginados cenários de terapia de exposição VR que se focavam em limitações prováveis e controlos desejados, e desafiámos os clínicos relativamente a repetição de sessões. Além disso, no fim do estudo, uma sessão maquete foi feita de modo a incluir os terapeutas em decisões de desenho mais diretamente.

O estudo contou com a participação de 10 terapeutas, e teve como perguntas de investigação: RQ1) Qual é o papel da tecnologia em terapia, RQ2) Qual é o papel de VR na terapia, RQ3) Qual é a posição dos terapeutas em relação a VRET, RQ4) Que controlo é que os clínicos querem em VRET, e RQ5) Qual é o futuro de VR em terapia?

O áudio das sessões foi gravado e transcrito e toda a informação foi codificada e analisada, dando uso a um protocolo de análise temática proposto por Braun e Clark [10]. Esta análise levou ao agrupamento de informação em sete temas, sendo estes: práticas correntes, a dinâmica do terapeuta e do paciente, progresso e avaliação, realismo estereotípico, customização e autoria, o papel de VR e outros cenários, o que nos levou a conseguir responder às perguntas de investigação, assim como levantar um tema interessante a explorar: a dinâmica do terapeuta e do paciente em VR.

Relativamente a esta última parte, o estudo demonstrou que uma relação terapêutica positiva entre o terapeuta e o paciente, leva a melhores resultados na terapia, o que é suportado por mais de 30 anos de investigação [16]. Os terapeutas demarcaram a importância de criar esta relação desde a primeira sessão, possibilitando o paciente a sentir-se mais confortável com o terapeuta.

Juntamente com o facto de que VRET é visto pelos terapeutas como um meio termo entre imaginação e *in vivo*, é levantada a seguinte questão: será necessário repetir o processo de habituação do paciente a esta nova imagem do terapeuta?

Além disto, foi demonstrada a preocupação que interações virtuais não conseguem substituir interações no mundo real. Por exemplo, terapeutas normalmente precisam de tocar em pacientes para os acalmar, o que é essencial na relação terapêutica. Existe já investigação sobre um fenómeno chamado de "phantom touch", em que pessoas dizem conseguir sentir toques virtuais [2]. Além disto, vários dispositivos estão a ser criados, como luvas, elétrodos e dispositivos de realidade mista [21], que permitem feedback tátil.

Relativamente à RQ1, terapeutas têm vindo a incorporar tecnologia na sua prática, visto que permite às sessões serem conduzidas online. Isto foi especialmente vantajoso durante a pandemia COVID-19. Os clínicos usam uma variedade de ferramentas tecnológicas como vídeos, websites, jogos, e aplicações móveis [35], de modo a tornar as sessões mais dinâmicas. Apesar disto, um dos maiores desafios é motivar os pacientes para usar tecnologia no contexto de terapia.

No que diz respeito às RQ2 e RQ3, embora investigação tenha demonstrado que VRET é bastante eficaz, apresentando melhores resultados em alguns casos comparada a *in vivo* [42, 7, 13], e sendo menos intimidante e mais aceitável para crianças [41], VRET é aceite pelos terapeutas em contexto terapêutico, mas apenas como meio termo entre imaginação e *in vivo*. Isto é em grande parte devido à ideia de que é necessário expor os pacientes a cenários no mundo físico, assim como à falta de estímulos presentes em VR como o toque e o realismo.

Sobre a RQ4, recebemos muito feedback positivo, assim como bastantes sugestões relativamente ao nível de controlo que os terapeutas querem ter dos ambientes virtuais. O estudo confirmou que o desenho de soluções VRET deve envolver clínicos no processo, a fim de atender às suas necessidades.

A investigação sobre o controlo dos clínicos em VRET está a ganhar força. Um estudo conduzido por Koller et al. [33] explorou a possibilidade de o terapeuta controlar uma pessoa na audiência diretamente com o uso de gestos físicos de braços e mãos.

E por último, acerca da RQ5, com a proliferação de novos fenómenos e concomitantemente de novas tecnologias, tais como as mencionadas por Alexdottir [2] e Gallace [21], assim como a inclusão de terapeutas no processo de desenho, VRET pode finalmente começar a ser mais aceite, e até usado em outros cenários tais como mutismo seletivo, distúrbios de alimentação [18] e medo de agulhas. Pode também desempenhar um papel importante na terapia ao possibilitar a interação direta entre o terapeuta e o paciente, mesmo que fisicamente distantes.

Finalmente, o nosso sistema *VRTherapist* apresenta uma interface com botões que permite o controlo direto em tempo real dos ambientes VR. É facilmente expansível com novos ambientes e controlos, enquanto continua a ser focado no usuário final. Apresentamos uma mudança de paradigma no desenho de soluções VRET: devem atender às necessidades dos terapeutas e dos pacientes. O desenho destas soluções deve ser acompanhado de perto por terapeutas de modo a construir soluções que sejam eficazes.

Palavras-chave: realidade virtual, terapia de exposição, crianças, distúrbios de ansiedade, VRET

Abstract

Throughout the years, anxiety disorders in children have become more prevalent, requiring tailored solutions to accompany this increase successfully. Although therapy exists, its two most common types, exposure through imagination and *in vivo*, have limitations associated with the maturity of children, high costs, and logistical problems.

Virtual reality exposure therapy is becoming increasingly more common in the field, tackling some of the limitations raised by the other two approaches. Still, these VRET systems are often not developed with either the therapist or the children in mind, featuring confusing interfaces and situations that are too stereotypical and do not allow personalisation to their needs.

In this thesis, we explore an approach where therapists can personalise the VR exposure therapy sessions to the needs of each child, being able to modify the VR scenarios directly in real-time.

To do so, we developed *VRTherapist*, a VRET system that comprises two applications: a virtual reality application and a computer application. The virtual reality application allows the patient to immerse themselves in various environments, while the latter allows the therapist to control these environments directly with an interface.

The development cycle featured informal meetings among the research team and therapists, which steered the development into a prototype ready for a study. This study gave us a lot of good feedback and suggestions towards current and new features that should be included, as well as understanding the current role of virtual reality in therapy as a bridge between imagination and *in vivo* exposure therapies.

Finally, our *VRTherapist* system is easily expandable with new environments and features while being focused on the end-user. We also present a paradigm shift when designing VRET solutions: they should attend to patients' and therapists' needs from an interactivity and feature standpoint. Working clinicians should closely accompany development to build robust solutions.

Keywords: VR, exposure therapy, children, anxiety disorders, VRET

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Acronyms

VRTherapist Virtual Reality Therapist.

2-D Two Dimensional.

ASD Autism Spectrum Disorder.

BPM Beats Per Minute.

CAVE Cave Automatic Virtual Environment.

ET Exposure Therapy.

HMD Head-Mounted Displays.

OCD Obsessive-Compulsive Disorder.

PTSD Post-Traumatic Stress Disorder.

RT Radiation Therapy.

SOP Sense of Presence.

SST Social Skills Training.

VE Virtual Environments.

VR Virtual Reality.

VRE Virtual Reality Environments.

VRET Virtual Reality Exposure Therapy.

Chapter 1

Introduction

Technology is becoming increasingly ubiquitous in our daily lives as new advancements and technologies continue to emerge. From our cars and smartphones to our appliances and televisions, technology has become a constant presence.

Recently, virtual reality has gained traction in the healthcare industry, particularly in exposure therapy, where it has shown promise in treating various anxiety disorders [3, 7, 29].

However, this has presented challenges for therapists who interact with this technology. Virtual reality systems often do not cater to the needs of either the therapists or the children, as they are not developed with them in mind [33, 11, 34].

This, in addition to the therapist's workload during therapy, both factor into the friction that is experienced by the therapist, possibly altering the outcome of therapy for the worse. A paradigm shift into focusing both on the therapists and the patients is necessary.

Our main motivation for developing this thesis is to democratise virtual reality exposure therapy for children by involving therapists in the design process of virtual reality solutions, which will allow them to author and customize the virtual environments, as well as the level of control to have over them.

1.1 Motivation

Anxiety disorders in children are becoming increasingly more common, especially after the COVID-19 pandemic [36], which is, in turn, increasing therapy wait times. There are multiple established ways to perform therapy, one of them being exposure therapy, in which the patient is exposed to problematic stimuli in order to decrease exacerbated reactions and avoidance behaviours.

The two most used and well-established forms of exposure therapy are *in vivo* and imaginal, but these have limitations. *In vivo* exposure therapy requires the patient to be taken to face the problematic stimuli in person, which in turn can lead to ethical issues (especially with children), alongside a break of confidentiality and high costs [50]. Imaginal exposure therapy, on the other hand, has the advantage that only requires the patient's imagination. Still, it fully depends on it to work, which with children can prove to be challenging due to maturity and lack of imagination capabilities. In each of the two approaches, the therapist has little to no control over the therapeutic session, or it becomes challenging for the therapist to conduct the session in a safe environment.

Virtual Reality (VR) has become increasingly common throughout the years in the context of health due to its affordability and practicality, giving the clinician more control over the therapeutic session. The clinician can customise the environment as they see fit, a clear advantage over both *in vivo* and imaginal exposure therapy. Moreover, it is also important to note that Virtual Reality Exposure Therapy (VRET) can be conducted inside a therapist's office, which is a relatively safer and affordable solution compared to *in vivo*. For these reasons, developing digital platforms (i.e., virtual environments and interfaces) that consider and adapt to patients' needs is essential. Some work has already been done in areas such as pain management [1, 8, 29, 45], preoperative anxiety coping [15, 48], and calming patients down through biofeedback [24, 49], among others; but most importantly in VRET [3, 7, 13, 22, 23, 28, 41, 42, 43]. Although these applications allow the control of the environments, they are often designed by non-therapists, which in turn don't cater to the therapists' needs. Furthermore, current solutions are a "one size fits all" and are not geared towards children [34].

In addition, it is important to consider that clinicians often encounter patients with unique and highly specific conditions, which can make it challenging to provide customized therapy [33]. To address this issue, VR systems must be co-designed with clinicians who work with children in order to tailor them to their needs and provide them with the necessary control and customisation options, as well as understanding the unique needs and particularities of children.

1.2 Goals

Our main goal was to democratise VRET with children in mind. In particular, we aimed to 1) include the clinicians in the design process of VRET, 2) give more control and authoring capabilities to clinicians, and 3) provide clinicians with a platform that can be used to easily perform VRET on children.

1.3 Approach

In order to achieve our goals, we started by conducting a literature review of the related work to our thesis. This included analysing multiple papers and identifying current limitations, gaps and existing solutions.

Afterwards, we had informal discussions with therapists, which helped us to define two problem scenarios. These scenarios consisted of situations and contexts that would benefit from our system, along with response scenarios that outlined solutions. This allowed us to focus on two particular anxiety disorders — fear of public speaking and fear of spiders. It also gave us insights into how therapy is performed and helped us to define our system requirements.

Our development process adhered to the system requirements and was centred around iterating two prototypes — one for a VR application and the other for a computer-based application. Each prototype iteration aimed to incorporate more of the features suggested by therapists. These features included various scenarios, forms of sensory feedback, the ability to create and manipulate elements, as well as the option to replay previous sessions. Furthermore, we worked on fine-tuning and enhancing the controlling interface for each scenario.

Lastly, we conducted co-design sessions with therapists to obtain feedback on our system and gather valuable suggestions for additional control and customisation options.

1.4 Contributions

Literature review of current VRET practices

Our initial contribution involves analysing current VRET practices and limitations while highlighting the gap in the literature with regard to VRET for children as compared to adults.

Understand current practices in Exposure Therapy (ET) and opportunities for VRET

Through initial meetings and interviews, we lay out the current practices in ET, as well as opportunities for VRET.

Co-design an end-user authoring system for VRET

Through co-design workshops alongside clinicians, we design an end-user platform and environments with the purpose of facilitating VRET.

A set of scenarios of VRET, co-designed with clinicians

Lastly, we contribute with a set of scenarios of VRET that were co-designed with clinicians and can be used for exposure therapy.

1.5 Publications

During the development of our system, we published two different papers:

- **Using VR and Sensors for Anxiety with Children and Adolescents** — This short paper [19] consisted of the initial portion of this thesis i.e., related work and presentation of limitations and opportunities related to VRET. This work was presented and published at the workshop Virtual Reality for Health and Wellbeing at Mobile and Ubiquitous Multimedia (MUM) on November 27th, 2022, in Lisbon, Portugal.

- **Digital Therapeutics with Virtual Reality and Sensors** — This research article [20] was presented and published by the main author on the ”Digital Therapeutics Evolution: What Kind of Research Will Make the Difference in This Area?” session of the Adjunct of the 2023 ACM International Joint Conference on Pervasive and Ubiquitous Computing & the 2023 ACM International Symposium on Wearable Computing (UbiComp/ISWC'23).

1.6 Context

This thesis was elaborated within the investigation group Tech&People, that has been investigating the areas of VR, Pervasive Healthcare, and Accessibility.

It was developed as a part of a project that aimed to support therapists in preparing, conducting and analysing VRET sessions, which consisted of two separate works: this thesis focused on the authoring capabilities of the therapists. with the development of virtual environments and a computer application to control them; the other work (currently in progress) is studying the use of physiological sensors for therapy, as well as the data gathering, displaying and analysis. While these were separate works, they intersect at some points. For instance, the platform developed in the course of this project stores all events in a shared database, so that it can be used in my colleague's work to associate physiological readings, save annotations and analyse the data.

1.7 Structure of the document

This document is organised into 8 chapters as well as appendixes:

- **Chapter 1 — Introduction**: in this chapter, we detailed the main current limitations and motivations that led us to develop our system. We also detailed the goals to reach as well as the main contributions of this thesis.
- **Chapter 2 — Background**: this chapter gives context to some topics that will be mentioned across this document.
- **Chapter 3 — Related work**: here we present the related work associated with our thesis.
- **Chapter 4 — Designing a system for authoring in VR**: we detail the problem scenarios, as well as response scenarios that we propose.
- **Chapter 5 — Implementation**: here we present the details of our implementation, along with previous iterations and decisions.
- **Chapter 6 — User study - design probe with therapists**: presents the protocol and details of the study, as well as detailing the findings.
- **Chapter 7 — Discussion**: in this chapter, we discuss the findings of the study.
- **Chapter 8 — Conclusions**: here we present the main conclusions taken from the developed work, as well as its limitations and further improvements and future work.
- **Appendixes**: includes initial patient examples given to us by therapists, as well as protocols and forms used in the user study.

Chapter 2

Background

In this chapter, we provide relevant context into the topics that will be mentioned in this document and are important to highlight.

2.1 Anxiety Disorders

Although anxiety is a normal reaction to stress and it can be beneficial in some cases [4], anxiety disorders differ from these normal reactions and involve an excessive amount of fear and stress [4]. Anxiety disorders can affect the patient's day-to-day life in contexts such as work, school, and personal relationships [4].

2.2 Exposure Therapy

Exposure Therapy is a therapeutic approach where the patient is gradually exposed to traumatic stimuli, which aims to help patients cope with feelings of fear/anxiety and decrease avoidance. The most common types of exposure therapy are *in vivo* exposure and imaginal exposure [50], while virtual reality exposure has been gaining ground in the field.

2.3 Virtual Environments

Virtual Environments (VE) are built using software and aim to recreate the real world. These environments immerse users in realistic settings, allowing them to engage intuitively and intimately with the digital environment [39]. Over the years, further improvements to their realism, general display, and tracking technology advancements opened the possibility for its use in health, accompanied by big displays or Head-Mounted Displays (HMD). This technology has already been used in a plethora of different approaches in the context of healthcare, such as reducing pain in children during painful procedures [45], calming patients through biofeedback [24], and coping with anxiety disorders. However, continued efforts are still needed to improve VRET when applied to children and adolescent mental healthcare.

2.4 Virtual Reality Exposure Therapy

VRET is a type of exposure that is performed using a virtual environment, with the use of HMDs or other technology (e.g., Cave Automatic Virtual Environment (CAVE), big screens) [50]. Because the therapy is done using virtual environments, it can be done inside the therapist's office, eliminating the confidentiality issues that *in vivo* exposure therapy presents [50]. Furthermore, it allows the therapist to have more control over the exposure [50], enabling it to be tailored for each patient and customisable while the therapy session takes place [6].

2.5 Self-Report Questionnaires

To assess one's health condition or how it evolved, one common way is to administer self-report questionnaires. Clinicians use several well-established and children-designed self-reports such as the Clinician-Administered Post-Traumatic Stress Disorder Scale for DSN-5 (CAPS-5), Screen for Child Anxiety Related Emotional Disorders (SCARED), and the Spence Children's Anxiety Scale (SCAS) [40]. However, self-report questionnaires possess some limitations, such as low reliability in young children [44], and being time-consuming (i.e., requiring time to answer), thus decreasing feasibility while exposure therapy takes place.

2.6 Sensors

Physiological sensors can track signals such as heart and respiration rates [13], galvanic skin response [31], and diaphragm expansions [49]. There are multiple types of sensors, such as electrodes, face masks, and gyroscopes, among others, that allow these data to be collected. They all offer objective information regarding the physiological state of the patient at a certain point in time.

Chapter 3

Related work

Virtual reality in the context of health is emerging with several examples. VR has already been used in multiple health-related environments and is constantly evolving. This section will give insight into multiple avenues already pursued with VR, with sensors, and their combination. Then, we describe VRET in more detail and conclude by presenting some limitations found in the review of related work and summarising the state of the art.

3.1 Virtual Environments

Virtual Environments, with the use of HMDs or other technologies, have been proven useful in various scenarios, even when it is the only technology being used, i.e., without sensors. This section will mention using VEs for pain management, reducing anxiety related to medical procedures, and Social Skills Training (SST).

3.1.1 Pain management

Pain is often present in children who undergo procedures such as burn wound treatment [29, 45], administering vaccines [8] and drawing blood [8], among others.

Children and adolescents with extensive burns are case studies that require further attention, as severe and acute pain unmanaged can lead to several adverse effects, directly affecting treatment. Opioid analgesics are broadly used in these scenarios. Still, they are usually not enough [29], requiring further solutions that can reduce the amount of pain the patient perceives they are feeling.

A scoping review conducted by Ahmadpour et al. [1] analysed several articles on using VR in pain and anxiety management in pediatric patients. Of the over 1300 articles published between 2013 and 2018, 18 were included in this review. Among the interventions identified in these papers, including helping the patient build capacities to handle pain and shifting the patient's attention strategically, distraction was found to be the most effective one [47]; by engaging patient's attentional resources in a task, especially an immersive one such as playing a game through VR with visual/auditory feedback and enjoyment, limited capacity is left to be allocated to process pain [8].

Even with this information, a question still arises. Is distraction from VR needed? Or is a simple game or small task for a patient to do during treatment as good as VR? Hoffman et al. [29] tackled these questions by comparing the use of opioids while playing a Nintendo 64 Two Dimensional (2-D) game as a distraction (serving as control) and opioids while immersed in a VR experience. Two patients were included in this study; both experienced both approaches and presented significantly less perceived pain with VR experience than with the 2-D game. Figure 3.1 presents the results of one of the patients. It is important to note that the patients' experiences

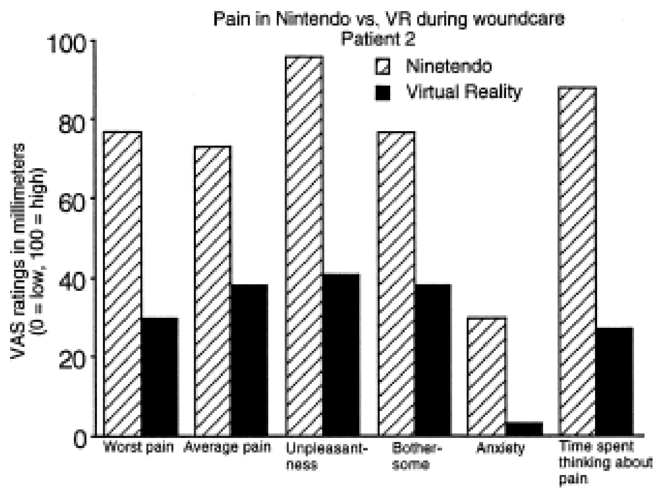


Figure 3.1: Pain ratings in VR compared to Nintendo64 2-D game [29]

between the 2-D game and VR differ. Patients could not look at their wounds during treatment while using VR, unlike in the 2-D game, where one patient was observed looking at his wound during gameplay. The authors argue that this may have contributed to reducing patients' perceived pain [29].

3.1.2 Medical Procedures

Anxiety before a medical procedure is often present in children. It can lead to adverse outcomes [17], varying in severity according to what operation or medical procedure is done. They can be the inability to stand still during procedures that force the patient to be immobile [48], needing rescue or general anaesthesia [17, 48], among other possible outcomes [12, 15, 17, 48].

Radiation Therapy (RT) in children is a procedure that normally is used to treat central nervous system cancers and other malignancies [48], requiring the patient to be completely still to optimize treatment and reduce healthy tissue loss [48]. Due to several factors such as child temperament, separation from parents, negative experiences with prior medical procedures, etc, acute distress reactions often occur, which affects RT efficacy [48]. For these reactions to be reduced and therapy to happen as intended, a general anaesthetic is routinely administered to children, with more prevalence according to their age [48]. Although it is considered safe, repeated sedation can be dangerous as it has related negative neurocognitive and emotional health effects, can be the cause for future fears and lead to a significant financial burden [48].

Tennant et al. performed a study published in 2021, exploring the effects of immersive Virtual Reality Environments (VRE) in preparing pediatric oncology patients for RT [48]. This study counted the participation of 30 children and adolescents, aged 4 to 18 years old, along with their parents, and it consisted of exposing the children (prior to the actual RT session) to the procedure and all of the apparatus surrounding their treatment, with as much realism as possible. To assess

Figure 3.2: Images of the child as an observer of the CT simulation procedure [48]

how well the exposure did in terms of helping the participants, several reports and self-reports were taken into account, alongside needing to use general anaesthetic or not. The latter is arguably the most important measure from which to derive conclusions. The results were promising; only one child required general anaesthetic out of the 30 participating in the study (3.33%), which is lower than the normal use of this combination of medications. The study also reported no adverse effects of VR exposure, and it was able to reduce children's anxiety, as well as the parents'. Although the results of the study were positive, some limitations were identified. For instance, the HMD was found to be too bulky for young children [48]. Moreover, the VR experience was more suitable for younger children than teenagers, as it accurately simulated the experience of younger patients [48]. Additionally, the prompts were complex and difficult to understand, which made it challenging to use the therapy at home [48]. It is also important to note that the children easily accepted the technology.

There is also a need to reduce anxiety towards an operation in children. Preoperative anxiety has a strong correlation with the "amount of postoperative pain, analgesic use, and length of hospital stay" [15]. A study conducted by Dehghan et al. aimed to evaluate the effect of VR technology on preoperative anxiety in children [15]. In total, 40 children aged 6-12 about to undergo abdominal surgery were included. The method consisted of the patient being presented with the simulated steps of going into the room where the operation would occur through eyeglass and a computer monitor. Headphones were also used to provide auditory feedback as well. The parents of the children were instructed to touch and comfort them before the operation. Two groups were analysed: interventional 1 and control 1. While the group interventional 1 was presented to the

Figure 3.3: Image of VE where the child acts as a participant in the VR Radiation Therapy [48]

VR exposure of the operating room, control 1 wasn't. Although there was no significant difference between these groups, there was a significant change in all subscales in intervention group 1 from the baseline results to the post-test, meaning that this approach successfully diminished preoperative anxiety in the children present in this study [15]. These results further prove that exposure to the hospital environment provides children with what to expect from the procedure, reducing the effects of stress [30].

3.1.3 SST

Social Skills Training, or SST, is a type of behavioural therapy in which the patients are taught how to react to certain situations, and it is proven to be effective in changing some social behaviours in children and adolescents with disabilities [25]. Autism Spectrum Disorder (ASD) is characterised by a lack of ability to communicate in a social environment and various patterns of repetitive behaviours [51]. Children within this spectrum often lack the ability to know how to react to certain situations, such as crossing the street with a red light, among others. Social stories are frequently used to learn these behaviours since they provide information that is easier to learn and understand and are mostly followed by role-playing [51]. However, some of these scenarios are not ethical to reproduce in real life, as they provide serious risks, such as the scenario mentioned above crossing the street with a red light. This limitation leaves a window of opportunity for VR, as virtually any scenario could be programmed into it and provide a safe(r) environment for learning how to cope with each situation.

Yuan et al. performed a study published in 2018 with 94 children within the spectrum (only 72 were included in the analysis) to provide social stories through VRE [51]. The exposure to the virtual environment was provided through a CAVE system with four sides, completely immersing the children within these depicted real-life situations. Six scenarios were designed, including four main training scenarios, and the sessions lasted one hour. These scenarios were designed to match as closely as possible to the real life of a "typical primary school-aged child in Hong Kong" [51]. The results were very promising, as subjective measures from both the children and the parents were positive. This method allowed the children to learn and to better respond to certain situations and scenarios. The parents and teachers confirmed these results as they noticed the children were ”much more proactive in greeting and communicating with neighbours and relatives” [51]. Although initially, some children struggled to engage in the training due to the need to use the stereotypical viewing goggles, after no more than three sessions, all participants were able to fully experience the therapy and improve significantly in the fields mentioned above.

3.2 Sensing and Feedback in Virtual Environments

In this section, we will mention diagnosing internalizing disorders using sensors and machine learning side-by-side, as well as the combination of virtual environments with sensors.

3.2.1 Diagnosis with Sensors

For doctors to diagnose mental health disorders such as depression and anxiety, they use self-reports from children, teachers, and parental guardians, but these come with their limitations. For instance, literature shows that using self-report questionnaires in children younger than eight is unreliable [44], while parental guardians’ reports are mostly inaccurate [44]. Furthermore, these reports usually take multiple hours to complete and assess, often spread across several weeks. Due to the rise of mental health-related problems in children [36], a better way to diagnose is in dire need.

A study performed by McGinnis et al. [44] aimed to achieve a better solution for child diagnosis of mental health disorders. This paper, published recently, tests a developed method that uses a ”belt-worn IMU (3-Space Sensor, YEI Technology, Portsmouth, OH, USA)” [44] to record the child’s data. The experiment consisted of the child being exposed to a task made to cause anxiety and fear (Snake task) [44], accompanied by other measures such as an interview and questionnaires designed for diagnosis. During this task, data provided by the belt would be recorded, and the 20 seconds of the potential threat phase was analysed and used for diagnosis. These 20 seconds

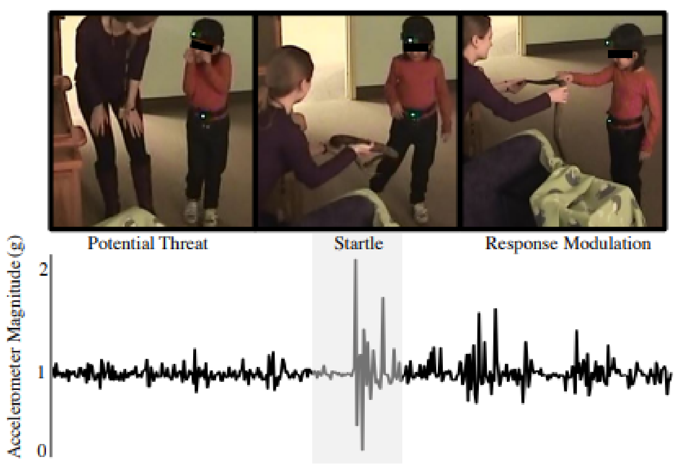


Figure 3.4: Example data from the ”Snake Task” accelerometer data. Photographs accompany each phase. [44]

were examined as they didn't require any specialised equipment to recreate, therefore being the most feasible [44] part of the experiment to analyse. To use this data for a machine learning-based diagnostic approach, several key features were extracted from the potential threat phase, such as mean, root mean square, and skew, among others [44]. Then, binary classification models were created using supervised learning to relate these features to internalising diagnosis. Several groups of models and features were used to compare the effect that these have on classification performance. The best-performing models were Logistic Regression and Support Vector Machines, with about 80% accuracy comparable to some golden standards such as Cohen's Kappa [44], and only at a fraction of the time. Moreover, the authors concluded that by pairing the 20 seconds of sensor information with machine learning, quick diagnosis of mental health disorders can be achieved, with comparable accuracy to some gold standards in the clinical field, further pointing to a future where the diagnosis is faster and may be achieved at home [44].

3.2.2 Biofeedback

Biofeedback in this context is characterised by one or more elements of the VR experience being controlled directly by one or more physiological signals of the patient. This element can be just a number on the interface of the environment, allowing the user to see how they are doing in real-time, or it can be a mechanic inside a game/virtual environment such as movement [49], or directly affecting the environment with these signals [38].

There are several ways to represent physiological signals directly in a VR setting, leading to the need to understand which ones are the best. Gradl et al. performed a study with 14 participants, comparing four different visualisations of their heart rate [24], one control, and three experimental ones. The control visualisation in this study was ”RefVis”, depicted in Figure 3.5. This type

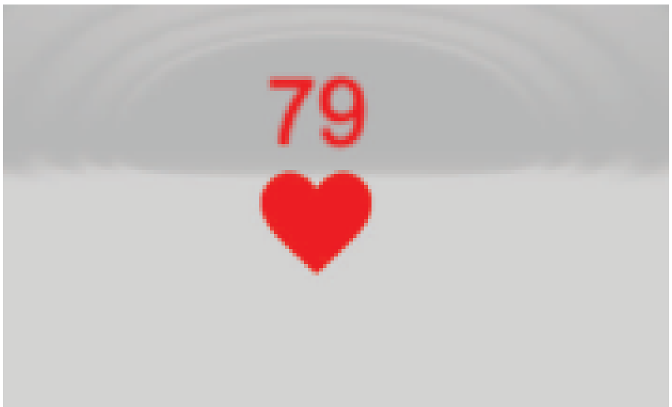


Figure 3.5: ”RefVis” visualisation [24].

of visualisation is very simple and direct, consisting of a pulsating heart symbol, with the heart rate showing above it in the form of a number, allowing the patient to see how their heart rate is instantly, contrasting with the other types of visualisations that are not this direct [24]. The second type used in the study was the ”RadialVis” visualisation. This visualisation of the user's heart rate consisted of a circle ”moving time-coherent around 360º in 20s before starting anew” [24]. From this circle, a line is created for each heartbeat from the middle of the circular disc, where its length and colour change according to the current RR interval (Time between QRS complexes, i.e., the agglomeration of three graphical deflections Q, R, and S, present in an electrocardiogram), which is the same as the Beats Per Minute (BPM) at that moment [24]. This visualisation is depicted in Figure 3.6. The third visualisation technique was "ScreenPulse". It consisted of a transparent,

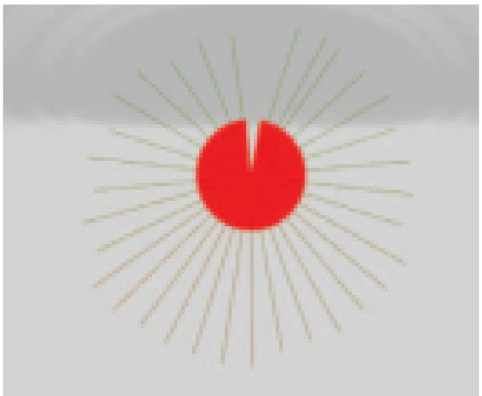


Figure 3.6: "RadialVis" visualisation [24].

circular and red overlay, which faded in and out according to the user's heart rate. This technique is often used in video games to depict low health [24]. Figure 3.7 consists of this visualisation. The final visualisation method used in this study was the "CubeGrid", characterised by several

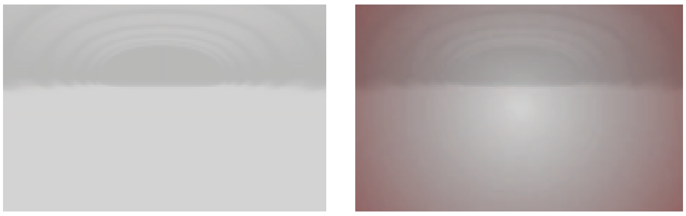


Figure 3.7: "ScreenPulse" visualisation [24].

cubes arranged in a two-dimensional grid on the ground of the virtual environment. These cubes bounced up and down according to each user's heartbeat. This was a simple approach to affecting the surrounding environment directly through a physiological signal in this study. This approach is depicted in Figure 3.8. To assess the best visualisation results, the *AttrakDiff* [27] questionnaire

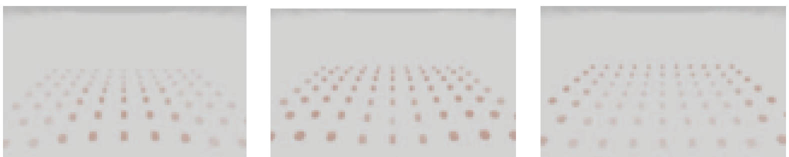


Figure 3.8: "CubeGrid" visualisation [24].

was used. Although the latter was only a basic approach to an adaptive environment, it yielded the biggest effect among all three non-reference visualisations, and it was also preferred among the participants [24]. The authors hypothesise that a modified version of this technique would be the most immersive visualisation type among all of these [24].

Rooij et al. created a VR game called DEEP [49], which placed the players in an underwater fantasy world with the sole purpose of exploring, as it didn't have any explicit goals to be achieved (Figure 3.9). However, the main feature of this game is the movement, which is done completely

Figure 3.9: DEEP's environment screenshots on the left and two pictures of children playing DEEP during the pilot study at the 2015 Cinekid Festival Medialab [49].

through the players' breathing. To achieve this, a diaphragmatic sensor was attached to the player, allowing for the diaphragm expansions to be ”recorded and directly fed back into the game” [49]. As the child correctly performed breathing motions, this data was sent back to the game to be used by it. For direct biofeedback information to the player, they were displayed an ”expanding and contracting circle” [49] in front of them, actively informing the patient how they were breathing. Furthermore, this information was used for the movement: as the player performed calm and deep breaths, they moved more efficiently in the aquatic environment, allowing for better control and, therefore, exploration of their surroundings. To evaluate the results, Roiij et al. used several self-report questionnaires: State-Trait Anxiety Inventory for Children (STAIC) and Positive And Negative Affect Schedule (PANAS) alongside Diaphragm expansions, which were sampled at 60Hertz (Hz). DEEP reduced state levels of anxiety in children, according to the comparison of results of self-reported state anxiety before and after playing the game [49].

3.3 Virtual Reality Exposure Therapy

Several key VRET research areas will be discussed here, representing some of the main topics found in the review [19]. First, we will start with Post-Traumatic Stress Disorder (PTSD), followed by School Phobia, Obsessive-Compulsive Disorder (OCD), move on to Fear of Flying, and finish with Social Anxiety and Clinicans' control in VRET.

VRET is a type of therapy characterised by being performed through the use of virtual environments, allowing for a safe exposure that can be customised for the patient's needs. In the literature found during our literature review, a clear gap was found: the lack of studies done on children and adolescents regarding anxiety disorders' treatment in VRET, which was also highlighted by Kothgassner & Felnhofer [34]. Because of this gap, the search was extended to papers using adults as their population in hopes of being able to extrapolate some information to children.

3.3.1 Post-Traumatic Stress Disorder

Post-Traumatic Stress Disorder (PTSD) usually manifests after a severe traumatic event, such as war [22, 23], and it can lead to several impairments in daily life. Both *in vivo* and imaginal exposure have limitations; in this case, *in vivo* can prove to be difficult to implement, as recreating a war scenario has its challenges, and imaginal exposure can prove to be difficult as the patients usually repress memories of traumatic events [37].

VRET can be a solution for this since it can recreate a real-world scenario in a relatively safe environment and at a low cost. Some studies emerged in this area, mostly regarding war/military veterans, who represent a percentage of the population that is especially prone to this disorder. Gamito et al. [22] and Gerardi et al. [23] performed studies on using this technology for war veterans.

The paper by Gamito focused on Portuguese war veterans who fought in former African colonies [22]. Ten patients were assigned among three groups: waiting list, imagination exposure, and VRET. The VRET scenario consisted of a path intended to be crossed by foot, with its sides covered by dense vegetation (Figure 3.10), where the goal of the participants was to follow several virtual soldiers to progress [22]. In this scenario, several cues could be activated to in-

Figure 3.10: PTSD VRET scenario [22]

crease engagement and Sense of Presence (SOP): ambushes, gun sounds, and tracing bullets were some of the possible cues, each ranging in a scale of intensity that could be activated as the patient needed. As seen in Figure 3.11, the exposure would get more intense from session to session,

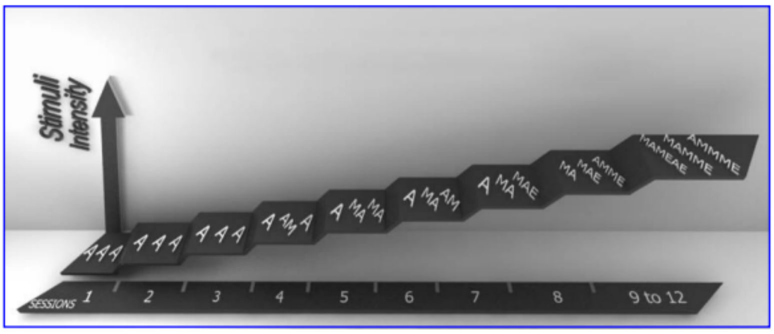


Figure 3.11: Increasing intensity scale from session to session [22]

with more severe cues being activated. Several self-reports were used to gauge how the patients compared with each other in different groups. The results of VRET were at least the same as imaginal exposure, with the added benefit of an apparent reduction in the participants' depression and anxiety levels. Although the sample size is really small, these results are encouraging and suggest that VRET could be helpful in the reduction of symptoms and quality of life improvement in PTSD patients.

The study conducted by Gerardi et al. [23] only included one patient, and the scenario consisted of a drive in a military Humvee through a highway situated in the desert either alone or part of a convoy, or in city scenes designed to resemble Iraq. Several stimuli were included in the experience, such as explosions, weapon fire, radio, and vehicle noises, among others. In both CAPS and PSS-SR reports, significant decreases in scores were obvious, suggesting an improvement in both these measures. Although this study comprised a very small sample size of one individual, the results further hint at the effectiveness of VRET as a treatment for some PTSD symptoms, allowing for a better day-to-day life.

3.3.2 School Phobia

A fear of school-related situations or environments characterises School Phobia. These situations can range from presentations, exams, presenting themselves to colleagues, getting bullied, and being criticised in front of the class, among others [41]. These fears can lead to lower school performance and an increased risk for the child/adolescent to drop out completely of school [41]. It is noteworthy that *in vivo* exposure was the most common therapy method at the time of this paper (2009).

In this study, performed by Gutiérrez-Maldonado et al. [41], two virtual environments were built: a school and a classroom. In these two environments, the children are exposed to several situations that would be present in a real school day. These would include finding a classroom when the bell rang, an intimidating character challenging him to meet after school, presenting themselves to class, and going to the board to answer some math questions, with various degrees of intimidating/neutral characters. Each environment had an ”easy” and a ”hard” level, each with nuances that would cause more or less discomfort. Self-report questionnaires were used as a way to measure subjective results and improvements (or lack thereof) before and after therapy. Overall, the results were positive, as the exposure reduced the intensity of school-related fears. Furthermore, since this was a VR study, several patients who were more reluctant to treatment managed to get involved, showing further validation that VRET is more approachable and less scary to children and adolescents.

3.3.3 Obsessive-Compulsive Disorder

Although VRET in children has shown encouraging results, there is still a lack of research on other mental health disorders, such as obsessive-compulsive disorder. This is mostly because this disorder is unpredictable and presents itself in various ways, making it difficult to treat. The five most common types of OCD are organisation, contamination, intrusive thoughts, ruminations, and checking. Usually, the obsessive and ritualistic behaviours (symptoms) can arise from an attempt by the patient to get more control of the surrounding environment and, therefore, lower their anxiety levels. In the review, we found evidence validating the use of VRET for contamination-type symptoms [13].

This study, performed by Cullen et al. [13], compared the use of *in vivo* exposure to VR

Figure 3.12: Sample of Bathroom Virtual Environment for OCD [13]

exposure in an OCD setting. Heart and respiration rates were recorded using physiological sensors to assess how each patient was doing, and several self-reports were used in conjunction. Overall, the results were comparable to *in vivo* exposure; both exposures triggered comparable ”increasing levels of anxiety across an exposure hierarchy” [13], but VRET patients showed higher therapy engagement and lower pre-session anxiety. These results suggest that VRET has a place in the treatment of OCD symptoms, but still needs more studies to develop this technology further.

Several papers try to review the literature and draw some conclusions [9, 32]. Still, as mentioned before, further studies and more literature need to be developed to generalise and accept this technology in clinical use.

3.3.4 Fear of Flying

Fear of Flying consists of fear of certain situations regarding flying on aeroplanes or other flying vehicles. These situations can consist of waiting in the airport before embarking on a plane, being inside it waiting to take off, taking off and landing, and various other situations. *In vivo* exposure can be extra difficult to perform in this context since it can lead to high costs (plane tickets), having to wait for a flight to be available and risking confidentiality breaks [50], since there would be more people on the plane.

In this context, since it’s such a common disorder and it is difficult to perform exposure therapy, several studies have emerged, and a lot of software designed for this purpose already exists.

A study conducted by Rus-Calafell et al. [43] tried to compare imaginal exposure to VRET for fear of flying. This study used a custom program designed by Botella and Baños and a clinician’s manual included with the software. The results were exciting, as both approaches decreased flying-related fears. Still, VRET offered better results concerning the patient's "perceived interference of fear" [43] in their lives.

Rothbaum et al. [42] compared somatic experience with VRET for fear of flying, and these two approaches got similar results in terms of effectiveness with an important key difference. When asked, most participants showed a particular preference for VRET. All of the results were maintained at a 6-month follow-up after the study, showing persistence in the results.

3.3.5 Social Anxiety

Social Anxiety is characterised by fear and avoidance of social situations such as public presentations and crowds. It represents a big impairment for several day-to-day activities that can influence normal life practices. Similarly to Fear of Flying, several papers already dive into VRET as a more accepted method and alternative to *in vivo* exposure [3, 6, 7, 28]. Usually, these environments focus more on public speaking, by creating auditoriums with small or big crowds, in which the patient has to give a prepared speech [6, 7].

Overall, results were comparable to *in vivo* [7], which further validates the use of VR as a replacement to *in vivo* exposure.

3.3.6 Clinician's Control in VRET

In ET and VRET, clinicians encounter patients with highly specific and unique conditions, creating difficulty in providing customised therapy. Consequently, VRET systems must be designed to address this challenge [33]. Very few papers mentioned the therapist's interface and controls during our literature review. This interface, which is available to the therapist, should be tailored to their needs, needing to have the possibility to control and give an overview of the VE [11] to allow the therapist to have more control over stimuli present and patients' response.

While VR technology has allowed patients to have immersive experiences during therapy, it also adds to the therapist's workload. The therapist has to 1) pay attention to controlling the virtual environment, 2) interact with the patient, and 3) take notes, all at the same time. Therefore, it is important to make this process as easy and seamless as possible for the benefit of both the patient and the therapist [11].

3.3.7 VRET Conclusions

By conducting this review of the literature [19], it was possible to identify that VRET is a promising method for the development of effective and accessible approaches to ET [13, 26, 50]. VRET allows the recreation of more intense scenarios that one would not typically find *in vivo*. Moreover, VRET is a less "invasive" option than traditional ET approaches, enabling the therapist to focus on the patient while having more control over the session, and most patients preferred VRET over *in vivo* exposure [15]. In relation to its effectiveness, VRET was found to consistently be as good, or in some cases even better than traditional therapy methods with the presented anxiety disorders.

VRET can be further augmented with the use of sensors to assess how the patient is doing physically at any given moment, informing the therapist how stimuli should be manipulated to increase therapy efficacy. In addition, sensors can be used to assess the effectiveness of the treatment, preferably if used in conjunction with self-report questionnaires or other subjective measures. The combination of sensors and self-report questionnaires seems to be a promising approach to attain further knowledge on the effectiveness of VRET and should be further studied in the future.

Performing more studies regarding VRET is of seminal importance, as it will make treatment more accessible, affordable, and less frightening for patients (including adults). It is also important to note that interfaces regarding these VEs should also be studied and worked on alongside therapists as a way of democratising and giving more control and agency to therapists.

3.4 Current challenges in VRET

Although VRET applications allow the control of environments and tackle limitations raised by imagination and *in vivo* exposure therapies, they are often designed with no therapist involvement, which in turn don't cater to their needs. Furthermore, current solutions are a "one size fits all" and are not geared towards children [34].

In addition, it is important to consider that clinicians often encounter patients with unique and highly specific conditions, which can make it challenging to provide customised therapy [33].

3.4.1 Other challenges

While the challenges mentioned above will be the focus of this thesis, we still want to mention the following limitations that were found in the literature.

One of the main limitations of VRET is the danger of cybersickness [46]. Cybersickness can often be caused by the lack of consistency of the patient's head movement in real life and the VE (high latency), lowering the effects of the therapy depending on the severity of the symptoms. These can range from nausea, eyestrain, headache, and dizziness, depending on the patient and their age and gender. However, children and adolescents are less likely to develop cybersickness, as most studies either don't report or report minimal symptoms across patients [12, 17, 48].

Despite cybersickness not being a significant limitation due to the targeted groups, some shortcomings still arise. Some younger children reported fear of "getting stuck in the headset and of seeing something scary like in a horror movie" [34], with some children even refusing to wear the headset turned off due to fear of losing control over the situation [12]. Even though these concerns are valid and important, some solutions can be applied so that the patient feels more at ease. Increasing the level of control a child perceives they have over a situation is an essential factor in mediating it. When patients feel like they are more in control of the situation, they adapt better and handle treatments more effectively. Simple measures like allowing children to choose the movie they want to watch can significantly increase their sense of control and promote faster adaptation to the treatment. A study conducted by Buldur et al. [12] demonstrated how letting children choose their preferred movie helps enhance their sense of control and make the treatment experience more positive. Similarly, Ahmadpour et al. [1] suggest that increasing the patient's perceived sense of control can lead to better treatment outcomes.

Another limitation of working with VR headsets and physiological sensors is that these are rarely made with children in mind. Moreover, the headset can feel bulky to the patient [48], or even just the sensors, which can make the child anxious or uncomfortable during therapy.

3.5 Summary

Virtual Reality in the context of health is becoming increasingly more prevalent as more approaches and solutions are designed to tackle problems in several fields.

Pain is usually present in children who undergo several painful procedures, such as burn victims [29, 45], cancer patients [1], etc. Opioids are usually used, but often these are not enough [29], so a solution that could accompany these is required. VR has been shown to reduce the pain perceived by the patient [29], mostly by distraction [1]. By distracting the brain with other activities/information that is immersive, the patient will perceive a lot less pain than another activity, such as a 2-D game on a screen [29].

Medical procedures often cause some anxiety beforehand, especially in children and adolescents, which directly affects the efficacy of treatment. It can also affect the amount of postoperative pain and length of hospital stay, among others [15]. Usually, this anxiety comes from the fear of the unknown, which several authors have tackled by guiding the child through each part of the medical apparatus through VR [48]. This has shown great results, and it worked as a way to reduce anxiety and post-procedure complications.

For ASD, teaching and exposing patients (especially children) to situations for them to learn how to behave and deal with certain problems that may arise from day-to-day life, i.e. SST, is paramount. Still, real-life role-play sessions are often not ethical and can present some dangers [51]. VR can mitigate some of these limitations by allowing the children to be exposed to these situations in a controlled and safer environment.

Diagnosis of anxiety and other internalising disorders often requires a long time, and self-report questionnaires of young children are not very accurate [44]. Sensors come as a way to mitigate some of these limitations by measuring the body motion of a child and using machine learning models to diagnose their internalising disorders. In the study performed by McGinnis et al. [44], the accuracy was comparable to ”normal” clinical methods that are proven and well-established.

Biofeedback improvements in a VR setting are getting more advanced, which has shown positive outcomes such as lowering patient anxiety, even by just playing a simple game [49]. Further advances in this field could lead to better solutions integrated into daily activities to influence and calm people down.

Imaginal and *in vivo* exposure therapies both have some limitations, such as lack of control of the therapist and ethical and confidentiality issues, among others. VRET has shown great promise in multiple areas such as: in PTSD [22, 23], the results were comparable to imaginal exposure, but with some advantages such as the perceived levels of anxiety/fear of the patients were lower with VRET; in school phobia [41], the study by Gutiérrez-Maldonado et al. managed to lower the school-related fears of children, with the added bonus of including more reluctant participants due to the nature of the study, VR; in OCD [13] results were comparable to *in vivo* exposure, with the caveat of having a bigger engagement and less pre-session anxiety; for both Fear of Flying [42, 43], and Social Anxiety [3, 6, 7, 28], several studies and software have already been designed with the sole purpose of providing exposure therapy in these contexts with positive results that are comparable to *in vivo* and imaginal exposures.

Providing customised therapy during exposure therapy and VRET can be challenging for clinicians as they often encounter patients with unique and specific conditions [33]. Therefore, it is important to develop VRET systems that cater to the needs of both patients and therapists to reduce attrition and workload [11]. Since patients and therapists have different roles, designing the clinician interface and the VE with their collaboration is crucial. Co-designing and co-iterating these interfaces with clinicians will help create a more effective and personalised therapy session.

Chapter 4

Designing a system for authoring in VRET

VR is emerging in the field of health in multiple different avenues [29, 15, 51, 22], showing promise when compared with more established ET methods like *in vivo* and imaginal [22, 13] by performing the same or slightly better, with the added bonus of being less scary and more engaging, especially to children. Despite this, the lack of focus in the literature review towards clinicians and children was apparent, shifting the entirety of focus to the validity of VRET itself [11].

It is important to build easy-to-use systems for therapists in order to reduce attrition between the therapist and the platform. At the same time, it is important to empower them with the necessary controls which they might not find in other ET approaches. Therefore, it is essential to pay attention to their requirements and thoroughly understand the therapy process to cater to their needs effectively.

Our aim was to attain this by involving therapists as co-designers of our platform, which allowed us to steer the design of our solution towards the creation of a VRET system that:

- Allowed the control of elements in the environment.
- Allowed previous sessions to be replayed and reviewed.
- Was easy to use.
- Allowed for multiple anxiety disorders to be tackled.
- Had the end users as the focus (therapists and patients).

4.1 Preliminary sessions

To develop our design methodology, we conducted two preliminary sessions with therapists. Our development pipeline was carried out in collaboration with PIN[1] (Partners in Neuroscience), a private clinic with two locations - one in Lisbon and another in Porto. The clinic offers care for

[1] https://pin.com.pt/

children and adults but primarily focuses on treating children. The therapists who participated in the sessions were associated with this institution due to our prior relationship.

During these two preliminary meetings, we identified which anxiety disorders to focus on in our platform: fear of public speaking, which is often generalised as social anxiety by clinicians, and fear of spiders, or arachnophobia. These meetings also helped us to understand and confirm the main limitations of current practices, such as the low possibility of controlling real-life environments and their unpredictability.

Based on our findings, we decided to prioritise certain initial features in our system, such as high control over virtual environments and the ability to compare and replay previous sessions. In addition, we also got basic insights into therapy which were useful to understand the pipeline: 1) exposure is done gradually, and 2) the therapy process is different for each patient.

Further small suggestions, patient examples (seen in Appendix A) and a clinical process example (seen in Appendix B), allowed us to define our system requirements, as well as construct two different problem scenarios that will be detailed next. In each scenario, a patient and a therapist are included, as well as a relatable context. Through the analysis of the problem scenarios, it is possible to place into a normal situation each of the solutions presented by our VRET system.

4.1.1 Problem scenario 1 - Fear of public speaking

Filipe is a 15-year-old student currently in his 10th grade. Every time he has an oral presentation approaching, he gets extremely nervous. When he has to speak in front of his classmates or in public, he feels a weight on his chest, his heart starts beating faster, and he sweats profusely. Furthermore, his voice breaks, and he is unable to speak properly. His hands start shaking, and he tries to hide them in his pockets. He has trouble sleeping the night before the presentation because he worries about being ridiculed in class.

Filipe's parents bring him to a therapist in order to help him cope with this anxiety. The initial sessions focused on educating Filipe about his fear of public speaking. With additional work, he was able to give a presentation in front of his therapist during the first exposure sessions. During therapy, when asked if he is ready to move on to the next step, which includes adding adolescents to the audience, Filipe expresses anxiety and explains that people his age make him nervous. After the therapist explains that it is important to help cope with his anxiety, Filipe, although scared, agrees in hopes of being able to overcome his problem.

The therapist also has trouble trying to arrange the exposure sessions with an audience. It is a challenge to find adolescents of the same age as the patient who are available, which leads to longer gaps between each session. Additionally, it is challenging to gradually expose the patient to adolescents as they are unpredictable and difficult to manage.

Due to the lack of success in therapy, Filipe wasn't able to control his anxiety during a presentation. The pressure of being in front of the class made him forget what he had to say, and some of his colleagues ridiculed him, making the situation worse. As a result, he had to leave the classroom to avoid further embarrassment.

4.1.2 Problem scenario 2 - Fear of spiders

Marta is a 12-year-old girl who is afraid of spiders. Whenever she sees a spider or a spider web, she gets extremely scared and starts screaming. Marta's grandmother is bound to a wheelchair and lives in a village in an old house, and every time she visits her, Marta gets anxious, knowing that there might be spiders around. As a result, she is unable to enjoy her time with her grandmother and refuses to visit her again.

Marta's parents took her to a therapist to help her cope with her fear of spiders. With the therapist's assistance, Marta was able to make progress in the therapy process and eventually reach a point where she could be in close proximity to spiders while managing her anxieties. However, Marta did not attend any therapy sessions during her summer break, which prompted the therapist to evaluate if her progress was maintained during this period.

During the exposure session for evaluation, the therapist was unable to use the same spider as before because it was no longer available. As a result, the therapist had to use a different spider, which had more erratic behaviour. This, in turn, made Marta afraid again. The therapist was unable to determine whether this response was due to the use of a different spider or the loss of progress during the summer break and couldn't evaluate her correctly, forcing him to start on the first step again.

Due to the extra delay caused by the poor evaluation, Marta continues refusing to visit her grandmother for an extended period of time, deteriorating their relationship since they can't spend quality time together.

4.2 Use cases

In this section, we will outline the possible applications of our platform, with specific reference to the problem scenarios mentioned earlier. For the purposes of this discussion, we assume that the therapist has access to a VRET platform, which enables them to conduct and monitor exposure sessions with ease.

It's worth noting that the platform we're discussing here can be utilised in a variety of situations beyond those outlined in the problem scenarios.

4.2.1 Response scenario 1 - Fear of public speaking

Filipe's parents bring him to a therapist in order to help him cope with this anxiety. The initial sessions focused on educating Filipe about his fear of public speaking. With additional work, he was able to give a presentation in front of his therapist during the first exposure sessions. During therapy, when asked if he is ready to move on to the next step, which includes adding adolescents to the audience, Filipe expresses anxiety and explains that people his age make him nervous. After the therapist explains that it is important to help cope with his anxiety, he proposes to Filipe the use of a VR headset for the initial exposure to an audience. Filipe is willing to try it as it is a technology he is familiar with, and he feels safer in the virtual world.

The therapist chose a virtual classroom environment that resembled a 10th-grade classroom. He had complete control over the audience's actions and was able to populate it with virtual adolescents easily. At the beginning of the exposure therapy, only two virtual adolescents were introduced into the room. During different sessions, the therapist added more and more people to the audience while incorporating some of the gestures that Filipe found to be more anxiety-inducing, such as side conversations, yawning, and clapping. The exposure was done gradually with a high success rate, allowing Filipe to transition into a real-life audience after a few virtual sessions.

As a result of his successful therapy, Filipe managed his anxiety and delivered a flawless presentation. Despite feeling nervous, he was able to recall all the information he needed to present and deliver it perfectly. His colleagues were impressed, and the teacher gave him a good grade, which made him happy.

4.2.2 Response scenario 2 - Fear of spiders

Marta's parents took her to a therapist to help her cope with her fear of spiders. The therapist decided to use VR as the form of exposure due to the safety and reliability it provides. With the therapist's assistance, Marta was able to make progress in the therapy process and eventually reach a point where she could be in close proximity to virtual spiders while managing her anxieties. However, Marta did not attend any therapy sessions during her summer break, which prompted the therapist to evaluate if her progress was maintained during this period.

During the evaluation exposure session, the therapist utilised the replay feature on the VRET platform. This allowed the therapist to replay the previous session exactly and observe Marta's reaction. Marta reacted similarly to the replayed session, which enabled the therapist to evaluate her successfully. As a result, the therapy process could continue as planned, allowing Marta to progress and eventually face real-life scenarios involving spiders.

Due to the progress of therapy, Marta finally agreed to visit her grandmother and was able to spend quality time with her.

4.3 System requirements

The system requirements involve the functional requirements (system functions) and the non-functional requirements (system properties).

Functional requirements:

- **Protection of sensitive data.** — guaranteeing the protection and privacy of information.
- **Mobility** — allow the patient to move freely within the virtual environments.
- **Multimodal feedback** — the inclusion of multiple forms of feedback such as visual, auditory and haptic.

- **Different scenarios** — the inclusion of multiple different scenarios.
- **Creating elements** — controlling the creation of different elements in each scenario.
- **Manipulating behaviour of elements** — allowing the manipulation of the different elements previously created in each scenario.
- **Reviewing previous sessions** — allowing for previous sections to be visualised in a timeline.
- **Replayability of previous sessions** — allowing the replayability of previous sessions exactly as they happened, possibly changing them in real time.

Non-functional requirements:

- **Usability** — a simple interface that is easy to use.
- **Extensibility** — easy to introduce and apply new features and scenarios.
- **Immersion** — allowing the patient to feel immersed in the different environments.

4.4 Design methodology

During our design process, we held a series of informal meetings where we worked on prototypes for both the VR and computer applications. We also had internal meetings within the research team. The cycle involved three meetings with therapists, which were very informative. The first two meetings helped us gather use cases and define our system requirements, which allowed us to start building our prototypes. The third meeting was a way for us to confirm some of the requirements and showcase our initial prototypes to therapists. This gave us valuable insight and suggestions that helped shape the rest of our design process.

4.5 Summary

In this chapter, we have presented two scenarios that showcase how our system can address specific situations and contexts (problem scenarios) by providing corresponding solutions (response scenarios). We gathered information from patient examples and informal meetings to create these problem scenarios.

Our system features virtual environments that enable patients to feel fully immersed while giving therapists complete control over each environment.

The therapist can manipulate various elements in these environments, from creating and removing them to changing their properties. Additionally, the therapist can replay previous sessions to enhance the patient's experience.

The design process involved three meetings with therapists. The first two meetings were used to establish the problem and response scenarios, as well as system requirements. The third meeting was held to present the initial prototype to therapists and get initial feedback and some guidance.

Chapter 5

Implementation

This chapter presents our VRET system — *VRTherapist* — as well as details and decisions taken in its implementation.

5.1 Overview of the system — VRTherapist

The Virtual Reality Therapist (*VRTherapist*) system consists of two components — a VR system/HMD application and a computer application. The VR application enables patients to immerse themselves in various environments and interact with their features, which is helpful for exposure therapy. The clinician can control these environments in real-time using the computer application, which allows them to guide and monitor the patient's exposure therapy sessions. These two apps have a symbiotic relationship, which means that one cannot work without the other. Their communication is established through a TCP connection, where the VR application serves as the server and the computer application as the client. Additionally, information about the timeline of different sessions is saved to the cloud using Google's Firebase.

5.1.1 Architecture

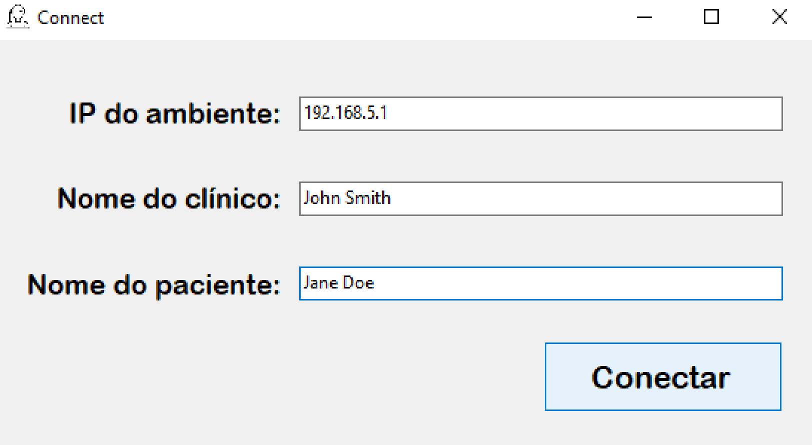
As mentioned above, our system comprises two applications.

VR application

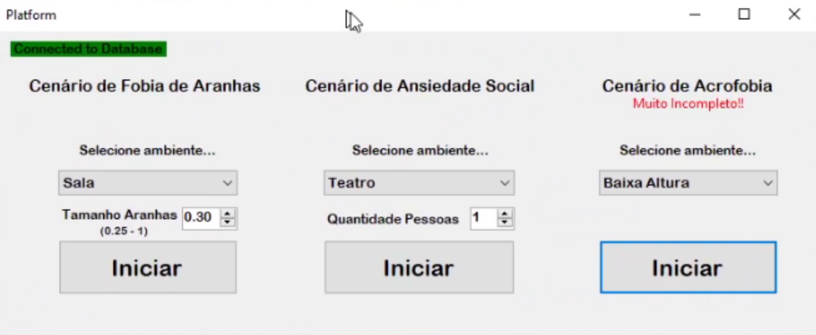
This application is designed for patients to interact with, and it includes various environments for different scenarios. For instance, it features a small classroom and a big theatre for those who fear public speaking. For those who fear spiders, there is a living room and an office. There are high walkways with three different heights for individuals who fear heights. Additionally, there is an initial area for connecting purposes.

Computer application

This application is designed for the therapist's use and provides control for each scenario. The first window that appears when you open the application is for connecting to the VR application and defining the therapist and patient's names. This interface is presented in Figure 5.1a. When the therapist clicks on "Conectar", it connects the application to the Firebase database and our VR application. This also opens the main control centre (Figure 5.1b), from which it is possible to start each scenario. The computer application also features a control interface for each scenario: fear of spiders, fear of public speaking, and fear of heights. These interfaces will be detailed in their respective sections.



(a) Connection interface.



(b) Main control centre.

Figure 5.1: Different screenshots showcasing the initial interface and main control centre.

Database

Our system uses Google's Firebase database in order to store and read data. The data structure of this database is detailed in Figure 5.2.

5.2 Functionalities

This section will mention the general functionalities of our system.

- **Communication between applications** — allows the communication between the VR and computer applications through a TCP connection.
- **Connect to Firebase database** — allows the connection to Google's database Firebase.

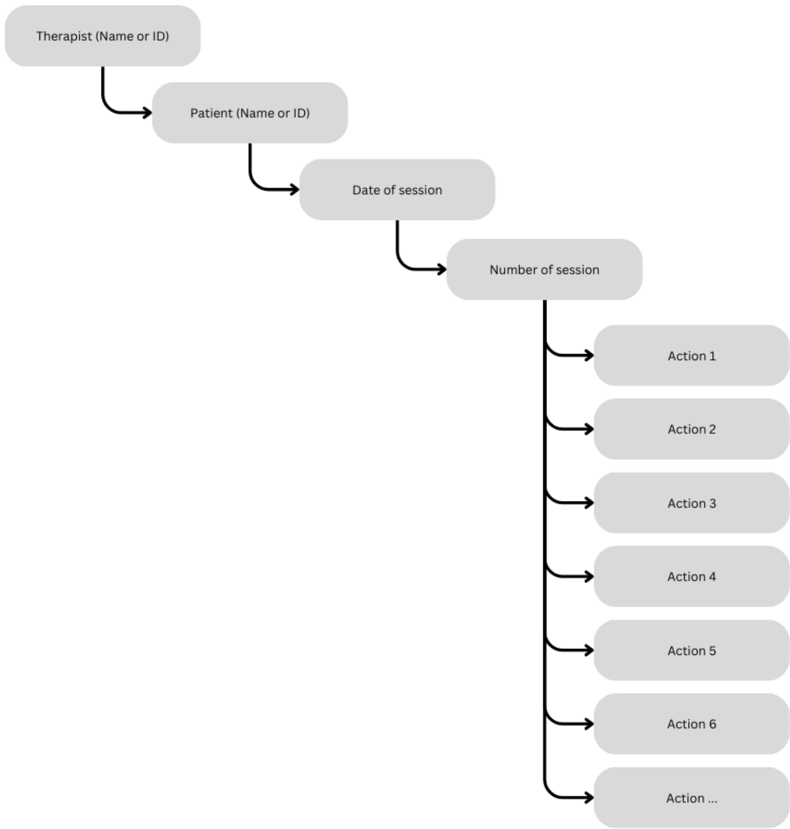


Figure 5.2: Database structure.

- **Save data to Firebase** — allows for data to be saved to Firebase.
- **Read data from Firebase** — allows for data to be read from Firebase.
- **Changing the patient's position in VR** — allows the therapist to remotely control the patient's position within the VR environments.
- **Patient's autonomous movement** — allows the patient to move freely within the VR environments.
- **Grabbing objects** — allows the patient to grab and move objects within the VR environments.
- **Creation of elements** — allows the therapist to create elements within the VR environments.
- **Deletion of elements** — allows the therapist to remove elements from the VR environments.
- **Element movement** — allows the elements to move autonomously and through the therapist's control.
- **Element animations** — allows for elements to play animations.

- **Sound manipulation** — allows for sound to be manipulated and played.
- **Vibration of controllers** — allows for the controllers to provide haptic feedback through vibration.
- **Review previous actions** — allows for previous actions to be reviewed.
- **Replay previous actions** — allows for previous actions to be replayed.

The VR application is mainly responsible for processing logic and data. It receives commands from the computer application for actions that must be performed in the virtual reality environment. However, the computer application takes care of saving and retrieving data from Firebase, as well as reviewing and replaying previous actions.

5.3 Scenario 1: Fear of public speaking (social anxiety)

In this section, we'll discuss the fear of public speaking scenario. It involves two different settings: a small classroom and a large theatre, as shown in Figure 5.3. The classroom environment has ten small desks with chairs for students and a larger one at the front for the teacher. There is a chalkboard on the wall. The theatre environment has 60 chairs arranged in five rows of varying heights, a ramp, and a stage. A sample image on the wall represents a big screen or projection. In both environments, the patient starts in front of the door.

Next, we will detail the specific functionalities of this environment and provide context into some of the decisions and previous iterations that occurred for certain features.

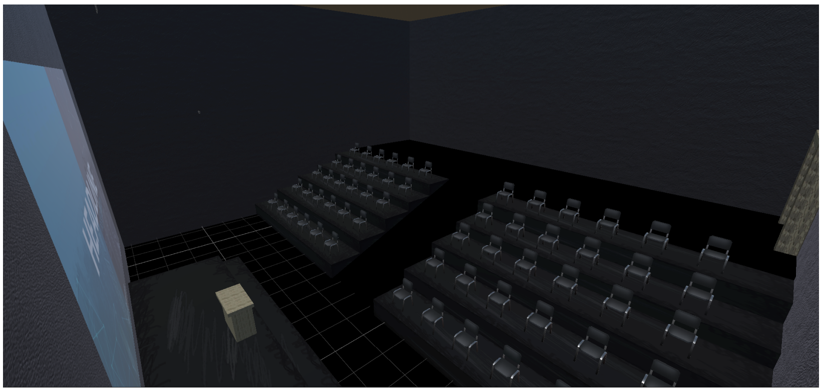
5.3.1 Main elements of the scenario - People in the audience

As we discussed earlier, these virtual environments aim to help people overcome their fear of public speaking. The audience is the key element that can be controlled in these environments. To represent the audience, we use a character model from Mixamo[1], which provides high-quality models and animations for free. The model we chose is that of a white male in his 20s, dressed casually, as we thought it wouldn't be too intimidating for users. However, this wasn't the first character model we picked. Initially, we chose a rougher model based on cubic characters that featured clothing randomisation, providing variety to the audience (Figure 5.4). Although clinicians initially thought it would be sufficient, we couldn't easily add animations to it, and some models didn't fit well within the context (e.g., thief, construction worker, etc). As a result, we decided to switch to a more refined model from Mixamo that supported a range of different animations and fit better within the context.

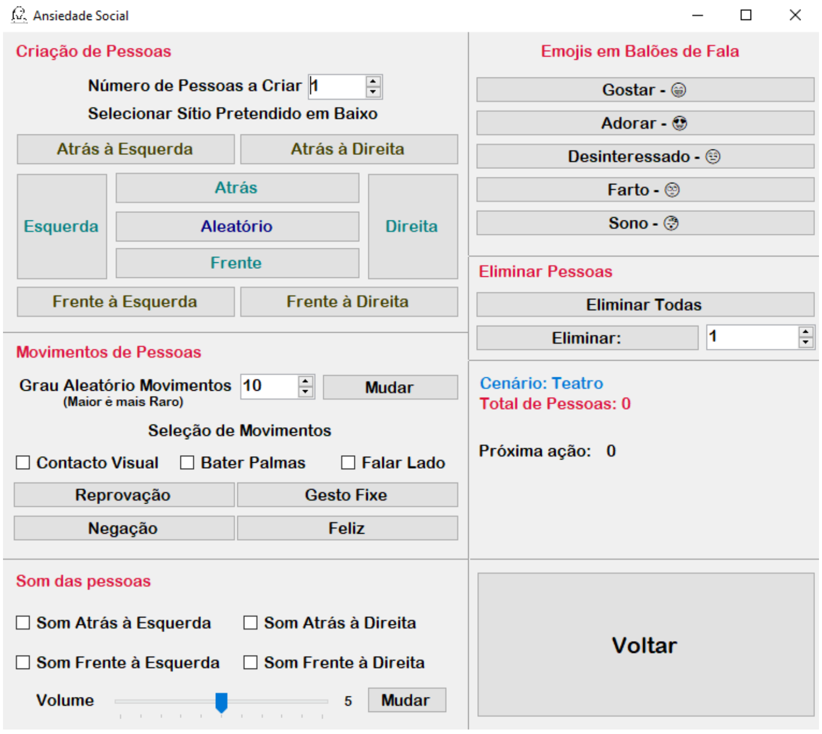
It is of note that, detailed in Figures above, the visual interface of the computer application can be seen. Although basic, it is a big improvement over our initial interface, which was just a terminal where each instruction had to be typed out. This interface can be briefly seen in Figure 5.4b at the bottom right.

[1] https://www.mixamo.com

(a) Classroom environment.



(b) Theatre environment



(c) Therapist's platform for fear of public speaking

Figure 5.3: Different screenshots showcasing both fear of public speaking environments and the platform controls for this scenario.

(a) Initial character models.

(b) Current character models, featuring an initial prototype of the platform in the bottom right.

Figure 5.4: Different screenshots showcasing the initial and current character models.

5.3.2 Creation of people in the audience

This behaviour is interacted with through the ”Criação de Pessoas” portion of the visual interface.

Initially, during the creation of the scenario, characters used to appear in the audience already sitting. However, therapists suggested that it would be more engaging for each character to enter through the door and slowly walk towards their seat. This presented two challenges: finding a vacant seat and guiding the characters towards it. In this solution, we will mention the theatre environment as an example, but it's worth noting that it is the same for the classroom.

Store all seat information

When entering the environment, the position data of each seat (60 seats in the case of the theatre) is saved into the list `positionList[]` in order, as well as its vacancy state `occupied`, which is by default set to `false`. This list also has the ability to store a prefab reference for each position, which will be useful later.

Find vacant seats

The first real step happens as soon as the therapist presses the corresponding button to the position in the audience they want people to appear, `place`, as well as the quantity, `numberOfPeople`. Then, the application starts checking in the `positionList[]` which seats are empty in the specified `place` and saves it in a list, `unnocupiedPositions[]`. This is achieved by iterating through certain indexes that are associated with each area of the audience; for example, to create people in the front seats, the function iterates through the indexes `0 <= i <= 11 and 30 <= i <= 41`. The only exception to this is when "Aleatório" is selected, which just iterates through every index to find empty ones.

Associating a seat with each character

After creating a list of empty seats, our program randomly assigns a seat to each person. However, since all characters are prefabs, it becomes a challenge to pass on information about the seat position to each individual. To overcome this challenge, the program instantiates the prefab in the corresponding seat, and the prefab saves its current position when it spawns. It is then immediately moved to the desired initial position in front of the door. This ensures that the seat position is successfully saved. We initially considered the possibility of each character briefly appearing in a seat, but after extensive testing, we observed no limitations with this approach and decided to stick with it. At the same time the character is being spawned, the program associates it to the seat position in `positionList[]`, as well as changing its `occupied` variable to true.

The algorithm for both finding vacant seats and associating a seat with each character is summarised following pseudo-code:

Algorithm 1 Find vacant seats and associate them to each character

Require: user clicks button to create people in audience
Ensure: $positionList[] \neq null$, $place \neq null$, $numberOfPeople \neq null$

procedure FINDVACANTSEATS()
    $place \leftarrow$ selected area in audience
    $numberOfPeople \leftarrow$ number of people requested to create
    while i within $place$ associated indexes **do**
        if $positionList[i].occupied == false$ **then**
            $SavePosition(unocupiedPositions[])$
        end if
    end while
    $seatPosition = random(unnocupiedPositions[])$
end procedure
procedure ASSOCIATESEATETOPREFAB()
    for $numberOfPeople$ times **do**
        $SpawnPrefab(seatPosition)$
        $positionList[seatPosition].occupied = true$
        $positionList[seatPosition].prefab = spawnedPrefab$
    end for
end procedure

From the door to the seat

Now that the character is at the door of the environment and has the seat saved as the final destination, we need to path to it. To achieve our goal, we have divided the path into three different

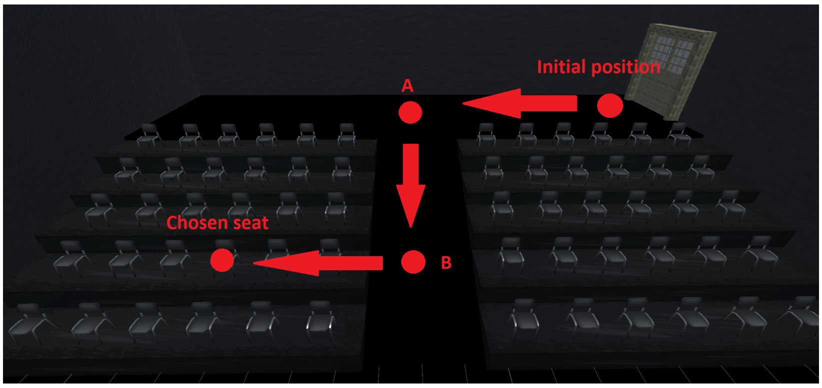


Figure 5.5: Pathfinding example of the character.

moments that connect the initial position to the chosen seat through two middle points, which we call small goals. For example, consider Figure 5.5: the first moment is from the initial position to the top of the corridor, with the first small goal being from the initial position to A. The second moment is from the top of the corridor to the correct row in the corridor, with the second small goal being from A to B. Finally, the third moment is from the corridor to the chosen seat, with the last small goal being from B to the chosen seat.

To ensure that each character in our program moves correctly, we must calculate two small goals. The first small goal, A, is the same for every character and involves walking towards the top of the corridor. The second small goal, B, is dynamic and depends on the chosen seat. To reach this goal, the character must walk down the corridor to the correct row height of the seat. To achieve this, we use the y and z values of the chosen seat's position and maintain the same x value as A.

In our project, we utilise Unity's methods to move the character to the desired locations. We follow a sequence of movements, starting from the initial position to point A, then to point B, and finally to the chosen seat. To achieve this, we use the `Vector3.MoveTowards()` method for movement, and the `transform.localRotation` attribute of the prefab to rotate it towards its goal. This rotation only occurs in the y axis to maintain natural movement. It is essential to note that both movement and rotation follow local positions and rotations, which are based on the parent's position and rotation, instead of global ones. This approach is necessary because the prefabs are instantiated inside the environment, which is the parent object.

5.3.3 Remove people in the audience

This behaviour is interacted with through the "Eliminar Pessoas" portion of the visual interface.

The process is similar to the one described in the previous section, "From the door to the seat", but in reverse. The character will stand up from the seat, walk to point B, then to point A, and

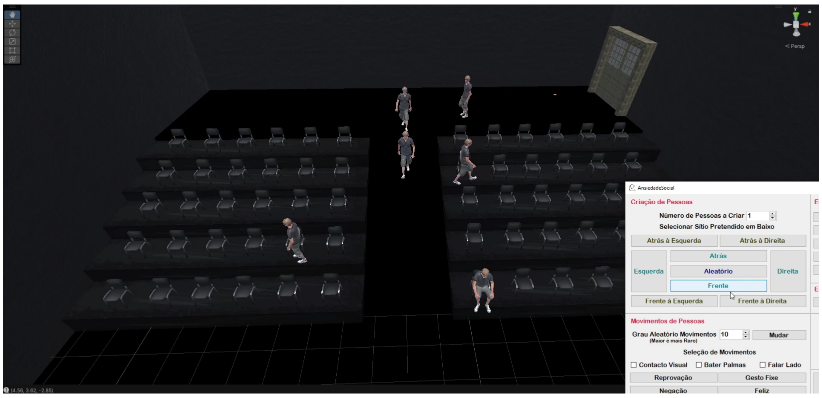


Figure 5.6: Screenshot of characters entering the theatre.

finally to the door, disappearing once it reaches it.

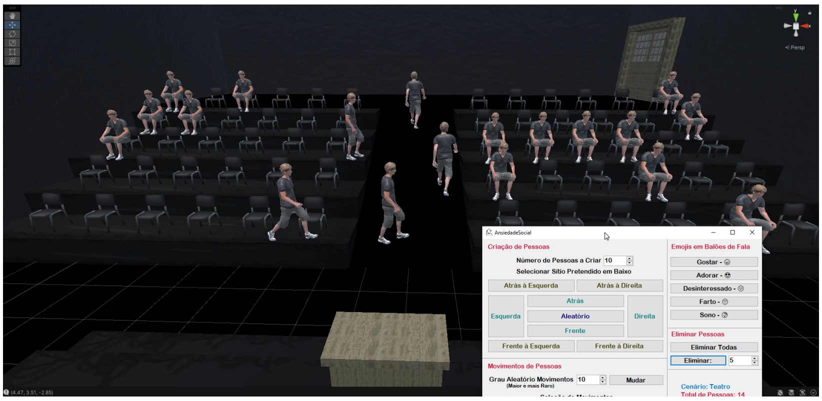


Figure 5.7: Screenshot of characters leaving the theatre.

5.3.4 Audience animations

This behaviour is interacted with through the ”Movimentos de Pessoas” portion of the visual interface.

As previously mentioned, we used character models from Mixamo. This made it easy to implement various animations, using Unity’s own animator in order to detail the hierarchy. Figure 5.8 details this hierarchy, which starts in the green ”Entry” state and moves to the ”walking” state. This state continues active until the character reaches a chair, which will then move the active state to ”sitting idle”, staying there indefinitely until the user activates another animation.

There are two types of animations: continuous and single-shot. However, the ”walking” animation, in which the character walks to or from a chair, is an exception, as it takes longer than single-shot, but stops automatically when reaching its destination.

Continuous animations

Continuous animations are those that can play continuously for an unlimited amount of time, only stopping when the user of the platform decides to stop them. These animations are associated with

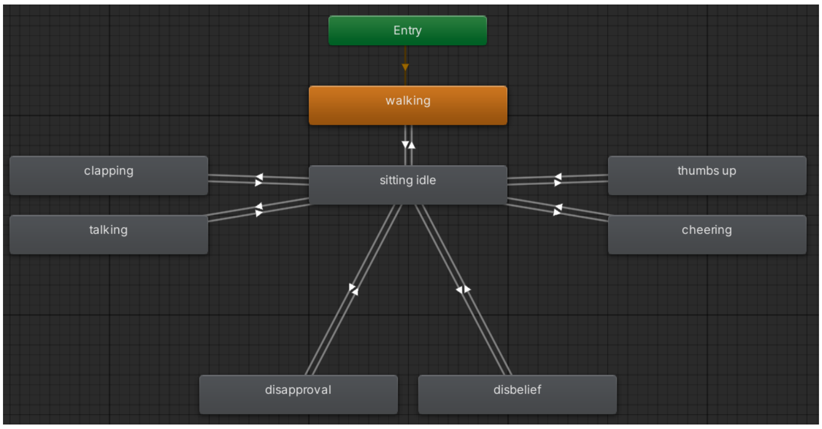


Figure 5.8: Unity's animator hierarchy for fear of public speaking character.

the states "sitting idle", "clapping", and "talking" in the animator hierarchy. The "sitting idle" state plays an animation of the character sitting down, starting with the transition between the standing and sitting positions. The character stays sitting, slightly moving the body while waiting for other states to begin. This animation serves as a fallback to every other one, except walking, when they end. The "clapping" state makes the characters clap, while the "talking" state has the characters leaning back and turning to the side, simulating a conversation with someone next to them.

Single-shot animations

On the other hand, single-shot animations play once and don't last long. These are associated with the states "disapproval", "disbelief", "cheering", and "thumbs up". The first two are negative reactions, while the remaining are positive.

Exceptions

Although most animations can be categorised into the two types mentioned earlier, there are two exceptions to this rule: the "walking" animation and the "eye contact" animation. The "walking" animation is programmed to have the character walk to or from a chair and stop automatically upon reaching the destination. It plays autonomously and does not require any input from the user. On the other hand, the "eye contact" animation is not included in the animator. This behaviour causes the entire character to face the patient and can be turned on or off as needed.

Playing animations

To play these animations on the platform, the user needs to press the respective buttons. The single-shot animations are associated with simple buttons, while their counterparts are controlled using toggles. It is important to note that when selected, these animations will play randomly among the audience based on the degree of randomness chosen. The degree of randomness is determined by drawing a pseudo-random number between one and the selected degree value. If the number drawn is one, the corresponding animation will play. Higher degree values will make the animations less frequent among the audience. This drawing process is repeated for each character present in the environment.

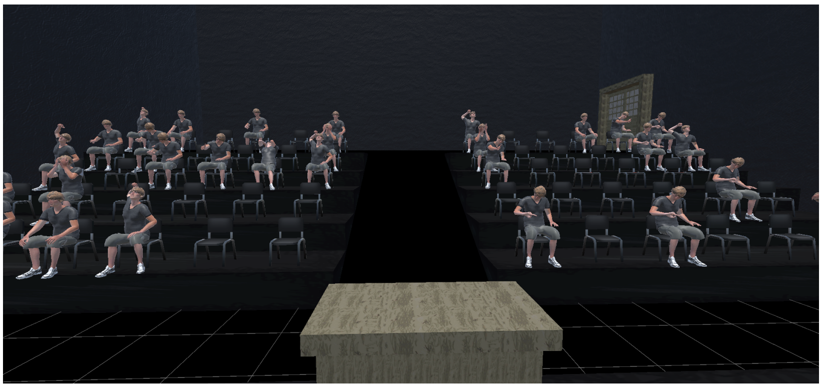


Figure 5.9: Characters playing different animations.

5.3.5 Depicting emotions in the audience

This behaviour is interacted with through the ”Emojis em Balões de Fala” portion of the visual interface.

We use thought bubbles with five emojis to convey emotions to the audience. These emojis include two positive emotions, two negative emotions, and one that signifies being sleepy. The clinician can select the appropriate emoji by pressing the corresponding button, which will then display the thought bubbles with the emoji above people in the audience. This can be seen in Figure 5.10.

Figure 5.10: Example of a positive emoji in the audience.

At first, we intended to convey emotions through facial expressions on the characters' faces. However, we chose to use thought bubbles instead for two reasons. Firstly, we couldn't modify the models provided by Mixamo to alter their facial expressions. Secondly, even if we could have made such modifications, facial expressions would have been difficult to discern from a long distance due to the size of the theatre. As a result, we opted to continue with the current approach.

5.3.6 Toggling sound in the audience

This behaviour is interacted with through the ”Som das Pessoas” portion of the visual interface.

To add sound to our environment, we utilise the audio system available in Unity. We play multiple audio sources with realistic sound placement, which creates an immersive experience for the user. The sound is delivered through the four corners of the audience, i.e., top-left, top-right, bottom-left, and bottom-right. This sound is dynamic and 3D, allowing the user to identify the direction and intensity of the sound. As a result, the user can sense if the sound is coming from the left or right, and the volume at which it is being played allows him to discern how far it is.

There are two audio samples that play from two different locations in the audience (i.e., the back areas and the front areas). They contain background noise of people talking and sometimes coughing. The clinician can turn the sound on or off and adjust the global volume of the sounds using a volume slider.

5.4 Scenario 2: Fear of spiders (arachnophobia)

In this section, we will discuss the scenario of fear of spiders, which involves two different settings: a living room and an office. These settings are shown in Figure 5.11.

The living room environment has a big table at the centre of the room, along with a glass on top of it and a handbag on the ground close to it. It also features a TV, a lamp, and some furniture. On the other hand, the office environment has six work desks with computers on them, as well as a conference table and plants.

In the living room environment, the patient starts in front of the table, while in the office, they begin in the middle of the room.

We will now provide details of the specific functionalities of this environment and provide context into some of the decisions and previous iterations that occurred for certain features.

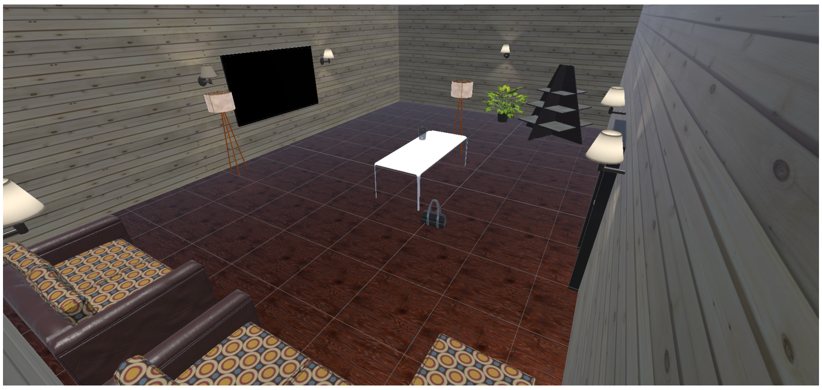
5.4.1 Main elements of the scenario - Spiders

As mentioned previously, the aim of these environments is to assist people in overcoming their fear of spiders. Therefore, the key elements that can be controlled in these environments are the spiders. To represent these spiders, we used a model from the Unity asset store[2], which provided a good balance between realistic and cartoony, with the added bonus of already containing support for different animations. The spider model is black with yellow spots on its back and was the first model incorporated into our application. Clinicians approved of this model, so we stuck with it until the end.

5.4.2 Creating spiders

The application allows the creation of spiders in three different areas:

[2]https://assetstore.unity.com/packages/3d/characters/animals/insects/animated-spider-22986



(a) Living room environment.

(b) Office environment

Figure 5.11: Different screenshots showcasing both fear of spiders environments.

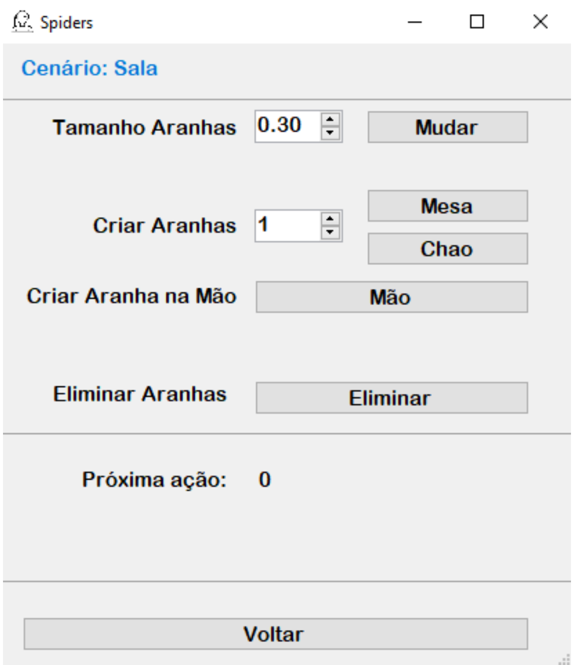


Figure 5.12: Therapist's platform for fear of spiders

Table (living room only)

In the living room, there is a table that allows for the creation of spiders. The spider appears randomly on the table, with its position determined by a pseudo-random number generator. The x and z coordinates are randomised within the bounds of the table, while the y coordinate is determined by the height of the table. This allows the spiders to be created on top of the table and never floating outside it.

Floor

In both environments, the spiders can be created on the floor, appearing at a random position that is generated using a pseudo-random number generator. The x and z coordinates are randomised within the boundaries of the floor, which are different for each environment. Spiders can also be created under furniture. Similar to the previous area, the y coordinate is the same as the floor, which means that spiders will appear on top of it.

Patient's virtual hand

The final area that allows the creation of spiders is the patient's right virtual hand. Here, the spiders' position is also generated through a pseudo-random number generator, with the particularity that all three axes are used. It is noteworthy that the patient's hand is used as a reference point, which means that local coordinates are used instead of global coordinates. This allows the spider to be created directly on the patient's hand, despite any variation in the hand's position.

5.4.3 Deleting spiders

There are two ways to get rid of spiders in the application. The clinician can use the control interface to delete them directly, which will make them disappear immediately. Alternatively, the patient can use their hand or the handbag to kill the spiders. The application works by deleting the corresponding prefab associated with the spider that needs to be eliminated. If the aim is to delete all the spiders, the application will delete all of them.

5.4.4 Spider movement

The spider movement is designed to imitate the realistic behaviour of actual spiders. The spider moves towards a random position, using a pseudo-random number generator while following the rules that were mentioned in the "Creating spiders" section. Once it reaches its destination, it stops for a random duration before setting a new goal and repeating the process.

To perform the movement, a goal is randomly defined. We use Unity's method, `Vector3.MoveTowards()` and the attribute `transform.rotation` to move in the direction of the goal. However, for the hand spider's movement, we use the `transform.localRotation` attribute to adhere to the hand's rotation. Once the goal is reached, the spider remains in place for a random amount of time within a predefined interval. After this, the spider calculates another goal that follows the position rules specific to the area in which it was created.

5.4.5 Change the spiders' size

The therapist can easily adjust the size of the spiders in the visual interface. This can be done by changing the value in the text box and clicking the "Mudar" button. The changes in spider size will be immediately displayed in real-time. Additionally, the clinician can adjust the spider size as a parameter before starting the scenario by using the main control centre.

5.4.6 Object interaction

The patient can interact with the environment in two ways: as mentioned earlier, by killing the spiders with their hand and grabbing two objects with two different functions.

Glass

The glass that sits on top of the table can be grabbed using the "grab" button on the quest controller. This method serves as a means to catch spiders. The patient can grab the glass, flip it over with the opening facing downwards, and capture the spiders inside it. The trapped spiders cannot move until the glass is removed. This technique was implemented to give patients a sense of control over the spiders.

Handbag

To kill spiders without using their hands directly, patients can grab the handbag that sits on the ground by pressing the "grab" button on the quest controller. They can then hit the spiders with the handbag to kill them. The purpose of this technique is to provide patients with an alternative and less direct way of killing spiders.

5.4.7 Spider sounds

Spiders produce a sound when they walk. This sound is designed to mimic the sound of their legs walking on a hard surface. The sound is three-dimensional, which means that the listener can determine the source and distance of the sound based on the perceived volume. It is of note that the sound plays individually for each spider and only when they are moving.

5.4.8 Haptic feedback

As mentioned before, a spider can be created in the right hand of the patient. When the spider walks, the controller triggers a slight vibration to provide feedback to the patient. The vibration is weak and stops when the spider stops, mimicking the sensation of a real spider walking on the hand. To achieve this, we use the `SendHapticImpulse()` method from the `UnityEngine.XR` framework associated with the spider's walking mechanism.

We added this feature because clinicians requested more patient feedback, which was positively received.

5.4.9 Animations

The spiders feature three different animations:

Idle animation

This animation is played when the spider is standing still, consisting of the spider's body slowly moving up and down.

Walking animation

This animation plays when the spider is walking, moving each leg in a realistic manner.

Death animation

This animation is played when the patient kills the spider, which consists of the spider being squished and disappearing.

5.5 Scenario 3: Fear of heights (acrophobia)

This section is dedicated to the scenario of fear of heights, which involves three different settings that are based around walking on glass beams with varying heights. These settings can be seen in Figure 5.13.

Out of the three scenarios, the fear of heights scenario is the least developed. It does not involve any therapist control and only allows the patient to walk and recover from falls. We decided to focus more on the other two scenarios due to the feedback from therapists in the initial meetings.

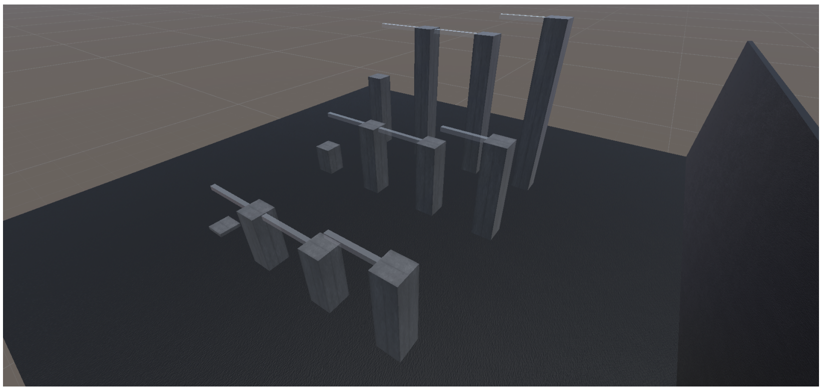


Figure 5.13: Screenshot showcasing height variation in fear of heights environments.

5.6 Reviewing and replaying previous sessions

These two behaviours are interacted through the use of our platform's "Sessões Antigas" interface, depicted in Figure 5.14. The clinician can easily access past sessions by searching for the patient's name and the session date. If there were multiple sessions on that day, the therapist can switch between them. The clinician needs to press the "Validar" button to view a specific session. After validation, the therapist can click on "Executar sessão" to replay the selected session automatically. This will change the interface to the one related to that particular scenario.

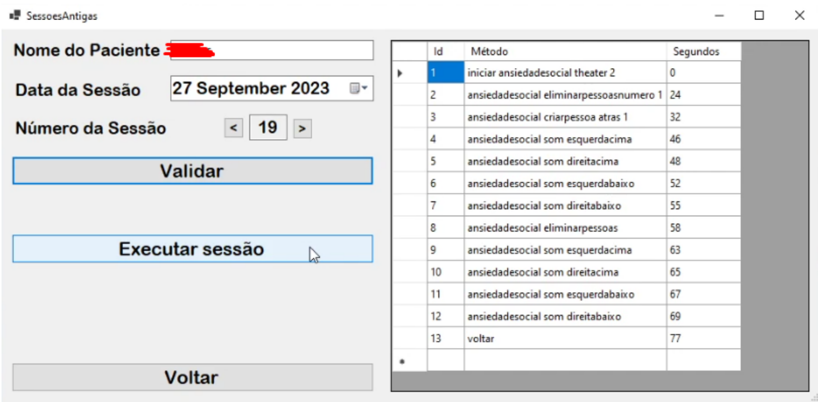


Figure 5.14: Past sessions control centre.

We decided to separate these two functionalities into this section since they are global to all three scenarios.

Reviewing sessions

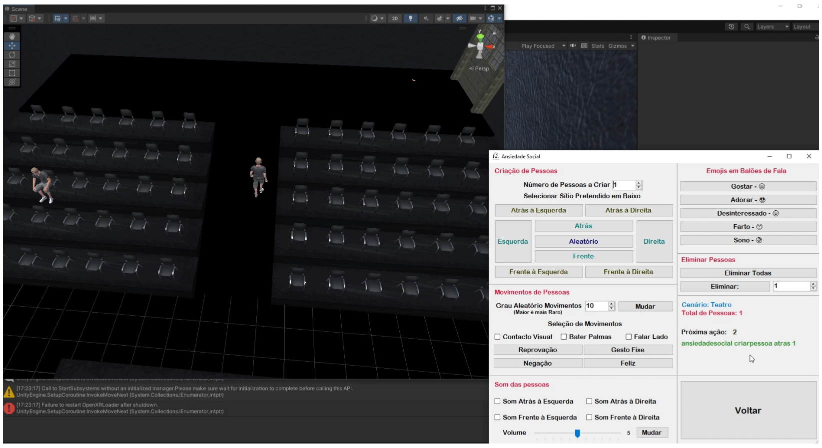
To display the actions for a selected session, we first need to count the number of sessions that occurred on that day. This helps us to ensure that the input related to the session number is valid and only allows the user to switch between existing sessions. For instance, if there's only one session on that day, the counter won't be able to be changed.

To display the information, we create a data table with rows consisting of the ID, method, and the duration (in seconds) to each action. While we do save the exact time when each action occurs, we simplify the display for the therapist by only showing the duration of each method. We calculate this duration by subtracting the time of the particular method from the time of the first one (which is usually the one that initiates the scenario).

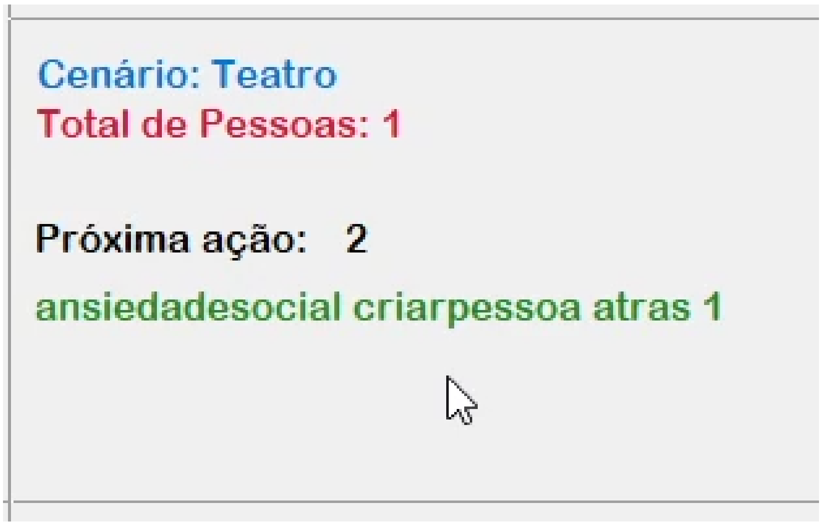
It is noteworthy that, while reading each previous session, a list called `listaOperacoes[]` is generated. This list includes the time elapsed between the previous method and the method itself (i.e. the time between a current action and the previous action instead of the first one). This list is important because it will be used for the replay feature.

Replaying sessions

The behaviour of replaying past sessions is based on the contents of the `listaOperacoes[]` list. This list contains the time it takes for each action to occur after the last action, as well as the method itself. The application reads this list and sends the instructions to the VR application for the method to be performed according to the time associated with it. The interface displays a countdown towards the next method to be executed, along with the name of the method. An example of this is illustrated in Figure 5.15.



(a) Previous session being replayed.



(b) Previous session being replayed - zoom.

Figure 5.15: Example of session replay.

5.7 Tools and libraries

This section will detail the tools and libraries that were used in order to develop both applications.

For the computer application, we used Visual Studio 2022. It is a WinForms C# app and it uses Firesharp to both read and write data to the database. Firesharp is a framework built to interact with Firebase through C#.

For the VR application, we used Unity, which is a game engine that uses C# as the script and natively supports VR applications, as well as different packages such as the `OpenXR Plugin`, which provides compatibility with several different VR headsets (e.g., Oculus, SteamVR, Index), as well as the `XR Interaction toolkit` which allows interaction between the VR headset controllers and the Unity application. We chose the `OpenXR` plugin instead of the `Oculus XR` since the latter is only compatible with Oculus-based systems.

In order to install our test APKs easily during development, we utilised a third-party software called ”Sidequest”. This software permits direct installation of APKs on Quest 2, which is not natively supported.

The TCP connection between applications, both on the VR and computer applications, was made using the `System.Net.Sockets` C# library.

5.8 System requirements

The system requirements that our applications need are as follows:

Computer application

The computer application was built and tested on both Windows 10 and 11, and it requires .NET 6.0 to run.

VR application

The VR application can be used in two different ways. Firstly, it can be used natively on the HMD. For this option, it is needed an HMD that allows sideloading (installing apks) and runs Android as the base. During testing, the application was found to work well with Meta's Quest 2 HMD, but it should also work with other HMDs that follow these rules. Secondly, the VR application can be used through a computer connected to an HMD using Unity's play mode. To use this option, the computer must meet the software requirements needed for the connection. The requirements to use the Meta Quest Link can be found on the Meta website[3].

Internet connection

In order for the two applications to communicate, they must be connected to the same internet network.

[3] https://www.meta.com/help/quest/articles/headsets-and-accessories/oculus-link/requirements-quest-link/

Chapter 6

User study - Design probe with therapists

Performing user studies is incredibly important in our field. It helps us better understand our platform, gather insights, and develop it further. Our ultimate goal is to create a clinician-driven pipeline that benefits all parties involved.

To that end, we conducted a study (Protocol on Appendix C) on identifying the essential features that should be present in a VE for VRET in the context of anxiety-related disorders. Examples of such disorders include public-speaking phobia, social anxiety, and arachnophobia. Our primary objectives were: 1) to comprehend the current practices utilised by therapists, 2) to gain insight into the potential impact of VR on the future of therapy, and 3) to determine how therapists would respond to a platform that empowers them to control the environment. To this end, we designed a semi-structured interview that included questions related to how therapy is usually conducted and the therapists' experience with technology in this context, hypothesised VRET scenarios focusing on probable limitations and desired controls, and challenged clinicians on session replayability. Furthermore, at the end of the study, a mock-up session was performed in order to directly include the therapists in design decisions.

6.1 Research questions

As a goal for this study, we wanted to answer the following research questions:

- RQ1: How do therapists perceive the role of technology in therapy?
- RQ2: How do therapists perceive the role of VR in therapy?
- RQ3: What is the clinicians' stance towards VRET?
- RQ4: What control do clinicians want in VRET?
- RQ5: What is the future of VR in therapy?

6.2 Participants

To be eligible for the study, participants were required to have training and professional experience in exposure therapy and preferably have experience in treating anxiety-related disorders. Due to our prior working relationship, we recruited 10 participants entirely from Partners in Neuroscience (PIN), a private clinic. The study involved a convenience sample of nine working clinical psychologists and one intern, all of whom had previous experience or currently work with anxiety disorders and exposure therapy. All participants were familiar with social anxiety disorder, with most having it as one of their main areas of work. It is worth noting that only n = 3 participants had previous experience with virtual reality. A summary of the participants' details is provided in Table 6.1.

6.3 Sessions

We conducted five sessions and interviewed psychologists in pairs, with a total of 10 participants interviewed. Sessions were divided into two phases: a semi-structured interview lasting around 30 minutes, followed by a 30-minute part using *VRTherapist*, which included a mock-up session and final questions.

6.4 Apparatus

Our study took place at the PIN clinic across two non-consecutive days. Four sessions were included on the first day, while the remaining one happened on the second day.

The room was divided into two areas: the interviews area and the mock-up session area.

Interviews area

The initial and VR-related interview area was set using a table with four chairs for the investigators and participants. On the investigators' side, two laptops were opened with the semi-structured interview questions on the screen and a notebook for taking important notes.

Mock-up area

The mock-up area was set using only one (more powerful) laptop that was able to run the VR environment smoothly without loss of performance. To immerse the participants into the VE, the Meta Quest 2 HMD was used, with a connection through a USB-C cable to the laptop using Quest Link. This proprietary Meta software allowed our VR software to be cast and controlled by the participant.

A TCP connection (detailed in the previous chapter) was made between the VE and the platform using the clinic's Wi-Fi to connect the VE to our platform.

Table 6.1: Clinical experience of participants.

Variables	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Sex	Female	Female	Female	Female	Female	Female	Male	Male	Female	Female
Experience (years)	<1	19	15	18	3	3	25	21	5	10
Certified	Professional internship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Experience with anxiety disorders	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Experience with Social anxiety disorder (SAD)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Experience with exposure therapy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Main work areas	PD SM	GAD Phobias SAD	NA	NA	SAD	SAD PAD	SAD VA	SAD PD PAD SA VA	ADHD SAD PAD	OCD Phobia ASD
Experience with VR	No	Yes	No	No	No	No	Yes	Yes	No	Yes

*NA: Non-applicable; PD: Panic Disorder; SM: Selective Mutism; GAD: Generalised Anxiety Disorder;
SAD: Social Anxiety Disorder; PAD: Performance Anxiety Disorder; VA: Videogame Addiction;
SA: Separation Anxiety; ADHD: Attention Deficit Hyperactivity Disorder; OCD: Obsessive-Compulsive Disorder;
ASD: Autism Spectrum Disorder;

6.5 Procedure

Each session started with the leading investigator describing the study's objectives and providing an overview of participants' involvement, including their rights. Following the presentation, attendees had the opportunity to ask any questions they had. Subsequently, participants were given an information sheet (seen in Appendix D) with study details and authors' contact and were asked to read and sign the written informed consent (seen in Appendix E).

Sessions were audio recorded. These audio recordings were transcribed while protecting the anonymity of participants by assigning them a code from P1-P10.

The session comprised two main phases, each focusing on different objectives.

Phase 1: Semi-Structured Interview

During the first phase, we gathered data on the current clinical practices used in treating anxiety disorders with ET. We also asked participants for their opinions on VR. Our aim was to understand and validate the challenges and limitations faced by traditional methods by collecting data and promoting discussions between clinicians. To facilitate this, we used a script divided into five categories to guide the conversation. The following categories were discussed during the interview:

- **Background**: In this category, we aimed to understand the participant's background in therapy and their experiences with anxiety disorders. We also discussed which anxiety disorders are more common in the clinic.
- **Therapy Characterisation**: This category focused on understanding the therapeutic method, initial therapy sessions, and any variations. We also talked about barriers and challenges that current ET methods (*in vivo* and imaginal) raise.
- **Evaluation and Problems**: These questions were important to understand how progress is evaluated and the differences between dealing with children and adults.
- **Technology**: In this category, we wanted to understand the participant's opinion on technology in the context of therapy before moving on to the VR-related questions.
- **VR**: Finally, participants were asked about VR in the context of health, their benefits, and shortcomings. We also discussed certain applications and controls they would like to have in the virtual environment.

Phase 2: Participatory Design (Mock-up session)

This second phase focused on a participatory design session alongside our participants to gather information on two main topics: VRET elements and VRET sessions. Here, we started with a small mock-up session in which one participant played as a patient and the other as a therapist. Participants were challenged to act as they would in a normal setting, following protocols and simulating conversations that would normally happen.

VR scenario

Although we have three different scenarios (public speaking phobia, arachnophobia and fear of heights), due to time constraints of the sessions, we decided to prioritise showing our public speaking phobia theatre scenario. Furthermore, this decision was further founded through our initial interviews, which confirmed it was one of the most prevalent anxiety disorders in the clinic. Despite this, we could still show other scenarios to some patients and get valuable feedback.

Mock-up session

Here, one of the participants was asked to play the patient role, and the other was the clinician. After the participant assigned to be the patient put on the HMD and the connection to the platform was done, the investigator loaded up the public-speaking phobia theatre scenario, and the ”patient” was encouraged to explore. Initial conversations between the therapist and the ”patient” were already happening, as the therapist would tell us what they would like to happen and be able to control. Throughout the session, we demonstrated the features we had developed and sought feedback from the participants while giving them control over the scenario.

Final interview

After completing the mock-up session, we encouraged the ”patient” to remove the HMD and join the other participant. Then, we demonstrated to the participants that we could replay the session they had just completed and asked some final questions about this feature, such as if it was interesting to be able to save sessions in order to replay them, understand how sessions differ from each other and if they are prepared ahead of time.

6.6 Data analysis

As previously mentioned, the sessions were recorded and transcribed. The data was coded and analysed using a thematic analysis protocol proposed by Braun and Clark [10]. This thematic analysis took place over several days, including a brainstorming session among the researchers to rearrange ideas and build connections among topics. A photo of the final board showing the affinity diagrams discussed by the team can be seen in Figure 6.1.

Due to connection problems between the two applications, we were unable to complete the mock-up part of the session with the first pair of participants. This problem was then fixed, and the sessions with the other four pairs were able to be completed.

6.7 Findings

In this section, we will provide detailed information about the findings obtained from our study, along with direct quotes from the participants.

Figure 6.1: Board of affinity diagrams discussed by the team.

During the analysis of the interviews, we were able to group information into seven themes: 1) Current practices in ET, 2) Therapist-Patient dynamic, 3) Progress and Evaluation, 4) Stereotypical realism, 5) Customisation and authoring, 6) The role of VR, and 7) Other scenarios.

6.7.1 Current practices in ET

Clinicians mentioned that age is a big factor that is associated with a higher prevalence of certain anxiety disorders — ”There are expressions of anxiety that are more seen at younger ages, for example, separation anxiety or social anxiety.” (P1) — such as the two mentioned ones, but also panic disorder, selective mutism and phobias. Another big factor is the presence of traumatic events in the past of the patient; for example, ”if a dog bites the child, the probability of developing a phobia towards dogs is high” (P2). Still, ”there are children that are bitten by dogs that do not develop phobias” (P2) and ”others that are not bitten by dogs and develop” (P2), so the first step into the clinical pipeline is understanding where each patient fits and ”create (...) the ID of this person” (P1).

However, it’s also essential for the patient to gain awareness of their clinical condition and ”identify the key moments where (...) he had to apply strategies” (P1) to manage his challenges. These key moments can be ”physical symptoms (...) that this person feels with anxiety” (P1) that should be associated with certain situations; for example, ”when I sweat a lot from my hands, maybe it’s because I’m afraid of having a bad grade on the exam” (P1).

Parents must also be educated on this topic as they are the ”main co-therapists” (P4) of the process and the biggest ”drivers of success or unsuccess” (P4): they can serve the role of enablers by giving in to the child’s symptoms by not associating a ”stomach ache” with an ”upcoming exam” (P4). Therefore, they must be strict and understand that ”every emotion has a function and communicates something" (P4) and that it is not negative to feel a "bad emotion" (P4); it is even adequate in some cases. These emotions must be "validated" (P4) and not challenged by the parental figures, even when they see their "own kid crying" (P3), having the risk of aggravating the situation and not helping at all.

The therapy process always starts with this initial "psycho-education" (P1, P2, P3, P5, P6) process, where the first sessions usually feature the parents in order to understand the family dynamic. After this introductory process, the therapist, alongside the patient, has to "build an exposure hierarchy" (P2, P4, P5, P6, P10) where they will "identify every situation that he is afraid of and classify it in the degree of discomfort" (P2) felt. These situations will be ordered in terms of "ability to face them" (P2), and then the therapist will make the list detailing the order of exposure to each one. Finally, exposure can begin.

Although this is the case, it is important to note, once again, that age, as well as other factors such as "not being prepared" (P2), can change the type of exposure that will be performed first, imagination or *in vivo*. While the latter is "particularly important" (P2) in disorders such as social anxiety, imagination can serve as an initial stepping stone in order to reach *in vivo*.

Exposure is a technique that "can't appear alone" (P2) and "has to always appear in conjunction with other techniques" (P2) and with a lot of the initial prepping work discussed above, which highlights the multifaceted process that is therapy. It is usually composed of small tasks, such as "sending an audio message to a friend" (P1) in the case of selective mutism. Regarding this last example, clinicians also raised the limitation in current practices that "some kids hate virtual" (P1) interactions with other people "because it's a very abstract question on how will the other person react?" (P1). Since they are not "directly seeing the receptor of the audio" (P1), the direct interaction is absent, and the patient can't see how the other person behaves while receiving the message.

While some exposure tasks are directly related to the fears of the patient, some tasks are not as direct: for example, for the fear of spiders, "spider webs" (P4) might be as, or even more, anxiogenic as seeing a spider directly because of anticipation. During the exposure process, the patient is also taught simple relaxation techniques, such as "self-affirmation phrases" (P4) and "breathing exercises" (P1, P3, P4), the latter being present even in our mock-up session roleplay during the study.

Technology was already present in therapy through the use of videos or even "360º videos" (P10) with virtual reality. Still, the COVID-19 pandemic changed care to be exclusively remote, "forcing therapists to find "alternatives (...) that could provide some dynamism to online sessions" (P5). For communication, therapists mentioned the use of "Skype, (...) Meet, Teams, (...) Webex" (P10), but the technology apparatus also included other types of systems such as "specific applications" (P10) designed for therapy, "games" (P8, P9, P10), "websites" (P8, P9, P10), and other platforms, which would always be bidirectional, meaning that both the patient and the therapist would use them. Despite this, exposure, especially for specific disorders like "social anxiety, during the pandemic, was very limited because there wasn't a context that would allow it" (P3), which still applies to online sessions nowadays.

Moreover, clinicians still raise some limitations when exposure can be done *in vivo* and in person. ”sometimes it’s hard to put into practice some elements that we think ’this would be ideal’” (P1). This can happen for multiple reasons: 1) sometimes it’s the environment itself and the organisations that don’t allow it, such as a ”school not letting that therapy is performed in that context” (P4); 2) sometimes the elements that do not cooperate, for example with a fear of bees, ”depending on the time of the year, it’s a lot harder to perform these exposure moments” (P3); 3) sometimes it’s dangerous to perform the exposure, an example given was someone with agoraphobia was already an adult, so driving was something that this person did, and ”one of the exposure moments was precisely driving (...), and there was one day that we were in that exposure phase and she had a panic attack while driving, which was clearly dangerous” (P4); 4) and sometimes in terms of logistics, with exposure often requiring the therapist to ”get out of the office, and go to the person to a certain environment” (P7, P8). This forces the clinician to book multiple hours for that specific patient instead of one and has associated costs.

6.7.2 Therapist-Patient dynamic

The therapeutic relationship between the therapist and the patient ”is one of the producers of success” (P2); this dynamic was mentioned directly by six (n = 6) of the therapists. This relationship starts forming in the first session. It develops along each session, with some situations that ”can be the determining factor in the therapeutic relationship” (P1), such as the feeling of ”competence” (P1) by the patient — ”Doctor press that button” (P1) — and asking the patient directly for help with something — ”I don’t understand how do I do this, can you help me?” (P1).

The importance of this dynamic transposes to the exposure sessions themselves, where having an avatar controlled by someone real, ”and it isn’t just a bot answering” (P2), directly affects the outcome of the therapeutic intervention. This was even more apparent when transitioning into the second phase of the study, where one pair, P5 and P6, assumed both participants would put the HMD on and be present in the environment at the same time, one serving as the patient and the other as the therapist — ”No, but I think we both go right? (...) How does this work, will it be the both of us?” (P5).

Clinicians also mentioned that during online sessions, they can’t touch a patient — ”I can’t touch a patient, meaning there are people that, in fact, need bigger... yes... need more proximity (...), and we can’t just get there and put our hand there” (P10).

6.7.3 Progress and Evaluation

As mentioned previously in the current practices section, exposure hierarchies are used throughout the therapy sessions, and associated with this hierarchy, clinicians use an anxiety scale. This scale allows the patient to quantify ”how hard that situation is, or how much anxiety it causes” (P5) and allows the clinician to decide whether they should move up or down on the exposure hierarchy. Usually, this scale ranges from ”1-5” (P4, P9) or ”1-10” (P1, P6, P9).

The goal is never to reach a zero on this scale, as this is not realistic — ”A zero is being dead, is what I’m used to saying” (P4) — but lower it enough to where the patient is able to handle the anxiety and be ready for the next step, not forgetting the previous ones.

One clinician expressed, ”when we jump to the next phase of exposure, I don’t like leaving the previous ones behind, so it’s like I am reading a text and stop at a paragraph, and I had to go to the previous paragraph to remember the story. I like doing this with them, although not necessary, but in my style, I like doing it” (P4). When presented with the platform feature of replaying previous sessions, participants said, ”it makes total sense” (P4) as it was interesting to be able to go back and ”understand that a situation that was thought to be more anxiogenic, actually doesn’t cause that much anxiety, or vice versa” (P6).

In addition to the aforementioned scale, other factors are also included in the patient’s self-evaluation, such as ”accelerated heartbeat” (P3, P4, P5), ”heavy breathing” (P1, P3, P5), and ”feeling more or less agitated, more or less hot” (P3), among others. Still, it is important to note that, when asked, clinicians at this institution stated that they don’t use any physiological sensors to measure these metrics — ”We don’t have nothing that measures heart rate, but is one of the signals they (patients) mention the most” (P4) — instead, it’s always based on self-reported symptoms. It was also mentioned that ”measuring heart rate increases the heart rate because they focus on the symptom (P4)”, especially in children with panic attacks.

In order to evaluate success, several key factors come into account: 1) ”if the child is functional and (...) if it is able to perform the tasks that are expected of her” (P5), 2) ”the intensity and frequency of the behaviours or the symptoms” (P9), 3) ”when we realise they stop avoiding situations” (P3), and 4) ”when vacations are over, and they (patients) didn’t have any therapy sessions and don’t regress is also a good measure” (P4). All of these metrics can be self-reported or reported ”by the parents” (P3).

The overarching goal is never to ”completely eradicate anxiety, because that wouldn’t be healthy, but the children being able to reduce the levels and although there is some anxiety present, be able to face situations that weren’t feasible before” (P6).

6.7.4 Stereotypical realism

”I work with obsessive-compulsive disorders. There is a myth about contamination that has to do with germs. I experienced not long ago an environment in which there are multiple germs, viruses, among others, that come flying in my direction (...) this won’t activate anyone” (P10) — This clinician, in particular, mentioned a VR application that she had experienced in the context of OCD, with contamination symptoms, which highlighted the lack of communication between VR tool developers and therapists. ”Usually, whoever does the design (of VRET applications), sometimes doesn’t have clinical experience” (P10), which in turn creates a stereotypical realism in these scenarios based on stereotypes that are not correct. In this case, ”the person is not afraid of the virus” (P10) but of the thoughts of being dirty and in unsanitary situations in their heads, such as a used tissue on top of a table or someone touching the door knob with their hands dirty.

It ”has to do with the degree of dirt” (P10), always within reason. Another clear example of an exaggeration is when we have ”extremely dirty environments” (P10); they are not realistic as ”I (the clinician) want to work with that person what is functional and adaptive” (P10), the purpose is not to remove ”the disgust from the person (...) but to teach that person to deal with its emotions” (P10). The person ”can feel disgusted” (P10) but needs to understand ”where the disgust and the anxiety become excessive” (P10).

Therefore, ”there is a gap” (P10) that needs to be bridged in order for the created scenarios to be realistic and accurate in relation to real situations. Clinicians named this comparison to real-life situations ”ecological validity” (P2, 10).

Ecological validity is important for the patient to ”identify itself with the scenario” (P2) because, without it, the experience might ”not be effective” (P2). For example, in the context of fear of heights, a normal environment to appear is a ”New York-like sky scrapper” (P2), which ”has nothing to do with the sky scrappers that I know of here in Portugal” (P2), and although it might be able to activate the patient, they might ”not feel like they fit” (P2), and not ”change the perception (...) of the phobia” (P2).

Despite ecological validity being crucial, clinicians also raised concerns about the graphical fidelity (physical realism) of the environments. It was mentioned that it would be good if, for some patients, ”we could have an environment closer to realism because (...) it is a very cartoony environment, and for some kids having a more realistic environment might help (...) because they would say ’alright, but this is because I know this is fake (...) and it’s not a problem here’” (P3).

Moreover, this realism might even be important because some patients might get stuck on judging the environment itself instead of being open to therapy — ”children (...) play, sometimes even virtual reality in other games, right? And the graphical quality is (...) a lot superior (...), and sometimes children themselves can be a little judgemental (...), which means that sometimes they get more stuck in evaluating the environment than actually (being open for therapy)” (P10).

6.7.5 Customisation and authoring

Comfort surrounding the hardware and software was also one of the talking points in the interview. Therapists were concerned that ”for some children when they are more anxious and mainly if they already have some hypersensibilities, physical stimuli can be particularly difficult (...) for these kids, the glasses (HMD) in the moment of exposure can be a problem (...) it exudes a lot of pressure on the face, and they become really hot” (P3), which coupled with the fact that ”since they know it is for exposure, the action of putting them (HMD) on will already make them anxious” (P4), starts forming negative feelings towards the HMD itself. To tackle the latter, a ”more ludic moment before entering” (P4) the therapy environment itself can be ”interesting to employ” (P4); even a simple activity such as ”hitting a hoop with a ball” (P4) can help.

The starting zone in VR can also play a role in the first impressions of the application. Clinicians stated that the current starting zone (Figure 6.2) looked like ”a dungeon” (P7) and that ”entering the virtual reality knowing that I will be exposed and having instantly a scene with a wall made of stone isn't captivating" (P5). It was suggested that, for the case of the fear of public

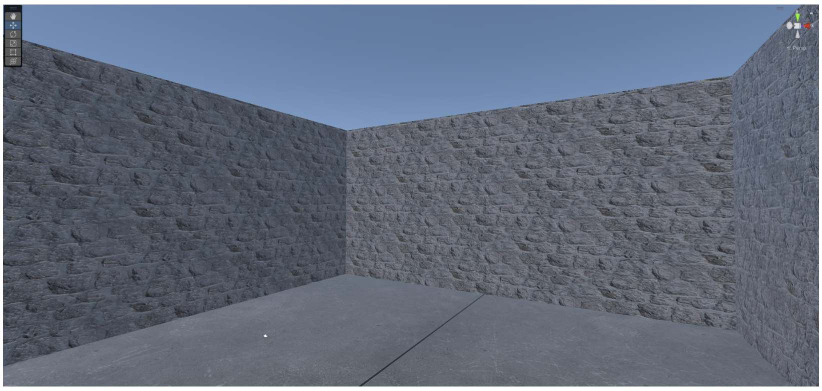


Figure 6.2: Starting/Calibrating zone in VR

speaking scenario (theatre), the exposure could start from the door, as "seeing the turned away audience (...) changes the level of anxiety, as well as being closer to the exit door" (P4), or even outside the theatre itself, starting "in the elevator" (P5) towards the theatre, and "the act of walking towards the place that causes anxiety can be the first step of exposure" (P6).

The interviews and mock-up sessions also generated more specific suggestions to improve therapists' authoring and customisation capabilities, which are described below.

Fear of public speaking

Good features already implemented:

- **Dark environment** — "The fact that the environments are dark is already anxiogenic" (P4).
- **Sound of the audience** — Clinicians asked if we had sound incorporated "Does it have sound?" (P6), which we did (sound of the audience).
- **Eye contact** — "Yes, that was the idea I had (characters looking at the therapist)" (P3), "if the colleagues are looking or not" (P9).
- **Gestures** — "That's cool" (P3), "I think it's great" (P4), "very well (referring to clapping)" (P5).
- **Quantity of people** — During the mock-up session, controlling the number of people in the audience was a very prevalent topic. "you are telling me two very important things P7, the first is the presence of more or less people, the quantity is what you're talking about?" (P8), "now it would be good that people started entering" (P9).
- **Audience leaving** — "The best would be someone getting up and leaving" (P4).

Suggestions of features to implement:

- **Change lighting** — "Is it possible to turn the light off in the audience, and leave it only at the podium?" (P4), "the lighting in the room (...) is important" (P9).

- **Sound** — Although we had implemented sounds, clinicians proposed even more sound diversity: ”If it’s darker, just hearing the sound” (P4), ”Does it have sound?” (P6); and sounds associated with gestures: ”the first gestures without sound, and then with sound” (P5).

- **Presentation with/without preparation** — The patient doing a presentation with or without preparation during the exposure session was mentioned: ”There are two things: it can be a reading presentation, which is a lot less anxiogenic, or it can be a thematic presentation where the person starts talking about that” (P4).

- **Recording** — ”One factor that sometimes aggravates anxiety for some, mainly teenagers, is if there is a recording (of the presentation) (...) there are kids that are fine with just a presentation, but if they know it’s being recorded, for example, it aggravates a lot further the anxiety” (P3).

- **More gestures and interactions** — Therapists mentioned several other gestures and interactions that should be at their disposal when controlling the audience:

  - Yawning — ”The yawning” (P4), ”if they start yawning, then my presentation is assuringly boring” (P7), ”but if the person is yawning, it’s activating” (P10).
  - Laughing — ”People laughing” (P5), ”someone that is laughing, it might not originate from the patient, but they don’t know that” (P9).
  - Facial expressions and posture — ”Getting closer and seeing a more judging face just to aggravate a little the social anxiety” (P4), ”people with social anxiety are hypervigilant in regards to the reaction of the other, the posture, the facial expression, so I think that would be important” (P6).
  - Interruptions during the presentation — audience ”commentating” (P9), ”This topic of the observation ’can you explain better?’, how? I only have 15 minutes to do this conference, for a person with anxiety... even for me” (P7).
  - Talking with the patient — ”If is just one person, it’s only going to talk to me, (...) so if he does talk to me, it’s gonna aggravate my anxiety” (P7 and P8).
  - Looking at the phone — ”other things like, for example, looking at the phone” (P3).
  - Audience asking questions — ”Can we control if people raise any questions?” (P6), ”raising the arm and asking questions” (P7 and P8), ”Is it possible to have them (audience) ask questions?” (P9).
  - People talking to the person next to them — ”Talking to the side, I think it makes sense” (P8).
  - Parallel interactions among the audience — ”If they start talking together” (P7), ”if they are talking or not” (P9).

  - Affirmations from the audience — ”There are other affirmations that can be done besides being asked ’can I ask a question?’, the ’I’m not understanding’ (...) or ’can you talk faster?’ ’Or slower?’” (P7).

- **Different characters** — The inclusion of different character models was mentioned several times in regards to the sex of the people: ”For some kids, it might be more or less threatening the audience being men or women” (P3), ”there are kids that respond differently to women or men” (P6); the age: ”people being older or younger” (P3), ”if the people are older, younger, or the same age (as the patient)” (P6); and the quality of the audience itself, ”they (patients) get more nervous when the people (audience) belong to the popular group”, ”the type of people sitting there (in the audience)” (P8), ”avatars with a more professional look (...) or a more informal look” (P8).

- **Create characters in specific chairs** — Participants mentioned creating people in the middle chairs ”Let’s create them in the middle” (P4), and at a specific chair ”in that chair close to the door” (P5), ”specificity is important” (P6).

- **Audience thoughts** — ”It would be nice to introduce feedback from the people almost like thoughts, but positive at a given time (...) rule of thumb, people with social anxiety get really anxious about what the other person is thinking”, ”is it possible to put phrases? Thought balloons, right? Yes but with phrases, is it possible? For example, this is boring” (P9 and P10).

- **Continuity** — One clinician mentioned the fact that continuity between a particular character in the audience can be interesting: ”What can be better (...) is the sequence of being turned to the side and suddenly, after some time, walks up and leaves. If the person (patient) has anxiety, it can get stuck to that character that is not showing interest” (P10).

Arachnophobia

Good features already implemented:

- **Ability to trap spiders** — When trapping the spiders under the glass, it was mentioned that ”that is very good” (P4).

- **Spider on the hand** — ”Putting it (spider) on the hand is an important variable” (P6)

- **Change the spider size** — ”The controlling of the (spider) size is an important variable, since, as it grew, I also started to feel more anxious when compared to when it was smaller” (P6).

Suggestions of features to implement:

- **Inclusion of spider webs** — ”And spider webs, is it possible? (...) Some kids are more disgusted by the spider webs itself than the... (spiders)” (P4).

- **Spider climbing a leg** — ”I was imagining that it would be interesting to control the spider climbing a leg” (P6).
- **Controlling the distance to the spider** — ”A body (spider) moving closer is normally a lot more anxiogenic than seeing it at a distance” (P6).

Global features

During the interviews, some smaller global features were mentioned, which are important to note:

- **The inclusion of music** was theorised as ”some kids have as their anxiety reduction stimulus music” (P4), which, coupled with ”self-praising” (P4), can help the children become more ”autonomous” (P4) in terms of reducing their own anxiety.
- **A way to score anxiety directly** ”in the beginning, middle and end” (P4), and in the end ”automatically having a graph that stays in the end of the session, which is very visual for the kids (...) and they can even print it and take it home” (P4).
- **”Cartooning” the situation** is sometimes done ”for younger kids” (P4), which could be included in the VR environment. For example, for the spider scenario it would be ”creating funny features on the spider, such as a clown nose, bunny ears” (P4).
- **A relaxation application** was mentioned during the mock-up session with the pair of participants P7 and P8 — ”Now would be a good time to change to our relaxation application” (P8).
- **Reviewing past sessions** associated with the replayability of sessions, which was a positive according to therapists, is important since it allows the patient to visualise his progress objectively — ”when we are trying to do that (review past sessions) with the patient, or with life events, they usually present counter-arguments” (P5) towards what actually happened.

6.7.6 The role of VR

VR is not here to replace *in vivo*, but instead to ”help bridge the gap” (P2) between imagination exposure and *in vivo*. VR allows the possibility ”of controlling some variables, and virtual reality can help here with more real imagery because the person is still in a safe place and, therefore, can remove the glasses (HMD) at any point if they want to stop” (P5). It’s ”better than (...) imagination, but it’s probably not as invasive and anxiogenic as an *in vivo* exposure” (P2), and is something positive to be added to the therapists’ arsenal. Still, it is only seen as a middle step since ”virtual reality is a virtual reality” (P5), and ”if we don’t make the passage into an *in vivo* context (...), there is no proper way to test if that phobia or if that anxiety has less impact” (P5).

Clinicians raised some concerns in regard to this technology. ”I imagine that some variables, like odour, that is present in the real situation, we can’t reproduce in the virtual reality” (P6). Furthermore, ”When a person transitions from a virtual world to the real one, they may lose their sense of security (...) This feeling of security can give them a sense of calmness, as it is a major factor that can help ease anxiety." (P5).

VR is a "technology that usually entices (children), right? Since there are even virtual reality games, I think it can be more captivating" (P5), so it has the possibility of playing the role of a middle ground between imagination and *in vivo* exposures.

It is more than therapy, as it allows to bridge a distance gap between the patient and the therapist "being able to have the situation of having my client at home, put on his glasses (VR headset), they don't have to be the same as mine ok? But be able to login into a platform in real-time, just like it was a videoconference with me" (P7), but also to play "games" (P4) and to provide "relaxation" (P10) in the middle or outside therapy.

6.7.7 Other scenarios

In this final section, we will mention other scenarios clinicians discussed that would benefit from VRET.

Dentists and vaccines (phobias)

It was mentioned by clinicians that they would like both phobia scenarios of dentists and vaccines to be explored in VRET — "I think this has the potential for something in particular (...), exposure to dentists (...), and to vaccines, where the parents go crazy, the dentists go crazy, and there is nothing like that, at least that I know of" (P4).

Selective mutism

Another scenario that was mentioned was selective mutism, and that VRET would be able to help — "We have to do this (VRET) for mutism. Really, it is a winning idea; the kids will take a lot less time to start talking" (P4).

6.8 Summary

In this chapter, we have discussed the research questions and methodology used in conducting a user study. We have also presented the findings of the study and categorised them into seven themes using a thematic analysis protocol by Braun and Clark [10]. These themes are: 1) Current practices in ET, 2) Therapist-Patient dynamic, 3) Progress and Evaluation, 4) Stereotypical realism, 5) Customisation and authoring, 6) The role of VR, and 7) Other scenarios.

We learned that therapy usually starts with a phase of "psycho-education", where the therapist learns where the patient fits and the patient develops coping mechanisms. Then, a personalised exposure hierarchy is created for each patient, and the type of exposure is decided upon. Exposure is usually accompanied by other techniques and composed of small tasks.

The therapeutic relationship between the therapist and patient is crucial, and the therapist's physical touch can be necessary in some cases. A subjective anxiety scale is used to evaluate the patient's anxiety levels, enabling the therapist to adjust the exposure hierarchy accordingly.

Therapy's primary goal is not to eliminate anxiety altogether but to help the patient learn how to manage it healthily. Current VRET solutions lack ecological validity, and scenarios are stereotyped and unrealistic. Therapists believe that VR can play an important role in ET as it can bridge the gap between the patient's imagination and *in vivo* situations. VR can also be used for relaxation, games, and communication.

The feedback and suggestions received from the semi-structured interview and mock-up session parts of the study were used to validate the platform, answer research questions, and get suggestions towards further clinician's control over the environment and elements.

Chapter 7

Discussion

In this chapter, we will discuss the results of the user study and address our research questions, as well as any additional relevant topics identified in this thesis.

7.1 Therapist-patient dynamic in VR

The study shows that a positive relationship between a therapist and their patient (known as therapeutic alliance) leads to better treatment outcomes. This finding has been supported by over 30 years of research [16]. Therapists emphasise the importance of building this alliance from the first session, which involves getting to know each other and providing psycho-education. This initial period helps patients feel comfortable with their therapist, enabling them to open up and discuss their issues.

The study also found that therapists view VRET as a middle ground between traditional *in vivo* therapies and therapies that rely solely on imagination. This raises questions about how introducing VR may impact the therapeutic alliance. Specifically, if the therapist is included in the VR environment, as mentioned by clinicians in section 6.7.2, will the dynamic change?

We believe that there might be a need for another adjustment period for the child to engage in a similar way with the virtual representation of the therapist. One question that arises is whether the visual representation should closely resemble the therapist's appearance or not and if some of the results of initial work into the therapeutic alliance would be present.

Furthermore, there is a concern that virtual interactions cannot replace real-life ones. For instance, healthcare professionals often need to touch patients to calm them down, which is an essential part of the therapeutic relationship. Can virtual environments emulate these stimuli, or will they lack the same effectiveness as real-life interactions?

Research is currently being conducted on a phenomenon known as ”phantom touch,” where individuals using virtual reality technology can feel the touch of a virtual person without physical contact or haptic feedback [2]. To bridge the gap between VR and real-life physical touch, various hardware options are being developed, such as wearable hand glove devices, electrodes for electric muscle stimulation, and mixed reality devices [21]. These advancements have the potential to be useful in therapy, as touch is crucial in supporting patients [14] and building a strong therapeutic relationship.

7.2 The role of technology in therapy — RQ 1

Therapists have been incorporating technology into their practice for some time now, as it allows them to conduct therapy sessions online. This has proven to be especially advantageous during the COVID-19 pandemic. The use of technology in therapy serves as a middle ground between imagination and *in vivo* therapies. It is more realistic than relying on one's imagination but less so than *in vivo* therapy. Additionally, it allows for easy personalisation, which is a clear advantage over *in vivo* exposure therapy.

Clinicians use a variety of technology-based tools such as videos, websites, games, and mobile applications [35] to engage with patients and make sessions more dynamic. However, there are limitations to technology-based exposure therapy, particularly when it comes to specific disorders online. One of the biggest challenges faced by therapists is to motivate and engage patients to use technology as an effective tool for therapy.

7.3 The role of VR in therapy — RQ 2, RQ 3

Research has shown that VRET is highly effective, and in some cases even better than *in vivo* exposure, according to studies by Rothbaum et al. [42], Anderson et al. [7], and Cullen et al. [13]. Additionally, VRET has been found to be less intimidating and more acceptable to children, as stated by Penaloza-Salazar [41]. Despite these findings, clinicians accept VR in the context of therapy but still view VRET as a middle ground between imagination and *in vivo* exposure. This is largely due to their belief that exposing patients to real-life scenarios is necessary and the perceived lack of stimuli such as touch and realism in VR.

7.4 Clinician control in VRET — RQ 4

We received a lot of positive feedback and suggestions regarding the level of control that therapists should have over VR environments. The study confirms that the development of VRET solutions should involve clinicians in order to meet their needs and be ecologically valid. Ecological validity means that the situations are realistic and relatable to the patients, making them more engaging and effective.

Clinicians have emphasised the importance of controlling the starting zone of an environment since it is the first interaction that the patient will have with the environment. They also provided several individual suggestions and feedback related to the controls of the platform itself. In the context of the fear of public speaking scenario, the features already present in the platform, such as sound, gestures, controlling the audience size and allowing someone to leave, were viewed positively. Suggestions were also made to complement the existing scenario, including control over lighting, more gestures and interactions with the patient, different characters with varying gender, professions and social status, as well as introducing feedback to the patient through audience thoughts.

Regarding the fear of spiders scenario, clinicians found the ability to trap spiders, create spiders on the patient's hand and change their size to be positive. They also recommended adding spider webs, spiders climbing the patient's leg, and direct control over the spiders' distance from the patient. Additionally, they suggested including music, scoring anxiety directly, and a relaxation application that could be used during therapy.

Research into the clinician's control in VRET is gaining momentum. Koller et al. [33] conducted a study that explored the possibility of a therapist controlling a person in the audience using physical hand and arm gestures. The authors argue that currently available systems only allow interaction through pre-recorded and pre-defined behaviours of avatars, which can be limiting. They propose a continuous interaction system that could reduce friction and improve efficiency by enabling direct and practically infinite interactions based on hand gestures and voice communication.

7.5 The future of VR in therapy — RQ 5

With the emergence of new phenomena and technologies, such as those mentioned by Alexdottir [2] and Gallace [21], as well as more involvement of therapists in the design process, VRET may finally gain wider acceptance. In addition to treating anxiety disorders, as mentioned in the related work section of VRET (section 3.3), clinicians have also suggested using VRET for other disorders, such as selective mutism and needle and dentist phobias, among others. Furthermore, VR can be utilised in a variety of other scenarios, such as treating addiction and eating disorders [18] and attention deficit hyperactivity disorder [18]. It can also play a significant role in online therapy, allowing both therapist and patient to interact directly even when they are geographically distant from each other.

Chapter 8

Conclusions

Throughout the years, anxiety disorders in children have become more prevalent, which requires tailored solutions to accompany this increase successfully.

Although therapy exists, its two most common types have limitations. *In vivo* exposure requires the patient to be exposed in person to the problematic stimuli, which can lead to high costs, ethical issues and logistical problems. Imagination, on the other hand, is easier to perform as it only requires the patient's imagination, but it fully depends on it to work, which can prove challenging, especially with children due to their lack of imagination capabilities and maturity.

Virtual reality exposure therapy is becoming increasingly prevalent in the field, as it tackles some of the limitations of the other two approaches, but it still has problems. These VRET systems are often not developed with the therapist in mind, featuring confusing interfaces and even situations that make no sense in the context.

In this thesis, we present *VRTherapist*, a VRET system that comprises two applications: a VR application and a computer application. The VR application allows the patient to immerse themselves in various environments for exposure therapy, while the computer application allows the therapist to control these environments with a press of a few buttons.

Our VR application was developed for *Android*-based HMD systems, such as Meta's *Quest 2*, while the computer application was designed for *Windows 10/11*-based systems. The communication between the two apps is provided through *TCP* using an internet connection on both devices. This can be bypassed if the VR application is launched from the computer, requiring only the computer to be connected to a network.

To maximise our success and learn more from current practices, the development cycle featured informal meetings among the research team and therapists. This allowed the development to be steered into a prototype that was ready for a proper study. This study gave us a lot of good feedback and suggestions towards current and new features that should be included for therapists to control, as well as understanding the current role of VR in therapy as a middle ground between imagination and *in vivo* exposure therapies.

Finally, our *VRTherapist* system features a button interface that can control the VR environments with ease. It's easily expandable with new environments and features while being focused on the end-user. We also present a shift in paradigm when designing VR solutions: they should attend to therapists' and patients' needs, both from an interactivity and feature standpoint. Development should be closely accompanied by working clinicians to build good and powerful solutions.

8.1 Future work

Our future work focuses on expanding our system with suggestions that we got from the user study, as well as further developing the interface in order to increase ease of use.

More scenarios

We deem important the exploration of more scenarios, including selective mutism, autism spectrum disorder, fear of needles and dentists, among others, as suggested by clinicians and related work.

More control

We conducted a study and received many recommendations on how to enhance the system for better control over the therapist. We recommend dedicating time to implementing the suggestions provided by the clinicians, with a focus on the therapist and the patient in mind.

Better interface

Although we have made significant improvements to the interface in comparison to the initial prototype that was terminal-based, it was not developed in collaboration with therapists nor was it properly tested. Although the labelling of each button and feature is correct, conducting a co-design session that centres on usability would be crucial in ensuring that the interface is user-friendly for the general public.

Data protection

In order to access the VR application on the computer, the therapist must enter both their own name and the name of the patient. However, this login system is quite basic and does not provide adequate security. To ensure that data remains protected, it would be advisable to implement a more secure password system that uses unique IDs.

Real-time sensing

As suggested by our related work, understanding the physiological state of the patient can prove beneficial. We foresee that the use of sensors can give that knowledge to the therapist, especially in real-time, but further studies in order to investigate how to do it in a positive way are still needed.

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Appendix A

Initial patient examples provided by therapists

Perturbação de Ansiedade Social

Filipe tem 14 anos e estuda no 10ª ano e sempre que se aproxima uma apresentação oral de trabalhos na escola começa a sentir-se "nervoso". Quando tem que falar em frente aos colegas, ou mesmo falar em público, começa a sentir "um peso no peito, o coração a bater muito forte e começo a suar imenso e a voz começar a falhar. Acho que não consigo dizer duas frases seguidas com sentido", surgem também o tremor nas mãos que procura esconder nos bolsos e o rubor. Na noite anterior tem dificuldade em adormecer preocupado com a possibilidade de fazer má figura em frente à turma.

Considera que não tem capacidades para realizar com sucesso as apresentações orais, temendo ser criticado ou ridicularizado pelos colegas. Durante a apresentação é comum pensar "não estou a fazer nada de jeito", "eles estão a rir-se de mim porque estou a ser um desastre" e "eles vão pensar que sou um idiota". Este receio de ser julgado em frente à turma levou a uma diminuição das notas, já que se recusou a fazer as apresentações orais.

Considera que desde pequeno que era tímido e reservado e com mais dificuldade em iniciar e manter uma conversa, principalmente com as outras pessoas, o que ajuda a justificar o escasso número de amigos.

Sabe que a ansiedade sentida é excessiva e irracional, mas não consegue gerir o seu aumento e isso afeta constantemente o seu rendimento escolar, tendo começado também a evitar outras situações sociais onde vão estar outras pessoas. Ultimamente e sempre que pode, evita lugares ou situações sociais que possam gerar embaraço, vergonha ou até mesmo humilhação, tais como ir a festas dos colegas, sair com os amigos, etc.

Fobia Específica

Ana tem 25 anos, é designer gráfica e revela que tem "medo de agulhas" e "Só de pensar que tenho que tirar sangue ou fazer algum exame que tenha agulha já começo a sentir o meu coração disparar". Revela que sempre se recorda de se sentir desconfortável quando tinha que ir fazer análises ou mesmo ser anestesiada com agulhas. Quando tem que se submeter a algum destes procedimentos, começa a pensar em "mil e uma desculpas para não ir", acrescentando "sou incapaz de lidar com situações em que tenha lidar com agulhas, seringas ou sangue".

Quando tem que ser submetida a este tipo de situação, é comum sentir que tonturas, náusea, tremor e sudorese nas mãos. Refere também a sensação de desmaio e de calor. Refere que aquando sinto o início dos sintomas tenta "controlá-los para impedir o aumento e a sequência que sempre acontece, mas parece que, quando faço isso, fico mais agitada, pioro". Identifica os seguintes pensamentos "eu não consigo tolerar este desconforto", "eu tenho que controlar isto", "se eu não controlar algo mau pode acontecer", "não posso desmaiar à frente das pessoas!". É comum sentir a ansiedade a aumentar e mesmo quando vê este tipo de situação na televisão fica incomodada e com sintomatologia semelhante, ainda que não tão grave. Esta sensação de embaraço leva a que várias vezes pense que os outros a vão criticar.

No dia anterior ao exame/procedimento começava a pensar sobre o que iria acontecer e ficava já nervosa e com insónia, notando também o "peso no peito e o coração a bater mais depressa".

Para tentar controlar esta situação, procura adiar ao máximo este tipo de procedimentos, mas também quando vai fica "extremamente ansiosa".

Caso Diogo (nome fictício)

O Diogo tem 14 anos, quase 15. Está no 7º ano. Ficou retido no 5º ano. Sentiu maiores dificuldades quando transitou para o 2º ciclo. Não propriamente pelas dificuldades académicas, mas sim pela interacção. No 1º ciclo as coisas pareciam ser mais fáceis de controlar. E o Diogo sempre se sentiu mais confortável quando está em controlo das coisas. Algo que o levou desde muito cedo a sentir uma grande aproximação com as tecnologias e mais propriamente com os videojogos. O Diogo nasceu em 2007, o que faz com que tenha encontrado toda uma gama de produtos tecnológicos que os seus pais já com quase cinquenta não tiveram oportunidade. O seu pai é Comercial e a mãe Professora do 1º ciclo. O Diogo é filho único. Os seus pais sentem que não têm possibilidade para ter um segundo filho, seja pela questão económica, mas também pela disponibilidade em acompanhar. Já com o Diogo sentem que têm grandes dificuldades em se conseguir organizar, e o Diogo ressente-se cada vez mais desse aspecto. E quando está em casa fica sempre mais à vontade para gerir sozinho e com autonomia suficiente a utilização das tecnologias. O Diogo tem alguma dificuldade em fazer novos amigos. Sente que não sabe muito bem como iniciar uma conversa ou ficar a fazer conversa com os colegas. Parece ficar desligado da situação de conversa ao fim de pouco tempo, e isso não lhe tem ajudado a manter as relações de amizade ou com os colegas. Curiosamente joga videojogos com alguns dos seus colegas de turma, ainda que tenha dificuldade quando está na escola em falar com eles. Diz que eles não parecem querer falar consigo e ele também não sabe como ir ter com eles. Mas quando está online sente que as coisas navegam de uma forma mais facilitada. Mais uma vez, o Diogo parece que se sente em controlo da situação. E isso é muito conseguido pelo tempo que o Diogo investe em conhecer mais e mais do jogo que está a jogar no momento. Não joga sempre a mesma coisa. Gosta de variar, mas sempre com a máxima de conhecer primeiro para jogar depois. A necessidade de controlo parece estar sempre à frente. As situações novas e inesperadas parecem causar-lhe dificuldade. No presente momento os pais trouxeram-no a uma consulta de psicologia. O Diogo parece não estar a conseguir controlar os resultados escolares e os pais estão preocupados.

Appendix B

Example of clinical process provided by therapists

O João tem 24 anos e encontra-se a frequentar o 2ª ano da Licenciatura em Direito após duas mudanças de curso. Surge em sessão trazido pelos pais, os quais solicitaram apoio terapêutico e foi difícil agendar a primeira sessão,tendo sido várias as vezes em que a primeira sessão foi remarcada a pedido do João.

Apresenta-se em sessão com humor disfórico e com uma postura defensiva. O utente mantém contacto ocular e o aspecto pouco cuidado. Reporta dificuldades ao nível do sono, especialmente insónias iniciais e também ao nível do apetite, apresentando uma diminuição do mesmo.

Pré-contemplação

Quando questionado sobre o motivo que levou ao agendamento da sessão, refere apressadamente "nem sei bem o que vim cá fazer. Os meus pais sempre com a mania habitual de acharem que preciso de ajuda!". Refere que só aceitou ir à sessão "para que deixassem de me chatear". Averiguado o motivo da discórdia familiar, o João refere que tem que ver com o tempo que passa a jogar videojogos e o impacto que isso tem na sua vida – "eu jogo todos os dias". Não raras vezes falta ás aulas para ficar a jogar e isso tem levado a reprovações e sucessivas mudanças de curso. Os pais "estão sempre a ameaçar" que deixarão de pagar as propinas e as suas despesas, mas nunca o fizeram. Questionado como se sente quanto a esta situação, o João refere que "não é o fim do mundo... até parece que sou o único universitário que falta às aulas para jogar".

Questionado sobre o tipo de jogo que joga, o João tem uma preferência pelos MMORPG, tendo começado a jogar há mais de 5 anos, sendo que habitualmente joga entre 8 a 10 horas por dia. Encontra-se inserido numa comunidade de gamers e joga com diferentes jogadores de outros países e em diferentes fusos horários. Considera que é um jogador respeitado na comunidade e com provas dadas no jogo, acrescentando que "a minha posição nos rankings fala por si mesma. Geralmente estou no top 3 dos jogadores das equipas a que pertenço". Refere que tem conhecido muitas pessoas online e que tem feito "grandes amizades lá", ao contrário do que acontece na vida offline, onde passa cada vez menos tempo com os amigos. Questionado sobre os motivos que levaram ao afastamento, o João acrescenta que os amigos não percebem o seu gosto pelo mundo dos videojogos – "eles gostam mais de fazer outras coisas e já nem me lembro da última vez que estivemos todos juntos".

No que diz respeito às suas expectativas para o futuro, o João refere que gostaria de encontrar um emprego na sua área de formação quando terminar o curso e de fazer uma roadtrip pela Europa com os amigos.

Contemplação

O João aceitou continuar a ser seguido tendo referido que tinha encontrado um sítio onde "podia falar de videojogos sem ser olhado de lado" e que seria importante continuar "até porque ás vezes passo-me a jogar e quando perco passo-me, isto para já nem falar quando não posso jogar". Refere que fica especialmente irritável quando perde ou quando fica impossibilitado de jogar – "no outro dia estraguei o teclado com um murro porque tinha perdido e ainda parti o candeeiro da secretária que caiu". A relação com os pais tem sofrido com estes comportamentos, tendo referido que "às vezes respondo mal aos meus pais e a minha mãe especialmente fica triste e mais distante comigo".

Por vezes nem se apercebe do passar do tempo e quando dá por ela já são 4 ou 5 da manhã e depois não se consegue levantar para ir para as aulas. Averiguado como está a correr o semestre e o João refere que está praticamente tapado por faltas e que só poderá fazer as cadeiras por exame final – "a avaliação contínua já era. Isto é do tipo perdido por 100 perdido por 1000, pelo menos no jogo estou a ganhar posições na hierarquia". Quanto aos conteúdos programáticos e apontamentos, o João refere que não tem muito à vontade com os colegas – "não os conheço muito bem e fica estranho chegar junto deles e pedir apontamentos." – o que dificulta o estudo e, consequentemente, o rendimento académico.

Manifesta-se apreensivo face à possibilidade de reprovar mais um ano e de ter que enfrentar os pais uma vez mais – "começo a ficar sem saber o que dizer e não há muitas mais justificações" e isso fá-lo sentir-se triste e culpado – "a culpa no fundo é minha, não posso dizer outra coisa e talvez seja importante fazer alguma coisa quanto a isto, senão não vejo meio de isto melhorar". No entanto, quando imagina deixar de jogar ou ter de se afastar dos videojogos diz ficar com "sensação de falta de ar" – "eu devia parar, mas eu não sei se consigo".

Preparação para a acção

O João em sessão relata que não fez nenhuma cadeira no semestre, mostra-se apreensivo, triste e com um discurso autocrítico – "não estudei nada, o que é que eu estava à espera?! Foi culpa minha. Se algum do tempo que eu estive a jogar eu tivesse estudado, talvez o resultado fosse outro". O relato do João foi acompanhado de alguma labilidade emocional, especialmente porque terá que contar aos pais o sucedido e teme desapontá-los ainda mais.

No seguimento da sessão, o João solicitou ajuda para "ver se ganho um rumo na minha vida e sozinho não consigo". Foram delineados os objectivos que o João pretendia atingir, bem como as suas expectativas e o João começou por fazer um horário semanal no qual ficou espelhado o tempo dedicado a diferentes actividades. Foram antecipadas possíveis dificuldades que possam surgir e solicitada a participação dos pais, enquanto elementos coadjuvantes no processo terapêutico. Foi explicado aos pais os mecanismos que favorecem a manutenção do comportamento aditivo.

Acção

O João chega à sessão e refere que tem sido particularmente difícil e se, por um lado, tem conseguido cumprir o horário, por outro lado, torna-se difícil lidar com a vontade de jogar fora do horário destinado para tal. Tem relatado que se sente particularmente ansioso quando não está a jogar e que nem sempre as actividades alternativas são gratificantes – " às vezes sinto que é uma treta e penso que era mais feliz quando jogava. Pelo menos não ficava tão ansioso e a contar os minutos para voltar a jogar e a andar de um lado para o outro". Está igualmente presente uma percepção de maior cansaço e de algumas dificuldades ao nível do sono - "ainda ontem antes de dormir dei por mim a pensar que iria haver um evento especial e que podia evoluir mais e no grupo do whastapp já estavam a circular mensagens para definirmos a estratégia da equipa...e há sempre eventos novos todas as semanas! Começaram a reparar que estou a jogar menos e perdi privilégios que tinha antes".

Manutenção da Acção e Recaída

O João tem cumprido as tarefas e tem-se mantido fiel ao estipulado em sessão, tendo obtido alguns ganhos, nomeadamente tem jogado menos e ido às aulas. Esta rotina tem vindo a ser adoptada e o João reconhece que o conflito com os pais tem diminuído, estando mais próximo dos amigos.

Recaída

Após um espaçamento entre sessões, o João volta a contactar pedindo ajuda, uma vez que voltou a jogar – "nunca faço nada bem feito, isto foi sol de pouca dura. Voltei a jogar esta semana e estou com medo de voltar ao mesmo. Soube na comunidade que ia haver um evento daqueles e joguei mesmo muito". O João relata que estava a ficar ansioso e pensou que se jogasse um pouco, talvez se sentisse um pouco melhor e poderia recuperar alguns lugares no ranking. Na realidade, o João relatou que durante essa semana mal foi à faculdade e quando foi teve mais dificuldade em acompanhar as matérias, pelo que o jogo serviu como uma forma de relaxar e lidar com o desconforto que sentiu. Os pais chamaram-no à atenção acerca do que estava a passar e de que a história se estava a repetir, o que levou a que o João se sentisse fracassado e com vergonha de ter voltado a jogar.

Appendix C

Study - Protocol

Motivation

Anxiety disorders in children have become increasingly more common throughout the years, especially after the COVID-19 pandemic [36]. While therapy options exist, most of them are not usually suitable for children. In Vivo and imagination exposure therapies are the most well-documented and used therapeutic approaches for anxiety disorders [5]. Although practices vary from clinic to clinic and children also vary, most current solutions are a “one size fits all” and are not geared towards children displaying difficulties with interfaces and not addressing their fears [34, 12]. Furthermore, the literature shows that Exposure Therapy’s (ET) lack of confidentiality and clinician control are two common limitations identified [50]. For example, regarding in vivo ET, the patient might need to be taken to a real-world scenario (e.g., an airplane) when fear of flying is present, risking a loss of confidentiality, high costs and difficult logistics. Regarding imaginal ET, the clinician has little to no control over what the patient is witnessing in their imagination.

Virtual Reality Exposure Therapy (VRET) is emerging as a suitable approach due to its affordability and practicality, giving the clinician more control over the session. The clinician can customise the environment as they see fit, a clear advantage over both in vivo and imaginal exposure therapy. Moreover, it is also important to note that VRET can be conducted inside a therapist’s office, which is a relatively safer solution when compared with in vivo.

For these reasons, developing platforms (i.e., virtual environments and interfaces) that consider and adapt to patients’ and clinicians’ needs is essential. Goal

This study aims to identify which features should be present in a Virtual Environment (VE) for VRET in the context of anxiety-related disorders (e.g., public-speaking phobia and arachnophobia). More specifically, we aimed to identify the degree of control the therapists perceived as desirable in terms of the elements that composed the VE and how the interactive visual interface should behave and be laid out.

Participants Selection

We will recruit a convenience sample composed of working clinical psychologists. To be eligible, participants must have 1) training and professional experience in ET, and 2) preferably applied to anxiety-related disorders (e.g., social anxiety, arachnophobia, fear of heights). Twelve participants will be selected, forming six pairs, which can be reduced to five if there is a lack of compatible/available clinicians.

Due to our prior working relationship with PIN, Partners in Neuroscience (private clinic), participants recruited will hopefully entirely comprise psychologists working in this institution while allowing for outside participants from other institutions if needed.

Sessions Duration

Each session will have a maximum duration of one hour split into two consecutive phases of 20 and 40 minutes, respectively; the latter is divided into two sub-phases lasting at most 20 minutes each.

Procedure

The session will start with the first author (i.e., JF) describing the study's objectives and providing an overview of participants' involvement, including their rights (please see the participant safety section for details). Following the presentation, attendees will have the opportunity to ask any questions. Subsequently, participants will be given an information sheet with study details and authors' contact and asked to read and sign the written informed consent.

Each session will be conducted with a dyad of participants and aim to gather participants' comments and insights regarding 1) current clinical practices in ET and 2) what elements should compose the VE, how the interactive visual interface should behave and be laid out, as well as improvements to the prototype developed.

Sessions will be audio recorded, and computer screen images will be taken.

We will split sessions into two phases. In the first phase, we will conduct an initial interview, primarily focusing on characterising the current therapy practices and how clinicians tackle particular challenges using known procedures. The second phase will be a participatory design session, split into two phases: 1) VRET elements, in which clinicians will have their first contact with the virtual environments in action, challenging the participants to think and co-design the environments as well as the control each environment will allow; and 2) VRET sessions, which will focus more on the sessions themselves. By driving a mock-up session for the clinicians to use the platform without help, we hope to incentivise exploration of the platform, allowing us to evaluate the ease of use; furthermore, in this sub-phase, we will also inquire about how the sessions should evolve, if they should be able to be saved and planned out before the session, among other questions.

Currently, the environment is comprised of three different scenarios 1) Arachnophobia; this scenario has two different environments, an office and a living room, each with the ability to create spiders and interact with the surroundings, 2) Fear of public speaking; this scenario has two different environments, a big theatre and a classroom, with multiple degrees of control ranging from creating people in the audience in different zones, as well as simple gestures and emotions 3) Fear of heights; this scenario has three different environments, each simulating different heights.

Although we have all these scenarios, due to time constraints of the sessions and lack of detail, the Fear of heights scenario will not be presented in these sessions, and only one of the environments of the other scenarios will be present (living room and theatre, respectively) while allowing for the other environments to be shown if requested.

These scenarios were created based on two initial meetings with four and three clinicians, respectively, where our goals were to get initial insight into the initial prototypes and collect ideas to improve the environments. These initial meetings allowed us to focus more on one scenario (i.e. Social Anxiety), the most common anxiety disorder treated by the clinicians interviewed. With this knowledge, we introduced more control and mechanics into the Social Anxiety scenario, such as non-playable characters (NPC's) eye contact, emotions and background noise of the audience. Furthermore, the spider scenario was also improved with requested features such as changing the spiders' size, allowing the patient to trap the spiders, and creating spiders on the hand of the patient while vibrating the controller for further immersion, as well as sound when the spiders move.

Phase 1 (Initial Interview)

This first phase will collect data on current clinical practices applied to ET in anxiety disorders.

We will conduct a semi-structured interview with each pair of participants. Although participants will be asked about their experience with ET in general, the interview script will focus on social anxiety therapeutic practices.

The goal will be to collect data and promote discussion between clinicians about each scenario, serving as a way to understand the inevitable roadblocks and compromises that the traditional methods lead to. To this purpose, a script divided into five categories was developed and will guide this part of the session.

Background

- Gostaria de começar por lhe perguntar como é que começou a trabalhar com perturbações da ansiedade? Há quanto tempo? Há quanto tempo trabalham em ET. Em que patologias, esta abordagem terapeutica é mais utilizada.

- Dentro das perturbações de ansiedade, as fobias são comuns? Sente que houve um agravamento/aumento de fobias nos ultimos anos? Foi coincidente com a pandemia? qual o papel da pandemia? Como foi o funcionamento durante a covid 19?

- Em crianças e adolescentes, quais a fobias mais comuns? há um tipo de perturbação que seja mais prevalente/common?

Technology

- Para terapia, dão uso a algum tipo de tecnologia? Videos, robôs
- Que papel ou oportunidades conseguem antever com o uso da tecnologia?

Therapy characterisation

- Proponham um cenário de medo de falar em público. Proponham um cenário consoante as vossas especialidades.
- Como seriam as sessões iniciais? Haveriam sessões sem exposição? Sessões de controlo de respiração, etc?
- Descreva uma sessão de exposição normal. Dentro do consultório? Lá fora? Confidencialidade?
- Como variam as sessões ao longo do tempo? Que diferenças na exposição existem entre várias sessões?
- Como descreveriam um protocolo típico/comum de TE.
- O protocolo tem fases de intervenção distintas ou é melhor caracterizado por um continuo mas progressivo intensificar .... (da técnica que eles utilizam).
- Na sua opinião quais as principais vantagens/barreiras que enfreta em TE?/Quais os prinicipais desafios que enfrenta com faz TE (desafios associados aos recursos, ao participante, ao tempo necessário)

Evaluation and problems

- Como é que o progresso é avaliado? Questionários self-report? Algum problema com estes?
- Quais as diferenças entre lidar com crianças e adultos? Que barreiras estas podem levantar? Como lidam com estes problemas?
- São levantados problemas por outros fatores? Protocolos, Questionários, falta de tempo, listas de espera.
- Se levantado problemas de lista de espera e falta de tempo, realidade virtual poderia ajudar?

VR related questions

- O que acha sobre realidade virtual? Beneficios, Limitações
- Já trabalhou ou viu ser trabalhado com realidade virtual no âmbito de terapia de exposição? Em que contexto? Porque nunca trabalhou?
- Acha que é algo util? Em que cenários?

Phase 2 (Participatory design session)

This second phase will focus on a participatory design session alongside our participants to gather information on two main topics: VRET elements and VRET sessions.

This will start with a small mock-up session in which one participant plays as a patient and another as a psychologist. Afterwards, participants will be asked to think about how sessions should be played out and varied and if it would be interesting for them to be automated and possibly shared among clinicians.

"Vamos começar com um mock-up de uma sessão em que um vai servir de psicólogo e o outro de paciente. Isto vai servir para percebermos se o que temos é util e intuitivo, e que alterações deviamos fazer ou o que deveriamos adicionar"

Mock-up session

Preparar os oculus e o unity para a sessão. Encorajar terapeutas a dar-nos instruções para realizar. Apontar problemas encontrados, encontrar boas features.

- Inicie um cenário de fobia de aranhas na Sala com um tamanho de aranhas de 0.25
  - Crie 3 aranhas no chão
  - Crie 5 aranhas na mesa
  - Mude o tamanho das aranhas para 0.5
  - Crie uma aranha na mão
  - Volte para o menu principal
- Inicie um cenário de ansiedade social no Teatro com 5 pessoas
  - Crie 30 pessoas no total em certas partes especificas do ambiente
    - Atrás
    - Frente à esquerda
    - Aleatóriamente
    - Atrás à direita
  - Ligue o som em certas partes da plateia.
  - Faça a audiência olhar para o paciente.
  - Faça a audiência fazer o gesto de negação. Experimente outros gestos se quiser.
  - Utilize os emojis para expressar uma emoção positiva. Negativa.
- O que achou da plataforma? O que mudaria? O que adicionava?
- Mantem a sua opinião sobre a tecnologia? Se não, o que mudou?

Automated sessions

Demonstrar a feature de conseguir ver sessões antigas e repetir, assim como adicionar métodos durante.

- Relativamente ao que acabaram de realizar, seria interessante conseguir guardar as sessões para voltar a repetir? Faz sentido tendo em conta progressão?
- Como prepara as sessões?
- Organizam as sessões de antemão?
  - Como? Timeline? Botões? Plataforma de criação, planeamento de sessões
- Como diferem as sessões entre si?
- ......?

Analysis, Treatment and Registration of Obtained Data

The data that will be obtained will be mostly qualitative. However, some quantitative measures will also be recorded, such as the time elapsed in each session. This time will be obtained by audio-recording the sessions, which involves the conversation between the researchers and participants and the mock-up phase. Recordings will be transcribed as field notes. Data will be coded and analysed according to a thematic analysis protocol as proposed by Braun and Clark [10]. We will then design an interface and virtual environments leveraging information from this study and the team's prior research on these environments. All screen recordings will be viewed and interpreted, maintaining the anonymity of the participants whenever people outside the research team access them. Photos will blur the participants' faces to prevent their recognition by third parties. Publicly, the information collected will be disseminated through random numbers assigned to the participants (PX-PY). All the information collected will be stored in the equipment that belongs to the researchers, only to be shared between them.

Safety Risks and Reporting of Adverse Events

Participants will have access to the contact details of the responsible investigator, Prof. Tiago Guerreiro, and the email address of the Director of the Faculty of Sciences of the University of Lisbon so that they can contact about any concern that may arise in the face of this study. No safety hazards or adverse events are anticipated. Still, any unexpected event will be duly and responsibly notified.

Participant Safety

Before participating in the study, participants will be notified that their cognitive ability or ideas will not be evaluated but the critiques and overall discussion regarding ideas and designs of the interface. They may withdraw from the study without providing any reason or explanation, just indicating to the researchers they intend to withdraw. Participants who refuse to give written informed consent or withdraw from participating in the study will not be included in this study, and such a decision will not have an impact on the respect and care given to them by the researchers.

Appendix D

Study - Information sheet

The study’s information sheet is present on the next pages.

Folheto Informativo

PROJECTO: Co-designing a VRET solution alongside therapists.

INVESTIGADOR RESPONSÁVEL: João Ferreira

Vimos desta forma convidá-la/o a participar no nosso estudo de investigação focado no uso de realidade virtual para realizar terapia de exposição no âmbito de distúrbios de ansiedade. Antes de decidir, gostaríamos de lhe apresentar os detalhes desta investigação, a sua motivação e utilidade potencial e as implicações da sua participação. Um membro da equipa da investigação irá acompanhá-lo na leitura deste folheto e responderá a quaisquer perguntas que queira fazer.

1 - Em que consiste o estudo "Co-designing a VRET solution alongside therapists"?

Este estudo insere-se num projeto de mestrado em curso, que tem por objetivo desenvolver uma plataforma com o propósito de suportar uma experiência de realidade virtual no âmbito da terapia de exposição.

Este estudo constitui a primeira fase de avaliação de uma plataforma que simula diversos ambientes, onde pode realizar um conjunto de tarefas relacionadas com terapia de exposição, como por exemplo, criar pessoas num auditório, controlar aranhas, entre outras. Nesta fase, estamos a convidar psicólogos a experimentarem a nossa plataforma.

O objetivo da investigação não é avaliá-la/o a si, mas recolher informação que nos ajude a identificar possíveis problemas ou barreiras à utilização da plataforma assim como, outros aspetos que mereçam melhoria. Por este motivo, pedimos-lhe que partilhe connosco as suas opiniões, comentários e críticas para que possamos melhorar versão final da plataforma.

Folheto Informativo

2 - Tenho de participar neste estudo?

A participação no estudo é totalmente voluntária. Vamos descrever o estudo e apresentar o conteúdo deste folheto informativo, incluindo os detalhes da sua participação. Se concordar em participar, irá assinar um Formulário de Consentimento Informado. Serão-lhe fornecidas cópias deste documento e do Formulário de Consentimento Informado.

3 - E se eu desejar desistir do estudo?

É livre de desistir, em qualquer altura, sem ter que fornecer quaisquer razões ou explicações. Caso decida não participar, não será prejudicado/a em nenhum aspeto. Nenhuma pessoa será informada da sua decisão caso opte por não participar. No decorrer do estudo pode interromper a sua participação, para o que bastará comunicar-nos a sua decisão.

4 - O que terei de fazer no âmbito do estudo?

No âmbito deste estudo, irá participar em numa sessão de avaliação de experiência de utilizador. Esta sessão tem por objetivo recolher a sua opinião sobre uma plataforma criada, a sua facilidade de utilização e eventuais problemas que identifique durante a sua utilização.
Esta sessão é composta por duas etapas e tem uma duração prevista de 60 minutos. A primeira etapa consiste numa entrevista onde lhe colocaremos algumas questões relativas ao seu trabalho e background. Na segunda fase da sessão será convidada/o a participar no design da plataforma e a experimentar o protótipo da plataforma desenvolvida. Para os fins acima descritos, iremos recolher o áudio das sessões.

Todas as recomendações e melhorias sugeridas permitirão fazer evoluir a nossa investigação e aprimorar a nossa plataforma e são bem-vindas.

5 - Quais as desvantagens e riscos de participar?

Não estão previstos quaisquer riscos associados à participação neste estudo e a expectativa da equipa de investigação é de que a sessão sejam uma experiência agradável para os participantes.

Folheto Informativo

6 - Quais os possíveis benefícios de participar?

De acordo com a nossa experiência, as pessoas gostam de participar em estudos que promovem a comunicação com a academia e o avanço do conhecimento científico. A sua participação irá ajudar a recolher informação importante que será depois utilizada para melhorar aspetos fundamentais da plataforma, que se pretende que venha a constituir uma ferramenta de suporte à realização de terapia de exposição com uso de realidade virtual.

7 - O que acontece quando o estudo terminar?

A análise dos dados terminará em 12/2023 Os resultados do estudo serão publicados em conferências e revistas académicas, salvaguardando sempre o anonimato dos participantes e confidencialidade dos dados recolhidos. Se desejar saber detalhes sobre os resultados e implicações do estudo, fazer-lhe-emos chegar uma cópia do relatório do estudo, mas não antes de 01/2024.

8 - E se ocorrer algum problema?

Se tiver alguma preocupação sobre qualquer aspeto deste estudo, deve falar com o investigador responsável, João Ferreira, que fará o seu melhor para o elucidar e responder às suas dúvidas, por telefone, 910800613 ou e-mail, jpferreira@lasige.di.fc.ul.pt. Caso esteja descontente ou queira apresentar uma queixa formal, pode fazê-lo contactando o Diretor da Faculdade de Ciências da Universidade de Lisboa [e-mail: direccao@fc.ul.pt].

9 – A minha informação será mantida confidencial?

Sim. Seguiremos todas as práticas éticas e legais e toda a informação recolhida será tratada de forma absolutamente confidencial. Para garantir a anonimidade, os registos pessoais estarão apenas disponíveis na sua integralidade, para o investigador responsável, e os membros da equipa de investigação apenas terão acesso aos dados que necessitarem de conhecer. Se os seus dados forem usados para publicações ou apresentações, serão totalmente anonimizados, sem qualquer referência, direta ou indireta, à sua identidade. Se forem tiradas fotografias, e for nossa intenção usá-las em alguma apresentação, ser-lhe-á pedida autorização prévia.

Folheto Informativo

10 - O estudo passou por um processo de revisão?

Sim. Com efeito, este estudo foi revisto pela Comissão de Ética para a Recolha e Protecção de Dados de Ciências (https://ciencias.ulisboa.pt/pt/prote%C3%A7%C3%A3o-de-dados). Esta comissão analisou a proposta de estudo, bem como todos os seus materiais e não levantou objeções do ponto de vista ético.

11 - Quem posso contactar relacionado com este estudo?

Prof. Tiago Guerreiro Faculdade de Ciências da Universidade de Lisboa tjvg@di.fc.ul.pt 217500566	**Prof. João Guerreiro** Faculdade de Ciências da Universidade de Lisboa jpguerreiro@fc.ul.pt	**Drª. Filipa Brito** Faculdade de Ciências da Universidade de Lisboa frbrito@fc.ul.pt

Sinta-se à vontade para nos contactar em qualquer matéria relacionada com este estudo.

Muito Obrigado.

Obrigado por nos ter dedicado este seu tempo e por considerar participar neste estudo.

O Investigador Responsável

____

João Ferreira

Appendix E

Study - Written informed consent

The study’s informed consent form is present on the next page.

Ciências ULisboa | Comissão de Ética para a Recolha e Protecção de Dados de Ciências

Formulário de Consentimento Informado

V2, 1-2-2018

PROJECTO: **Co-designing a VRET solution alongside therapists.**

INVESTIGADORES RESPONSÁVEIS: João Ferreira, Filipa Ferreira-Brito, João Guerreiro, Tiago Guerreiro

Agradecemos o seu interesse e colaboração neste estudo.
Por favor, preencha o formulário que se segue. Receberá uma cópia quando sair.

Confirmo que li e compreendi o folheto informativo associado ao projeto.	
Foi-me dada a oportunidade de ler e considerar a informação apresentada, e fazer perguntas, as quais foram respondidas de forma satisfatória.	
Compreendo que a minha participação é voluntária e que sou livre de desistir do estudo em qualquer altura, sem ter que dar quaisquer explicações e sem quaisquer consequências.	
Compreendo que os dados recolhidos durante o estudo possam ser do conhecimento dos membros da equipa de investigação, sempre que necessário para o estudo. Autorizo que os membros da equipa tenham acesso a esses dados.	
Compreendo que, caso esta investigação venha a ser publicada, todos os dados serão mantidos anónimos e nenhuma informação será identificável como sendo minha.	
Gostaria que me fosse enviado o relatório final do estudo. O meu endereço de e-mail é: ______________________________________	
Gostaria de ser contactado para o endereço acima acerca de sessões ou estudos adicionais relacionados com este estudo.	
Declaro que não comuniquei nenhuma razão potencial de qualquer natureza que constitua um eventual fator de risco para a minha saúde ou integridade física.	
Declaro que participo neste estudo sem qualquer remuneração ou contrapartida.	
Declaro que aceito que as minhas entrevistas sejam gravadas apenas em áudio e vídeo.	
Declaro que tomo a minha decisão de forma inteiramente livre.	
Concordo em participar neste estudo.	

____ ___/___/___

Nome do Participante Assinatura Data

Sou da opinião que o participante compreendeu os aspetos relevantes da informação fornecida e está apto /a tomar uma decisão informada.

____ ___/___/___

Assinatura do Investigador Responsável Data