VR Game Design for Obsessive Compulsive Disorder Rehabilitation

Revisão Pós-Defesa

João Pedro Caldeira Natário

Relatório para obtenção do grau de Mestre em
Design e Desenvolvimento de Jogos Digitais
(2º ciclo de estudos)

Orientador: Prof. Doutor Frutuoso Silva

Dezembro 2021

To my parents.

For their endless love, support and encouragement throughout the years.

Acknowledgements

I would like to extend my sincere gratitude and appreciation to my advisor, Professor Frutuoso Silva, for all the help, feedback, patience and availability throughout the project development.

I would like to thank my family, specially my parents, for the unconditional love and support throughout my journey.

A thanks to all the medical health professionals that were a part of this project, without them this work wouldn't have been possible to achieve.

A heartfelt thanks to my partner, André Torrão, who helped in the development of this project. It was a journey with a plethora of setbacks and obstacles that were only possible to overcome with his support.

Lastly, a huge thanks to my close friends for always keeping me motivated, for sharing ideas and for the given feedback.

Work developed at "Instituto de Telecomunicações" under supervision of the Prof. Frutuoso Silva.

Resumo Alargado

Na presente realidade digital, com a rápida emergência da cultura dos video jogos na sociedade moderna, o média dos video jogos é explorado por outras diversas áreas predominantes. Com a introdução da Realidade Virtual, foi colocado ainda mais ênfase no uso deste média para além do seu objetivo lúdico. O elevado nível de imersão entre utilizador e mundo virtual, introduzido pelo uso de realidade virtual, proporcionou variáveis relevantes a áreas de pesquisa cientifica, especificamente a área da psicologia. No processo de terapia de transtornos de carácter psicológico já são utilizadas ferramentas reais e diversas metodologias aplicadas ao processo de terapia, porém grande parte das metodologias aplicadas não geram resultados positivos devido à resistência de determinados pacientes à exposição a situações sugestivas no âmbito do tratamento. Neste caso, a realidade virtual pode vir a suportar as metodologias de tratamento preexistentes, através da utilização de ambientes virtuais, especificamente criados para simular a realidade do paciente, onde este é exposto às suas fobias. Com o desenvolvimento deste projeto, pretendeu-se criar um protótipo com características lúdicas aplicado à Terapia Cognitivo-Comportamental(TCC). O utilizador é transportado para um mundo virtual, para o expor a situações sugestivas, desafiando a Perturbação Obsessiva Compulsiva (POC).

Segundo pesquisas realizadas, comprovou-se que o desenvolvimento de video jogos e realidades virtuais no âmbito da sua aplicação à área da saúde psiquiátrica, mostra um crescimento gradual, através de jogos educativos, com o público infantil como público alvo. Este estigma que video jogos têm unicamente como demográfica alvo as crianças é derivada da perceção do video jogo como uma atividade unicamente lúdica. A escassez de video jogos como ferramentas de terapia, destinados à audiência adulta com POC, é assim justificada devido ao estigma existente. Este projeto procura englobar ambas as audiências, crianças e adultos, através do facto de a realidade virtual ser uma nova tecnologia atraente a fãs de video jogos existentes em ambas as demográficas. Este

projeto procura inovar a interação entre o especialista e pacientes diagnosticados com POC, durante o processo de terapia, através da utilização de um jogo de realidade virtual com a finalidade de analisar e dissimular as compulsões do paciente de forma lúdica. Devido à natureza deste projeto, e no âmbito de transformar ações reais em jogabilidade, sem criar algo que poderia causar transtorno em pacientes, ao invés de obter resultados positivos, procurou-se suporte no parecer de vários profissionais de saúde mental. Este parecer foi chave para o desenvolvimento deste projeto, dando início ao processo de design e desenvolvimento de um jogo de realidade virtual para a reabilitação de pacientes com POC.

Este video jogo foi desenvolvido em parceria, por dois estudantes, devido à complexidade e à abrangência de duas áreas-chave, design e programação de um jogo de realidade virtual. A conceptualização deste projeto só foi possível através de reuniões com profissionais de saúde (Psiquiatras e Psicólogos) para definir as compulsões mais comuns nos subtipos de OCD identificados, estes sendo, ordem e simetria, dúvida e verificação, contaminação e taboo. Devido ao subtipo taboo ser demasiado específico a cada paciente, este acabou por ser descartado, rendendo o seu foco aos subtipos restantes. O jogo, intitulado VR-POC, é um jogo de realidade virtual do género de puzzles, exploração e simulação, jogado na perspetiva da primeira pessoa, com o foco na capitalização das vantagens da realidade virtual para servir como ferramenta de terapia de pacientes com POC. O jogo, através da utilização de interfaces de controlo e um capacete de realidade virtual, permite ao jogador interagir com objetos familiares dentro de uma habitação comum e completar objetivos definidos num quadro de objetivos no próprio jogo para progressivamente dissimular as compulsões do paciente. O conceito do nível do jogo foi desenhado como um apartamento segmentado em três divisões, cada uma contendo diferentes puzzles destinados ao processo da dissimulação de compulsões provenientes do subtipo ordem e simetria, através da interação com sequências e padrões. O primeiro puzzle desenhado está disposto no quarto, onde o paciente tem que organizar camisolas dentro de um guarda-roupa de forma contra intuitiva, guiando-se em base numa dica, representada através de cores, num monitor de computador disposto na mesma divisão. O segundo puzzle, presente na sala, consiste na organização de livros numa estante de parede. O paciente tem como objetivo a arrumação de livros, espalhados pela habitação, porém este puzzle obriga o jogador a pensar de forma contra intuitiva para o conseguir resolver, devido ao posicionamento dos livros(que são coloridos) ter correlação com a cor das estantes, obrigando o paciente a ignorar a cor

dos livros já presente na estante. O terceiro e último puzzle, presente na cozinha, convida o paciente a encontrar e a ordenar copos de diferentes tamanhos. Como dica, é representado na televisão da sala uma sequência de números gerada aleatoriamente, onde cada número (um a seis) é referência ao tamanho de cada copo. No contexto do impacto da situação pandémica, o escopo do projeto divergiu do plano original. A necessidade de trabalhar remotamente num projeto relacionado com realidade virtual tornou certas tarefas banais de desenvolvimento, tomadas como certas antes do início da pandemia, em tarefas longas e exaustivas, devido ao impacto negativo na comunicação entre a equipa. Como consequência, os subtipos de OCD previamente definidos, contaminação, dúvida e verificação, foram removidos do desenvolvimento do projeto, alternando o foco para um único subtipo, ordem e simetria.

Para desenvolver o projeto foram necessárias ferramentas especializadas na conceptualização e construção de mundos digitais. Estas ferramentas são usadas pela maior parte das empresas *Triple A*(AAA) de video jogos existentes no mercado e são chave para a tradução de um conceito para um produto real. Foi também criado um Documento de Design de Jogo(DDJ) com o intuito de registar métricas, mecânicas e mudanças efetuadas no decurso do desenvolvimento do jogo. Este documento serve como um "escudo" contra o possível enorme número de mudanças efetuadas durante o desenvolvimento de qualquer produto, mantendo o design conciso e organizado, reunindo todos os componentes chaves do design do protótipo no mesmo ponto de referência. Mostrou-se necessário a criação de um ambiente de jogo que evitasse ser invasivo, onde o jogador se sentisse calmo e confortável. O primeiro passo foi a criação de uma *White box*, para delimitar a área do jogo e definir a disposição dos objetos que iriam, mais tarde, popular o mundo virtual. Esta *White box* serve como uma área de teste para o desenvolvimento do projeto, onde o movimento, interações e lógica do jogo pode ser testada já com a informação espacial do mundo virtual final. Na sequência da criação da *White box*, diversos objetos foram criados não só para construir e popular o mundo virtual do jogo, mas também para servir como objetos de interação. A metodologia de criação de objetos adotada é uma reflexão do processo utilizado por empresas de carácter AAA da indústria dos video jogos. A habitação desenhada pelos objetos previamente criados, é composta por três divisões, uma sala com cozinha, um quarto e uma casa de banho. Na criação de uma interface de utilizador, foi criado uma página inicial com o intuito de mostrar quem criou o jogo, seguido de um menu onde o profissional de saúde mental tem à sua disponibilidade, as opções e o botão de início jogo.

No âmbito dos testes do protótipo, nos inquéritos, após a clarificação do cargo do profissional e da experiência e exposição a video jogos e à realidade virtual, foi disponibilizado o acesso a um video representativo da jogabilidade do protótipo, seguido de questões de carácter qualitativo e quantitativo da estética e da hipotética eficácia do jogo. Após uma detalhada análise aos resultados dos questionários, concluiu-se um grande interesse, por parte de todos os Psicólogos e Psiquiatras inquiridos, na possível aplicação da experiência de realidade virtual nas suas sessões terapêuticas. As regras impostas no decorrer da pandemia impossibilitaram a concretização de testes de carácter físico com pacientes reais. Como o objetivo de mitigar esta limitação e conseguir justificar a eficácia do protótipo no processo de terapia, foram criados os questionários previamente mencionados, especificamente para serem apresentados a profissionais de saúde mental. Embora não ter sido possível a aplicação da metodologia de testes originalmente planeada, os dados obtidos no inquérito elaborado para mitigar as circunstâncias da pandemia, foram extremamente positivos e fundamentam o potencial da aplicação da realidade virtual como ferramenta terapêutica.
Como trabalho futuro fica a adoção da metodologia original de testes com pacientes, assim que sejam levantadas as restrições da pandemia. Fica também planeado o desenvolvimento de uma aplicação de telemóvel que funciona em parceria com o protótipo, onde o profissional de saúde mental pode alterar as variáveis de exposição e navegar entre os diferentes níveis sem ser necessário interagir com o protótipo em si.

Palavras Chave

Realidade Virtual, Video Jogos, Design de Jogos, Terapia Cognitivo-Comportamental, Perturbação Obsessiva Compulsiva.

Abstract

In the epoch of digital reality, with the widespread phenomenon of video game culture in modern society, the use of the video game medium in diverse areas of application is a common reality. With the introduction of Virtual Reality (VR), this concept is even more emphasized than ever before. This cutting-edge technology was quickly adopted by areas other than the video games industry. From VR interactive movies, to entire music festivals being presented in a VR environment, this elevated level of user engagement and immersion, would become a valuable variable for scientific research, more specifically the realm of psychological therapy. Through the use of a VR device, one can reproduce concepts and values, adapted from real environment interactions, in order to maintain a high level of authenticity and promote engagement between the user and the virtual world. The main objective of this project was the development of a prototype through the application of game design elements and principles to the Cognitive Behavioral Treatment (CBT) process. The Obssessive Compulsive Disorder (OCD) patient is exposed to various levels of triggers in a tailored VR environment, where the analysis and dissimulation of compulsions is the main goal. In order to validate the effectiveness of the prototype and to conform to the imposed global pandemic restrictions, the prototype was reviewed by medical professionals by means of recorded gameplay video format.

Keywords

Video Game, Virtual Reality, Game Design, Cognitive Behavioral Treatment, Obsessive Compulsive Disorder.

Contents

List of Figures

List of Tables

Acronyms

VR Virtual Reality

OCD Obssessive Compulsive Disorder

UI User Interface

CBT Cognitive Behavioral Treatment

3D Three-Dimensional

2D Two-Dimensional

GDD Game Design Document

PC Personal Computer

VRET Virtual Reality Exposure Therapy

AAA Triple A

Chapter 1

Introduction

The first chapter of this document starts by introducing the project, the scope of the video game is presented in section 1.1. The project's motivation in section 1.2. The objectives and methodology in section 1.3. Section 1.4 closes the chapter off by exposing the structure of the report.

1.1 Scope of the Project

With technology increasing its grasp on the cogwheel of society and its inner workings, it has become the main engine of progress for many areas. This symbiotic relationship between user, technology, and research led towards the conceptualization and development of tools that strive to facilitate user interactivity and by consequence increase the user's immersion while using such tools. With the introduction of VR, this branch of technology that makes use of motion tracking and Three-Dimensional (3D) Computer Graphics, was quickly adopted not only by the video game industry, but also by key areas such as: Defense, Science, Medicine and Engineering with the main objective of being integrated in the process of training, therapy, and simulation technology. This project's aim is to support the field of rehabilitation, more specifically the treatment of OCD, making use of the medium of video games as a vehicle to achieve positive results in the treatment process.

1.2 Motivation

In the context of applying game design elements and game principles to the OCD treatment process (gamification), this project has as motivation the design and development of a Virtual Reality game that acts as a tool that strives to achieve a symbiotic relationship between tool and therapy professional, with the objective of gamifying the treatment process, leading to a fun and rewarding experience for the patient. The objective was to introduce a new technology in order to reduce the emotional drain of each treatment session. The use of VR, a technology said to enhance the user's immersion, in the psychology area, while still scarce, may produce very positive results and positively impact the patient's quality of life by leveling up the quality of the treatment.

1.3 Objectives and Methodology

The main goal of this project is to design and develop a video game interactive experience that works as a platform for medical professionals to engage in therapy sessions with OCD patients. This work intends to be an immersive and engaging experience for the patient with the intent of proving a correlation between the use of a crafted VR environment and the well-being of a patient during therapy, regulating stress levels and provoking the patient thoughts through exposure to their specific obsession over the course of multiple therapy sessions. This removes the need of replicating specific environments and exposures in the real world from the process, due to the availability of these environments and experiences in the crafted virtual reality experience. In order to achieve this objective, two students, one with a games design background and the other with a computer science background, set out on a journey to design and develop a VR video game which allows for the tweaking of variable customizable levels of exposure defined by the therapist, allowing the VR video game to adapt to different patient archetype and therapy needs. The patient's vital signs can also be measured though the use of biofeedback technology, so they can be used in comparison with the patient control going through usual treatment procedures, in order to justify if there is a positive outcome on the patient, and its effectiveness.

1.4 Report Structure

The document will be structured in the following order:

- Chapter 1, Introduction, starts by defining the scope of the project, the motivation behind the topic, the objectives, and methodology used to accomplish the goals of the project and a brief description of the report's structure;
- Chapter 2, Related Work, lists several studies and video games relevant to this project and the area of Psychology, thoroughly analyzes the structure of each work and their different characteristics, identifying any correlations to this project and pinpointing which areas can benefit from innovation;
- Chapter 3, Game Design Concept, delves into the thought process behind the design choices for this game, ranging from controls and gameplay, to world setting and possible restrictions;
- Chapter 4, Prototype Design and Development, exposes the development process of the game after conceptualization, going in depth into the game environment and the asset creation behind the current state of the game;
- Chapter 5, Tests and Results, presents the results of a survey tailored towards mental health professionals in order to define if there's an interest in supporting the project;
- Chapter 6, Conclusions and Future Work, defines the conclusions brought about by the development of this project, listing some improvements to be considered to be implemented in the project on a future date;
- Appendix A, Game Design Document (GDD), has the full GDD, which was used to register the most important components and metrics of the game while it was being developed;
- Appendix B, Objects and textures, shows the most complex 3D objects which were modelled to build the game environment, along with their assigned textures if applicable;
- Appendix C, Survey and Test Results, presents the survey that was used to gather data and all its answers available in graphs and charts;

- Appendix D, Scripts, presents the scripts necessary for the navigation in the User Interface (UI).

Chapter 2

Related Work

2.1 Introduction

Section 2.2 delves in the most relevant work already developed in the field related to the theme being worked upon. The main objective of this section is to dissect and segment all the relevant work, individually analyzing the structure of each work and the way it translates the process of OCD therapy into a gameplay experience.

2.2 Related Games

The task of finding related work that had a link between the utilization of VR technology and interaction with OCD patients revealed itself difficult, however this means that there is a niche market where a video game that explores this subject is able to thrive.

2.2.1 Treasure Hunt

Treasure Hunt[1] presents itself as a therapeutic video game based on the principles of CBT. The video game objective is to support psychotherapists in the cognitive-behavioral treatment of children between the ages of 9 and 13. In Treasure Hunt, the player goes through six levels, each one mirroring a step in the methodology of the CBT process. These steps are all intrinsic within the narrative of a pirate treasure hunt. Captain Jones, Polly the parrot and Felix the cat go on a journey on their pirate ship, represented in Figure 2.1, to find the treasure. This journey has the player

go through multiple linear tasks that help interpret and internalize the CBT process, by showing the player how he can make choices without letting OCD take over the decision process.

Figure 2.1: Treasure Hunt Ship image taken from [1]

2.2.2 Ricky and The Spider

Ricky and the Spider[2] was developed at the Department of Child and Adolescent Psychiatry of the University of Zurich for children between the ages of 6 and 12, in order to provide support for therapists in their treatment of children with OCD through the use of CBT tactics. It wasn't created with the purpose of being a self-help game, but as a platform for the help of OCD treatment to be used by the patient and the medical professional. The game makes use of metaphors adapted to the target audience's age. The correlation of its narrative and each step of the treatment can be observed incrementally throughout the game.

Figure 2.2: Ricky, together with the spider, taken from [2]

Represented in the first level, is the subtle introduction to the origins of the mental

affliction, through the use of metaphor, this affliction gives life to the Spider illustrated in Figure 2.2, the game's antagonist. Ricky and Lisa explain why they feel the need to follow the spider's orders, them being Ricky only being allowed to hop across the meadow in a pattern and Lisa having to count the spots on her wings every evening before she goes to sleep.

Figure 2.3: Dr. Owl confronting Ricky e Lisa, taken from [2]

In the second level, depicted in Figure 2.3, Dr. Owl has a dialogue with Ricky and Lisa, making a comparison between our thought process and a river, noting that our thoughts are filtered the same way a river is. He explains that what the Spider is doing, is disrupting the flow of the river, leading to the absurd thoughts they suffer from.

Level three is where the children are introduced to the game's win condition. During the children's conflict with the Spider, Ricky and Lisa need to achieve four steps, they are:

- Be kinder with themselves;
- Have the courage to change;
- Have patience;
- Having someone to help them.

These four objectives are represented as a four leafed clover, which is introduced alongside with the gameplay. One of the strategies of externalization which is recommended by Dr. Owl is for the child to think about ridiculous names for the Spider.

In the fourth level, Ricky and Lisa are tasked with gathering every order that the Spider makes them accomplish and proceed to evaluate how difficult it is to not obey these orders. Together, they need to create a compulsion map in order to create tasks of courage. The child is also tasked in creating their own compulsion map. In level five, after helping his two friends, the Doctor asks Lisa to practice her tasks of courage various times per day and Ricky decides to help.

In the subsequent level, Lisa receives a list of tasks and is encouraged by Ricky and the child to not cease the fight against the spider. Dr. Owl strongly recommends that his friends don't skip tasks before finishing the previous one. Continuing, in level seven, Ricky is tasked with additional tasks to complete. With Ricky beginning to hesitate, Lisa and the child need to encourage and motivate him using the four leafed clover.

Finally, on the last level, in order to congratulate Ricky and Lisa, Dr. Owl awards each of the children with a certificate. The child also receives a physical certificate, which states that they can request help at any point in time. With each level, the concept of each treatment step is explained. After the first four levels, an interactive sheet is introduced to the child for them to solve, this sheet can also be printed from the Ricky and the Spider website to serve as homework for the child.

2.3 Related Studies

2.3.1 Anxiety Provocation and Measurement Using Virtual Reality in Patients with Obsessive-Compulsive Disorder

The study, elaborated by Kim et al.[3] for the journal CyberPsychology & Behavior depicted in Figure 2.4 is a preliminary test of a VR anxiety-provoking tool using a sample of participants with obsessive-compulsive disorder (OCD). The tasks were administered to 33 participants with OCD and 30 healthy control participants. In the VR task, participants navigated through a virtual environment using a joystick and

head-mounted display. The virtual environment consisted of three phases: training, distraction, and the main task. After the training and distraction phases, participants were allowed to check (a common OCD behavior) freely, as they would in the real world, and a visual analogy scale of anxiety was recorded during VR. Participants' anxiety in the virtual environment was measured with a validated measure of psychiatric symptoms and functions and analyzed with a VR questionnaire.

Results revealed that those with OCD had significantly higher anxiety in the virtual environment than healthy controls, and the decreased ratio of anxiety in participants with OCD was also higher than that of healthy controls. Moreover, the degree of anxiety of an individual with OCD was positively correlated with his or her symptom score and immersive tendency score. These results suggested the possibility that VR technology has a value as an anxiety-provoking or treatment tool for OCD.

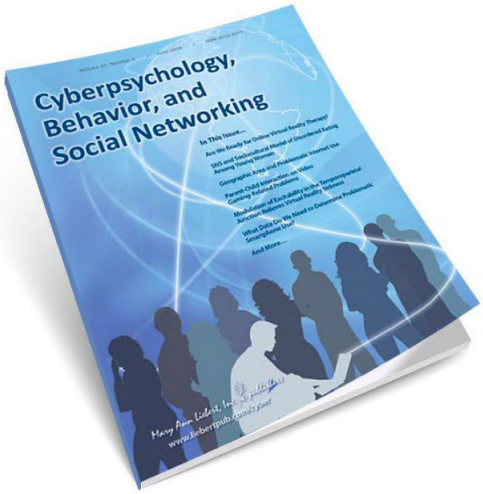


Figure 2.4: CyberPsychology & Behavior Peer Review Journal, taken from [3]

2.3.2 Virtual reality exposure for OCD: Is it feasible?

The article [6] introduces the analysis of the utility of (Virtual Reality Exposure Therapy (VRET), from the perspective of OCD patients. The author points out that exposure and compulsion dissimulation is an essential treatment component, however, even when medicated, half the patients do not respond to CBT as expected. These failures may be due to some patient's reluctance to engage in self-exposure, along with being required to follow an intensive treatment regimen. The author also mentions that other reason for

CBT failures is the inflexibility from the delivery of this procedure, that do not allow for a unique approach to the special requirements of each patient. The article proposes the use of computer-aided treatments, more specifically the use of VR, to promote exposure and the engagement between the patient and the treatment process. It reports the results of testing VRET on four women with the cleaning and contamination subtype, where each person had to go through four tasks relevant to their shared OCD subtype. These tasks helped in accessing their level of presence, emotional engagement, reality judgement, anxiety, and disgust. The execution of these tests was possible through the use of a television connected to a laptop and a Kinect [7] device. The reported results reflected the increase of anxiety and disgust levels as the simulation progressed with the increase of the degree of contamination. This correlation was connected with the level of immersion of the patient, justifying the potential in the use of this technology to mitigate the patient reluctance to engage in live exposure therapy.

2.4 Target Audience

After thorough analysis of related work found when searching for gamified experiences related to psychological therapy, it can be identified that most video games and studies developed with the objective to treat OCD or expose patients to VR experiences, are aimed at children due to the stigma of video games being solely targeted at the younger demographic. However, VR serves as a gateway that's appealing to both adults and children, for being a new and exciting technology, promoting a high level of immersion and interactivity which breaks the mold of the CBT process.

2.5 Project Innovation

It is apparent that the VR experiences created solely for this type of treatment aren't focused on the simulation of an interactive experience, being almost uniquely sold as an informative experience instead of a game, lacking the real-world feedback and interactivity of a truly immersive Virtual Reality game. This allowed to identify a specific niche in the market for this type of platform, to aid in the therapy of OCD patients. This project is a VR game to be used as a platform for treatment of OCD, which is something that doesn't currently exist. The time to introduce such tool is

now, where VR technology keeps being improved and its limits and boundaries are constantly being pushed.

2.6 Conclusions

In this chapter, both video games and peer reviewed journal publications related to psychological therapy through the use of video games were thoroughly analyzed. In conclusion, a niche in the market was pinpointed, defining the blueprint for possible design and development in order to capitalize in where it should stand out. The scarcity of a VR application in the field of OCD treatment is the perfect foundation for this project can be build upon, through the gamification process of the therapy session, with the objective of de-ritualizing the rituals developed by patients to cope with their obsessions, in order to dissimulate the compulsions of the patient.

Chapter 3

Game Design Concept

3.1 Introduction

Due to the nature of this project, in order to accurately pinpoint what could be translated into gameplay, without developing anything that could possibly cause any repercussions towards the patient and being perfectly in tandem with their struggles, there was a need to have feedback from several mental health professionals. This input was key to make this project feasible, immediately kick-starting the design and development process of a VR video game for OCD rehabilitation.
In section 3.2. the decision behind the chosen pathologies is defined, and all the gameplay actions belonging to each pathology are identified. Section 3.3. exposes the creation of the game concept, detailing the game's therapeutic actions and identifying the possible interactions, while also presenting the different game mechanics that were considered, even if they did not make it into a part of the gameplay. Section 3.4. goes into detail about the conceptualization process of the game environment, as well as the different stages of its development. In section 3.5. each defined puzzle and hint system is presented in detail. Finally, in section 3.6. the restrictions and limitations to the development process, brought by the global pandemic, are identified.

3.2 Pathology Gamification

In order to become familiarized with the different pathologies of OCD, at the start of the project's conceptualization, multiple meetings were held with psychologists that

showed interest in the presented proposal, with the sole focus of defining the guidelines and strategy to translate said pathologies into gameplay. The identified pathologies are the following:

- **Order and Symmetry:** Symmetry, ordering and excessive tidiness;
    - Order and Symmetry OCD example:
        - Extreme anxiety that something bad may happen if the number of items somewhere scattered inside or outside one's home or workplace is uneven, for example, shirts on a wardrobe, cups on a cupboard, items on a wall are misaligned or unordered bookcase;
        - A Repulsiveness towards asymmetry – words on a page, cutlery on a dinner table, or any number of things that "don't line up evenly";
        - Being overwhelmed by the need or urge for things to be balanced; for example, needing to hold a cup of coffee with both hands exerting the same amount of pressure on each side of the cup, or crossing doorways with both hands and shoulders at the same level.
- **Contamination:** Excessive cleaning or washing;
    - Contamination OCD example:
        - A person loves to keep a neat and orderly home. Ever since he was a child he felt safe and in control when her immediate surroundings were clean and in order. So when does someone's love for a clean home become too much? Here is an example of some cleaning routines of people that suffer from this type of OCD pathology:
            - A person that takes a lint roller and rolls their entire bedroom floor in case any hair has fallen;
            - A person that brushes their teeth while knelt down at the bathtub because they don't want to dry out the bathroom sink, which is one of their rituals (compulsion) to cope with their obsession.
- **Checking:** Doubt and verification, compulsive checking and re-checking;
    - Checking OCD example: A person gets stuck trying to leave the apartment, checking for safety hazards.

A person is at risk of being late to work again. Even though they got up early, got ready in time, and could have easily made it to the right bus – they were once again stuck in their apartment and bombarded with intrusive thoughts such as:

- "Did I remember to turn off my stove?";
- "Did I really lock the windows and unplug the toaster?";
- "What if a fire starts? What if someone gets hurt?";
- "I couldn't live with myself if it was my fault.";

- **Taboo:** Forbidden thoughts.

  - Taboo OCD example: Having psychological triggers such as:
    - Obsessive thoughts about their sexual orientation;
    - Intrusive thoughts and obsession with suicide.

After thorough investigation and discussion with psychologists, the Taboo pathology had to be discarded, due to being too specific for each patient, which would render impossible the design and development of experiences that would target every patient that was affected by that specific pathology. After identifying the pathologies that could be used as a gameplay element, the next course of action was to pinpoint different actions from each type of pathology that could be translated into gameplay. Focusing on having a closed and controlled environment, it was decided on designing a house where these actions could be taken. The considered actions can be seen on table 3.1.

Living room	**Bedroom**
Chairs (Order)	Desk (Order)
Sofas (Order/Contamination)	Computer (Checking)
Dining Table (Contamination)	Bed (Order/Contamination)
Bookshelf (Order)	Wardrobe (Order)
Windows(Checking)	Windows(Checking)
Lights (Checking)	Lights (Checking)
Floor (Contamination)	Floor (Contamination)
Bathroom	**Kitchen**
Shampoo (Order)	Cutlery (Order)
Shower (Contamination/Checking)	Plates (Contamination)
Towel Closet (Order)	Cooking Ingredients (Order)
Bidet (Contamination)	Bidet (Contamination)
Faucet (Checking)	Faucet (Checking)
Lights (Checking)	Lights (Checking)
Floor (Contamination)	Floor (Contamination)

Table 3.1: Possible gameplay actions in each chosen room

3.3 Game Concept

As previously mentioned in section 1.3, two students from different previous academic backgrounds, games design and computer science, teamed up to conceptualize a VR video game platform for OCD patient therapy. This game was titled VR-POC, as a direct reference to the Portuguese translation of OCD(Perturbação Obcessivo-Compulsiva). The game was developed with a VR headset for display and position tracking, and two control interfaces as the main user input devices. This hardware lets the patient interact with the digital world through the use of real-time position and motion tracking, allowing the player to delve much deeper in the realm of immersion, compared to a normal controller or keyboard.

3.3.1 Game Description

VR-POC is a computer first person, puzzle, exploration, simulation game that capitalizes on the strengths and advantages of VR. The game is based on the principles of CBT where a OCD patient is able to immerse themselves in a handcrafted virtual reality game experience, that takes place in a game world tailored specifically to act as a medium between OCD patients and the mental health professional.
In this VR game the patient has to solve puzzles with randomly generated solutions that have as their main objective the dissemination of their compulsions through the use of intrinsic gameplay mechanics. The player starts the game in a cozy three-room apartment, built to feel inviting and relaxing. This environment was tailored to act as a safe environment, a bubble, to make the player feel at ease at the start of a therapy session. The player is introduced to the first objective of the game through a text prompt which appears in their field of vision, guiding them to the chalkboard on the wall. This board acts as an objective tracker for the rest of the game, which displays the randomized objectives after they interact with it. With the board's directions, the player is invited to solve various puzzles, spread throughout the environment, implemented in unison with the environment layout. These puzzles consist in the player searching for specific objects ranging from clothing articles to drinking cups, in order to arrange them in a non-intuitive order, all while a timer lets the player and the medical professional know how long they've been inside the simulation.
VR-POC is not a self-help video game, as such it should not be available to people unless they are in psychotherapeutic treatment, considering that the full benefit of a psychotherapeutic game can only be achieved if it is used with the support of a mental health professional.

3.3.2 Style

In the early concept stages, VR-POC was originally intended to be a realistic game, however there are hardware limitations to consider. Obtaining the VR headset and having the necessary hardware to run extremely detailed VR simulations can become quite costly. The polygon count has to be kept to a decent amount for performance to be acceptable and friendly on most systems. There is also the consideration of being able to run VR-POC on newer VR headsets which support wireless play, promoting accessibility. As such, VR-POC is visually represented as a semi-realistic game,

making use of real-time lighting rendering techniques and high-quality textures, models and physics interactions.
There was a need to have a semi-realistic game world due to having a direct correlation with the level of immersion the player can achieve inside the game environment, while taking in consideration the hardware's limits.

3.3.3 Genre

VR-POC is defined by the following genres:

- **Virtual Reality:** Makes use of a Virtual Reality headset to display a VR environment;
- **Simulation:** Tries to replicate activities from real life in the form of gameplay;
- **Exploration:** The player is free to explore the game world and interact with it;
- **Puzzle game:** The game emphasizes puzzle solving and provokes the player problem-solving skills.

3.3.4 Player Character

The player character has no predefined identity, motivation or individual characteristics. The playable character and its traits are the players themselves. The player's movements, height and position are translated into the game through the use of motion tracking technology, giving agency to the player. While inside the virtual environment, the player has all the tools needed to be able to interact with the world despite these variables.

3.3.5 Key Elements

A video game has to boast a certain number of unique characteristics that make it marketable to an audience. The key elements that compose VR-POC are:

Game Character: The player character is defined by the player characteristics in the real world, such as height, their movements and position.

Goals: The player has as motivation the completion of compelling puzzles that boast multiple randomly generated solutions, shaping every therapy session into a unique experience.

Decisions: The player decisions reflect their success on finishing the puzzles.

Immersion and Presence: Through the use of VR technology, VR-POC boasts a high degree of immersion, with the intent of maintaining the player in a state of flow for as long as possible, even if its not possible in all situations due to the therapeutic nature of this experience. The player is able to grab objects, and interact with game objects that have physics properties such as gravity and weight.

3.3.6 VR Hardware

The use of VR is a key factor when it comes to the player's immersion. As such, the right hardware can make or break the experience. The Oculus Rift S's [5] headset, which comes bundled with the excellent Oculus Touch motion controllers, boasts the support for whole-room VR, a technology that allows the player to scan its environment, by drawing a "bounding box" on the floor, generating the boundaries of the player's movement. This VR headset also has a very high refresh rate, which promotes a smooth and seamless experience for the player, reducing the probability for nausea or fatigue from use. VR-POC uses the VR touch motion controllers intuitive controls to allow the player to interact with the game world like they would in real life by grabbing, throwing or pinching objects in their vicinity. In chapter 4, the VR headset will be discussed more thoroughly.

3.3.7 Platforms

VR-POC is intended to be played on a Personal Computer (PC), which meets the minimum requirements to be able to run properly. The PC also needs to be compatible with the already mentioned VR headset, or else it won't run the game. Other platforms were considered, mainly consoles due to their accessibility and large availability, however developing for multiple platforms would extend the development schedule for each build, something that was not feasible, considering the short deadline and small team.

3.3.8 Target Demographic

Therapeutic Video games have always been developed with the youth in mind due to the stigma that video games are for children. However, VR-POC breaks the mold, by developing an experience through the use of a growing technology such as VR, which boasts an ambitious plan for the future that's attractive for both adults and children.

3.4 Game Environment Concept

In the early stages of conceptualization, the game environment which would hold the playable area took many shapes and forms. However, having defined the target audience for the game and taking into account that VR-POC was a VR video game with its main focus being the gamification process of a therapy session, a blueprint was designed in order to accommodate all the variables defined previously. A homely, yet modern looking environment was created in order to emulate a familiar environment. Figure 3.1 shows the different stages of the game environment.

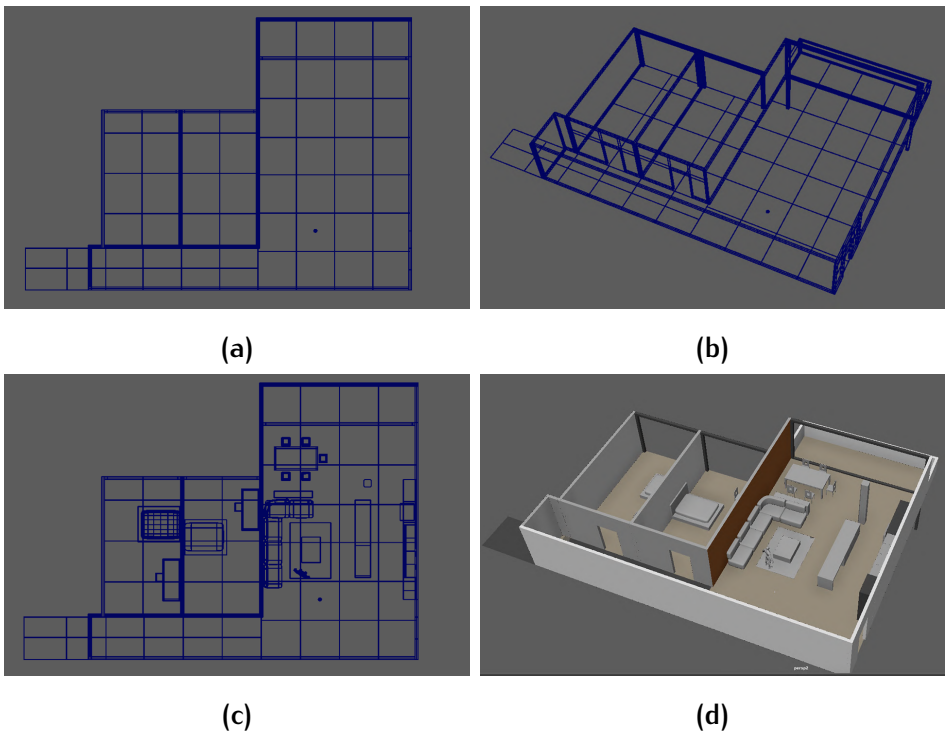


Figure 3.1: Different progress stages of the Game Environment

There was a need to adapt the environment to the requirements of every possible

types of actions, each type of OCD would have its specific level where it could be expanded on. It was decided to create a concise design with decently sized, easy to access rooms, while avoiding designing a claustrophobic environment where the player would feel restricted. The design decision with the most impact in the game environment was to fuse the kitchen and living room into a larger room, which not only created more space for the player but increased the amount of possibilities for future interactions due to less constrains.

3.5 Gameplay Concept

Having decided to focus on the *Order and Symmetry* OCD subtype, the development team's main goal was to develop a level that suited the needs of a OCD patient who struggles with the mentioned subtype. Based on the actions defined in the aforementioned Table 3.1:

- Bookshelf;
- Cooking Ingredients;
- Chairs;
- Sofas;
- Desk;
- Bed;
- Wardrobe;
- Towel Closet;
- Shampoo;
- Cutlery.

The main use of these objects are to be used in a way that promotes the dissimulation of the patient's compulsions through interaction. As such, the actions selected were "Bookshelf", "Cutlery"(Kitchen cups) and "Wardrobe". All these actions had a similar purpose, to force the player to think non-intuitively and break patterns, exposing the

player to triggers, such as anxiety, which the player would have to face in order to complete the objectives.

3.5.1 Wardrobe

The Wardrobe puzzle was the first puzzle to make it through the concept phase. Even though it deviates from its original design, which would have it behave like a music instrument, where each colored piece of clothing would produce a different note. The main goal of the puzzle was for the player to compose a melody by re-arranging the colors in a predefined random position. This concept was eventually given a thorough redesign so all the different locations of the game environment had similar gameplay. It was also taken in consideration that not every patient would have the same music theory knowledge, or that the player could even possibly be tone-deaf, making it impossible to solve the challenge without guessing the positions, defeating the puzzle's purpose. This decision was made in order to keep the set of possible interactions concise and intuitive, so the patient was able to grasp the controls and to not overwhelm the patient with several contrasting mechanics. The PC monitor in the same room as the wardrobe, as shown in Figure 3.2, displays a hint that is critical to the patient's success in determining the order of the colored shirts inside the wardrobe, an example is shown on figure 3.3.

Figure 3.2: Example of the computer being located next to the wardrobe

Figure 3.3: Example of a color hint for the wardrobe puzzle displayed on the computer monitor

3.5.2 Bookshelf

The bookshelf followed the same puzzle thematic as the shirts, yet instead of sorting by color, it was based on color matching. Each shelf shares the color of the corresponding book that is required to be placed in that position. However, two shelves with books that don't share the same color will always exist, as shown on Figure 3.4. This puzzle's goal is to deceive the player into placing the books next to the books that share the same color, instead of following the hint, which entices the player to try to match the book to the shelf color instead of the books themselves. This conundrum generates displeasing feelings in OCD patients and might trigger anxiety.

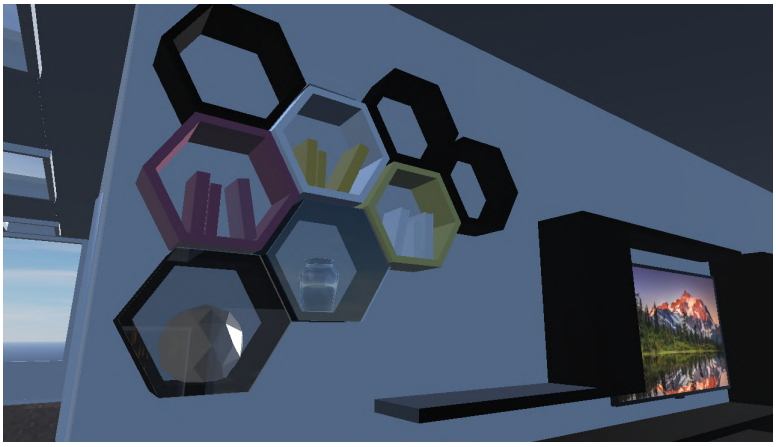


Figure 3.4: Example of a color hint for the bookshelf puzzle

3.5.3 Cups

The last task consists in the ordering of cups. Though the puzzle appears to be straight forward, a slight mechanic change differentiates it from the other puzzles. This time, the cup sizes are the key to beating the challenge. The cups are randomly positioned throughout the game environment and the player's goal is to order them on top a small kitchen tray on top of a cupboard, which can be seen on Figure 3.5. This order is displayed on a television screen in the living room, as seen on Figure 3.6, where each number has a direct correlation with each cup's size.

Figure 3.5: Example of the cup's tray

Figure 3.6: Example of a hint for the cup puzzle

3.6 Impact of COVID-19

As a consequence of the widespread turmoil caused by COVID-19, the project was forced to deviate from the planned objectives, which had to be adapted to the new safety and health regulations, due to the nature of the project, in order to meet the requirements to continue development. These changes narrowed the scope of the game quite significantly.

- The necessity to work remote led to certain menial tasks, which were taken for granted before the global pandemic, to take quite longer than expected due to the negative impact on team communication and feedback;
- Forced to narrow the scope of the game from three levels, one for each OCD subtype to a single level with various tasks;
- Patient feedback became impossible due to the implications of requiring physical hardware to be used. This led to the development of a professional survey tailored towards medical professionals instead;
- The negative psychological impact on the team from being confined and adjusting to the rules imposed.

In the early concept stages of the game, all the previously defined subtypes were considered, however, as development continued, the challenges brought by the global pandemic made it difficult to obtain results. As such, after thorough consideration, it was decided to narrow the scope of the game towards a single type of OCD in order to focus development resources towards achieving results given the limitations. As mentioned previously, the new imposed health and safety guidelines voided the possibility to conduct physical tests. These tests were key to gather a suitable control group, by having the possibility of testing multiple OCD subtypes inside the three previously defined levels. Ultimately by focusing on a single subtype, it was possible to mitigate some of the limitations imposed by the global pandemic, as such the prototype development pipeline was honed and was able to achieve higher quality results.

3.7 Conclusions

This chapter delved into the early concept stages of the prototype, justifying the reasoning behind each design choice and its motivation. The possible actions and interactions were defined, and the conceptualization process was exposed. A detailed description of the game was presented, alongside with the thought process behind the values of the game. The genre and player identity was defined and categorized, key elements and main selling points were identified. Afterwards the reasoning behind the chosen platform and target demographic was justified. After a brief overview of the hardware and the game environment concept, it went into detail of the gameplay concept. The impact of the global epidemic forced focus to shift, which led to the narrowing of the project scope in order to achieve higher quality results through a testable prototype.

Chapter 4

Prototype Design and Development

4.1 Introduction

Although the original scope of the game was narrowed due to the negative impact of the global pandemic, this chapter will detail what was decided to not be cut from the project. Section 4.2. delves into the development tools used in this project, justifying the choice behind each one. Section 4.3. presents the Game Design Document (GDD) created during the development of the project, as well as explaining why having a GDD is benefit for a team of developers. In Section 4.4. an in depth look into the Environment Design is presented, detailing the construction of the White box as foundation, as well as exploring the asset creation pipeline used in the development of this project. Section 4.5. expands on the physics engine of the game and how it was used to achieve realism. Finally, Section 4.6 goes in depth into the prototype's controls.

4.2 Development Tools

This section defines the tools chosen for this project development and their characteristics in other to justify why they were specifically chosen for this project.

4.2.1 Unity Game Engine

Unity 3D [4] is an all-in-one platform for video game development and other key areas such a cinema, created by Unity Technologies. This development platform has

gained a tremendous following by the game development community due to its features, supportive pricing for new developers and strong influence in the video gaming industry. With its ability to function as a cross-platform game development tool, supporting most devices in the market, saving developers time and budget when developing for multiple platforms. Some of Unity's most attractive features are:

- **Game Development Accessibility:** Unity is excellent for cross-platform development and multi-platform games. Platforms like Unity have simplified the process, making a single script able to be compiled and using on multiple platforms. It also provides access to plenty of Virtual Reality libraries, streamlining the development process of such applications;
- **User Interface:** Unity makes use a UI that is appealing, intuitive and easy to learn;
- **Asset-Store:** The Unity Asset store is a growing library of assets, published by members of the community and Unity developers themselves, with most requiring a microtransaction to be used by the user. These assets range from textures, 3D models, animations, to entire projects, extensions or tutorials;
- **UI:** Concise and intuitive UI, as shown in Figure 4.1, which boasts a modular approach to development, allowing for the user to set up a custom workspace to adapt to their needs;
- **Physics Engine:** Unity supports NVIDIA PhysX [8], which is one of the major three players in 3D physics currently in the market (others being Havok [9] and Bullet [10]) for realistic interaction between objects while not having a considerable impact in performance.

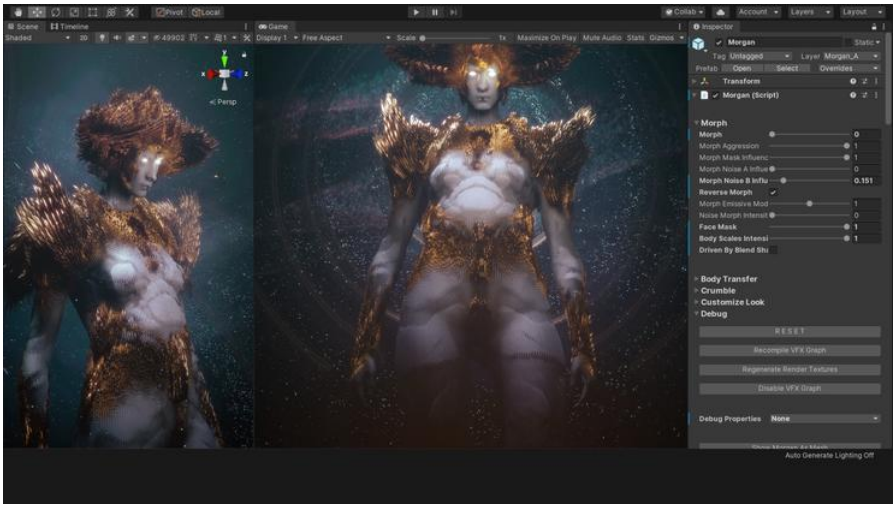


Figure 4.1: Unity Game Engine, taken from [4]

4.2.2 Oculus Rift S and Accessories

In order to access the reasoning behind the choice of hardware for this project, some key variables had to be considered. To be able to accommodate to the different infrastructures in which the prototype might be utilized, there was a need to not rely on devices which needed a multiple camera setup in order to track the player inside the play area. This multi-camera setup would be very intrusive in the consultation area due to storage after usage not being user-friendly, leading to the hardware always occupying a considerable area in the workspace. The Oculus Rift S, as can be seen on Figure 4.2, solved this conundrum, due to the camera tracking being implemented on the headset itself, unlike other devices which use a multi-camera setup. This device comes bundled with the headset itself, 2 ergonomic controllers with a set of infrared trackers in order to be tracked in the 3D space by the Oculus Constellation system, 2 cables, video output adapters and batteries. In order for the device to be used, there is a need to have a computer which meets the minimum hardware requirements and connection compatibility specified by the user manual.

Figure 4.2: Oculus Rift S headset and controllers, taken from [5]

4.2.3 Autodesk Maya 2020

Autodesk Maya 2020 [11] is a 3D computer animation software with powerful modeling, texturing and animation tools for artists, modelers, and animators. Some of its most prominent characteristics are:

- **Student education program:** Autodesk allows users to get a free one-year student license to many Autodesk products and services, for as long as the user is eligible;
- **User-friendly:** From a pool of various 3D software programs in the market, Maya continues to be the most user-friendly of them all, counting with an improved GUI.

Autodesk Maya was chosen for this project over its direct competitor, Blender, mainly due to the previous experience using the software.

4.2.4 Adobe Photoshop 2020

Adobe Photoshop [12] is the industry standard software when it comes to editing digital graphics. In fact, the uses of Photoshop seem to be limitless due to being a software with a plethora of applications in the real world. This application was chosen for this project's development due to:

- **Tools:** The surplus of cutting-edge tools at one's disposal;

- **Features:** The unparalleled editing features.

Photoshop was used to edit and tweak texture files for the creation of materials inside the Unity game engine.

4.2.5 Substance Designer

Substance Designer [13] is regarded as the video game industry's reference material creation tool. It is reported that 95 percent of Triple A (AAA) video game projects currently in development use this tool. Substance Designer was used to create textures, called materials, in order to flesh out the project's environment.

4.2.6 Substance Painter

Substance Painter [14], contrary to Substance Designer, can be likened to a 3D version of Abobe's Photoshop for digital painting work. The main purpose of Substance Painter is to texture 3D models through the use of layers and masks. This means that progress can be seen in real-time, which allows for a more detailed end result.

4.2.7 Marmoset Toolbag 4

Marmoset Toolbag [15] is a real-time rendering, texturing and baking suite. It's one of the most used software application in the AAA video game environment due to its extensive Normal and Ambient Occlusion baking solutions.

4.2.8 Visual Studio Code

Visual Studio Code [16] is a free, open-source code editor, developed by Microsoft for multiple platforms. It's considered one of the most versatile code editors by its users. Some of Visual Studio Code most attractive features are:

- **Customization:**It allows the user to change the theme, keyboard shortcuts, preferences to set up a unique workplace;
- **Improved experience:** It has numerous amounts of plugins and extensions to improve the experience and overall functionality;

- **Language-agnostic:** Instead of a project system, it allows users to make use of different directories that can be saved in the workspace and be reused, allowing to choose a certain programming language to a certain task.

4.2.9 Sony Vegas Pro 17.0

Sony Vegas Pro 17.0 [17] is a paid tool used to edit and render video. With it, it was possible to render a video sample of gameplay to be shown at meetings due to the global pandemic, as well as a specifically tailored version created to be presented to the medical professionals through the survey.

4.2.10 Google Forms

Google Forms [18] is a free platform used to create forms and surveys, as well as to quickly process data through the use of its data summarizing tool. It was used in order to create the survey go gather feedback on the prototype.

4.2.11 Unity Collaborate

Unity Collaborate is a source control paid subscription service which makes it easy for teams to save, share and sync their Unity projects. This service is cloud enabled and build directly into Unity. It was the source control tool of choice due to its flexibly in managing project versions and merging scenes.

4.3 Game Design Document

In the early concept stages of the project, a Game Design Document (GDD) was started, to register every change to the prototype. A GDD is an invaluable tool when working in a team of developers, it helps communicate between difference disciplines in a hassle-free way. It brings the key parts of a game design together and records the main ideas, dissects the gameplay and lays it out in an organized manner. This document allowed the team to:

- List all the ideas brainstormed during the conceptualization of the prototype;

- Lay down all the gameplay mechanics, actions and interactions;
- Record critical assets necessary for the function of the game, such as sounds, animations, style;
- Register all the metrics and their changes throughout the development process.

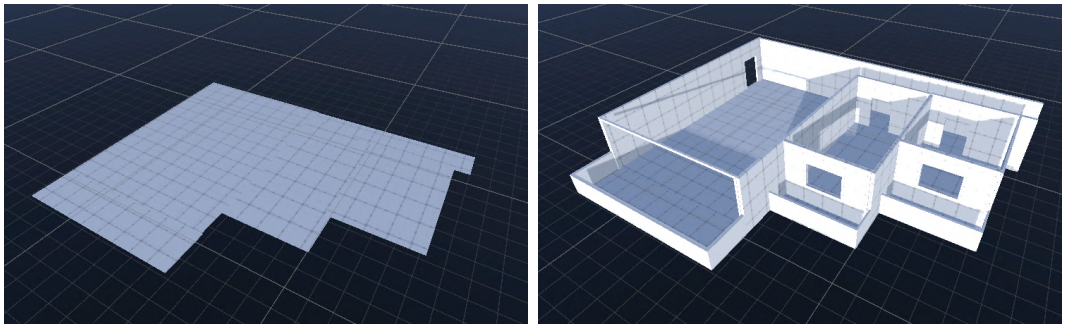
The GDD acted as a shield against the constant flood of changes that might have caused negative effects on the game creation. This document is available in Appendix A.

4.4 Game Environment Design

The game concept required the design of a non-invasive, familiar environment where the player could feel safe and at home. This section delves into the creation process of the components used to build the game world, from the environment prototyping phase to the asset creation process.

4.4.1 White Box

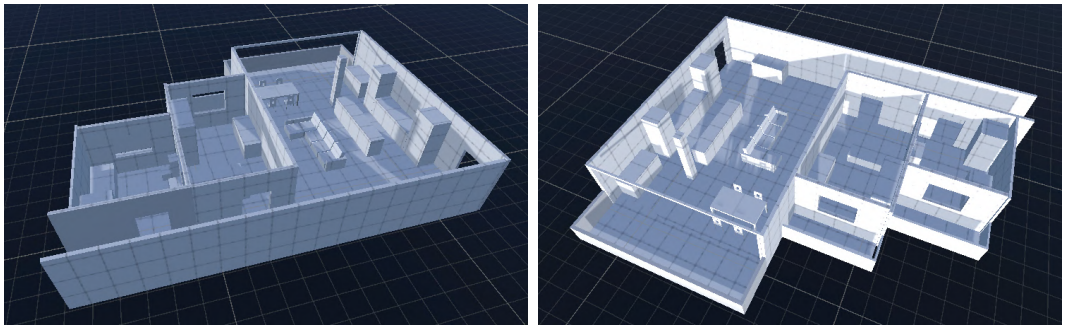
In order to build a prototype environment, Unity has at its disposal ProBuilder, a white box building tool. This tool enables the user to effortlessly create polygonal shapes, with various degrees of complexity, in order to place them in the game environment as a means to build an environment for testing. As such, ProBuilder was used to create the apartment's foundation. White boxing is an extremely important step in the process of designing an environment as it allows the developer to focus on the most important aspects of game design, as the core game mechanics and pacing, user interactions and puzzle mechanics while still having a reference to the boundaries and play area of the game without exhausting precious resources required elsewhere during early development. This methodology is akin to architectural practices in where a reference blueprint is drawn and then built upon.
The foundation of the apartment was the first element to be created, as see on Figure 4.3 (a), followed by the boundaries of the house, shown on Figure 4.3 (b). This stage of the white box allowed for early movement and collision mechanics to be developed, as well as helping define the scale of the world while inside VR, to have a metric reference for asset creation.



(a) (b)

Figure 4.3: White box first stage

The final step in the white box process was to implement all the originally planned assets related to the in-game actions already defined in Section 3.5 inside each location, as can be seen in Figure 4.4 (a) and Figure 4.4 (b).



(a) (b)

Figure 4.4: White box final stage

4.4.2 Rendering Pipeline

In Unity, it is possible to choose between different rendering pipelines. The Universal Render Pipeline was the one chosen for this project. It is highly flexible and configurable using C# and has scalable graphic quality, which pushes maximum graphic quality in high-end devices and optimized performance on lower-end devices. These traits are perfect when dealing with VR development, where performance can be a volatile subject.

4.4.3 Asset Creation Pipeline

Asset creation involves a multidisciplinary set of skills, from 3D modelling to texturing, from animation to creating visual effects. In order to populate the game environment and build upon the already established concept and white box, multiple assets were created through the use of a industry based pipeline. Some of the more complex 3D models and textures can be seen in Appendix B.

Using ProBuilder inside the Unity engine, multiple rough drafts of the game asset's characteristics, such as size and shape were created, as depicted on Figure 4.5. These rough drafts were key to identify the scale of the objects in relation to the game world. Having these drafts already correctly positioned inside the engine also facilitated the future placement of the finished assets by just re-importing the asset and replacing the draft versions by using their existing co-ordinates in the game world.

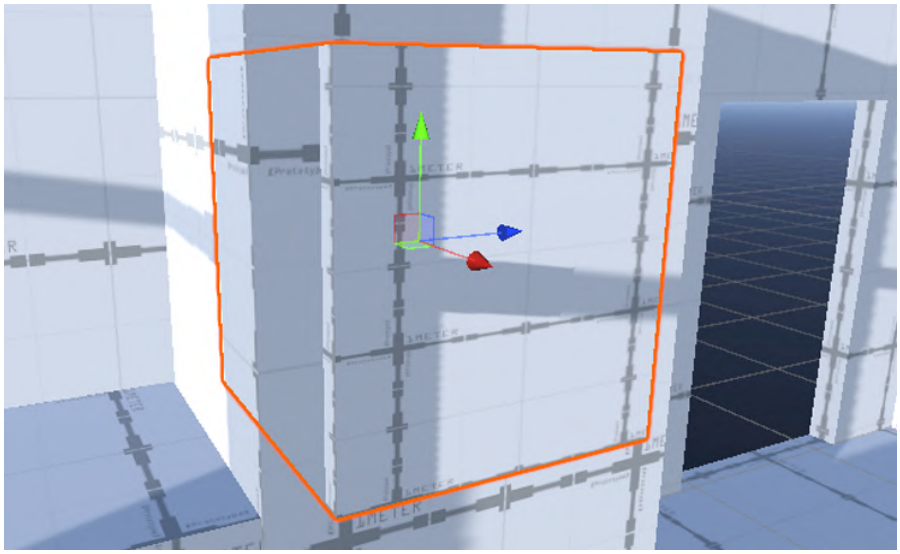


Figure 4.5: Object Draft

After exporting the polygonal mesh created previously in Unity to Autodesk Maya, the modelling process can take place. It is necessary to fix any mesh problems originated from ProBuilder's mesh creation tool, or even re-create the mesh using the imported draft as reference. Afterwards the object is modelled to detail in Maya, as depicted in Figure 4.6 , adding geometry to create a high poly mesh. The reason we create a high polygon mesh is to later use it to bake their normal maps on a lower polygon count mesh.

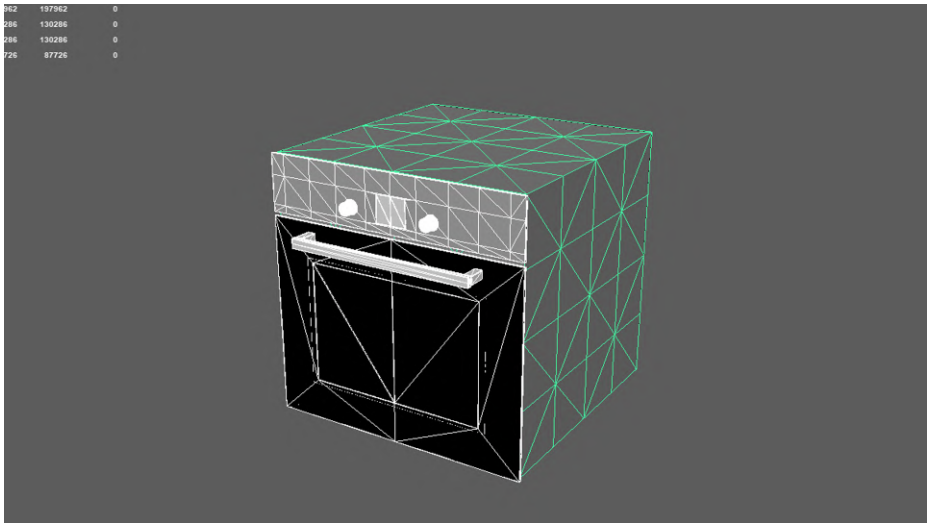


Figure 4.6: Work in progress of a 3D asset

After the modelling of the high poly mesh is finished, it is necessary to reduce the polygon count of the mesh. This can be achieved in different ways, however the most common ones are through the use of decimation techniques included in the application, which automatically reduce the amount of faces on the mesh or by retopology. The former being unpredictable due to its destructive workflow, since it has no regards about maintaining correct topology, the shape or lines of a 3D model. It is best used in static objects which are not going to be rigged and posed for animation, as seen in Figure 4.7. The latter, retopology, is the process of simplifying a high-resolution model in order to be used in video games and animation. There are plenty of applications that are able to automate the process of retopology, however the end result is imperfect and an ongoing area of research.

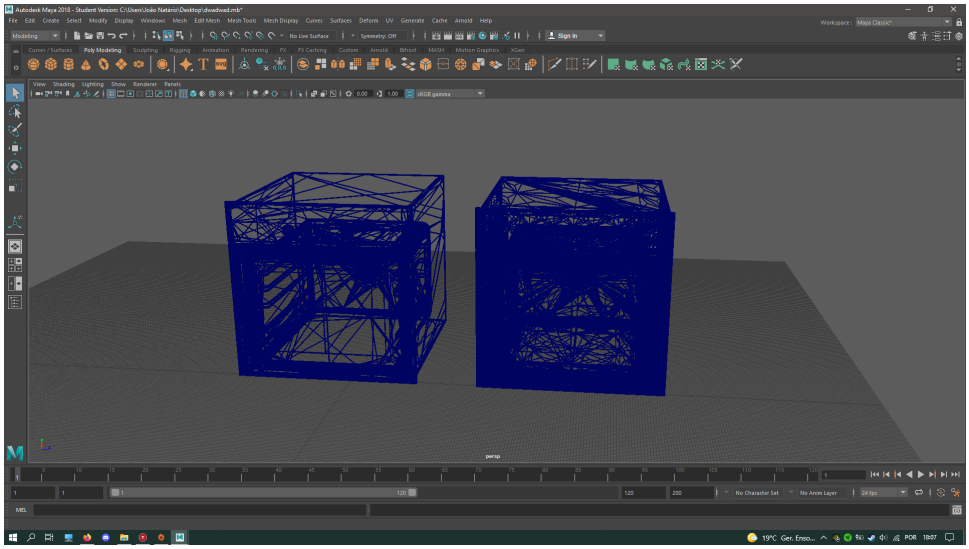


Figure 4.7: High polygon mesh (right) next to a decimated version (left)

In order to apply and display textures properly on the 3D models, each model's need to be UV unwrapped. "U" and "V" denote the axes of the Two-Dimensional (2D) texture. This technique is the process of projecting the faces of a 3D object on a flat plane, as shown in Figure 4.8, in order to easily wrap textures. This process might be the most important step in the creation of 3D models, since a badly unwrapped model might present stretched textures or visible seams, ruining a otherwise proper asset.

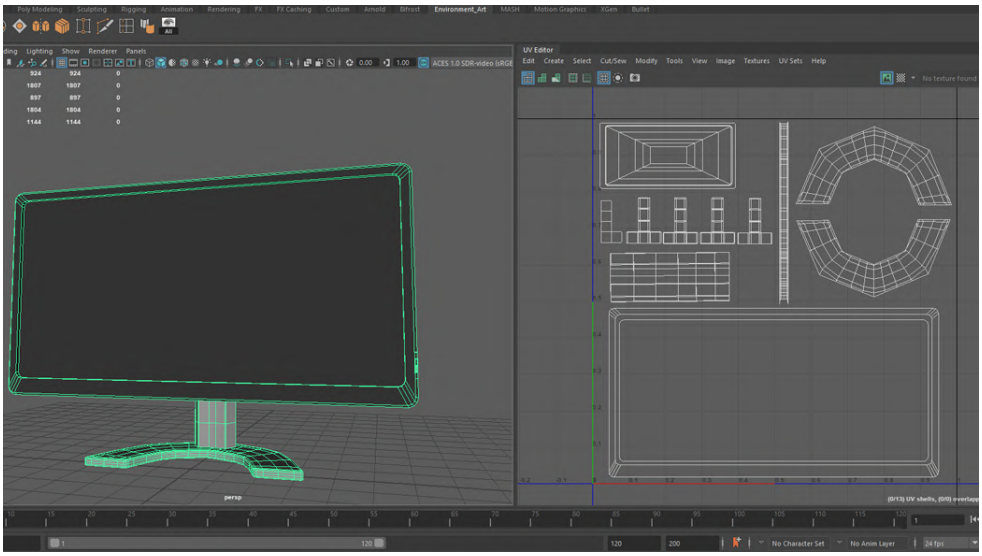


Figure 4.8: Computer monitor UV map

Following a successful UV unwrap, the models were ready to be baked. In order to maintain an acceptable level of performance while playing the prototype, the project can't use the high polygon assets due to their massive polygon count, instead low polygon meshes with baked normals are used. This works by transferring the normal information from the higher polygon model, as seen in Figure 4.9 to the low polygon model, depicted in Figure 4.10, simulating how light bounces from each face.

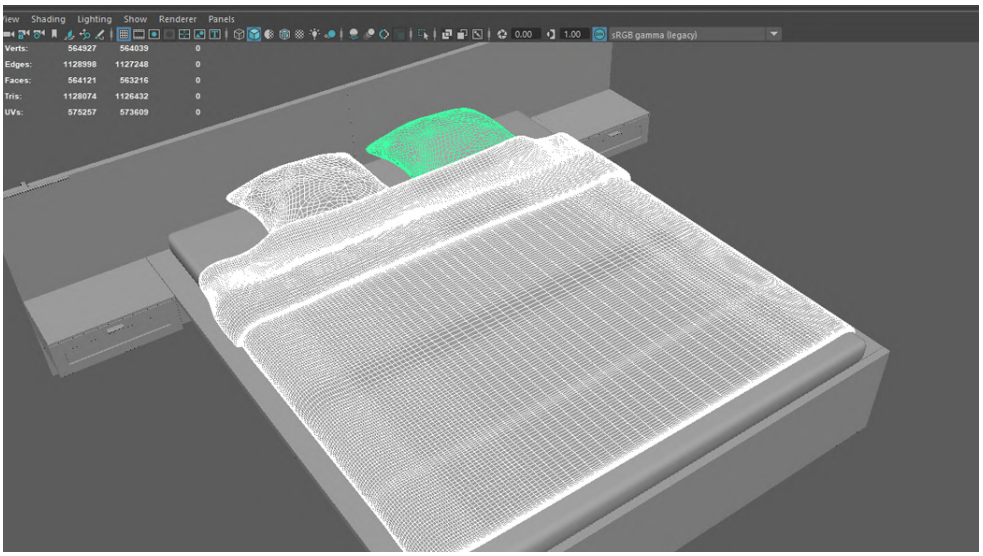


Figure 4.9: Example of the bed's high polygon version

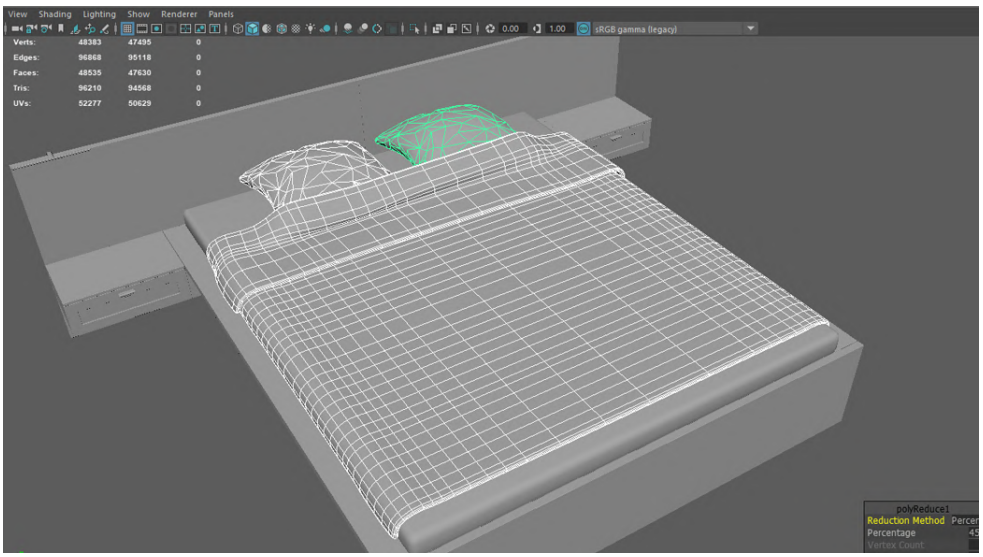


Figure 4.10: Example of the bed's low polygon version

This technique is important to convey the look of a high-quality asset while using

a low polygon mesh. This is required in order to maintain graphic fidelity of the game while keeping the game from using unnecessary resources. To achieve this, Marmoset Toolbag 4's baking function was used, by importing the high (HP) and low poly (LP) meshes into the application, adjusting the required variables for each model in the baking setup, making sure both objects share the same world space coordinates, so the objects align inside the baking cage, as seen in Figure 4.11, in order to avoid map errors.

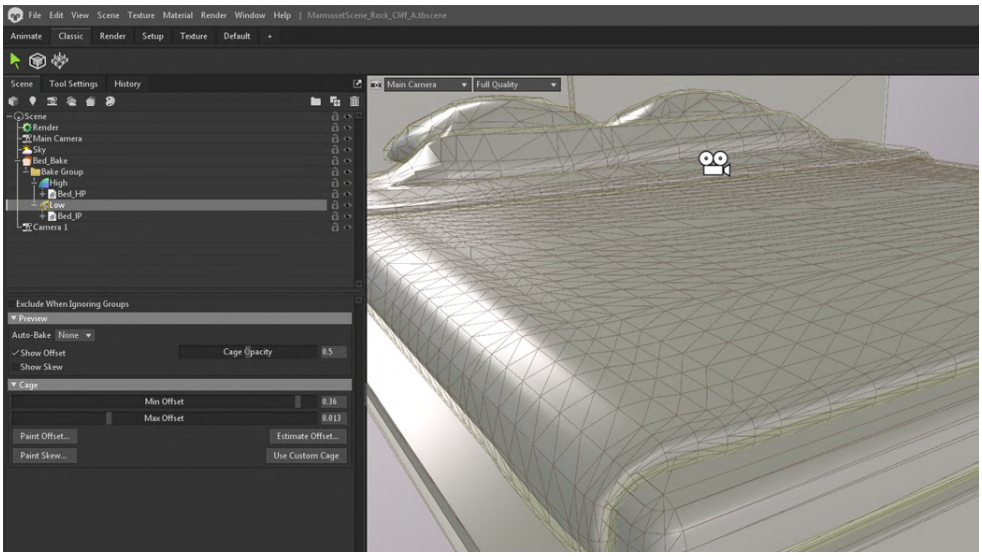


Figure 4.11: Example of the Marmoset Tollbag 4's baking cage

This cage makes sure all the light bounce data gathered from the high polygon mesh normals are saved and stored in the final normal map in order to be applied to the low polygon mesh version. The end result, as depicted on Figure 4.12, is a 3D mesh that displays a high amount of detail while having a lower amount of polygons.

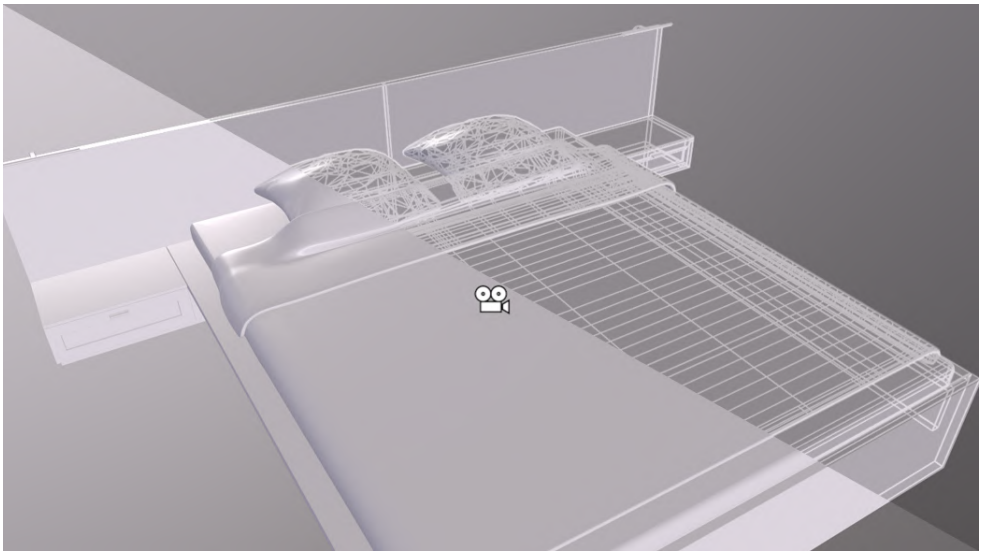


Figure 4.12: Example of a low polygon model with a high polygon normal data

Texturing the models was done by using Substance Painter library of preexisting materials, or by creating a procedural original material in Substance Designer to be usable inside of Substance Painter. The way textures are painted in Substance Painter is akin to how Photoshop works. Layers are painted, as depicted in Figure 4.13, which overlap to create effects such as wear and tear and use masks to create seamless transitions between materials.

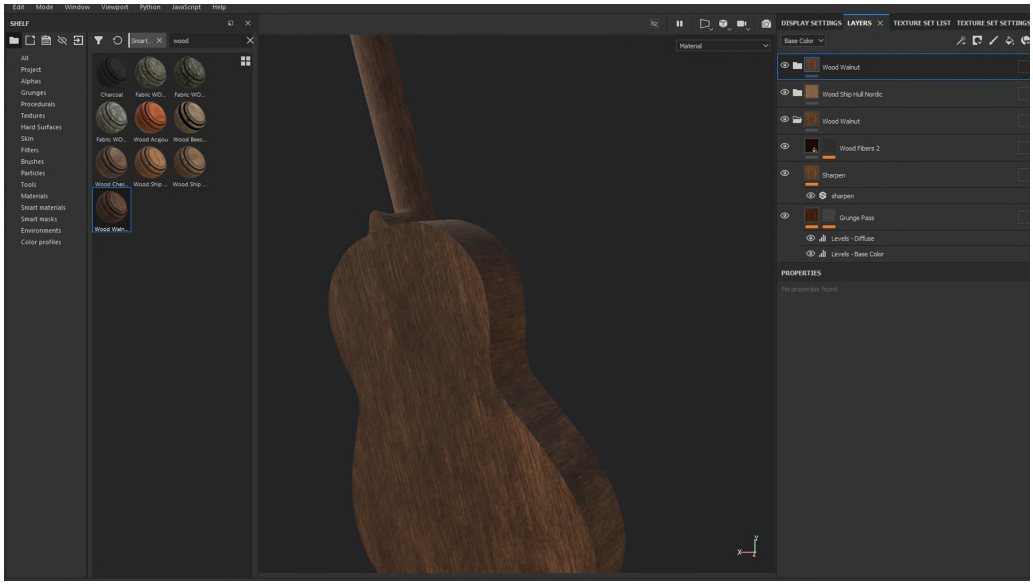


Figure 4.13: Substance Painter Layer Paint

By exhausting every step in this workflow pipeline, a 3D Asset is considered finished and ready to be imported into Unity game engine, where a material is created with all the texture information previously generated and applied to it.

4.5 Water Particle System

While still trying to design a game which involved every OCD subtype, a small water effect was created for the game with the Unity Particle System (seen in Figure 4.14). Unity Particle System is a robust particle effect system where particle simulation can be created. This water particle effect was to be used in tandem with a controllable pressure system that would be used in a variety of contamination related puzzles.

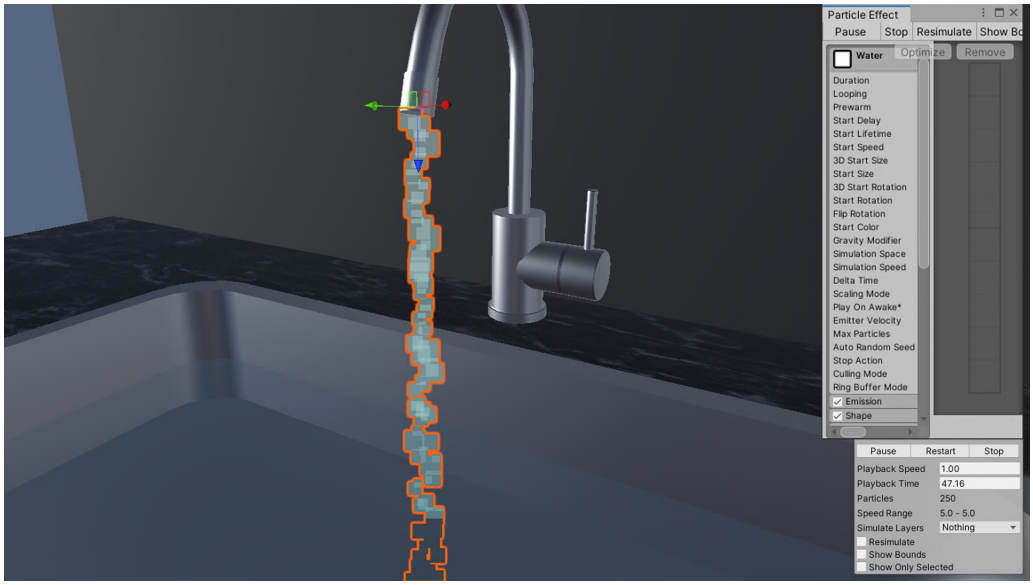


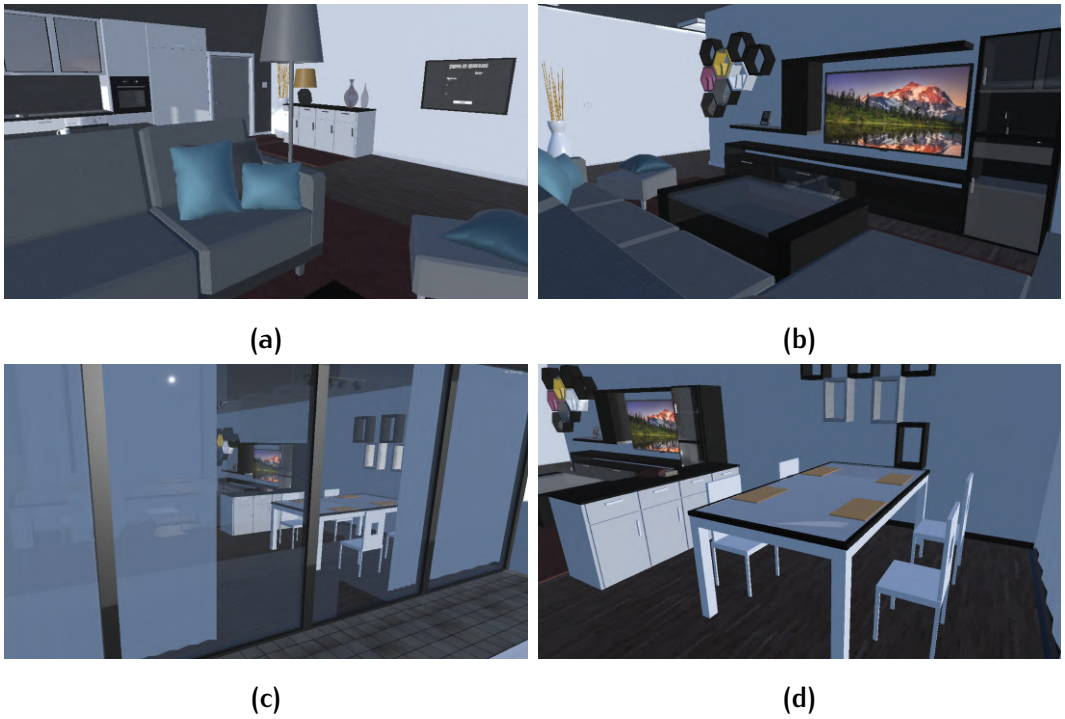
Figure 4.14: Water Particle Simulation

4.6 Game World Composition

As mentioned previously in section 3.4, the game environment took the shape of an apartment to meet the familiar mood the project was trying to convey. This apartment was divided in three different rooms, a living room with an open kitchen, a bedroom and a bathroom. Each room is centered around a different interactive experience depending on the selected level.

4.6.1 Living Room and Kitchen

The living room is the centerpiece of the game world. It's where the player spawns and the game level starts, as such it was decided to extend this play area by fusing the living room and the kitchen. This decision is the result of feedback throughout the early conceptualization phase of the game environment, in which it was concluded that having a large area with access to more options and interactions would promote the player's engagement with the game world. This section holds a lounge area, as seen on Figure 4.15 (a and b) and a small dining area (Figure 4.15(d)). With the intent of intrinsically guiding the player at the start of the level, the objective board was placed in this area, depicted in Figure 4.15(a). This area also boasts a balcony space which is inaccessible in-game (seen on Figure 4.15(c), however its objective is to break the environment's composition through the addition of a horizon line. As mentioned in section 3.5. the lounge section of the room holds the color changing bookshelves belonging to one of the puzzles (seen in Figure 4.15(b)).



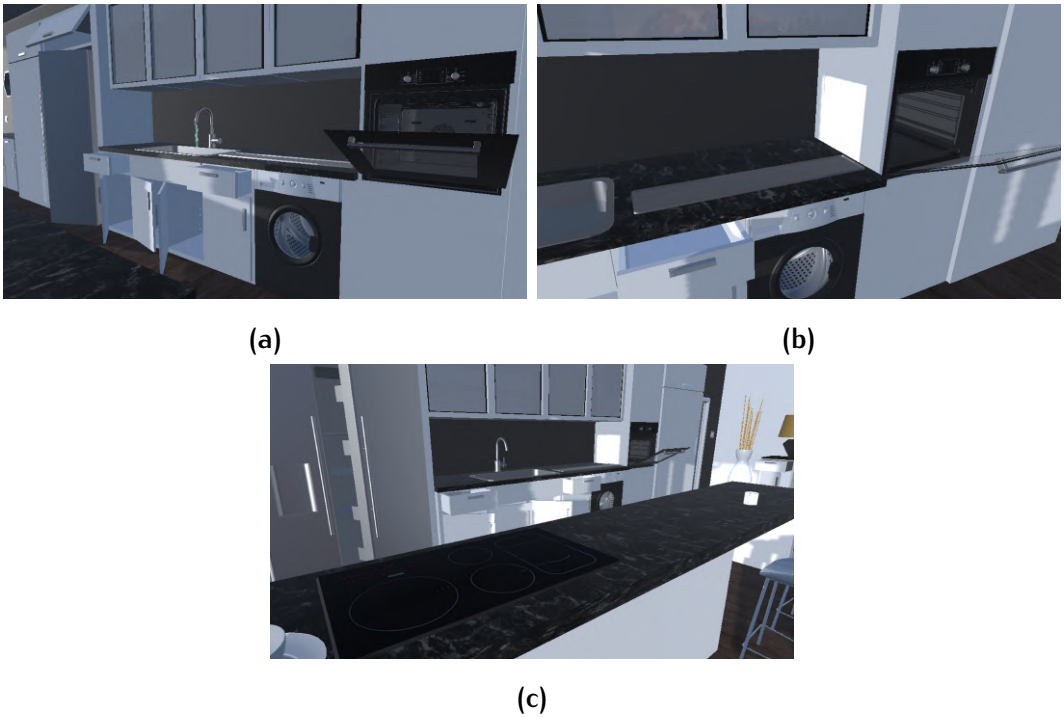
(a) (b)

(c) (d)

Figure 4.15: Images of the living room area

The kitchen section of this room has a plethora of interactive objects. The drawers, faucet, cupboard, and appliances doors can all be interacted with. These features were

skimmed from the game's scope, however they are still present in the game and can be interacted with, as shown on figure 4.16(a). This section of the room is where the tray to order the cups is placed (seen in Figure 4.16(b)). The large kitchen island, depicted in Figure 4.16(c), acts as a support area for the player to store the cups while solving the puzzle.



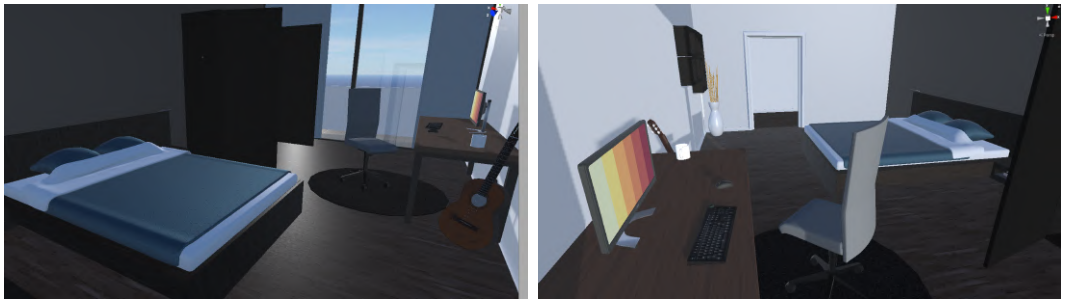
(a) (b)

(c)

Figure 4.16: Images of the kitchen

4.6.2 Bedroom

As depicted in Figure 4.17(a and b) The Bedroom is composed of a large bed, a desk, a guitar, shelves and a wardrobe. In the early conceptualization stage of the project, it was planned to use the bedroom as an environment for the contamination OCD subtype, by having cup ring marks on the desk or dirty clothes scattered around the room. This, however, was cut due to the narrowing of the project's scope. The computer and the wardrobe are the main actors in one of the puzzle. The computer monitor and the wardrobe are right next to each other for accessibility, as mentioned in section 3.5.1.

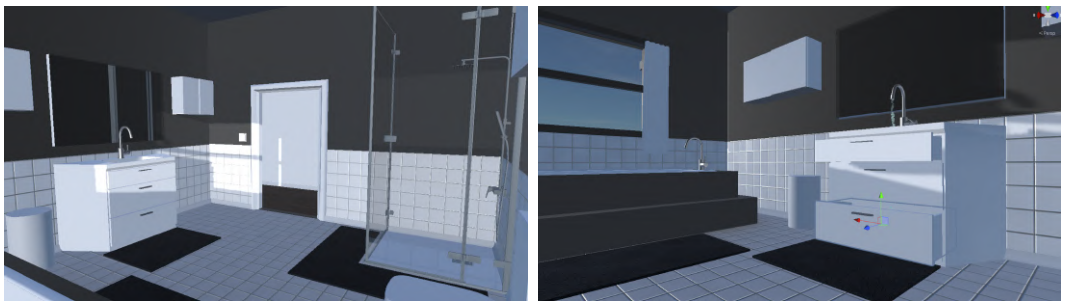


(a) (b)

Figure 4.17: Images of the bedroom

4.6.3 Bathroom

In the original scope of the game, the bathroom (seen on Figure 4.18(a)) was planned to be the focus of puzzles related to the contamination subtype. However, due to the change in the scope, which led to the sole focus on one OCD subtype, currently it only acts as an environment for the random placement of puzzle items. There are some remnants of interactive objects from past iterations of the concept, as depicted on Figure 4.18(b).



(a) (b)

Figure 4.18: Images of the bathroom

4.7 User Interface

A good UI allows the user to effortlessly interact with the game system, receiving input and returning feedback. The game needed an UI to start, quit and access its options, as well as an in-game UI to be able to interact with the objective board. The script

required for the UI to function is available in Appendix D.

4.7.1 Menu Screen

In order to launch the game, the medical professional needed an interface to start the VR game. As such, a UI was developed to act as the menu for the project. The menu would start by introducing the team that developed the prototype, depicted on Figure 4.19(a), and automatically advance to the game start menu. This UI allows the medical professional to change graphic and sound options in order to adapt to the user and hardware. The menu screen also allowed the game to be started through the "Start" button (as seen on figure 4.19(b)). This menu was also planned to allow the medical professional to choose the game level and the degree of patient exposure to triggers, but that feature was cut.

(a) (b)

Figure 4.19: Splash screen with team logo (left) and game menu (right)

4.8 Conclusions

This chapter went through the design and development process of VR-POC, from its concept and foundation up until the finished build. Several asset creation techniques were explored in-depth while justifying their application. A small particle animation was created through the use of the Unity Particle System. Finally, the UI of the game is presented with the reason behind its components explained. The main objective of this project development was to create a semi-realistic, yet accessible game world, where the patient could engage in the exposure to triggers, with the supervision of a medical professional, in order to effectively achieve success in the CBT process.

Chapter 5

Tests and Results

5.1 Introduction

As a consequence of the ongoing global pandemic, being able to physically test the prototype using a VR headset became an impossibility. The original testing methodology consisted in the testing of patients along the timeline of their scheduled therapy program, using a biofeedback monitor to measure their anxiety levels in order to justify the effectiveness of the prototype's usage. As a means to adapt to the restrictions imposed by confinement, a feedback survey was created. In order to validate the effectiveness of the prototype as a therapeutic game, the survey was exclusively presented to mental health professionals. This survey together with its answers are available in Appendix C, as well as the graphs with the quantified results.
In section 5.2. the medical professionals that took part in the survey are isolated into different control groups in consequence of their specialization, workplace and experience. Section 5.3. denotes their general expertise when it comes to video games and VR. Section 5.4. ultimately exposes the inquiries related to the gameplay video example presented in the survey, in order to attempt to quantify the effectiveness of the prototype.

5.2 Medical Background

This section contains the questions regarding each specialist's profession, workplace, experience and the most predominant subtype of OCD in their therapy sessions. In

order to analyze how the prototype would behave when looked upon by different perspectives, both psychologists and psychiatrists were queried, independent if they were experienced or inexperienced with this specific OCD mental health disorder.

5.2.1 Field of Expertise

Psychologist	Psychiatrist	Total
7	3	10

Table 5.1: What's your field of expertise?

Breaking down the answers to the first question, as represented on Table 5.1, it is denoted that a large part of the survey participants were psychologists, while only a small part being psychiatrists. As a means to achieve a significant number of participants, both psychologists and psychiatrists were targeted. This control group was isolated into two groups in order to keep data concise and to compare results between both specialized fields.

5.2.2 Workplace

Speciality	University	Clinic	Private Consultation	Hospital
Psychiatrists	0	0	0	3
Psychologists	2	3	1	1

Table 5.2: Where do you work?

Table 5.2 depicts the workplace diversity of the queried medical professionals, with a single case of self-employment due to having their own private consultation. Considering the bureaucratic process required to obtain licenses and new equipment, having access to data on workplace variety is important. Such data enables to identify correlations between the medical professional's degree of acceptance towards a specific type of therapy and their work methodology and infrastructure.

5.2.3 Medical Experience

Speciality	1-5 years	5-10 years	+10 years
Psychiatrists	3	0	0
Psychologists	0	0	7

Table 5.3: How many years have you been working in your field?

It is noted that, as shown in Table 5.3, the psychologists that were a part of the survey have been working in the field with patients for a longer period of time, with every single one stating that they've been working for more than 10 years. This is considerably more than the psychiatrists, who worked for 1 to 5 years. However, in this specific case, experience can't be exactly quantified and compared between the two different groups, since psychiatrists go through an extended formal education for an average of 5 years. While not brandishing the same practical experience as the psychologists did, their feedback was still highly relevant.

5.2.4 Most Frequent Patient Pathologies

Speciality	Order	Doubt	Contamination	None of the above
Psychiatrists	1	1	2	0
Psychologists	1	3	2	4

Table 5.4: Which Pathology is more frequent in your patients?

While contamination and doubt both had 4 answers, as show in Table 5.4, order and symmetry was the least common subtype of OCD. This was surprising to say the least, due to symmetry and organization being more commonly addressed as OCD than the other subtypes. The high number of participants with no frequent subtype can also be noted. This occurrence can be justified by the psychologist's lack of direct interaction with OCD patients. It is also important to note that contamination being an easier subtype to translate into gameplay, when compared to doubt, can be a possible target for future VR game development for OCD therapy.

5.3 Video game and VR Headset Knowledge

This section of the survey will aid in measuring the grasp on concepts related to video games, VR and their current understanding of them. This data allows to define their stances on video games, which in correlation will affect their overall experience.

5.3.1 Device History

Devices	Psychiatrists	Psychologists
PC	3	2
Android Phone	1	6
Apple Iphone	1	0
Nintendo Switch	0	0
Playstation 4	0	0
Playstation 5	0	0
Xbox One	0	0
Xbox Series X	0	0

Table 5.5: Please check which devices you have used.

Table 5.5 depicts the predominant devices used by the queried medical professionals, having computer and mobile phones being the only ones selected. This data indicates that in order to develop a video game to support the medical professionals, the platform used must be one where familiarity is predominant, promoting an intuitive experience. However, while mobile phones are the most used devices it is not possible to develop a prototype for it, but can instead be possibly used in the future as a support device to change levels or increase the level of exposure of the VR game remotely.

5.3.2 Video game Familiarity and Exposure

Familiarity Level	Psychiatrists	Psychologists
5	0	0
4	0	1
3	2	3
2	1	2
1	0	1

Table 5.6: Are you familiar with video games? (1 being not familiar at all and 5 being extremely familiar)

Exposure Level	Psychiatrists	Psychologists
5	0	0
4	0	0
3	1	2
2	1	2
1	1	2
0	0	1

Table 5.7: How often have you had contact with video games? (0 being not at all and 5 being extremely often)

The degree of knowledge about video games of the control group has shown itself to be rather basic, as depicted on Table 5.6 and table 5.7. Moreover, there is a defined lack of contact with the medium, where only 1 professional has reported on having average knowledge and exposure to video games. The intersection of this data might indicate a minimal level of acceptance towards video games as something else than just entertainment from most participants.

5.3.3 Familiarity with the concept of Immersion and VR

Familiarity Level	Psychiatrists	Psychologists
5	0	0
4	0	3
3	2	2
2	0	2
1	1	0
0	0	0

Table 5.8: How familiar are you with the concept of Immersion and Virtual Reality? (0 being not familiar at all and 5 being extremely familiar)

Speciality	Yes	No
Psychiatrists	2	1
Psychologists	1	6

Table 5.9: Have you had any hands-on experience with Virtual Reality?

Speciality	Yes	No
Psychiatrists	0	3
Psychologists	2	5

Table 5.10: Do you own, or know anyone who owns a VR device?

On the topic of VR, as shown in Table 5.6, Table 5.9 and Table 5.10 the participants were inquired on the level of familiarity with the concept of immersion inside VR and contact with a VR headset. The gathered data notes a lack of access to a VR headset, alongside several answers where the professional has never even tried the experience before. Where contact with the VR device had lacked, the familiarity question revealed positive results, where more than half of the participants claimed to be familiar with the concept of immersion inside VR. This seemed contradicting at first, however, access to

such information has been made easier through the use of the internet, where everyone is interconnected, making it easier to grasp concepts and being able to understand their effectiveness.

5.4 VR Tool Gameplay Example and Feedback

In this section, a video sample[1] of gameplay is provided. The participants are then tasked with watching it in order to answer several questions relevant to the quality of the prototype as a therapy support tool. While the video shows the prototype's gameplay, it does not picture the necessary setup required to be able to play the VR game, as it's a one time procedure that shouldn't be needed to configure further after the first setup. This video example was exclusively recorded in order to receive feedback on the VR game mechanics, however due to the nature of the prototype, it was meant to be played and experienced in virtual reality and not on a static screen, something we couldn't achieve due to the restrictions of the global pandemic. Nonetheless, this video sample helped mitigate some negative impact of not being able to test the VR game in-person.

5.4.1 OCD Therapy Approach

Speciality	Smoothing the patient	Provoking the patient
Psychiatrists	1	2
Psychologists	1	6

Table 5.11: Do you think that a video game build to help OCD should be:

It is noted that, as shown in Table 5.11, eighty percent of the queried medical professionals from both control groups believe that a therapy game targeted towards OCD patients should strive to provoke the patient's thoughts. The majority agrees that in order to successfully treat the patient there needs to be a certain degree of exposition which allows for the patient to be provoked, in order to understand and dissimulate the compulsions that ensue.

[1] Video sample available on: http://y2u.be/L3pNDLfbbV8

5.4.2 Game World and Gameplay Feedback

Game World Quality	Psychiatrists	Psychologists
10	0	0
9	0	1
8	1	3
7	1	2
6	0	0
5	1	0
4	0	0
3	0	0
2	0	1
1	0	0
0	0	0

Table 5.12: Where would you classify the game world shown in the video? (0 being not adequate to the experience and 10 being very adequate)

Gameplay Quality	Psychiatrists	Psychologists
10	0	0
9	1	1
8	1	1
7	0	2
6	0	2
5	0	1
4	0	0
3	0	0
2	1	0
1	0	0
0	0	0

Table 5.13: Where would you classify the gameplay shown in the video?(0 being not therapeutic at all and 10 being very therapeutic)

This question asks for direct feedback on the potential of the prototype as a therapeutic tool, based on the gameplay video. The Table 5.12 and Table 5.13 presents the medical professionals feedback on the elements included on the video sample, which were the game world and gameplay. The gathered data shows a predominant positive response that supports the potential of the game as a therapeutic tool. The lowest score attributed to the project was from a medical professional who on a previous question claimed that a therapeutic game should try to soothe the patient instead of the original objective of this prototype.

5.4.3 Prototype Interest

Speciality	Yes	No
Psychiatrists	3	0
Psychologists	2	0

Table 5.14: Would you be interested to try a game like this out with patients as a possible therapy method? (This question is only for those who work with OCD patients, feel free to skip if that doesn't apply to you)

This question was exclusively directed towards medical professionals with previous direct contact with OCD patients. They were inquired about their interest in trying the prototype as a possible therapy method. This question was met with a unanimous positive response, as shown in Table 5.14, showing the eagerness in wanting to test the prototype as a therapy tool with OCD patients. The realm of video games is well known to be captivating and exciting, these properties can be translated into the therapy process, shaping the therapy session into a motivational experience, promoting rehabilitation.

5.5 Ideas and Feedback

The last question was presented as a blank canvas for the medical professionals to share which activities they would like to have introduced in the prototype. Unfortunately less than half the participants answered this question.

- The first answer proposed to resume development and expand upon the amount of OCD subtypes available in the prototype in order to cover the most common compulsions.

- The second answer criticized the short amount of clothing items available in the game, while also wanting more colors to be implemented.

- The last answer supported the VR game effectiveness in provoking anxiety in the OCD patient, allowing for the analysis and dissimulation of the compulsions that follow during the therapy session. The participant also adds that it is a platform for early consultations, but can be expanded into a specialized tool.

5.6 Conclusions

After a thorough analysis of all the survey data, it was concluded that the prototype had a strong positive response that supported its effectiveness as a valuable tool for the medical professional to use during OCD therapy sessions. This survey helped mitigate the setback imposed by the global pandemic by validating the effectiveness of the project. In addition, the results of the project are in a paper titled "A VR Game for Obsessive-Compulsive Disorders Therapy" that was accepted for publication in the International Conference on Graphics and Interaction (ICGI'2021), which will be held on November 4/5, 2021 at the Faculty of Engineering of the University of Porto, Portugal.

Chapter 6

Conclusions and Future Work

This chapter will present the conclusions taken from the design, development and testing process of this project in section 6.1. In section 6.2 the list of planned future improvements to the prototype are listed.

6.1 Conclusions

This project started normally, however at the early development stage of the game, it was caught in the turmoil that was the emerging threat of the global pandemic. One of the main objective of this project was to have two control groups of OCD patients, one where biofeedback data was collected while playing the VR game and another group undergoing normal CBT, in order to compare results and prove the effectiveness of the prototype.
With the impact of the global pandemic, conducting tests on patients became impossible due to the health and safety regulations imposed. The utilization of the VR equipment meant the use of the headset and controllers by multiple patients, which was not feasible at the time. The VR equipment was also not build to withstand being disinfected after every session since it was composed of highly sensitive components in order to operate, and could be damaged. Despite all this, the project development continued, however, looming in the distance was a whole world confined to their homes. With the increased number of restrictions imposed, a new plan was set up. In order to validate the effectiveness of the prototype as a therapeutic tool on would be patients, while complying to confinement restrictions, feedback from mental health professionals

was required. This was done through the creation of a specially tailored online questionnaire, together with a gameplay video sample of the prototype, in order to deduct if they would be interested in the application of this type of therapy in their CBT sessions. In the end, the response was positive, with every inquired medical professional displaying interest in trying this prototype with their OCD patients. Concluding, even with the scope shift, the project's design flexibility throughout the development process helped overcome its limitations and displayed promise and potential. Obtaining positive feedback from mental health professionals, despite the main objectives not being possible to achieve, makes it clear that there is potential for VR to thrive in the field of OCD treatment.

6.2 Future Work

After the experience earned while developing the initial prototype and the analysis of the feedback gathered from the surveys, the following plan was devised:

- Diversify the amount of subtypes available in the game along with the development of new puzzles relevant for each new subtype, restoring the original scope of the game.
- Adopt the original testing methodology as soon as it's able to meet safety and health guidelines, testing the prototype in-person with real patients together with the medical professionals.
- Improve the overall aesthetic of the game, by further improving the lighting setup, post-processing effects, material maps and composition.
- Optimize the game to use less resources by reducing certain geometry and material resolutions in order to perform better.
- Implement a player character body which the player can see in-game and react with the environment, allowing it to cast shadows.
- Develop a mobile application in tandem with the prototype that allows the medical professional to tweak in real-time the degree of exposure to triggers and to navigate between levels.

The future goal of this project is to further expand upon the already established conceptualized game and finally make it widely available in the mental health therapy scene in order to prove that the medium of video games can become the foundation to a better world.

References

[1] Brezinka V. 2008. *Treasure Hunt - a cognitive-behavioral computer game*. Available in: https://www.treasurehunt.uzh.ch/en.html. Online; Last accessed 13 December 2020.

[2] Brezinka V. 2012. *Ricky and the Spider.* Available in: https://www.rickyandthespider.uzh.ch/en.html. Online; Last accessed 20 December 2020.

[3] Kyung Ryeol Cha Junyoung Park Kiwan Han Yun Ki Kim Jae-Jin Kim In Young Kim Kwanguk Kim, Chan-Hyung Kim and Sun I. Kim. *2008. Anxiety Provocation and Measurement Using Virtual Reality in Patients with Obsessive-Compulsive Disorder*. online;. *A*vailable in: https://www.liebertpub.com/doi/10.1089/cpb.2008.0003. Online; Last accessed 2 December 2020.

[4] Unity Technologies. *Unity Real-Time Development Platform.* Available in: https://unity.com/pt/products/unity-platform.

[5] Oculus VR. *Oculus Rift S: VR Headset for VR Ready PCs.* Available in: https://www.oculus.com/rift-s/. Online; Last accessed 10 January 2021.

[6] Carmen Carrió J.A. Lozano-Quilis Jose-Antonio Gil-Gomez Amparo Belloch, Elena Cabedo and H. Gil-Gómez. 2014. *Virtual reality exposure for OCD: Is it feasible? . Revista de Psicopatologia y Psicologa Clinica*, 19.

[7] Microsoft Corporation. *Kinect for Windows.* Available in: https://developer.microsoft.com/en-us/windows/kinect. Online; Last accessed 10 January 2021.

[8] NVIDIA Corporation. *NVIDIA PhysX System Software.* Available in: https://www.nvidia.com/en-us/drivers/physx/physx-9-19-0218-driver/. Online; Last accessed 13 January 2021.

[9] Havok. *Havok: Power to the creators.* Available in: https://www.havok.com/havok-physics/.

[10] Bullet Physics. *Bullet Physics SDK: real-time collision detection and multi-physics simulation for VR, games, visual effects, robotics, machine learning etc.* Available in: https://github.com/bulletphysics.

[11] Autodesk Maya. *3D computer animation, modeling, simulation, and rendering software.* Available in: https://www.autodesk.com/products/maya/. Online; Last accessed 11 January 2021.

[12] Adobe Photoshop. *Photo Design Software.* Available in: https://www.adobe.com/products/photoshop.html.

[13] Substance Designer. *Discover the power of procedural creation.* . Available in: https://www.adobe.com/products/substance3d-designer.html.

[14] Substance Painter. *Paint in 3D. In real time.* . Available in: https://www.adobe.com/products/substance3d-painter.html.

[15] Marmoset Toolbag 4. *Real-time rendering, texturing, baking tools.* . Available in: https://marmoset.co/toolbag/.

[16] Visual Studio Code. *Code editing.Redefined. Free. Built on open source. Runs everywhere.* Available in: https://code.visualstudio.com/.

[17] Sony Vegas Pro 17.0. *Video audio for professionals.* Available in: https://www.vegascreativesoftware.com/us/vegas-pro/.

[18] Google Forms. *Google Forms: Free Online Surveys for Personal Use* . Available in: https://www.google.com/forms/about/https://www.google.com/drive/.

Appendices

A Appendix A

A.1 Game Design Document

This Appendix presents the Game Design Document created during the course of the prototype development in order to record the main components of the game.

GDD V1.0

1

VR-POC

Game Design Document

Dev: André Torrão

Designer: João Natário

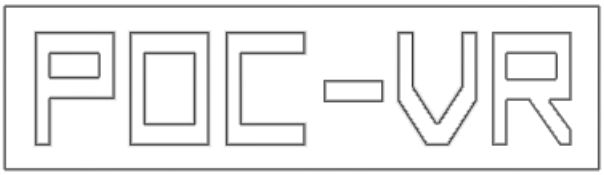
QA: André Torrão, João Natário

Title: VR-POC (Virtual Reality- Perturbação Obsessiva Compulsiva)

Version: 1.0

Written By and Contact Details: André Torrão, João Natário

Game Logo:



GDD V1.0

3

Team Logo:

Team Roles:

- André Torrão- Programmer
- João Natário- Game Design and 3D modelling

Revision/Editorial: Last revision accepted. Acceptance: João Natário, 02/09/2021

Game Objectives: The main objective of this project is to design and develop a video game interactable experience that acts as a platform for medical professionals to engage in therapy sessions with OCD patients in a more immersive and interactable way, while regulating stress levels and provoking the patient thoughts through exposure to their specific obsession over multiple therapy sessions.

Genre: Virtual Reality, Simulation, puzzle, exploration, Therapeutic game

The Big Idea: The main goal of this project is to design and develop a VR video game interactable experience that acts as a platform for medical professionals to engage in therapy sessions with OCD patients that suffer from

- **Target Audience:** OCD patients
- **Game storyline/narrative or focus**: No intended Storyline
- **USPs/hooks:** Innovative support for CBT Treatment. Virtual Experience that eases the treatment process.

Platform: Oculus Rift S, Windows PC

Technical Requirements:

- Processor: Intel i3-6100 / AMD Ryzen 3 1200, FX4350 or greater;
- Graphics Card: NVIDIA GTX 1050 Ti / AMD Radeon RX 470 or greater;
- Memory: 8GB+ RAM;
- OS: Windows 10;
- USB Ports: 1x USB 3.0 ports;
- Video Output: Compatible DisplayPort video output.

Story/Narrative: The game doesn't follow an ingame narrative. The game acts as a medium between patient and therapy professional, strictly as a ludic tool.

- **How does the player start the game?** The player starts in a tutorial area that teaches them how to use the controls. The player spawns in the main area of the scene(living room) and is directed towards the objective board.
- **How does the player get from one location to the next?** Making use of locomotion controls such as dynamic moving or zone jump movement selected by the player.
- **What is the ending?** Completing all the randomly generated puzzles introduced by the game world.

Exposition: The player is introduced to the in-game controls through a small tutorial area and a small cutscene. The player is spawned directly into the game, the controls are explained through the medical professional.

Controls: This device presents two normal buttons, a home button, an analog stick, a trigger in the front and a side button. The mapping for VR-POC is:

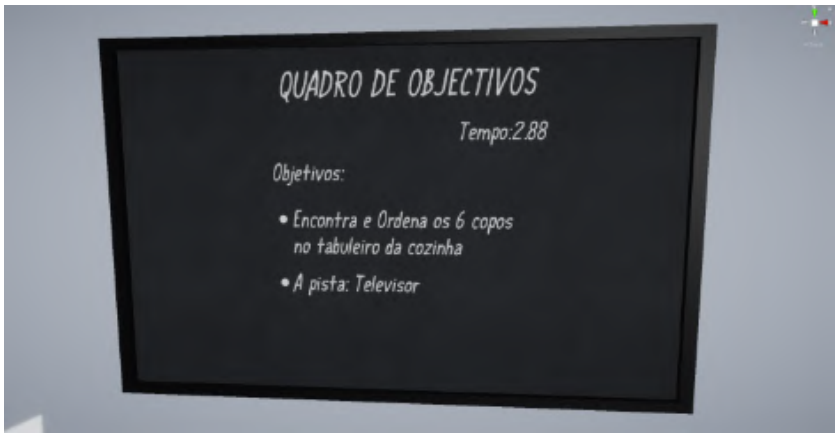
- The left analog sticks control movement;
- The right analog sticks control rotation;
- Trigger in the front controls chalkboard interactions;
- Side button controls grab interactions.

Technology requirements:

- Required to Use Unity as the game engine(André, João).
- Virtual Reality implementation, through the use of the Oculus Rift S(André).
- Source control tool: GitHub Unity Collaborate
- Blender Autodesk Maya
- Adobe Photoshop
- Quixel Suite Substance Designer
- Substance Painter
- Marmoset Toolbag4

Camera: First Person Virtual Reality Camera

User Interface:



Credentials: Team Logo when booting up the VR game

Menu Screen:

- Start
- Options
- Quit

Loading screens: When starting the game, between scenes. Average 2-5 seconds loading time.

Game Overview.

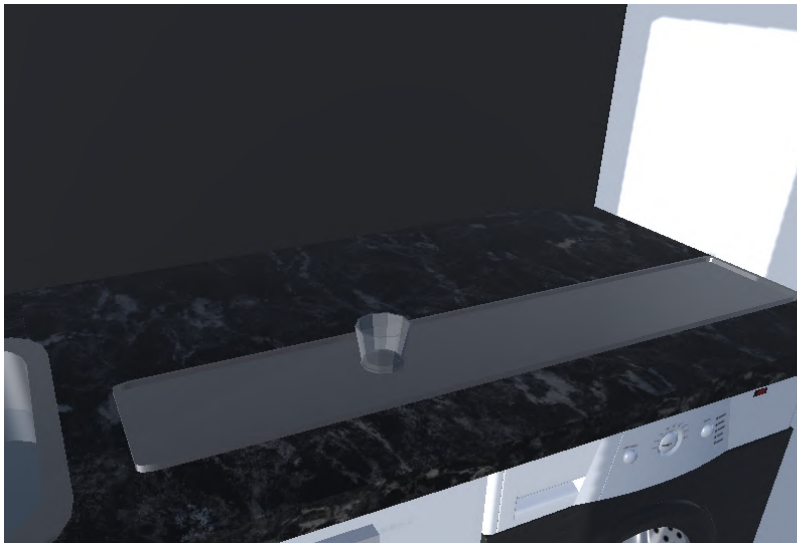
Core Game Mechanics:

- Movement
- Interactions:
  - Grab Object
  - Throw Object
  - Snap Object

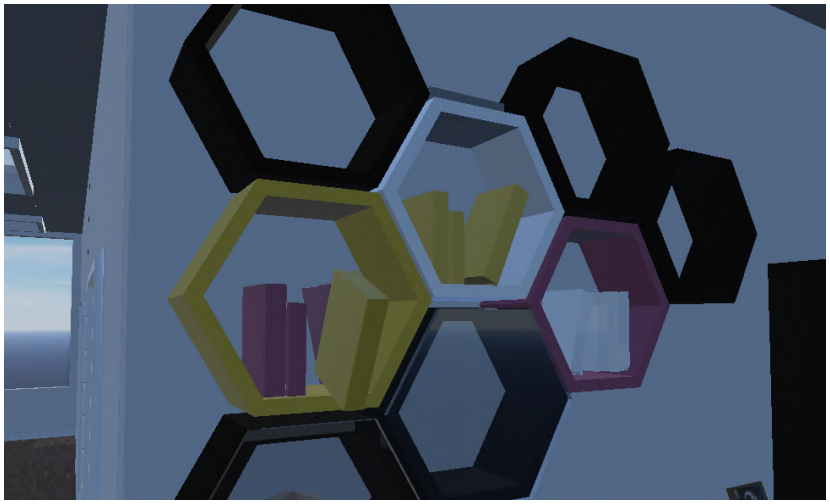
Puzzles

Timer: At the start of the game, a timer is initiated, which is displayed on the objective board(see UI section). This timer allows the medical professional to measure the session time and how well the patient is progressing through the puzzles.

Cup Puzzle: The player is tasked in ordering 6 cups scattered throughout the house. This order has a direct correlation to the hint displayed in the monitor, where each number is a cup size.

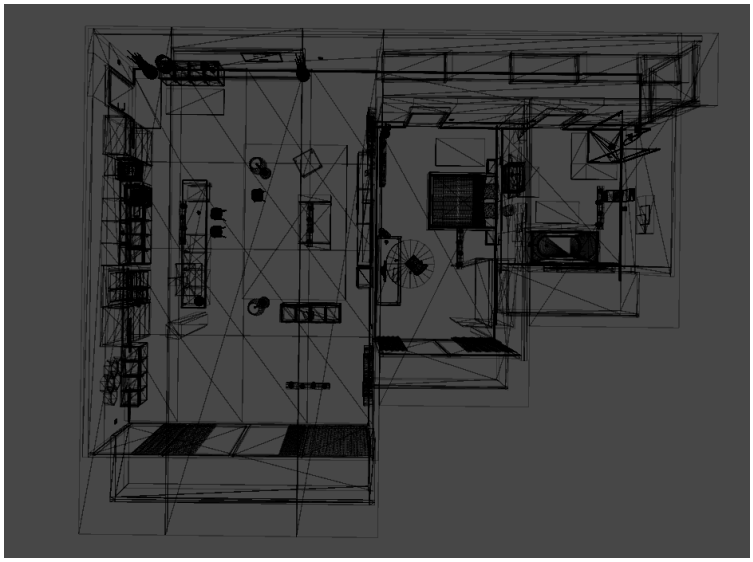


Book puzzle: This puzzle is located in the living room. The player is tasked with organizing colored books that are scattered throughout the environment, in a colored bookshelf. This puzzle's objective is to trick the player into putting the colored book together with the same color books already on the shelf, however the objective is to match the shelf color.



Wardrobe Puzzle: This puzzle is located in the bedroom.The player objective is to organize articles of clothing in order to produce a soothing melody. The player's objective is to organize colored shirts according to the hint displayed on a monitor closeby.

World overview:



The Levels:

- . Apartment level with 3 rooms, a living room with a kitchen, a bedroom and a bathroom.

Player Progression Outline:
The player must solve a puzzle to progress to the next one. The player progression pace is mainly dictated by the medical professional.

Audio:

- Free Sample background music;
- Footstep Sounds;
- Menu interaction sounds.

The Player.

Player character: The player itself
Player matrix:

- 1.85m Height;
- 0.40m wide;
- 2 visible hands that allow interaction;
- Collision Box which spans the entirety of the player body, up until the VR camera position.

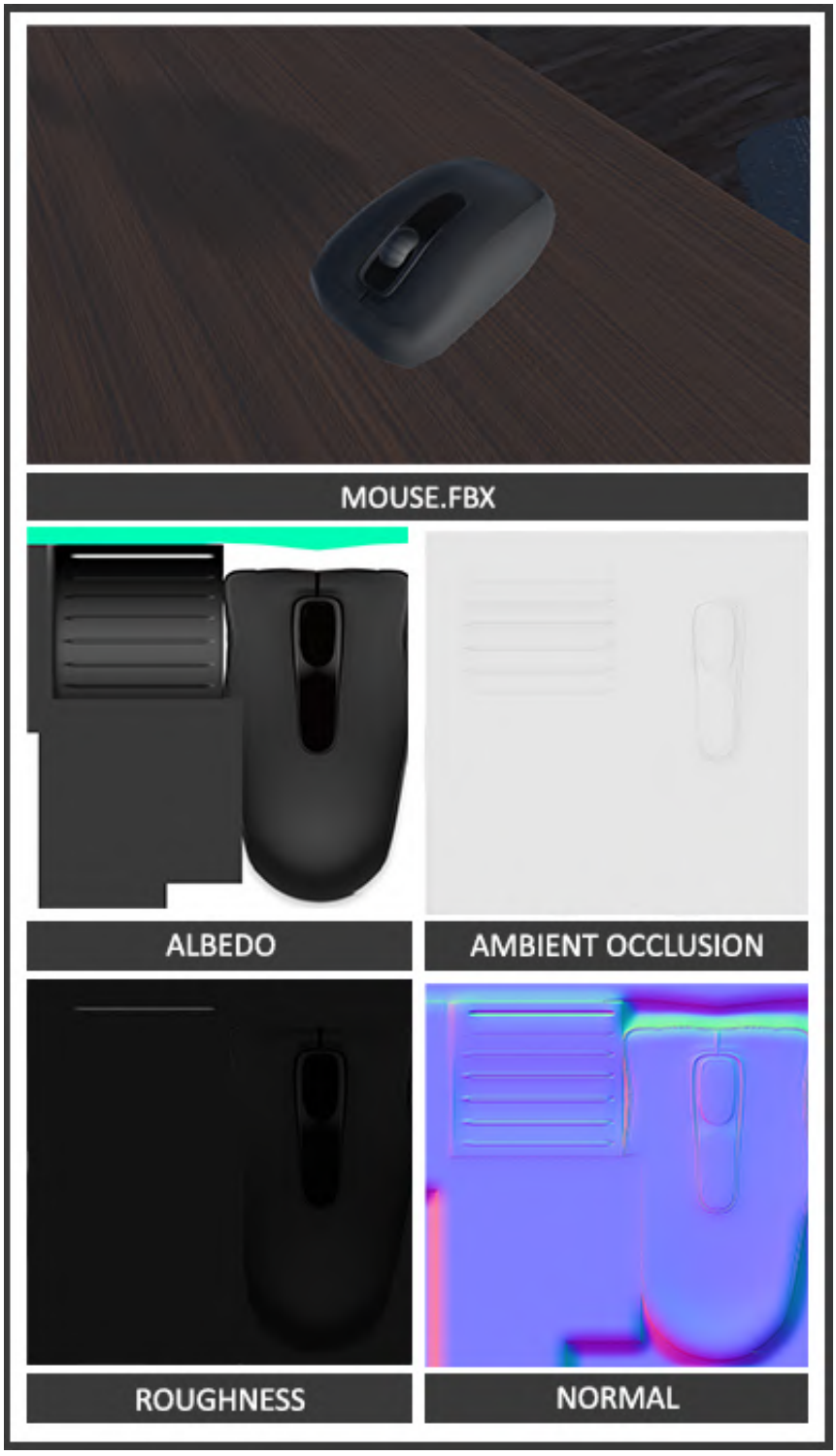
B Appendix B

B.1 3D Meshes and Textures

This appendix presents all the 3D meshes and textures developed for the game.

B.1.1 Keyboard

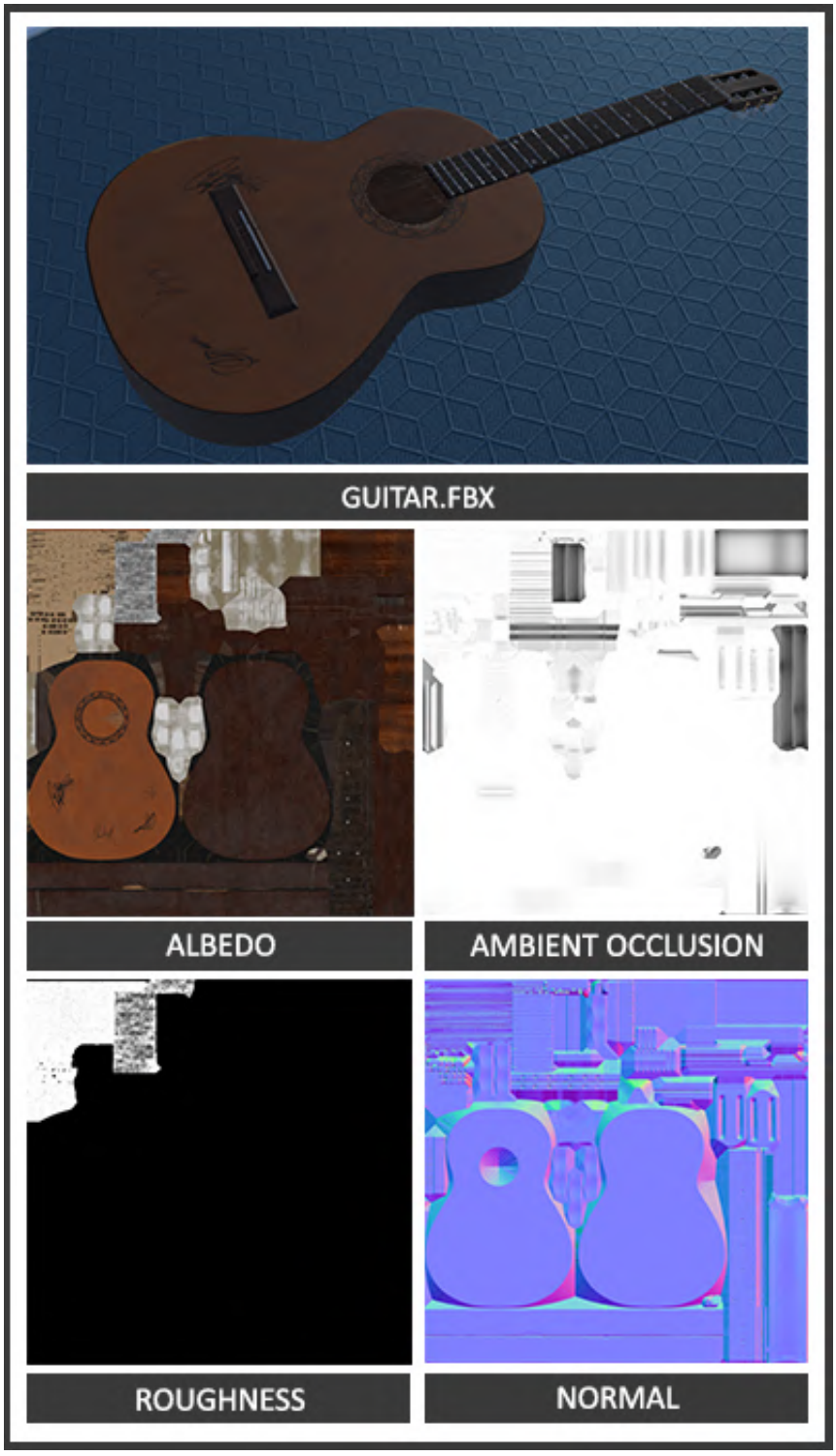
B.1.2 Mouse



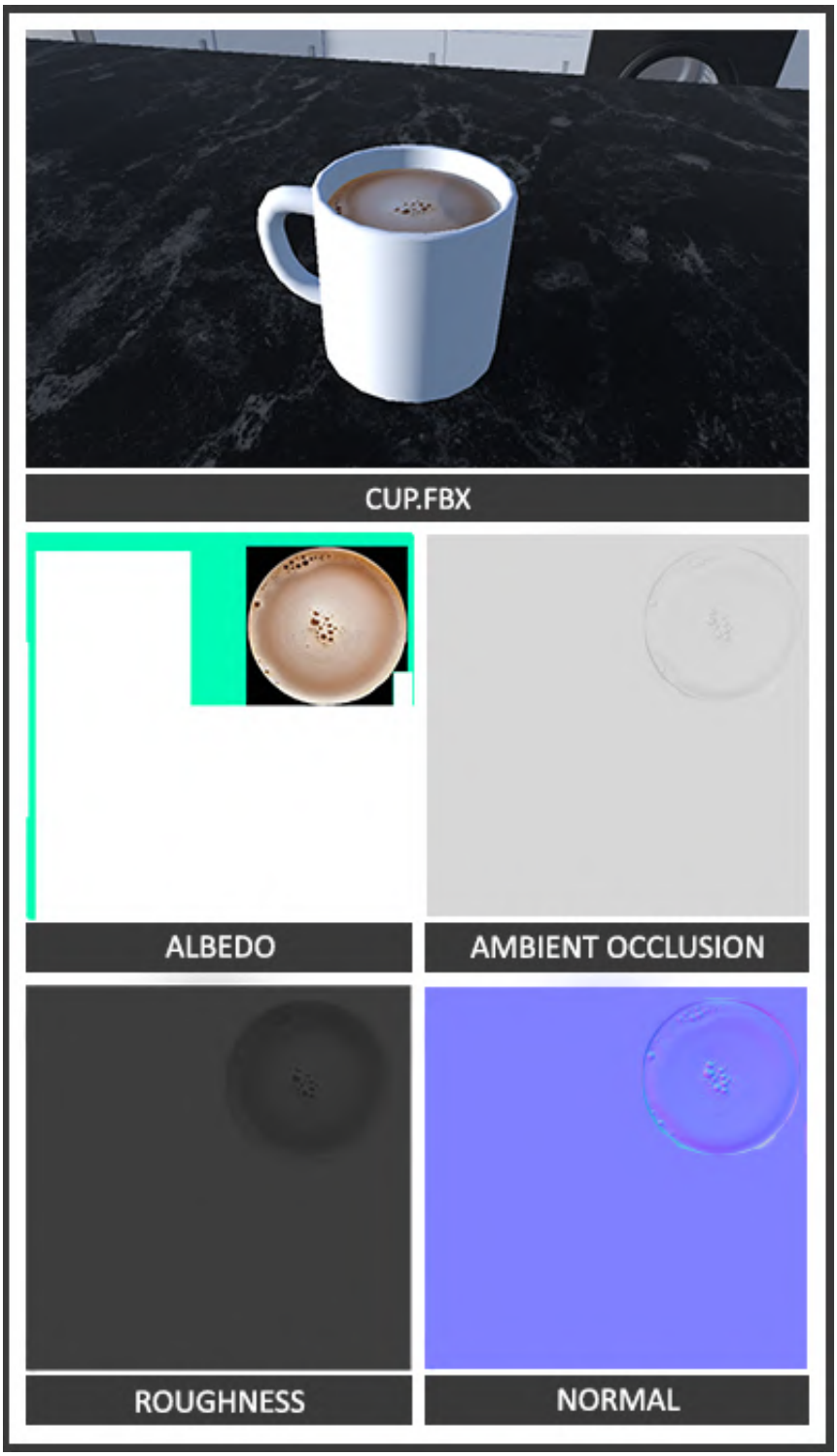
B.1.3 Monitor


3:35
Monday, August 10
MONITOR.FBX
ALBEDO
AMBIENT OCCLUSION
ROUGHNESS
NORMAL

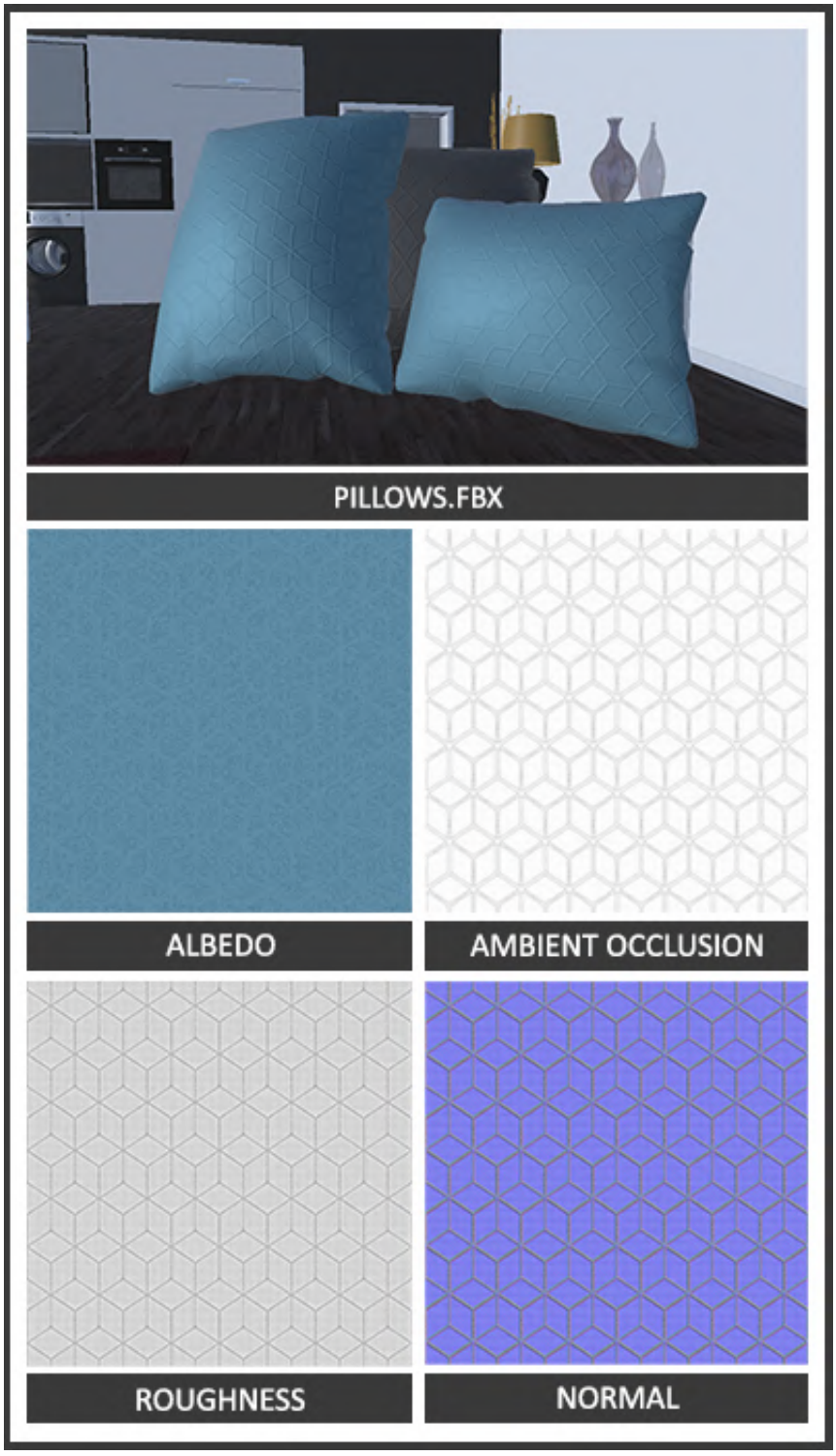
B.1.4 Guitar



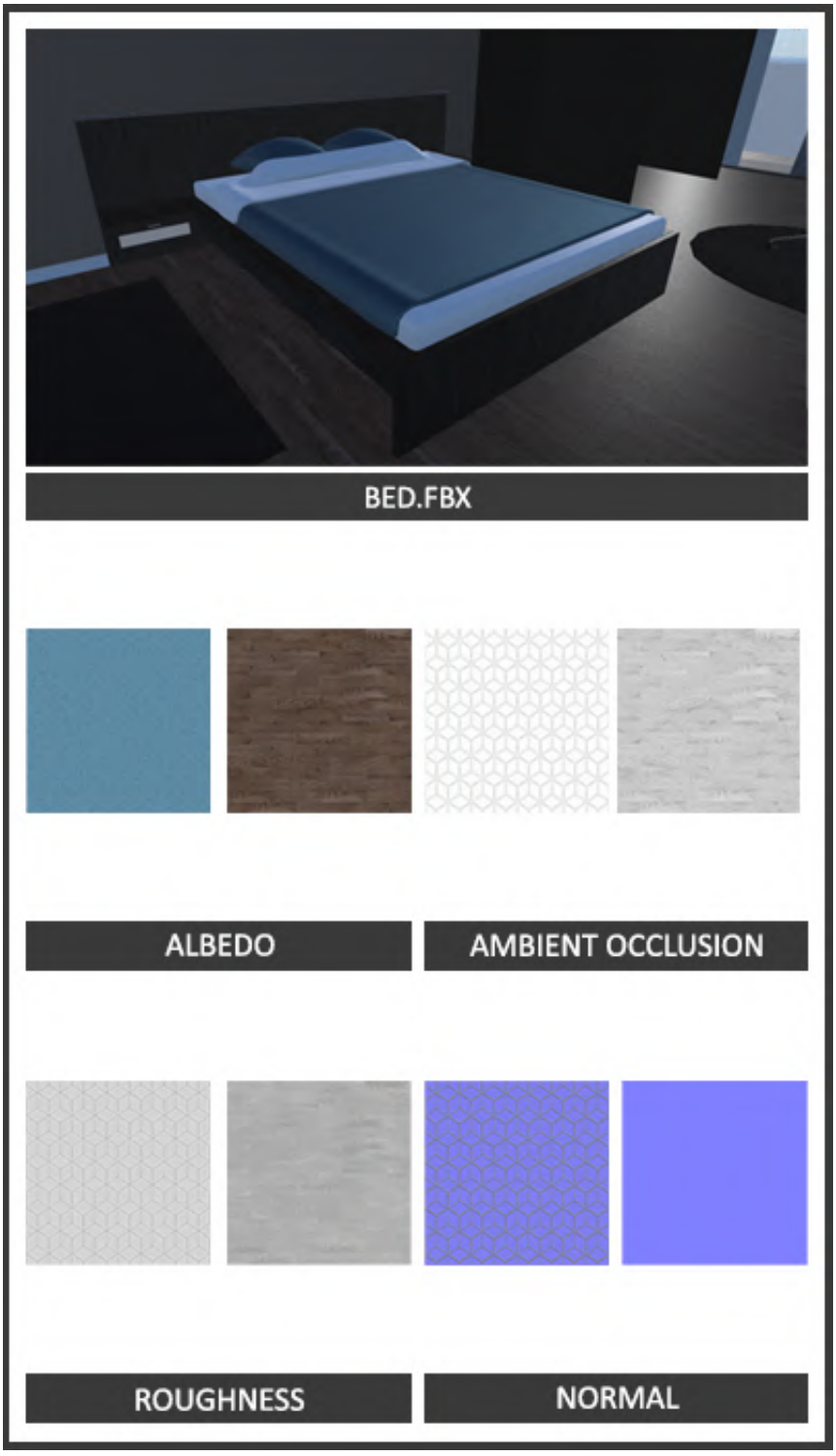
B.1.5 Cup



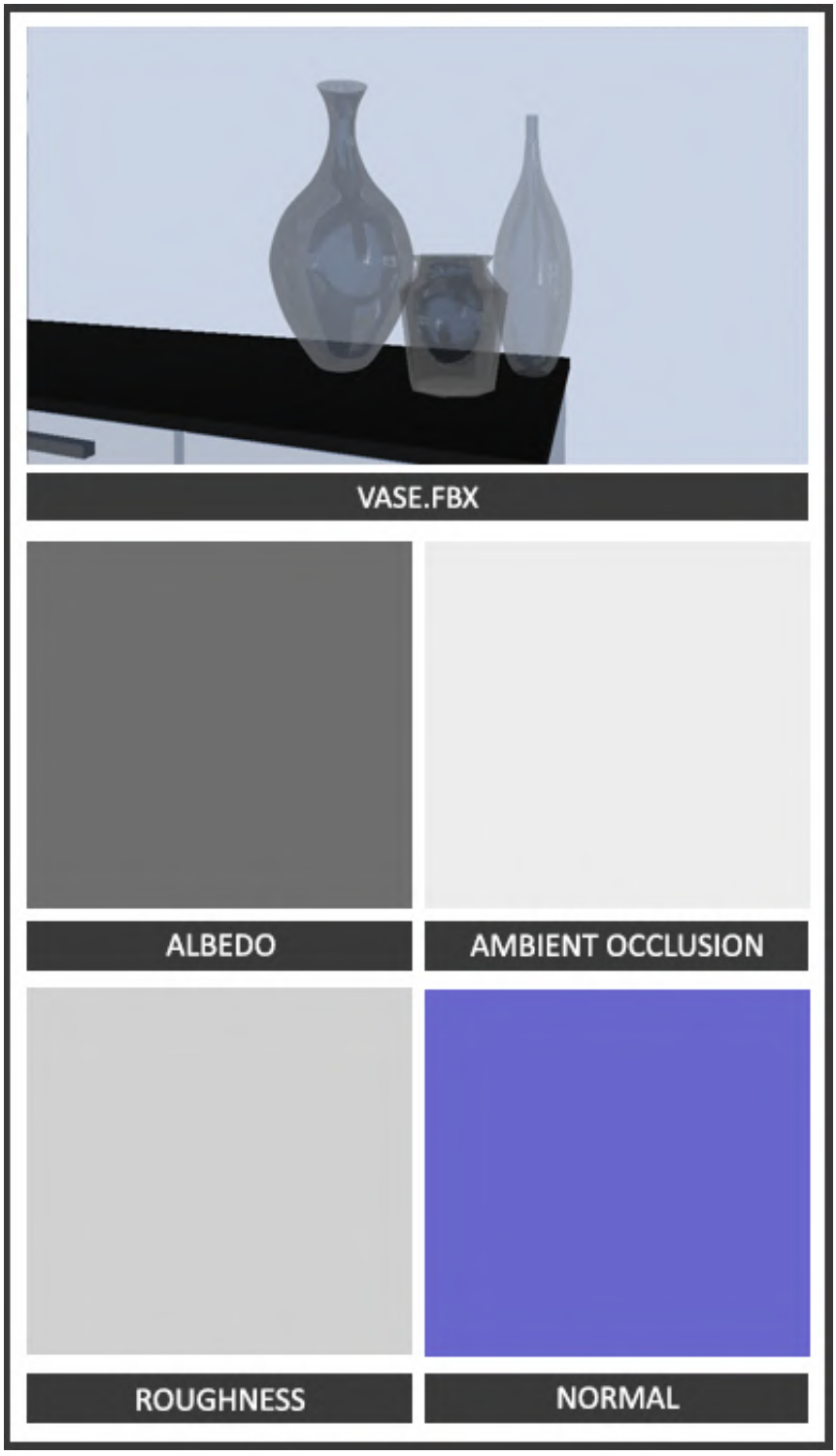
B.1.6 Pillows



B.1.7 Bed

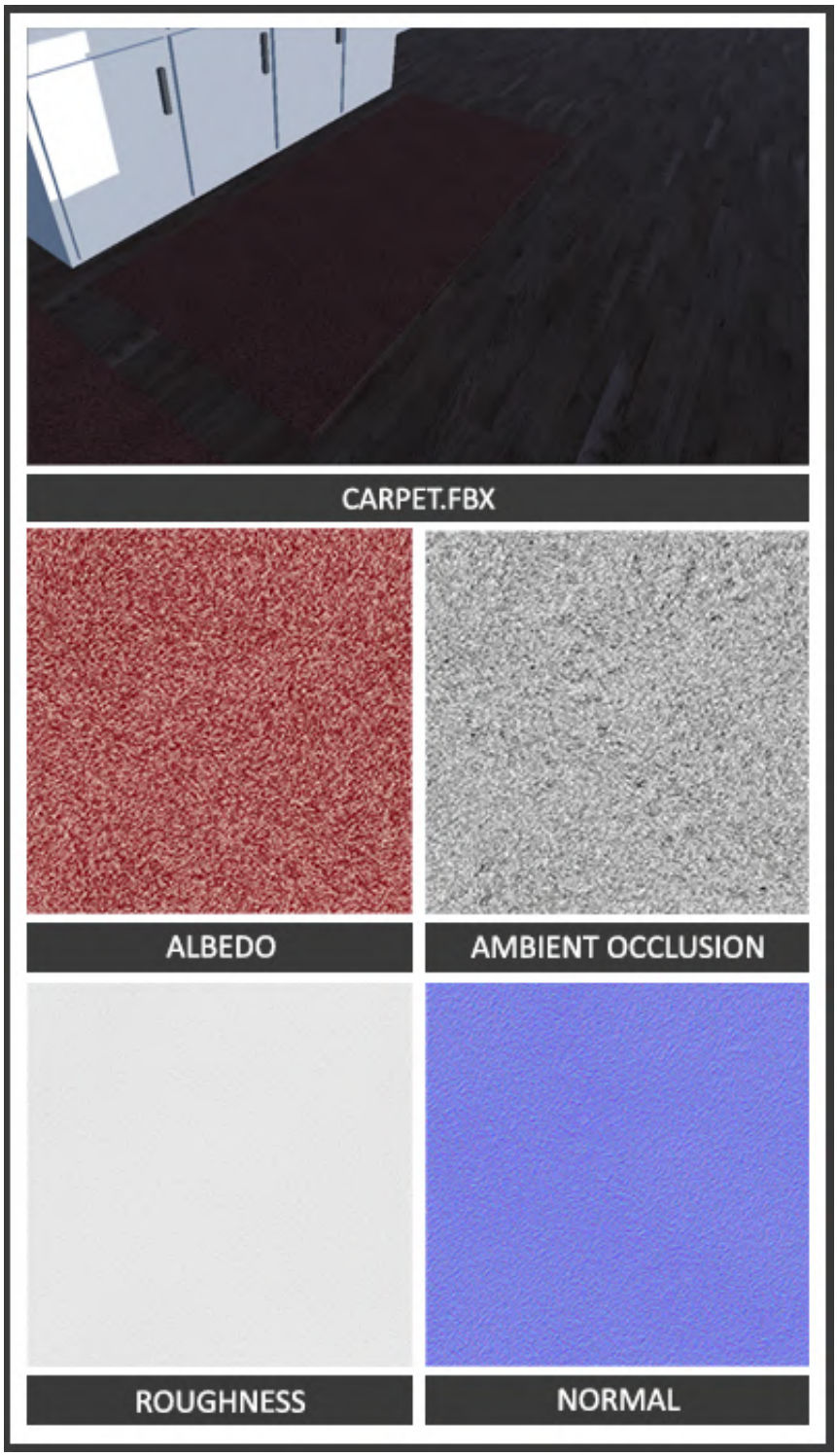


B.1.8 Vases



B.1.9 Stove

B.1.10 Carpet



B.1.11 Shower Box

This asset uses generalized textures used by multiple meshes.

B.1.12 Oven

This asset uses multiple textures generated in-engine, together with reference images.

B.1.13 Washing Machine

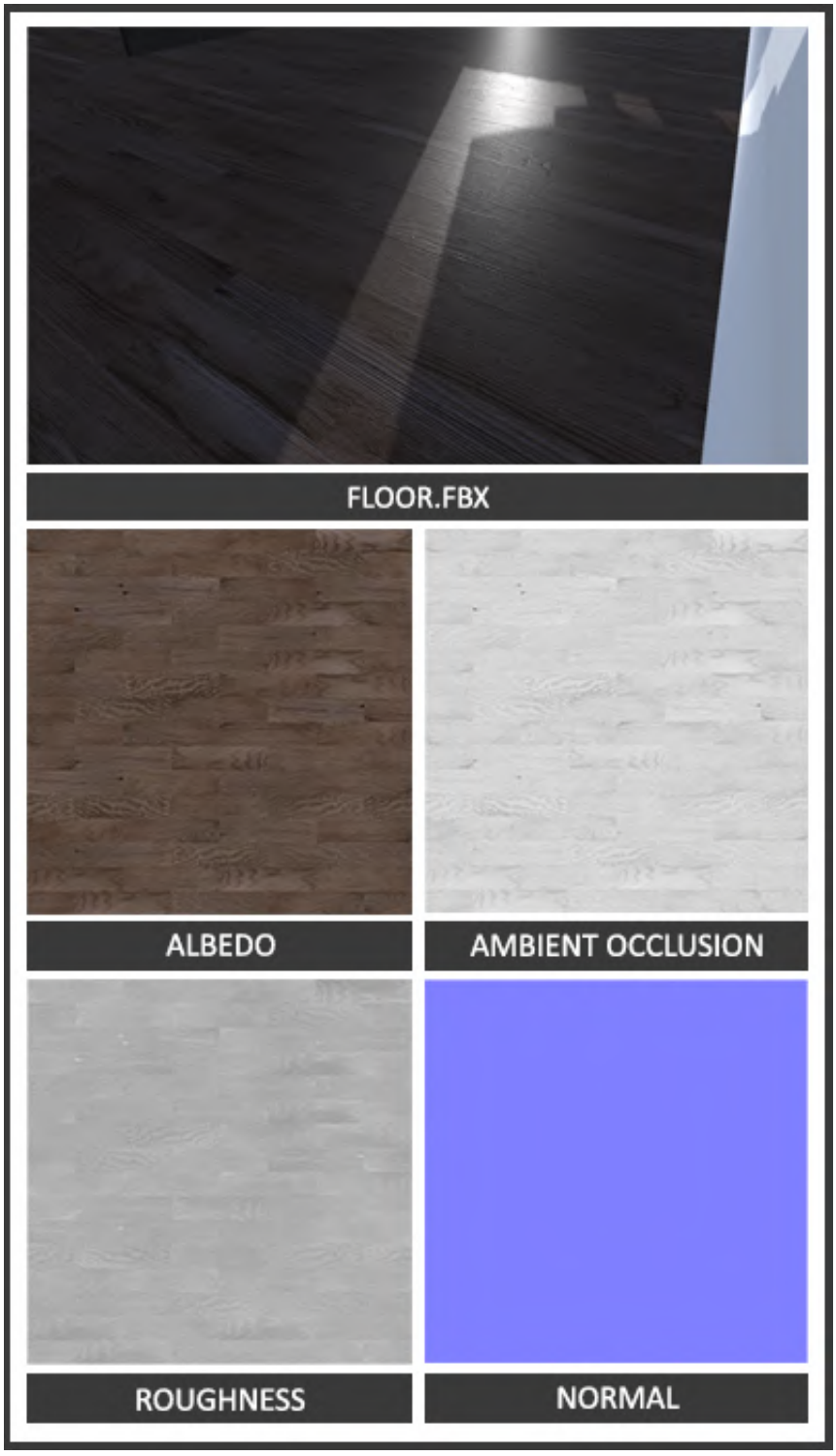
This asset did not have custom made textures due to the removal of the contamination OCD sub-type.


WASHINGMACHINE.FBX

B.1.14 Walls


WALLS.FBX & PILLAR.FBX
ALBEDO
DISPLACEMENT
ROUGHNESS
NORMAL

B.1.15 Floor



B.1.16 Balcony

C Appendix C

C.1 Survey and Test Results

C.1.1 Prototype Quality Survey

Presented is the survey distributed to 10 medical professionals, as mentioned in chapter 5.

VR as a tool for OCD treatment feedback

Thank you for taking your time filling this survey.

We are Game Design and Development Master's students from the University of Beira Interior. For our Project Report, we're currently developing a VR platform to be used as tool for OCD (Specifically the Order and Symmetry subtype) therapy sessions.

The objective of this VR platform is to, through the process of gamification, attempt to engage in the de-ritualization of the OCD patient through puzzles, inserted in a familiar environment, created considering the struggles and challenges of OCD patients. The purpose of this survey is to identify the positive and negative contributions of this platform towards helping OCD therapy sessions in tangent with a medical professional.

Due to the unfortunate Covid-19 outbreak, our testing and feedback ability was limited to digital, rendering physical testing impossible. Attached is a sample of a gameplay demonstration to review before replying to this survey: http://y2u.be/L3pNDLfbbV8

1. Medical Background

What's your field of expertise? *

- ◯ Psychology
- ◯ Psychiatry
- ◯ Other: _____

Where do you work? *

- ☐ Hospital
- ☐ Clinic
- ☐ Private Consultation Office
- ☐ Other: _____

How many years have you been working in your field? *

- ◯ 1-5 years
- ◯ 5-10 years
- ◯ +10 years

Which pathology is more frequent in your patients? *

- ☐ Order and Symmetry
- ☐ Cleaning and Contamination
- ☐ Doubt and Verification
- ☐ None of the above

2. Videogame and VR Headset Knowledge

Please check which devices you have used. *

- ☐ Playstation 4
- ☐ Playstation 5
- ☐ Xbox One
- ☐ Xbox Series X
- ☐ PC
- ☐ Nintendo Switch
- ☐ Android Phone
- ☐ Apple Iphone

Are you familiar with videogames? (1 being not familiar at all and 5 being extremely familiar) *

1 2 3 4 5

How often have you had contact with videogames? (0 being not at all and 5 being extremely often) *

0 1 2 3 4 5

How familiar are you with the concept of Immersion and Virtual Reality? (0 being not familiar at all and 5 being extremely familiar) *

0 1 2 3 4 5

Have you had any hands-on experience with Virtual Reality? *

- Yes
- No

Do you own, or know anyone who owns a VR device? *

- Yes
- No

VR tool gameplay example and feedback

http://y2u.be/L3pNDLfbbV8 - This example shows the player finding and sorting items which will always be in an order that will provoke the pathology of Order and Symmetry. After watching this gameplay example, proceed to the next questions.

Do you think that a video game built to help OCD should be: *

- ◯ Soothing the patient
- ◯ Provoking the patient thoughts

Where would you classify the game world shown in the video? (0 being not adequate to the experience and 10 being very adequate) *

0	1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Where would you classify the gameplay shown in the video? (0 being not therapeutic at all and 10 being very therapeutic) *

0	1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Would you be interested to try a game like this out with patients as a possible therapy method? (This question is only for those who work with OCD patients, feel free to skip if that doesn't apply to you)

- ◯ Yes, I would.
- ◯ No I wouldn't.

What other activities (if any) should be added to the video game, whose focal point is to provide a therapeutic experience to people afflicted with OCD? Feel free to leave your suggestions here.

Your answer

Submit

Page 1 of 1

Clear form

Never submit passwords through Google Forms.

C.1.2 Survey Results

These results were automated by the Google Forms [18] platform and sped up the data processing.

VR as a tool for OCD treatment feedback

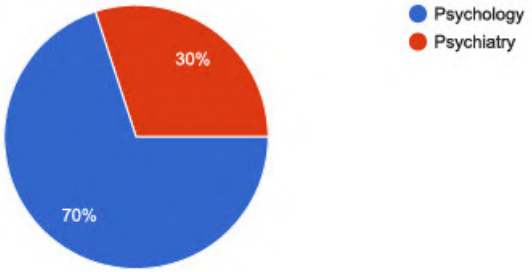
10 responses

Publish analytics

1. Medical Background

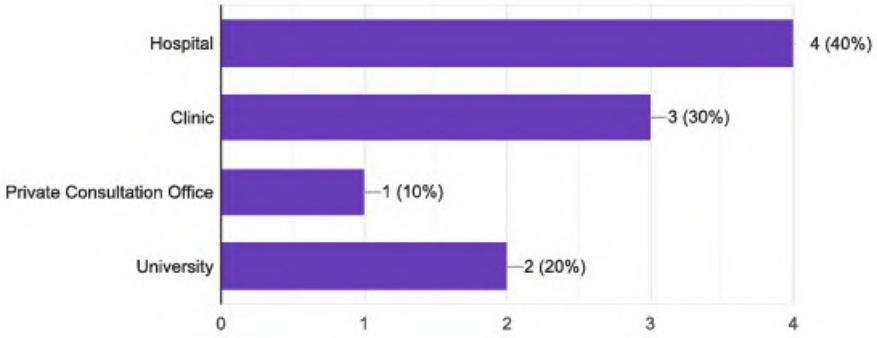
What's your field of expertise?

10 responses



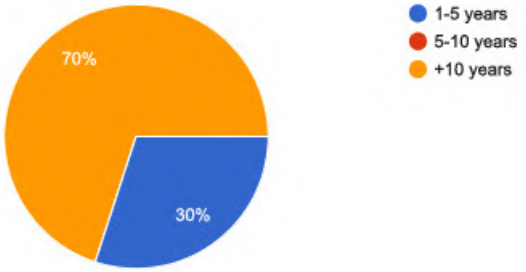
Where do you work?

10 responses



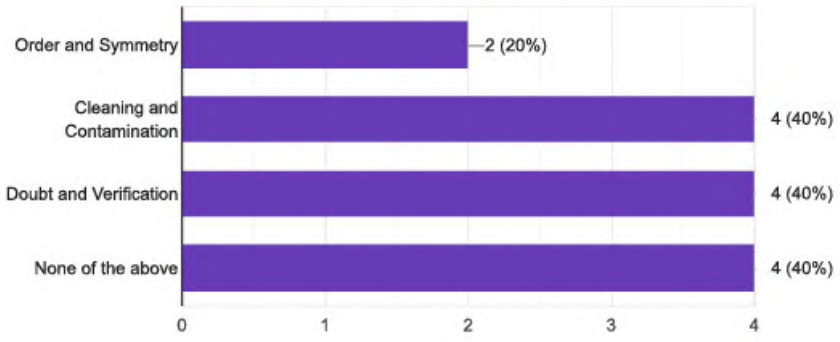
How many years have you been working in your field?

10 responses



Which pathology is more frequent in your patients?

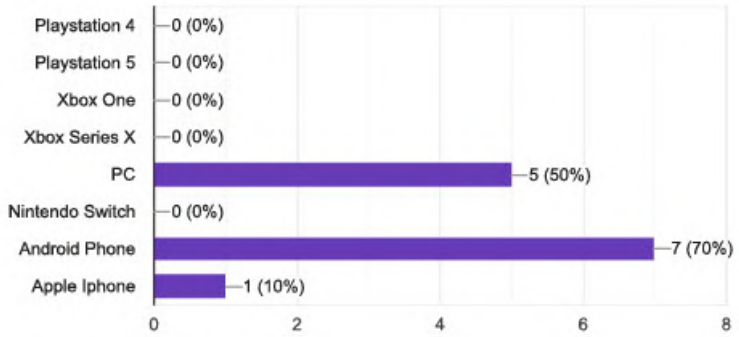
10 responses



2. Videogame and VR Headset Knowledge

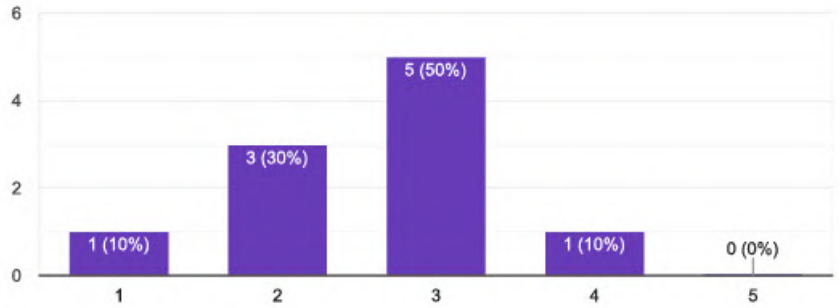
Please check which devices you have used.

10 responses



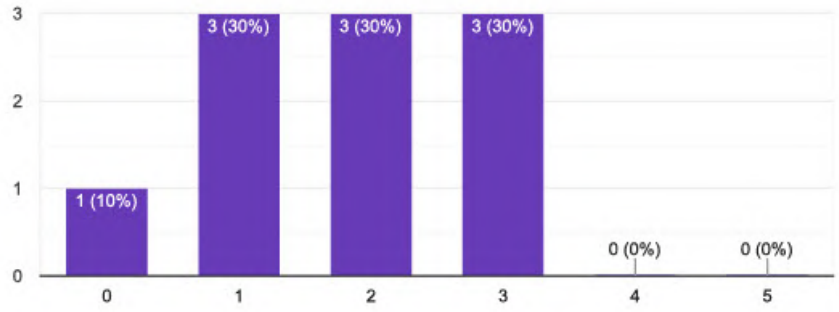
Are you familiar with videogames? (1 being not familiar at all and 5 being extremely familiar)

10 responses



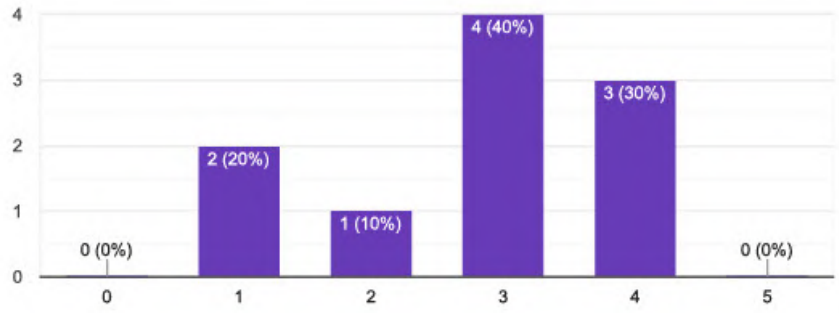
How often have you had contact with videogames? (0 being not at all and 5 being extremely often)

10 responses



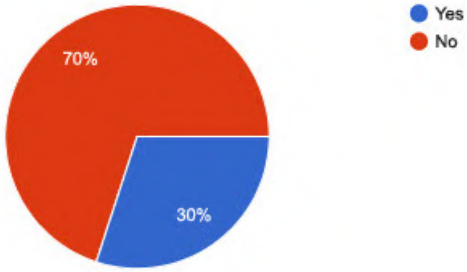
How familiar are you with the concept of Immersion and Virtual Reality? (0 being not familiar at all and 5 being extremely familiar)

10 responses



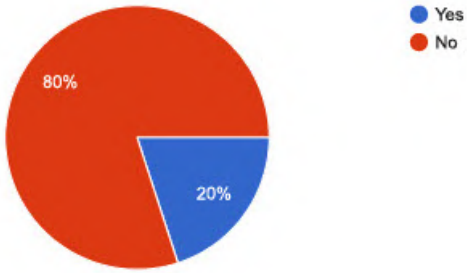
Have you had any hands-on experience with Virtual Reality?

10 responses



Do you own, or know anyone who owns a VR device?

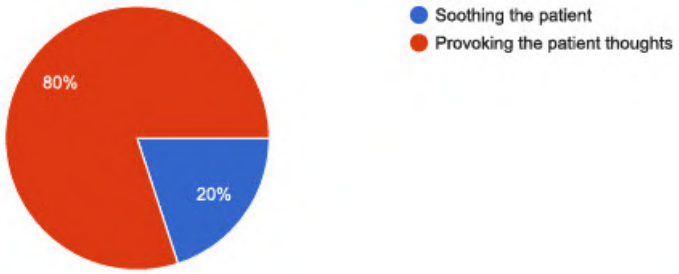
10 responses



VR tool gameplay example and feedback

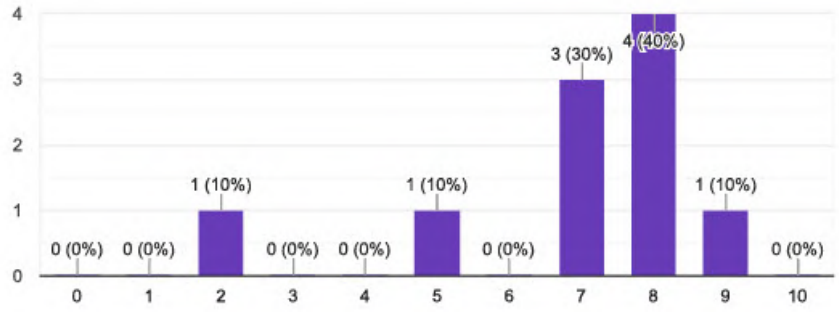
Do you think that a video game built to help OCD should be:

10 responses



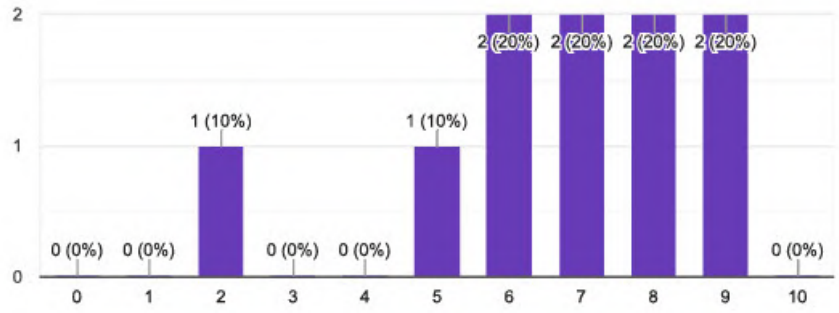
Where would you classify the game world shown in the video? (0 being not adequate to the experience and 10 being very adequate)

10 responses



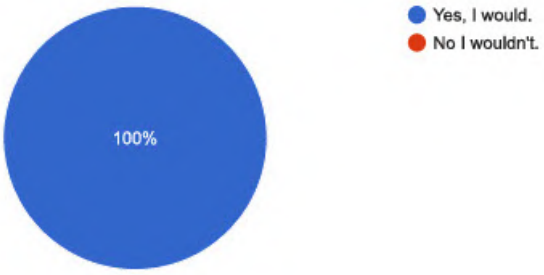
Where would you classify the gameplay shown in the video? (0 being not therapeutic at all and 10 being very therapeutic)

10 responses



Would you be interested to try a game like this out with patients as a possible therapy method? (This question is only for those who work with OCD patients, feel free to skip if that doesn't apply to you)

5 responses



What other activities (if any) should be added to the video game, whose focal point is to provide a therapeutic experience to people afflicted with OCD? Feel free to leave your suggestions here.

3 responses

Creio que o jogo tem potencialidades para o fim a que se destina, isto é, evocar ansiedade que será trabalhada pelo psicólogo em consulta. Creio que se destina sobretudo a uma fase inicial do tratamento de determinadobtipo de perturbações, mas pode servir como ferramenta de trabalho.

In second task (to organize the shirts), the order should be more random, that is, with more different colors, and could have different pieces of clothing.

In the future I sugest continuing to develop the game in sub types. As an example one directed for fear of contamination, other for anxiety around symetry and order, etc. Furthermore I believe this would be an excelente tool to introduce in my clinical practice. I work in an eating disorder unit with patients who also present diagnose of OCD. As per my experience most of the adolescents are very familiar and motivated to engage with computer games such as mine craft, etc. Using this tool could be an excelent asset to keep patients motivated within the therapeutic process.

D Appendix D

D.1 Scripts

This appendix depicts the scripts needed to start, quit, and navigate between the game levels.

D.1.1 Scene Manager Scripts

The following scripts are called by the interaction with the "Start" and "Quit" button in the main menu, it plays a previously created animation which progressively increasing the opacity of a game object over a set amount of time(two seconds) that fills the entire screen with black, smoothly transitioning between screens. The scripts and objects are kept from being destroyed after loading the next scene, enabling it to progressively decrease the opacity of the game object again in the new scene.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class ManagementScene : MonoBehaviour
{
    public GameObject: FadeScreen;
     void Start()
    {
        Debug.Log("Loading VR Experience");
        DontDestroyOnLoad(this.gameObject);
    }
    public void LoadLevel()
          {
           FadeScreen.GetComponent<Animation>().Play("FadeAnim");
           yield return new WaitForSeconds(2);
           SceneManager.LoadScene("MainScene");
           yield return new WaitForSeconds(2);
           FadeScreen.GetComponent<Animation>().Play("UnFadeAnim");
          }
```

```
}
```

Source Code 1: FadeToVRGame.cs Script

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class ManagementScene : MonoBehaviour
{
    public GameObject: FadeScreen;
     void Start()
    {
        Debug.Log("Ending VR Session");
        DontDestroyOnLoad(this.gameObject);
    }
    public void LoadLevel()
          {
           FadeScreen.GetComponent<Animation>().Play("FadeAnim");
           yield return new WaitForSeconds(2);
           SceneManager.LoadScene("MainMenu");
           yield return new WaitForSeconds(2);
           FadeScreen.GetComponent<Animation>().Play("UnFadeAnim");
          }
}
```

Source Code 2: FadeToMainMenu.cs Script

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class ManagementScene : MonoBehaviour
{
        public void QuitGame()
    {
        Application.Quit();
    }
}
```

Source Code 3: QuitGame.cs Script