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EXPANDING HUMAN PERCEPTION THROUGH PUZZLES IN VIDEO GAMES

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Structure

Abstract.....	2
Chapter I Interaction in game design	
1.1 What defines a game.....	3
1.2 Game Design	7
1.3 Puzzles in games	9
Chapter II Optical illusions	
2.1 Perception and illusion.....	13
2.2 Illusion in art.....	16
2.3 Case studies	21
Chapter III Game implementation:	
3.1 Game concept.....	26
3.2 Galerist game design.....	28
3.3 Galerist game development.....	37
Chapter IV Testing and conclusions	
4.1 Questionnaire.....	44
4.2 Conclusions	48
Bibliography.....	50
Annex	
-Game design document.....	52
-Gallerist Gantt chart.....	61

Abstract

The thesis aims to answer the following question: How can we design a game that can change the player's visual perspective? And how can we understand the space around us in a different way? I attempt to achieve this by finding the right development pipeline for this game. I admire the visual style of M.C.Escher's paintings which served as the base concept of the virtual space I want to create with the goal to experiment and bring these optical illusions to life in an immersive medium, through gameplay.

In Chapter One I will talk about artists that inspired me in the creation of my game, what puzzle games are where the perception is formed, and how. In order to develop an experience that interacts with the player and create a meaningful experience in Chapter Two I presented the concept of game design followed by several case studies from this genre, in order to analyze both positive and negative aspects, and how other designers applied mechanics in video games to give the change of perspective feel.

I will argue my theory with a questionnaire in order to answer what the users enjoy in this game and whether they had a meaningful experience or not. In the final chapter, I will describe the development process based on the knowledge acquired in the first two chapters, the difficulties, feedback from the players, and future goals. As well as a conclusion to the question at hand.

Method of research: case studies, questionnaires, feedback from players, practical video game

Keywords: perspective, illusion, deformation, interaction, engagement, puzzle, game, logic, intuition, abstract.

Chapter I - Interaction In Game Design

1. 1. What defines a game

In this chapter, I will take into account, what defines a game and what are they exactly, what game design is, and the role in a puzzle game. How do we understand and immerse ourselves in these mediums, what makes a game fun to play, and where does this information form, as well as going through where the perception is formed in the human brain, why, and how can we influence this perception in generating emotion?

The first question I am trying to answer is what exactly is a game? There are different ways from which you can answer this. Chris Crawford describes them as being a “*closed formal system that represents a subset of reality*”¹ in this sense he defines a closed system as being complete, having a structure, and being fully described. He describes formal as in having a very specific ruleset, and system for all the interconnected parts in all of their complexity.

Another definition comes from the authors of The study of games, Elliot Avedon and Brian Sutton-Smith “*Games are an exercise of voluntary control systems, in which there is a contest between powers, confined by rules in order to produce a disequibrial outcome.*”². With this approach, I agree with the fact that you enter them voluntarily and that you give some kind of consent upon entering the game. Here as well are described the rules, and a new idea, is introduced, the one of a contest which I am not in complete accord because of the nature of cooperative games in which the players work together to a common goal not competing one with the other.

Although incomplete I admire the simplicity in which Jesse Schell describes “*A game is a problem-solving activity, approached with a playful attitude.*”³ Here I find the first description of a game where the idea of playfulness comes in. This expresses that a game should give some sort of amusement, or pleasure from it because in itself humans, have been playing from all our existence. With the goal of pleasuring and amusing ourselves in our day by day activities.

¹ Chris Crawford - The Art of Computer Game Design, Reflections of A Master Game Designer, McGraw-Hill 1984, U.S. page 7

² Elliot Avedon and Brian Sutton-Smith, The study of games, New York: John Wiley & Sons, 197, page 405

³ Jesse Schell - The art of game design a book of lenses, Morgan Kaufmann Publishers, Burlington 2008. page 37

A game is formed from rules, a system, the wish to interact with it, and extend this in a pleasurable activity to us. I think of games as opportunities for us to emerge ourselves into a different world with interesting puzzles to resolve while learning on the fly about the world and ourselves as well.

Ernest Adams in the book *Fundamentals of Game Design* defines a game by being “A game is a type of play activity, conducted in the context of a pretended reality, in which the participant(s) try to achieve at least one arbitrary, nontrivial goal by acting in accordance with rules.”⁴ Here we see the notion of pretending coming up where in order to engage in the game our player must pretend in being someone or something else.

In order to understand what a game is we first need to find out what are the essential elements in a game, and from the definitions before we can extract, a goal, rules, play and pretending.

Pretending similar to acting in this context is a conscious creation of an alternative reality in one’s mind. Dutch historian Johan Huizinga defined this form of reality created by impersonation is the *magic circle* in his book *Homo Ludens*⁵. The magic circle is strongly associated with the world of imagination, in which each of us embarks when engaging with a work of fiction. Also connected to spiritual, ceremonial, and other types of activities that require some kind of ritual, he defines a type of boundary that separates the rules, ideas, and concepts of the real world from those in the magic circle. Also dividing the reality from the fictitious Figure 9

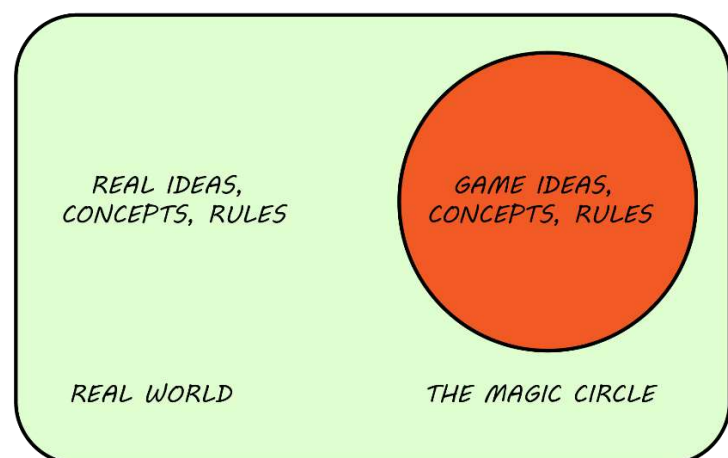


Figure 1 Magic Circle

In games, this structure follows for example in a single-player game the user enters the magic circle at the point where he makes the choice to play. In multiplayer games, a convention is established and they all must agree upon it.

For board games is the same case, all players agree to the rules, and pretend to be someone else, in a sense the player leaves his former self at the border with reality and

⁴ Ernest Adams, *Fundamentals of Game Design*, second edition, New Riders, Berkeley, 2010 page 3

⁵ Johann Huizinga, *Homo Ludens: A Study of the Play Element in Culture* Beacon Press, Boston, 1955.

immerses himself into the magic circle where everyone follows the specific rules, goals, and ideas.

Goals are a big part of games, of course, there are sandbox games where things are not as well defined and no specific goal is given by the game, although similar to a toy, the player is left to play with the game in what way he wants, leaving him to decide at what to do in the environment. For all the other games out there a goal is what moves the player from one place to the other, this can give momentum through the gameplay and finally after fulfilling the goal, the player receives a form of satisfaction, being Experience Points (used to award the player in video games, often used to level up your character skills), gold or an awesome sword to prepare him for the next encounter in the game. Goals can be specific or ambiguous, for example, a quest has a very specific goal set to it “in order to complete this quest you must defeat the dragon from the top mountain” and in order to do that you must find the mountain, slay the dragon and get back to collect your reward. A more ambiguous goal is set in the form of puzzle games, where you know what you need to achieve in general but you are not given specific instructions on how to achieve this goal, the reward a player gets from solving a puzzle consist in having the satisfaction you have outsmarted yourself and completed the challenge.

The rules are instructions and definitions that the player needs in order to participate in a game. Rules have several purposes for a game they define the goal of the game and how to reach it, while at the same time creating the context in which the game is set in. Rules specify to what extend can players do certain actions and those that are forbidden, a ruleset should define the following:

“■ ***The semiotics of the game*** are the meanings and relationships of the various symbols that the game employs. Some symbols, such as innings and outs in baseball, are purely abstract. Others, such as armies in Risk, have a parallel in the real world that helps us to understand them. This book won't go into the theory of game semiotics in detail. It is a complex issue and the subject of ongoing research, but it is beyond the scope of an introductory work.

■ ***The gameplay*** consists of the challenges and actions the game offers the player.

■ ***The sequence of play*** is the progression of activities that make up the game.

■ ***The goal(s) of the game*** is also known as the objective of the game and is defined by the rules.

■ ***The termination condition***, as described in the previous section, is the condition that ends the game (if it has one).

■ ***Metarules*** are rules about the rules. These might indicate under what circumstances

the rules can change or when exceptions to them are allowed."⁶

Even if it's a computer, board game type is in our nature to play. I see the wish to play more like a means to discovery, when you see a child outside pretending to be the captain of a big ship, he engages in that role and visualize how to drive the ship, give commands to the other sailors and learns how it would be if he was in that position. We discover in our lives as we grow up that there are more games in the world that we world originally imagined, at the same time we take pleasure from all of them and this forms us as human beings.

J Bernard Gilmore states that *"play refers to those activities which are accompanied by a state of comparative pleasure, exhilaration, power, and the feeling of self-initiative."*⁷

When we play with a toy this does not come with instructions or rules on how to play with it, it doesn't really have a specific goal that needs to be fulfilled in order to get satisfaction from playing with it. Even though some toys have the form of a car, for example, this does not mean that you should always play with it by driving it on the road, children often get more enjoyment when they treat the object in unexpected ways like having the car go underwater or flying with it. This action requires creating a story, filled with whatever we wish, and giving the objects attributes that may vary depending on the circumstances we find ourselves in, where the extent of playing becomes limited only by our own imagination.

Play can be defined as a form of entertainment in which you can participate, different from films, book or theater where the viewer engages in a passive way with the work presented to him by the author, in games you can make choices that lead you on unpredictable paths often leaving you with a sense of exploration. Making a game different each time you play it, this act of play gives you certain freedom on how to engage with the game, what decisions you take, and how you craft that experience is unique for each of us.

⁶ Ernest Adams, Fundamentals of Game Design, second edition, New Riders, Berkeley, 2010 page 8

⁷ J. Barnard Gilmore, "Play: A Special Behavior." New York: John Wiley & Sons, 1971, page, 311

1.2. Design in games

First of all, we must understand what design is, and from Donald A. Norman writer of *The Design of Everyday Things* states that “*Two of the most important characteristics of good design are discoverability and understanding. Discoverability: Is it possible to even figure out what actions are possible and where and how to perform them? Understanding: What does it all mean? How is the product supposed to be used? What do all the different controls and settings mean?*”⁸ Things we use on a day by day basis should incorporate intuitive design, the same applies in video games in order to guide a player on a path the level design should be clear and easy to follow, otherwise the player can feel lost and encounter frustration.

“*Design is concerned with how things work, how they are controlled, and the nature of the interaction between people and technology. When done well, the results are brilliant, pleasurable products. When done badly, the products are unusable, leading to great frustration and irritation.*”⁹ The same can happen with badly designed mechanics, if the player doesn’t understand how to use an interaction mechanic because of the complicated way it works, it is the designer’s job to make it feel easy to use and so let the player discover interesting ways in which he can use it.

Form Follows Function and why this is so important in the design of a game

Originating quoted in an article called “*The Tall Office Building Artistically Considered*”¹⁰ by Louis Sullivan is a fundamental principle of design mostly found in 19th and 20th-century architecture and in industrial design. This maxim has found its way into game design mostly because of how a game works and explaining that designing an experience for the player must first be clear what its role has in a game (function) and then how to make it esthetically (form)

Let’s take for example of a one-handed axe, first of all, we must define its function by answering a couple of questions: Against what types of enemies is this axe good? How far should it have the range? How much damage it does?

The axe has the following function:

- Close range attack
- Great against fast-moving enemies
- Deals medium damage

⁸ Donald A. Norman, *The Design of Everyday Things*, Basic Books, New York, 2002, page 3

⁹ Idem pg5

¹⁰ Sullivan, Louis H. *The tall office building artistically considered*. Lippincott's Magazine, March 1896.

Knowing the function its form will have the following characteristics: a short handle in order to move it swiftly at close range and against fast moving enemies with a larger blade indicating that it deals medium damage.

This principle can help designers have a more rational approach to their process while at the same time giving the player a more believable experience overall because he is already used to this type of approach in his everyday life.

When designing a game first you need to understand the needs of the player, why is he playing this game? Is it for the discovery element or his competitive nature, maybe he only wants to have fun playing this game with his friends? Whatever the case, to create a good experience for the player you must understand his behavior so that you can deliver a product based on his expectations.

Game mechanics are defined by the skills of the player, if he uses mental or physical skills this will dictate what inputs and parameters should the mechanic have in order to achieve the desired result.

When teaching a new mechanic to a player a repetition must occur in order to make the player understand completely. First, you need to show him what the mechanic can do, next to let him try it on his own, by practicing he improves the use of it and finally mastering it. It is essential to make the player learn how to use the game mechanics because they are the medium through which he interacts with the game, and have a result in the player's satisfaction.

Creating a challenge for the player is vital, in order to engage him with the game a clear goal and a way to solve this goal must be provided. A game quest is the perfect example of a challenge, often you receive this quest from a non-player character (NPC), which sends you on a journey to retrieve a mysterious item or to defend a village from some barbarians, in the progression of the quest you encounter many hurdles and by overcoming them the player receives satisfaction from this actions. Upon completing the quest, often the game rewards you with gold, experience points, and in some cases items to use on your character's development. By giving a player something to do and offering a sense of completion the journey in which he embarks feels meaningful"

To create a good game design, you must follow intuitive rules and take into account the things players are already familiar with them, as well as testing how various groups of people interact with the game and observe which of the components in the game give them pleasure and which don't. The game design of a game is not a fixed process, through iteration and feedback the game designer can improve the overall feeling, aesthetics, and simplicity of a game.

1.3 Puzzles in Games

Puzzles are a series of mechanisms with many moving parts some visible and many invisible to the user throughout his experience in the game. As said by Jessy Shell that “*every game is a problem-solving activity, approached playfully.*”¹¹ starting from this premise that means that every puzzle is a game?

Let’s take a closer look at the relation between games and puzzles.

First of all, many puzzles are single-player to some extent, but this can’t be the difference because anything from Half-Life¹² to the Last of Us¹³ is still a single-player where the conflict lies between the player and the system, not two players. Also, the case of solving a jigsaw puzzle with a friend can be a fun activity but not quite a game.

There is the question of puzzles not being interactive since they don’t respond to the player, this is actually questionable since some respond to the user, in video games. When giving the same input the system will return the same output would be categorized more like a puzzle than a video game. In this case games like Zork¹⁴, Final Fantasy¹⁵, or Legend of Zelda¹⁶ might not be games at all. But we all know that is not the case.

From puzzle master Scott Kim we have a quote “*A puzzle is fun, and has a right answer.*”¹⁷ The paradox seems to be when you find the right answer, the puzzle is no more fun. A strategy that is overused to win a game is called a dominant strategy and, when you use this same strategy in a game, it takes the fun out of it. While also being the very definition of a puzzle. To quote the definition of Jessy Shell “*A puzzle is a game with a dominant strategy.*”¹⁸

Puzzles, as we knew them, have lost interest over the years, but they have evolved over time in video games. Old fashioned puzzles like riddles are now gone, in favor of the more hands-on approach. A puzzle is a mental challenge that makes you stop and think, so even in a circumstance where you need to figure out where to throw the water barrels over the pool of

¹¹ Jesse Schell - The art of game design a book of lenses, Morgan Kaufmann Publishers, Burlington 2008. page 208

¹² Video Game 1998, developed by Valve published by Sierra Studios

¹³ Video Game 2019 developed by Naughty Dog published by Sony Computer Entertainment

¹⁴ Video Game 1977 developed by Infocom published by Personal Software

¹⁵ Video Game Franchise 1987-2020 developed by Square Enix, published by Square Enix

¹⁶ Video Game Franchise 1986-2019 developed and published by Nintendo

¹⁷ How Puzzles Improve Your Brain: The Surprising Science of the Playful Brain Scott Kim. Pg. 316

¹⁸ Jesse Schell - The art of game design a book of lenses, Morgan Kaufmann Publishers, Burlington 2008. page 209

lava, or which series of levers you need to pull in sequence to open a door, even in a racer where you optimize when to push the N₂O in order to get the highest score. All of these are hands-on puzzles that integrate with the gameplay itself.

How can we design a good puzzle?

“Puzzle Principle #1: Make the Goal Easily Understood”¹⁹

People should understand what to do by the design of the puzzle itself. If the player isn't sure what to do, he will abandon the game and quickly lose interest. The goal of the puzzle should be clear from the start and difficulty should escalate gradually.

“Puzzle Principle #2: Make It Easy to Get Started”²⁰

Once a player gets on with the puzzle and starts solving it, even if he fiddles about with a couple of moves forward and backward eventually by trial and error it will give a sense of progress.

“Puzzle Principle #3: Give a Sense of Progress”²¹

In order to keep the player engaged a puzzle can be made from a series of steps in which each step gets progressively harder than the earlier one. In this case, the user will have many small achievements as opposed to a riddle for example where you find the answer after struggling for a while and the satisfaction is substantial.

“Puzzle Principle #4: Give a Sense of Solvability”²²

In close relation with principle three, there is a sense of solvability if the player senses that the puzzle can't be solved, he will soon see it, as a waste of time and give up. There needs to be a way in which the player understands right away that it can be solved.

A very good example of this is a Rubix cube, which comes in the box already solved, and after twisting and flipping it a couple of times, the user finds out that there are a greater number of moves that need to be done to solve it than it took to shuffle it.

“Puzzle Principle #5: Increase Difficulty Gradually”²³

Similar to the sense of progress, there is a need to increase the difficulty gradually in a series of steps that lead to a couple of goals, not just a big one. To give a very good example found in the book of how a jigsaw puzzle is solved: “

1. Flip all the pieces so that the picture side is up (mindlessly easy)

¹⁹ Jesse Schell - The art of game design a book of lenses, Morgan Kaufmann Publishers, Burlington 2008. page 211

²⁰ Idem, page 212

²¹ Idem, page 213

²² Idem, page 214

²³ Idem, page 215

2. Find the corner pieces (very easy)
3. Find the edge pieces (easy)
4. Connect the edge pieces into a frame (a slight challenge, rewarding when completed)
5. Sort the remaining pieces by color (easy)
6. Start assembling sections that are obviously near each other (a moderate challenge)
7. Assemble the pieces that could go anywhere (a significant challenge) “²⁴

Although it sounds easy, this is a very difficult task in achieving a balance between the difficulty curve of each puzzle and the consequent one.

“Puzzle Principle #6: Parallelism Lets the Player Rest”²⁵

If the player finds itself stuck in a puzzle an excellent way to combat this situation is to give him several different related puzzles at the same time to juggle with one or the other and help him not to lose his interest by hitting a wall which can't be passed until he figures out the solution.

“Puzzle Principle #7: Pyramid Structure Extends Interest”²⁶

If you experiment with parallelism you can send the player to a pyramid structure. Here each puzzle gives a small clue about a greater puzzle for example in Assassin's Creed where you have two or three missions where you gather specific info that leads to the location, behavior, and weaknesses of your target.

“Puzzle Principle #8: Hints Extend Interest”²⁷

Well-timed hints are an excellent tool to entice the player to continue when he feels frustrated and wants to give up, a quick two-word hint like a staircase scratching, a brief sound of music or a light flickering can raise the interest of a specific situation whilst in other ways would be decisive for the player.

“Puzzle Principle #9: Give the Answer!”²⁸

The most pleasurable thing about a puzzle is after a long struggle on the player's behalf is the eureka moment where he finds the answer to the situation. Of course, there is the option to search forums or YouTube for a solution, but the reward is much more fulfilling when you figure it out by yourself.

“Puzzle Principle #10: Perceptual Shifts are a Double-Edged Sword”²⁹

²⁴ Jesse Schell - The art of game design a book of lenses, Morgan Kaufmann Publishers, Burlington 2008. page 215

²⁵ Idem, page 216

²⁶ Idem, page 216

²⁷ Idem, page 217

²⁸ Idem, page 218

²⁹ Idem, page 218

To make the user decide whether to get involved in the puzzle or not is a two-sided sword, in a way the player is able to make a perceptual shift and get a lot of pleasure out of the experience, but on the other hand, if the puzzle is too difficult for his skill level, he will be disappointed by the decision he has made.

To wrap things around, a great puzzle is hard to be pulled off by the designer, but if he takes close attention on what the user will be subjected to, and tests it over and over again he will give the player a wonderful experience when he will solve the puzzle by itself and figure out the solution even in some unexpected way.

I followed most of these principles in constructing the puzzles in my game, especially by removing the dominant strategy and letting the player find different ways to solve the puzzles, creating a clear goal, like exiting the room, creating a sense of progress through the game levels, making each one of them unique in their way. Using a difficulty curve, I increased the difficulty gradually throughout the game. At the same time, some principles were harder to adapt to the current linear game structure like creating parallelism or a pyramid structure, although I intend to incorporate these principles in the future by creating a hub where the player can return and try solving other levels when he finds itself stuck in a puzzle.

Chapter II – Optical Illusions

1.1. Visual Perception

For a better understanding of how the player perceives the medium in which the game immerses him, a closer look at the way visual perception is formed and how illusions can trick our minds into thinking that something else entirely different is happening.

The human brain contains over 100 billion neurons and each of them interconnected by thousands of synapses, which allow the neurons to pass electric signals from one to the other. At each moment there are trillions of synaptic connections happening allowing the processing of vast amounts of information. Feedback from our internal systems that keep all of them functioning in the right parameters as well as stimuli from the outside world through seeing, hearing, smelling, touching and tasting the outside world our brain can adapt the working systems inside to each circumstance in particular

Each and one of us has the ability to perceive the environment around us although in slightly different ways. There are some people with quite a fascinating condition, they aren't able to recognize their own face in the mirror. This type of condition is known as Prosopagnosia, a neurological disorder that impairs a person's ability to recognize faces, this disorder is caused because the part of the brain delegated to perceiving faces is not working how it should be. His eyesight works fine when interacting with common household items and from this example, we can make a clear distinction between Sensation and Perception:

- Sensation is the bottom-up process by which our senses, like vision, hearing, and smell, receive and relay outside stimuli.
- Perception is the top-down way where our brains organize and interpret that information and put it into context.

The process in which the visual perception of an object works is by light bouncing off the object and into our eye which receives that energy and transforms it into neural messages that your brain processes and organizes into that specific object. As seen in Figure 2

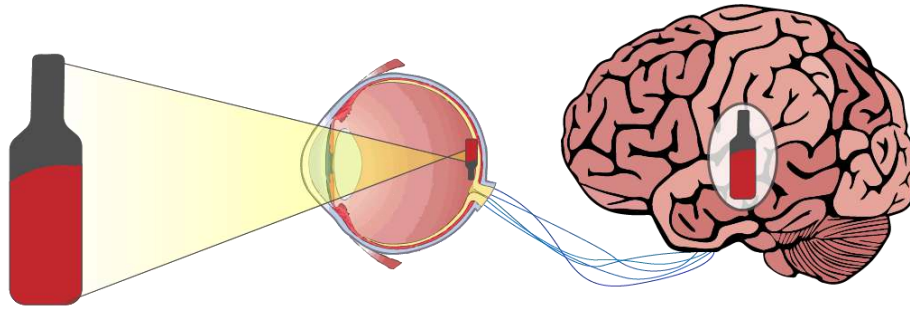


Figure 2 Visual Process, Personal creation

By understanding how this process works we can learn how to deliver information to the user. The subconscious mind has been hardwired to exclude some parts of the ordinary life due to prolonged exposure over time, things like how to walk, breathing, and other actions with a repetitive nature have been deliberately automatized in order to leave access to new experiences.

Optical illusions often feel so impressive because of their way of tricking the brain and giving visual information in an uncommon way, they rely on assumptions made by the brain and upon closer inspection proving it to be wrong.

These illusions can be classified as Gregory categories of illusion did in Figure 3

Kinds and classes of visual illusions			
Kinds of visual illusions	Classes of visual illusions		
	<i>Physical</i>	<i>Physiological</i>	<i>Cognitive</i>
<i>Ambiguities</i>	mist shadows	size – distance for a single stationary eye real – apparent motion	Necker cube Jasrow's duck-rabbit Rubin's vases
<i>Distortions</i>	(of space) stick in water (of velocity) stroboscope (of colour) filters refraction diffraction scattering	(of space) adaptations to length or tilt or curvature Café wall (of brightness and colour) simultaneous and sequential contrast	Ponzo Poggendorff Orbison Hering Müller-Lyer Zöllner figures
<i>Paradoxes</i>	mirrors (eg seeing oneself in the wrong place, and duplicated)	when visual channels disagree aftereffect of motion: moving yet not changing position or size	Penrose impossible objects Escher's pictures
<i>Fictions</i>	rainbows Moiré patterns	afterimages autokinetic effect migraine patterns	Kanizsa's triangle filling-in of the blind spot and scotomas

Figure 3 Gregory, Richard (1991). "Putting illusions in their place". *Perception*. 20

By using these as a basis for the level design (the process in which game levels are assembled in the engine) we can give the user an unexpected yet intriguing experience, trying to develop puzzles is a difficult task, making them good is even harder, trying to incorporate optical illusions into game levels raises an entirely new level of complexity, and this is why I wanted to take this challenge and try to develop a unique experience in for the player.

How to create illusions in a virtual reality? To answer this question, we must first understand what reality is.

First reality is subjective and everything we sense is more than a simple reflection of the world, each and one of us interprets and creates its own sense of reality “*Subjective reality is the way an individual perceives and experiences the external world in his mind.*”³⁰ This is why in a virtual space each player will sense something different, have a different experience, and in the end, will appreciate or not the game.

As an example, a well-known drawing of a rabbit or a duck (Figure3), what each of us sees first, is a case of how our subjective experience influences us in perceiving this optical illusion, the objective reality represents a black and white image drawn on a piece of paper or displayed digitally through RGB pixels. This is also how we create a virtual reality; in a game, we use digital copies of the world around us which put in the right context to make the experience believable.

We view the world around us and question

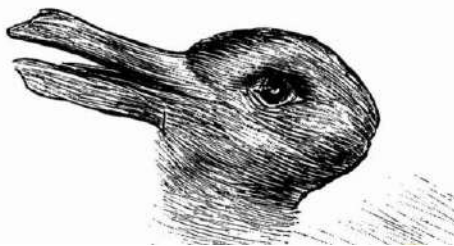


Figure 4 "Kaninchen und Ente" ("Rabbit and Duck") from the 23 October 1892 issue of *Fliegende Blätter*

Space perception is the “*process through which humans and other organisms become aware of the relative positions of their own bodies and objects around them. Space perception provides cues, such as depth and distance that are important for movement and orientation to the environment.*”³¹

In order to create a believable 3D space aspects like depth, distance, lighting, and proportions must be taken into account in order to immerse the user’s brain into that specific place, other environmental attributes such as wind animation on plants, and trees, the flow of water in a river, or other animals or humans present

³⁰ Jerald, J., The VR Book: human-centered design for virtual reality, Association for Computing Machinery, 2016, page 59

³¹ : Kai V.J. von Fieandt, E. Jaakko Järvinen, Louis Jolyon West, Pekka Yrjö Korkala, <https://www.britannica.com/science/space-perception> added to online database on Aug 12, 1998

in the space, create a more realistic vision of what that space should look like in comparison with the real world.

I used these techniques in the game development process to ensure that the first contact with the virtual world would be as lifelike as possible, from the moment that the player accepts the convention he is playing a video game and confines himself to the rules of the system, his journey begins, and with it so does the decreasing in subjective realism, all the geometry becomes more unbelievable in their architecture, bigger structures with less and less contact with the real world develop like a set of platforms held in the middle of a room secured only by steel wire from the tall fifteen-meter walls. This approach is meant to guide the player through spaces that are more and more unpredictable and visually interesting in their form with the purpose of approaching the climax point he will be shocked, intrigued and curious about what he sees, rather than confuse and frustrated this is a part of the hypothesis which will be tested through the questionnaire analysis.

Illusions are here a great part of my project because of the way it sets the mind frame for the player, that there is an abstract unevenly space, as the player progresses through the levels they become more and more broken in a sense that the normal physical spaces found in our reality become twisted and defragmented in a sense until the boundaries of usual perception leave the spaces altogether, similar to how fractals work I created an infinity staircase level where all the normal physics are broken and a bunch of floating staircases compose the level.

I see illusions as a great opportunity to unveil the mind of the player and to help him better understand the medium and himself, I also think that through the means of optical illusions you can trick the brain into a more immersive experience and here is why. As you let yourself wonder upon an illustration that baffles you, a certain realization happens at the moment the effect is clear, at that moment you become more aware of the environment and the things around you, being immersed in a video game experience and having this realization makes the whole experience more real at a subconscious level. Engaging the player with these “brain candy” and carefully constructing the experience that follows, gives the designer a unique tool for his process, which depending on the situation can be good or bad for the game.

1.2 Illusion in Art

The whole idea of impossible objects and mathematical art has fascinated a whole lot of artists, mathematicians, and philosophers along the time. One of them is Maurits Cornelius Escher (1898-1972), he started studying at the School of Architecture and Decorative Arts in Haarlem, a city in the province of North Holland after realizing that he wasn't all that interested

in architecture a teacher by the name of Samuel Jasserun de Mosquita encouraged him into pursuing graphic arts after seeing his drawings from and well-crafted lionel cuts.

After finishing school a journey through Italy makes him cross paths with his future wife Jetta Umiker, they move to Rome and until 1935 Escher traveled every year across the country to make sketches and drawings that he would later use in his studio to create woodcuts lithographs and wood engravings this was a great period of inspiration for him years after he left Italy he would come back to the sketches and use them in his work.

His opinion about the art of making woodcuts is that *“the ability to make such powerful prints is precisely because the artist needs to restrict himself to black and white and because cutting a picture into wood is such a difficult process a graphic artist is in a better position to express an idea clearly and purely and is less inclined than a painter to produce something with a hollow effect.”*³²

In this sense, I truly understand the frustrations and the amount of work that needs to be put in a project to make it unique and special, in a sense I can see a resemblance between the art of woodcutting and 3D modeling, both are complex and long processes, from starting with a box and building towards a bridge, giving it form and texture by using simple and primitive tools. Also, the thought process that happens before even touching the surface is a major task in itself, trying to find the best approach that leads to the desired result somehow the process of a 3D artist and a woodcutter is not that different after all in my opinion.

From Escher’s style I have integrated into my game key elements which served as an inspiration for the art style a couple of themes heavily influenced my work as follows:

The concept of symmetry refers to a *“sense of harmonious and beautiful proportion and balance”*³³. To better understand this concept, I studied the 17 plane symmetry groups which consist of a collection of wallpapers analyzed from a mathematical stand based on their Lattice type, rotation orders, and reflection axes.

³² M.C.Escher, Escher on Escher Exploring the Infinite, 1986 page, 28

³³ Zee, A., Fearful Symmetry, Princeton University Press. New Jersey, 2007, page 51



Figure 5 no. 18. 1938. An HH tiling used in the print "Day and Night."

As an example, let's take Escher's drawing

This image can be integrated into symmetry group nr.7 (pmg) it contains reflections as well as glide reflections, both perpendicular to the reflection axes. With a rotation order of two on the glide axes, it sits halfway between the reflection axes. It has a 180° rotation with interlaced symmetry. The gees in the drawing seem similar, although on closer analysis the white gees have their tails turning up while the blue ones have their tails pointing down. The choice of colors dark blue and white cream creates contrast in

order to highlight the drawing's symmetry.

The tessellation process consists of covering the entire surface with multiple geometric shapes without any overlapping or gaps using tiles.

I used these symmetry groups in the process of creating the paintings for the gallery, using them to create different feelings and perspectives in each of the rooms. The painting's symmetry influenced the perception of space.

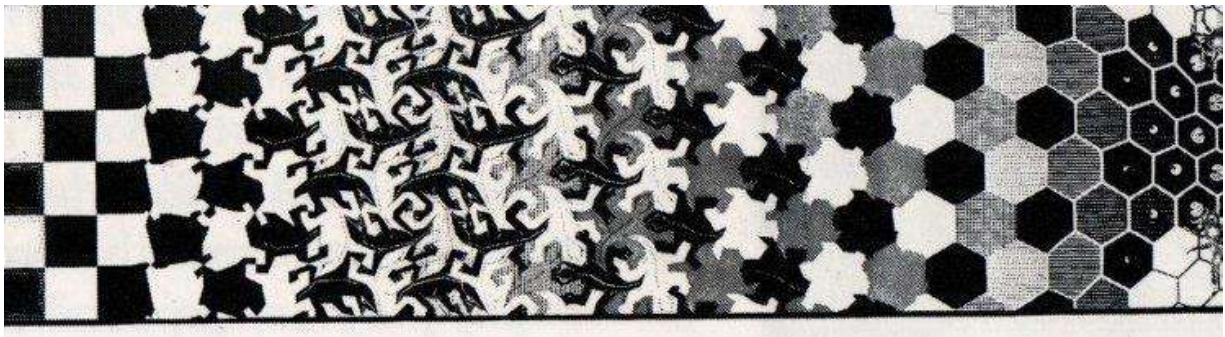


Figure 6 Part of Metamorphosis II

Metamorphosis

The process in which Escher created Metamorphosis II involved clearly defined abstract shapes like squares and hexagons, for example, then changing in concrete easily recognized forms, resembling lizards and back. A continuous theme of morphing and cycles is defined by Escher in his work growing from flat 2D images into 3D ones with unique perspectives seen from one point creating an illusion in that space, bends twists and sharp lines define this drawing.

I used this process in generating a journey for the main character in the game, she as well goes through a metamorphosis changing the space around and herself at the same time, until the point where she defines what style and what personality suits her the best.

Perspective

Escher explored classical perspective in art where because of the collections of parallel lines between them there is no vanishing point.

What Escher discovered and made a lot of use in his drawings is the Zenith and Nadir, by using these to create perspective, his way of twisting and challenging this perspective is what creates the fascinating style he has.

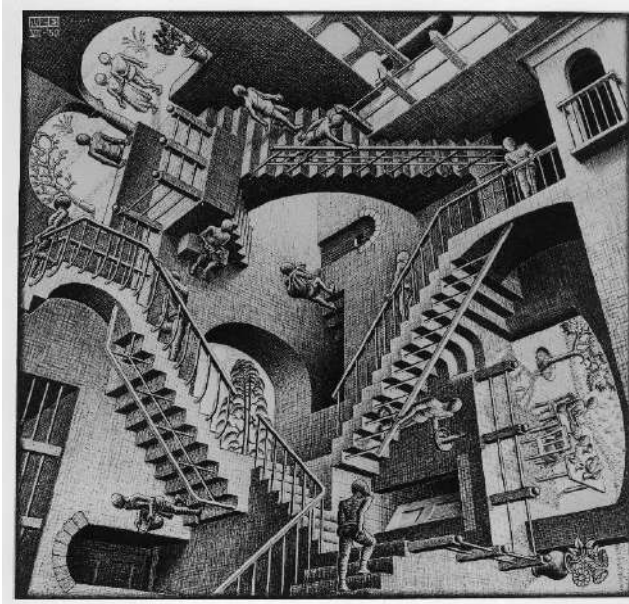


Figure 7 Relativity

In his work *Relativity* lithograph, from 1953 he created three different worlds, each figure in the drawing can be grouped to one of these worlds following different rules and seeing things from a different perspective. This woodcut coincided with the most challenging level I developed in the game, I tried to reproduce the different path the player can achieve by changing the rules applied to him.

Being one of the most famous graphic artists in the world his work inspired World-leading cosmologist Professor Sir Roger Penrose, which intrigued by the ways in which Escher expressed the world around us, motivated him to try and design one of the forms which have become so widely recognized around the world, the triangle which overlaps on itself seamlessly also known as the Penrose triangle. From this figure I also draw inspiration for the game logo.

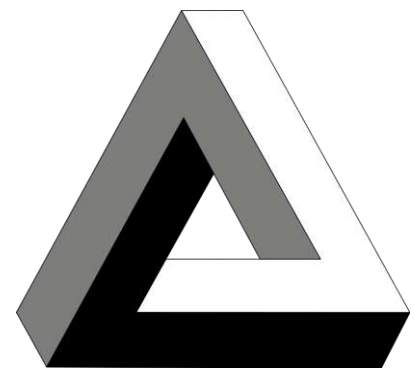


Figure 8 Penrose Triangle

A similar structure was created in the game having the objective to describe what these objects would look seen from different points in the space.

René Magritte

Rene Magritte born in 1891 in Lessines, Belgium he was one of the most remarkable artists of the Surrealist movement, he drawn his inspiration from minimalist, conceptual and pop art, creating paintings with incredible dream-like worlds, one quote from him inspired me a lot *“If the dream is a translation of waking life, waking life is also a translation of the dream.”* This enigmatic works of art are almost inexplicable, and are not really meant to be explained, their goal is to offer a different perception upon reality that the classical one, a similar thing I intended to accomplish in the game, space doesn’t really need to be understood by the conventional rules of this world bit more like an accepters from the player in complying to the different and unexpected rules in the game.

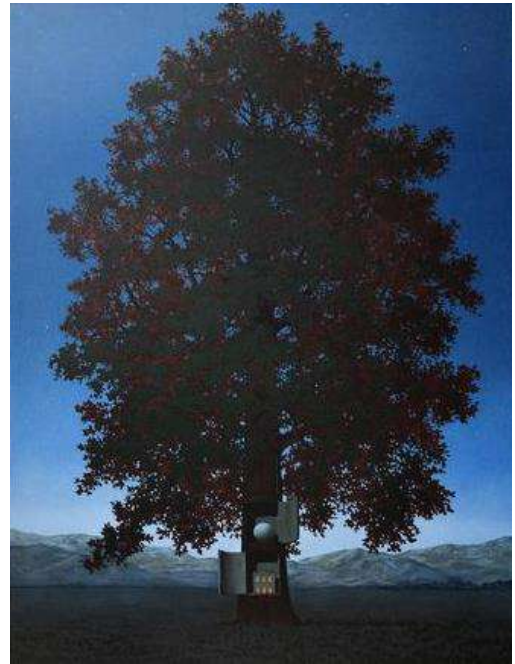


Figure 9 La Voix du sang

In his painting “Voice of Blood” Magritte uses a realistic scenery using natural elements as the central tree where inside the trunk are elements from a different space in order to create a world inside this inspired me to exploit this concept in the game as well, I used portals as doors to different realities creating impossible worlds in abstract spaces.



Figure 10 Galerist Level 4, Front Wall

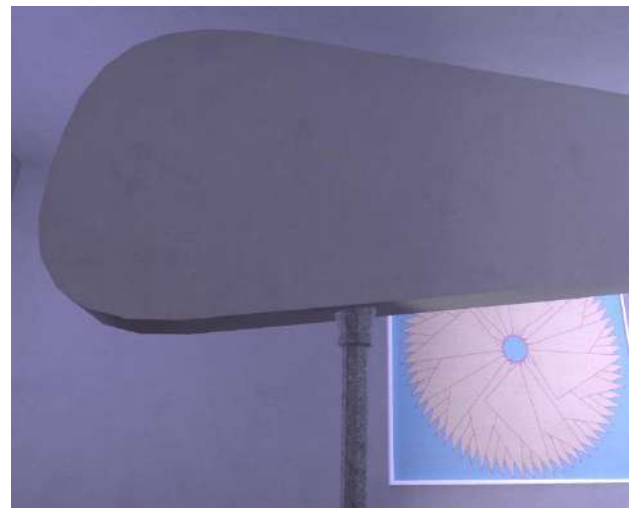


Figure 11 Galerist Level 4, Back Wall

1.3 Case Studies

Manifold Garden

Manifold Garden³⁴ developed by William Chyr 2019 is a first-person abstract indie puzzle game in which you explore Escheresque worlds filled with great structures that expand into infinity. You start the game in a room with a window that gives you a glimpse in what to expect by playing the game, as you progress through, it becomes more and more ambitious in its grandeur and achieves a feeling of smallness in a world in which it's hard to wrap your head around how it works at some points.

Game Mechanics

- Gravity change: when you approach a wall, you can either press the “spacebar” or “right mouse button” to change the global gravity on that wall, which now becomes the floor.
- Object interaction: you press “E” to press switches or interact with cubes that need to be placed on pads with the same color
- Falling: because of its infinite repetition of spaces the player can fall from the base of one level on the top of the same level, accessing through this a previously unavailable area

Game Art

The inspiration for this game is quite obvious the art of M.C. Escher had a great impact on the development of the game, from infinity columns and stairs that on one part you climb them but if you change the gravity you go down the stairs, this is clearly the strong point of the game. The art style can be defined as abstract, it uses straight clear lines that define the overall form of objects, flat colors are used and little texture, the whole world has a gradient applied to it from a warm orange tint when you look up to a bluish color when you look down, this chromatic distinction creates a sense of equilibrium for the player and helps him to understand which way is up and which way is down because in some cases it gets confusing. They used 6 colors to define the direction the gravity is at that moment and a white crosshair in the middle of the screen changes color when you approach a wall to that specific color.

Gameplay

The game starts with some easier puzzles, press a switch, move a cube from one place to the other and at sometimes, they become pretty smart like balancing a cube one on top of

³⁴ Video game, 2019, designed by William Chyr, published by William Chyr Studio

the other in order to touch a pad which otherwise would be inaccessible because the cubes are gravity-dependent, meaning that a blue cube only is moved when you are on the blue floor which leads to some pretty smart puzzle situations overall.

As confirmed by the designer as well, thorough the game there is not always a clear way in which you are supposed to go, I have spent some time wandering around with no idea where to go next.

The falling in this game is an interesting mechanic which I wish I would see in other games done as well when you fall the level repeats itself and often you access some places that otherwise were inaccessible, other times you must find in which direction you should go in order to fall into the right direction which leads to some interesting gameplay moments.

Sound

The sound design of the game is brilliant, each action interaction or event is responsive and has an appropriate clear and pleasant sound accompanied to it. One very good example of this is the sound the cube which you carry makes when it hits something, the sound is unique and resembles a Xylophone which you can actually make music with it when dragging the cube on the stairs. The music is in it by itself a great composition and feels connected with the space provided.

Technical

The main difficulty when making repeating geometry was optimization the developer states in an article published in gamasutra.com *“We achieved this effect by replicating objects in a grid to encompass all of the player's view frustum. In practice, this means that we have to render up to 500 times more geometry in our world.”*³⁵ Although they managed to achieve this effect in some parts of the game there are considerable frame drops and this breaks the immersion with the medium, they created.

Conclusions

Manifold Garden is a great source of inspiration, the things that I would like to incorporate into my game are:

Gravity Change, I think this mechanic is a great tool for the player to discover the level from different perspectives, also it makes you think outside of the box where it comes to solving puzzles. From the technical side, I think the movement when you change gravity creates motion

³⁵https://www.gamasutra.com/view/news/356304/Designing_Manifold_Gardens_believably_unbelievable_world_and_puzzles.php accessed on 18.05.2020

sickness, and in order to correct this, I will try to take out the animation so it doesn't force involuntary motion.

Infinity spaces, creating this types of spaces I am sure it will be a challenge but the way the user is rewarded I consider it is worth it, also I want to recreate some spaces which challenge the perception of the human mind while at the same time create an emotion the same way I felt when I was playing this game.

Antichamber

The game is a first-person puzzle game developed by Alexander Bruce 2013, in which you explore a minimalistic well-contoured set of interconnected rooms, your goal is defined from the start where you find yourself in the anti-chamber which acts as a hub from where you can control the settings access the minimap and see the exit sign indicating that you must exit this twisted surreal maze

Game mechanics

- It's first hidden mechanic is portals, from the beginning of the game where you see yourself making a choice going left or right on a set of staircases either of which will lead you to the same decision, the use of hidden portals that teleport you to the beginning of a level is a brilliant way to create illusions.
- Movement, the game makes very clever puzzles based on the players movement, some doors open when you walk backwards through them, platforms appear when you move slowly and others when you jump in the right direction, none of this information is provided to the player in a direct way, leaving the user to experiment in finding the right way to solve the developers riddles
- Cube Gun, this isn't a conventional weapon, the gun allows you to take cubes which you find throughout the level and store them inside for later use, often blocking or activating lasers in order to move forward.

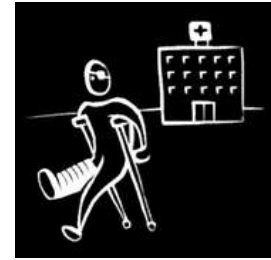
Game Art

The minimal, abstract use of hard lines and color creates a unique space, geometric sculptures, mind-bending corridors, and the overall feel is well thought and esthetically pleasing. The games don't overdo it the primary colors used to define the space are black and white, with accents of red, green, purple, and blue light surrounding the tunnels you walk through, decreasing in intensity towards the end. At sometimes even color becomes a mechanic, following the green path leads you to the exit, and staring from it gets you in the same place.

Gameplay

The game overall is well made and balanced, the movement control feels natural, details like black and white signs that explain the metaphor behind the puzzle you have just solved give you an insight in what the developer thought, and what he wanted to say with this game. The puzzles are clearly the strong point in this game, the seamless transition from one room to the other, the feeling of running in circles and the fact that mid-way through the game you find

the room which you first thought it was the exit and behind it is a wall with a sign that says “*Life isn’t about getting to the end*”³⁶. Finding all of these sketches, have a deeper meaning, the game you play, is a metaphor for life events that happen to each one of us and we keep going further until the end, the same as the last sketch which states that” *Everything must come to an end*”³⁷.



Sound

The game soundscape created by Robin Arnott is a masterpiece, from the sound effects of walking falling and hitting the ground to the sound cubes make when you fire them from the gun everything is well thought and brilliantly implemented. The thing that impressed me the most was the ambience of outdoor sounds like birds chirping, forest sounds and waterfalls introduced in a context that is quite the opposite indoor closed spaces, this opposing state creates a feeling of space and breathing where instinctually there wouldn’t be one. Music in this game is well-orchestrated, introducing itself at exactly the right time through the gameplay.

Technical

This is a game where the major difficulty from the implementation point of view is performance, each portal renders a different thing depending on the way you look through it, meaning that in a room with thirty portals like this (the gallery room) simple geometry, and rendering resolution are a must for optimization, and keeping the frames per second at a reasonable rate

Conclusions

I intend to use the portal mechanic for my game as well in order to create non-Euclidean spaces and the feeling of running around in circles, like in Antichamber, the portals will be hidden into the space, using them as a door to a new and intriguing space.

The puzzle design is a great inspiration, creating mind-bending puzzles that make you question everything is one of my goals, also achieving this will be a difficult task and requires research into the fields of psychology, neuroscience and visual perception in order to be done right.

³⁶ Video Game Antichamber 2013 There’s No Way In Level, developed by Demruth published by Demruth

³⁷ Idem, The Escape Level

Chapter III - Galerist Design and Development

Starting from the concepts and research conferred in the first two chapters I started the development of a first-person narrative puzzle based on the art of M.C. Escher, this game aims to create a unique experience for the player where he can explore impossible spaces, unique structures, and a captivating storyline. In the following chapter, I will describe the game design process, it's difficulties and what I learned from this, team and management what software was used to develop the game, I will present game assets pipeline from creation to the engine implementation as well as the different types of assets used, textures, shaders. The programming of the mechanics developed in the game and how each of them influenced the overall game design, the soundscape of the game where different techniques were used to create the audio medium. In the end, I will analyze the overall experience of players and conclude if the goal was achieved.

3.1 Game Concept

The concept of this game was developed on a timeframe of two months in which research papers, academic journals, and art exhibitions alongside careful analysis of Escher's most impressive paintings were conducted. Immediately after the research stage, I constructed a game design document, where examples of game mechanics, art directions and reference games were provided, right from the start I was more focused on the concept of organic game design meaning that in a project the design of the game gets changed overtime when difficulties, limitation, creativity and other factors like these influence the direction where the game is heading and what it will become in the end.

With this idea in mind, the major task was to keep everything simple and set clear guidelines so that a base exists on which everyone can build upon.

The game is played in the first person or in other words as seen from the eyes of the characters, this view has been chosen in order to create a more direct approach with the space you explore, another reason why a first-person perspective was chosen has come from a technical limitation for future virtual reality development, which is essential to achieve immersion. The player achieves this immersion through the medium of a virtual reality headset that sits over his head and two displays render the game from the camera object in the game.

A puzzle based on impossible paintings with twisted perspectives is not an easy task to create, one of the first challenges in this direction was that by studying the works of M.C. Escher one thing became apparent; all the fascinating structures and landscapes portrayed by him were mainly possible only from a fixed point perspective, meaning that one question arises: How can I translate this perspective in a three-dimensional space where the player has free movement and can observe them from each point he wished. Here the solution has come while designing the level, you don't or not quite, it is impossible to achieve this feeling from every point in the level and would take immense effort to make allowance for all these possibilities. The workaround with this problem was to create only a few spots where the effect was at its best and to attract the player's attention through other stimuli like visual signs, or audio.

After three months of development I and my team realized that something was missing, the idea of a storyline didn't come from the beginning, at first we were focused on building the main game mechanics and a couple of levels to test them on, I started to research other games with great stories like Bioshock³⁸, What remains of Edith Finch³⁹, The Last of Us⁴⁰ and Hellblade⁴¹, from which I extracted the essential elements and created a character sheet with a couple of ideas where the story should go, and what is the objective of this narrative. I contacted a writer to help me with the dialogue and another member has joined the team.

The game follows the story of a young artist trapped in a museum with her artworks in it trying to find the exit, as she ventures more and more into the gallery she discovers more about herself and what she loves so much about art, each painting reflecting a different part of her personality. The evolution of the character is in corresponding with the environment, the space around her deforms, and becomes more defragmented as she progresses through the game. In the end, she discovers that this was a journey through her subconscious mind, finding her own style and her love for art as well. Waking up as a different person and seeing the painting she loved the most form in front of her eyes.

One very important skill while researching a game is the ability to play it both as a first-time player and as a game designer as well, first, you need to be guided through the flow

³⁸ Video Game 2007, developed and published by 2K

³⁹ Video Game 2017, developed by Giant Sparrow, published by Annapurna Interactive

⁴⁰ Video Game 2019, developed by Naughty Dog published by Sony Computer Entertainment

⁴¹ Video Game 2017, developed and published by Ninja Theory

of the game, and upon closer inspection, you should do a breakdown of what elements comprise the game and makes it great in what it is.

Once an art direction is set this must be kept uniform through the entirety of the game. In my case, the reference for the gallery has been modern architectural spaces, elements from real-life give the whole experience a sense of believing and once this direction is assumed it can be broken, in my case the style of realistic galleries only exist in the first part of the game, and from there on each space becomes more abstract and unbelievable in its nature.

The sound of my game is composed from different layers, it contains ambiance, music folly, and voice over assembled in a manner that creates and delivers the story and other environment feedback to the player.

3.2 Game Design

The design process started with one idea, how can I expand the understanding and perception of players in order to create and influence their learning process of reality. The first time when I realized what an important learning tool can interactive applications and games can be was when I struggled to understand four dimensions in mathematics, being human and constrained by our three-dimensional world, the abstraction of higher dimensions can be a difficult task to comprehend. Once I played 4D Toys⁴² in VR things became much clearer, I understood that like a 3d object that intersects a 2D plane is only a slice in time and is visualized as a circle the same happens with 4D objects that pass through the three dimensional world in time.

From this concept of learning, I started the research process of impossible objects where I first found paintings of M.C.Escher and R.Penrose which were intrigued and inspired by the creation of these objects, analyzing the drawings, sketches, and reading about each one of their creative processes. The next step in the research was to find games, test them and use them as a source of inspiration when I create the mechanics and art style, some of the games used for research are analyzed in-depth in chapter II, along with them games like Superliminial⁴³ for its aesthetic and color pallet, What remains of Edith Finch⁴⁴ for an unbelievable well-constructed

⁴² Video game 2017 developed and published by MTB Design Works, Inc.

⁴³ Video game 2019 developed and published by Pillow Castle

⁴⁴ What remains of Edith Finch 2017 developed by Giant Sparrow, published by Annapurna Interactive

storyline and Monument Valley⁴⁵ for an Escher inspired isometric puzzle game with captivating puzzles.

From the research phase I devised a series of key mechanics that would translate the game's ambitions into gameplay, the gravity change mechanic was chosen in order to allow the user the freedom to see the levels from different perspectives, or in other words, I used one of the limitations (the one-point perspective) and used it to my advantage, in this way the player can find interesting and different creative ways to find solutions to the given puzzles.

The game puzzles aren't the conventional puzzles they are shaped more like mazes arranged in different and unpredictable ways, the key concepts of puzzle making have been taken into consideration in the making of each level, and as a result of this the complexity varies, and the difficulty curve is balanced through the level design itself, meaning that in order not to frustrate the player, an arbitrary scale from 1 to 5 has been devised in order to keep track of each difficulty level in particular. The aim is that after her difficulty level 5 a level 3 of difficulty will be next in order not to overwhelm the player but not to lose his interest as well.

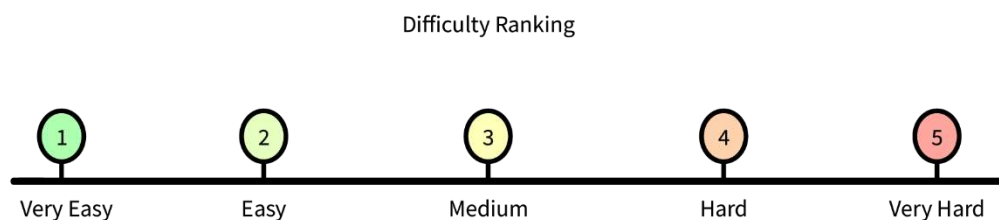


Figure 12 Difficulty Ranking, personal illustration

Another way in which the frustration is kept down is by the calm space in which you are at the moment, in an art gallery with peaceful paintings and relaxing ambient sound the brain embraces the state of calm. At other points in order to create a state of alertness heavy industrial noises and dark music is used to increase the attention of the player.

The difficulty of the entire game is controlled by the difficulty curve this details at what moment the difficulty rises goes down or stays the same, in some games this changes according to the player's gameplay, in my game the difficulty curve is closely related with the story, meaning that the game starts slowly and as we discover more about our main character, the puzzles become harder, diving deep into the unconscious mind where things are intertwined it is harder to understand and conceive the difficulty in the architecture of the levels.

⁴⁵ Video game 2014 developed and published by Ustwo Games

After the Climax the difficulty decreases gradually in order to give the player time to retrospect on what has happened, the final part of the game is mainly story with the player wondering through the mazes with not too much effort, the design starts to resemble an art

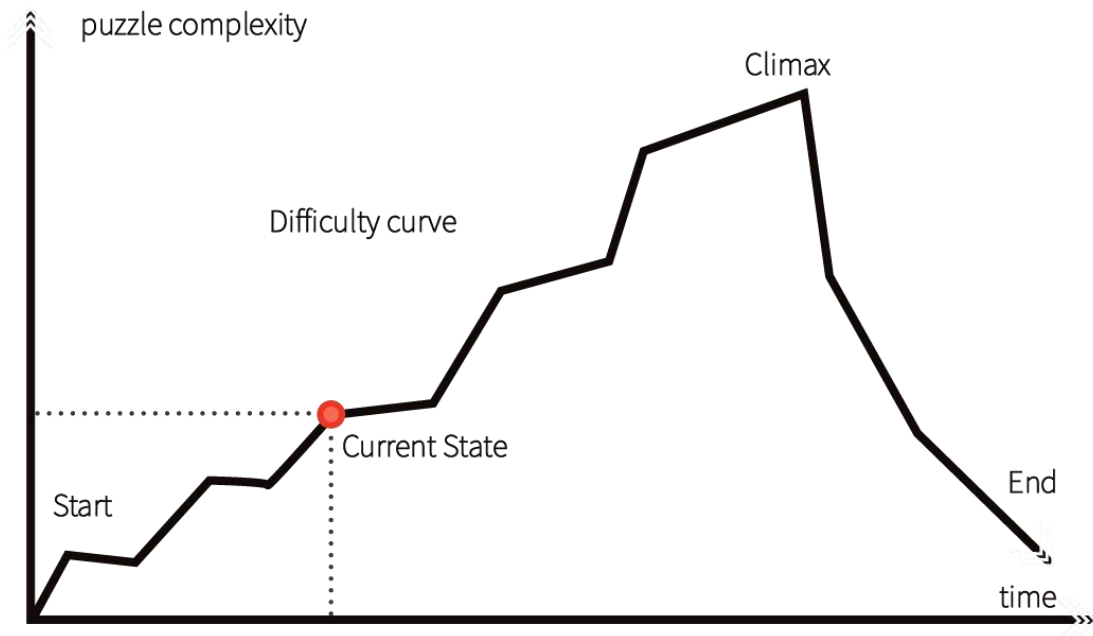


Figure 14 Difficulty Curve, personal illustration

gallery again, similar to how it was at the start of the game and in the end she wakes up in the museum with a painting in front of her with her name on it. The red dot represents the current state of the game, it represents the five levels that have been created until this time and gives a representation of where the development is going in the future. Level list:



Figure 13 Galerist Level 1

1

Level 1(Figure14) this level is the tutorial level here the player is presented with the ground floor of the gallery, paintings can be seen in each room from this level, a skylight fills

the room with light as the player wonders around and a few lines of dialogue expressing confusion are transmitted to the player, he reaches an upside down door and a writing on the wall in which the main mechanic is presented, gravity change, he must use this mechanic in order to advance to the second level.

1

Level 2(Figure15) going up on a flight of stairs the player reaches the second level here he finds sketches and woodcuts made by Escher, the light changes to a warmer tone representing the passing of time and embracing the new atmosphere, now the player is stuck in a loop going in circles he can't find a way out, in order to exit he must hear the wind which comes from behind a painting, on closer inspection the painting leads him to level 3.



Figure 15 Galerist Level 2

2

Level 3(Figure16) in this level the player finds himself in front of a jigsaw puzzle with the pieces all ordered in the wrong way, by pressing “E” he can rotate the pieces in the correct order. The painting resembles a lot of stairs seen from within, if the player solves the puzzle the painting fades away and he enters the next part of this

level where he finds himself on a cluster of floating stairs that go both ways, going on one side of the stairs leads him somewhere while going on the other side may lead him

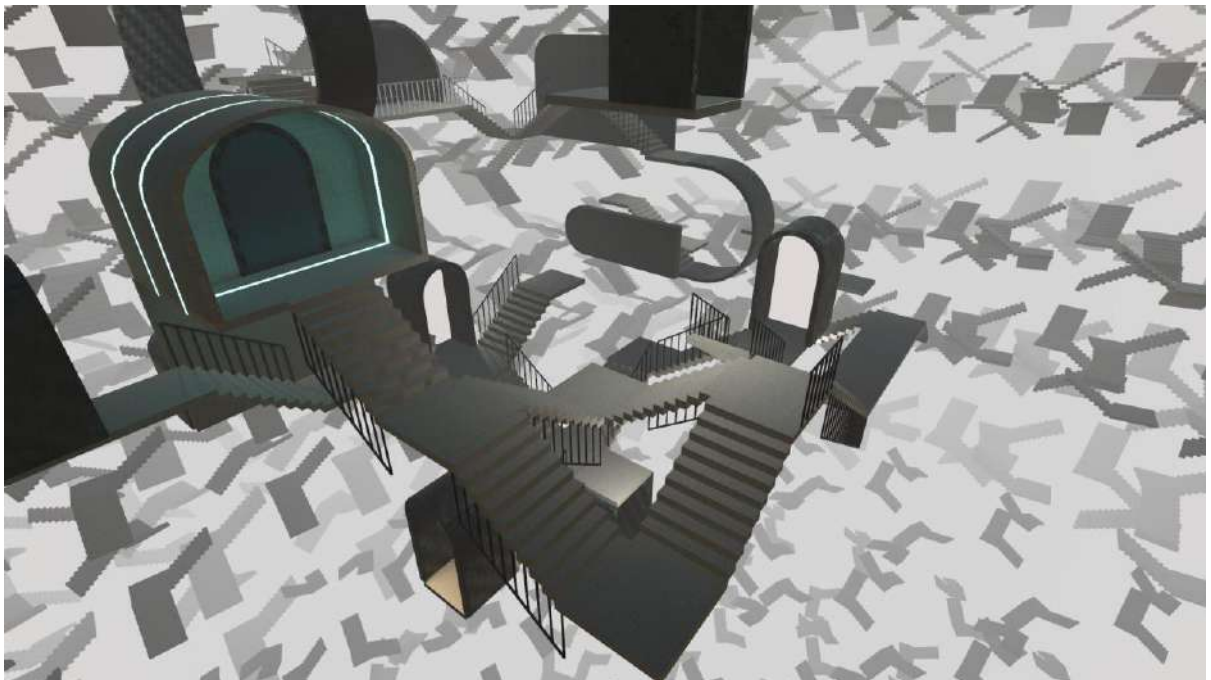


Figure 16 Galerist Level 3

to the exit. Everything has a white glow and bright intensity, making it difficult to find where the exit of this level is.

2

Level 4(Figure17) after reaching this level a small concrete room with tall ceilings and a structure that divides the room into two parts is found. A 15m painting, resembling metamorphosis (a type of painting in which different forms are created and



Figure 17 Galerist Level 4

the medium between this form is presented as evolution) is on the wall in front. On the concrete structure the words “Welcome to He” are presented and two letters appear that have fallen on the ground, in this room we only have lights only from spotlights, with no natural light. The player climbs on the structure and at the end, he finds a hole with a white spiral in it, by jumping through the spiral-like tunnel he reaches level 5.

3

Level 5(Figure18) after falling into this level the sound of rain and repeating music envelops the player a wooden structure built out of several platforms hangs by the walls suspended by steel wires, the exit is at the center of this platform. Red and orange fog mysterious floating pyramid sized shapes and glowing tubes that rise from the ground and through the walls create an unpleasant atmosphere for the player. Through his exploration he finishes the puzzle and finds itself to the credits.

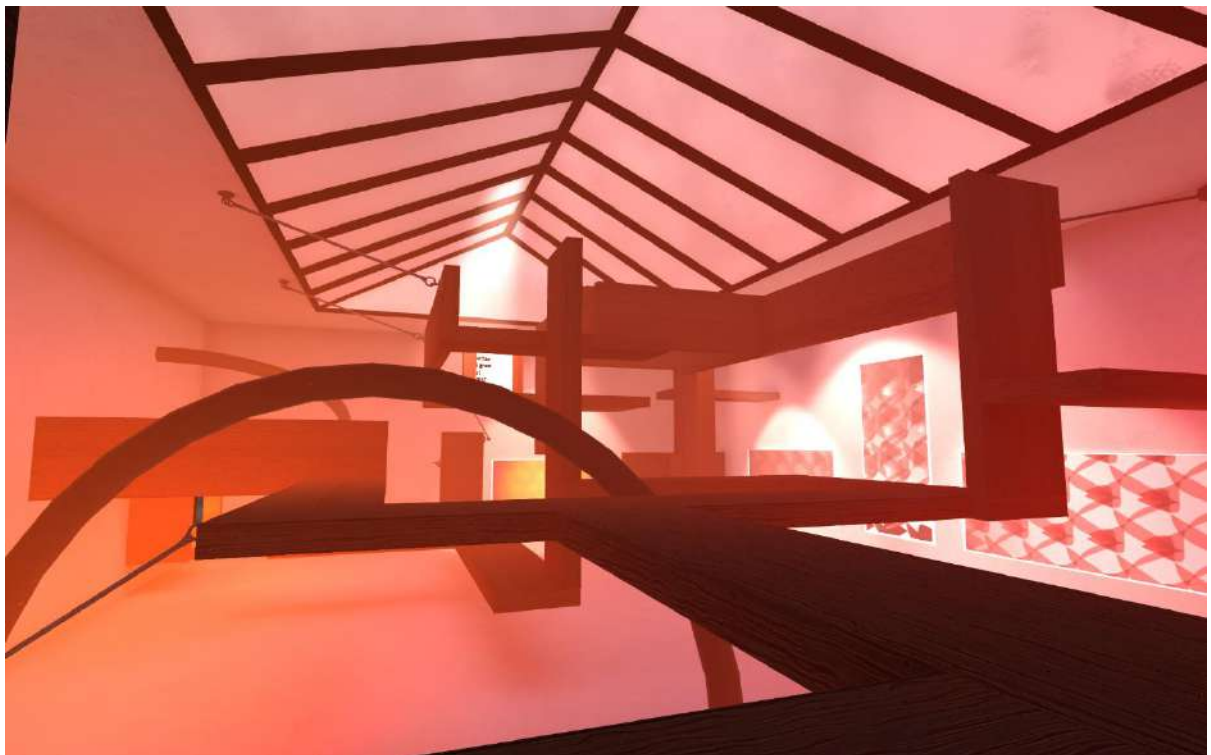


Figure 18 Galerist Level 5

These are the levels developed until this point, there is a plan to finish the rest of the game in the following year, and the engagement has been made from the wish and passion to finish this project (maybe irrelevant)

Iterative design has been a major part of dealing with such complex levels, this process allowed for more rigorous testing, and a hands-on approach on how each and every level feels independent and in conjuncture with the others. The first step in this process is to sketch a map of the level you want to create, after the sketch is finished a blockout (the rough shapes of the geometry are defined) of the level is created in the 3d modeling software, for example in the

case you have a staircase a simpler geometry can be used like a 45° plane can be used in order to simplify the modeling process.

All of these basic geometric shapes are then in the game engine and played around until a state of flow is reached and the level is cohesive at this point any other geometry that is added or removed should be created in the 3D application in order to exist a 1:1 representation of the current level scheme, this is a vital step in order to proceed to the next part. Each iteration of the level should be monitored and the measure of unit must be kept the same for the entirety of the project.

The next step is to create more detailed assets, as in the example from earlier, the stair now will have each individual stair shown as well as other railings or elements that are needed to achieve the intended visual aesthetic, the proportions must be the same with the one in de blockout, because in the earlier phase we took care to have the general proportions and physical locations of each object in our scene, the new assets can be created starting from those instances.

The final step of the process is importing the new geometry alongside with the UV layout, textures, and materials back into the game engine replacing the original ones. Again, the level is tested but furthermore from a visual point of view as well in order to correct any mistakes like UV stretch, flipped faces, or pieces of geometry overlapping one another.

The game loop of the game is represented by a sequence of actions completed in a sequence in order to advance to the next stage, it is a loop because the actions repeat themselves until the player decides to quit. The game loop of the game can be seen in the figure below (

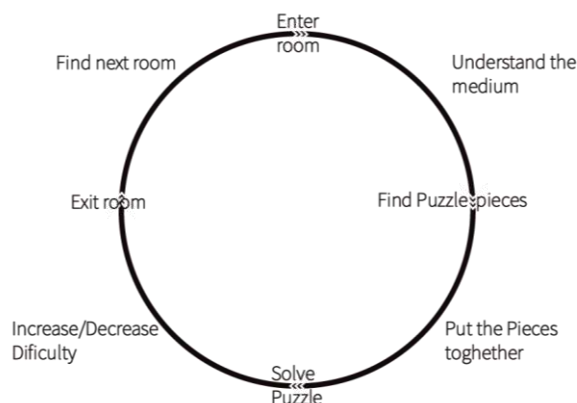


Figure 19 Game Loop, personal illustration

Each game loop is unique for every game.

For my game the loop follows, Figure12:

When the player enters a room, he must first observe all the different actions happening around him, the more attention he pays to these elements the clearer will be to complete the puzzle. After he understands the medium around him he can proceed to

finding the puzzle pieces in some cases they are more obvious than others but in others the pieces are harder to find, if he succeeds finding all the right pieces, he can concentrate on

finding the right order in which the actions need to be completed in order to solve the puzzle. Based on each player in particular, the difficulty will be subjectively increased or decreased based on the number of attempts and the time required for completion. For each level in the testing phase of the design process, a couple of players have been monitored to find a baseline for the complexity of each level, based on this data the level design has been changed accordingly and the location on where each level should be in the players progression has been decided. Upon exiting the room his duty is to find the next room where the loop begins again.

The sound design has been accomplished from the mix of different audio sources in order to achieve the right feeling for the game here the voiceover plays a very important part in revealing the story to the player, the screenwriter has devised a script in which fragments of the story independent from one another have been recorded, so as in order to keep the main branch of the story cohesive I placed in the environment the crucial segments of information where the player would certainly hear them, for example near the entrance of a room, near the exit, on corridors, at the same time leaving other less important facts in rooms where he can go but can miss them as well without affecting the main story.

Other elements like folly have been sourced from audio libraries, footsteps, falling sounds, interaction noises and much more have been integrated with the gameplay in a noninvasive manner, in order to give the player auditory feedback of his surrounding and his actions.

The music was developed by two composers from the team, the sound evolves and is placed in the level at crucial points in the players progression in order to amplify his emotions and is used either with the objective of relaxing or tensing up the user. Each sound is formed as a continuous loop so that no matter how much time the player spends in the room the music won't stop.

Ambiance sounds resembling wind, rainfall and museum sounds have been used to fill the space with life, the sound of a game is an essential part of the gameplay experience, this can encourage, enrage, frighten or even discourage the player's actions, a very powerful tool that when used properly can change the entire atmosphere of a game.

Game mechanics are the core of a game, however in order to fulfil the design of the game mechanics have to be chosen to sustain the goal of the game, in my game the mechanics have an important role in how the game flows and the interaction through this are key. I will present the following

- Player Movement: The user uses “W”, “A”, “S” and “D” keys to move forward backward left and right and progress through the game environment

- Gravity Change: “Spacebar” is used to change gravity from one surface to the other, allowing the player to see objects from a different perspective
- Object Interaction: Pressing the key “E” allows the player to interact with objects in the game world which have a highlight on them, in some cases the user triggers an animation, object rotation, position or story piece essential to the progression
- Portals: This is an invisible game mechanic which has the purpose to define space and time in order to create impossible rooms or situations meant to be used by the player in his advantage

All the game mechanics presented above play a key role in the design process, viewing them as building blocks to the player’s experience, overusing them or not using them at all can lead to unsatisfactory gameplay, the key is to balance all the game mechanics in order not to overwhelm the player with too much information, but not to make hi bored as well, the careful balance of the game mechanics is essential in order to achieve a state of flow in gameplay avoid frustration and unexpected circumstances.

A game designer cannot predict all the ways in which the players will use these mechanics and neither the players in some points, giving freedom to the player to experiment with the gameplay elements is a risky but rewarding experience. In order to simulate how the players will use the game’s mechanics, in the testing phase I watched the players behavior, realizing in some points that the some of the mechanics where overused while other weren’t used at all, in order to create a solution to this problem, I redesigned the levels in order to make use of one or two of the main mechanics, and in others removing the need to use those at all. For example, the gravity change mechanic is key to resolving two-thirds of the puzzles in the game, and also in some levels you can progress without the use of it at all, in the puzzle painting zone for example. In this way, I balanced the progression so that the player becomes familiar with all the tools he can use so that he can unleash his creativity and find unexpected solutions to the puzzles.

The puzzles don’t have only one right answer to them, there are at least three different cases in which the player can move to reach his destination, although with this in mind in the testing phase I have discovered more than twenty solutions to a puzzle which made me realize that it is very hard to predict what a human can do when he is forced to think outside of the box in order to solve a problem. From this experience has emerged another quantifiable unit for level difficulty (the number of solutions to a puzzle).

3.3 Game Development

The development process can be described as a collection of skills, plans, ideas, and passionate people working towards a common goal which in my case is a game. Design is only the first step in this long and complex process, in the chapter below I will describe in detail the development process of the video game as well as different techniques required for implementation, management, planning, and testing.

I have comprised a diagram that visually describes the development process applied

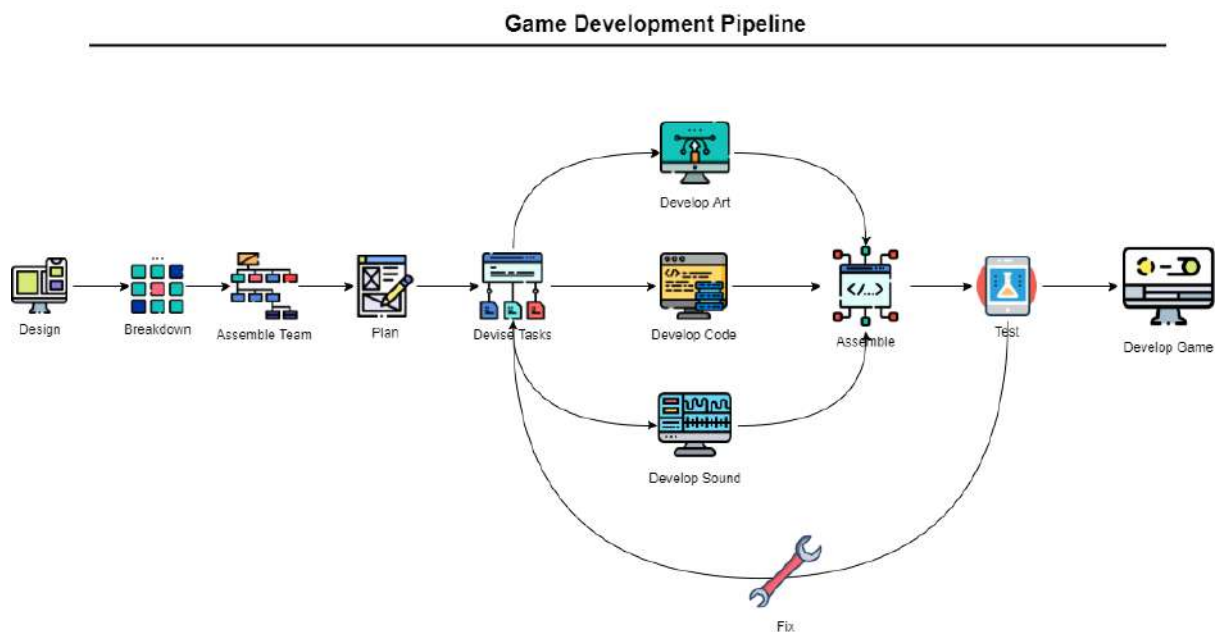


Figure 20 Development Pipeline, personal illustration

for my game.

Before anything can start a careful research and design must be put in place, the game design document is a powerful tool that if done right can optimize unnecessary work and clears the concept, it's goal is to serve as a guideline for all the team members in order to keep track of the game's core concepts, the more detailed it is the more easier it becomes to overcome the challenges that may come further in the development timeline.

The Breakdown of all components is essential for a better understanding of the scale the project has; the projects necessary has been devised into categories as follows:

Table 1 Game Assets

Graphic Assets	Visual Effects Assets	Code Assets	Sound Assets
Walls	Portal Shader	Player Movement	Ambiance
Stairs	Painting Shader Blend	Player Interaction	Footsteps
Railings	Fog	Gravity Change	Object interaction
Arch doors	Burn Shader	Portals	Fall
Doors	Prism Shader	Camera Movement	Dialogue
Windows	Glass	Player Respawn	Music
Paintings	Glow	Menu	
Menu	Volumetric Light	Object Glow	
Platforms		Sound Script	
Plants		Moving Platforms	
Bench		Object Spawn	

After the breakdown has been made, now the team can be chosen in order to finish all the assets in the proposed timeframe.

The GDD (Game Design Document) also served as a starting point in acquiring the team for this particular project. After a pitch involving two universities a team was formed, based on the breakdown developed at an earlier point, now the essential team members have been chosen based on their interest in the project, their skills, and past experiences with game development. In this case, a team formed from programmers, graphic artists, screenwriters, and sound designers was formed, in this project I played different roles in the development process in order to fill in the gaps where we couldn't find a team member or in consequence with the task at hand it would have become an inconvenience to find someone to do this. The game design document can be found in the Annex

After the team has been decided, careful planning of the project's timeline has been created in order to keep track with the objectives set in mind by each deadline.

Upon this point there have been two major deadlines:

- Game Prototype at this stage which had a timeframe of about three months the goal was to create a functional prototype in order to test the game mechanics and art style. In this stage we have completed the core mechanics of the game tested the game for bugs, which were a lot, and created three levels including the tutorial where the basic gameplay is thought to the player.

- Polishing the Mechanics and add more levels the goal of this deadline was to improve and polish the core mechanics developed in the Prototype phase, here we have improved stability, performance, and overall feel of the game, as well as adding another two levels to the game and credit's room.

All of the goals have been met upon the respected deadlines, for a more in-depth look at the project's timeline the Gantt chart can be found in Annex

The tasks have been created with each of the team members skills in mind, taking into account each one of their inclinations, some of them being more artistic and others with a better technical approach over things, the series of tasks have been centralized over "Trello" an online task management platform where you make cards with each task in particular, giving details about complexity, stages, adding images or files to these cards and in my case arranging them into three categories labeled: "To Do", "In Progress" and "Done".

Assigning the task and keeping the track of them has been done through Trello as well, being able to add team members to the cards has been very helpful in the moments where for example a programmer and an artist had to implement the graphic for the User Interface in the main menu, for this particular task there was a need for a 2d artist to make each icon and a programmer to implement the functionality of the buttons. After this task was done It will be tested in-game and if the result was satisfactory, I would move it in the Done column and move next to another task, this approach gave me real feedback in what each of the team members was working on and how much time it would take.

After the tasks have been assigned the development cycle of creating, implementing, and testing began, for each mechanic, sound, and visual asset created for the game, has gone through this cycle.

Art Development:

In the development process of the game art we had different types of graphic assets divided in the following categories:

- 2D Art: Here we can include the Paintings, Textures and Menu Interface
- 3D Art: Representing the environment in which the player can explore we had to construct Walls, Arches, Stairs, Windows, and other enticement objects
- Custom Shaders: This category represents materials that have incorporated in them mathematical functions that make the engine perceive them in a different way for example, Glass Windows, Translucent prisms, water and fire

- Visual Effects: Created with particle systems these are emitters that spawn 2D textures in order to create various visual simulations like dust, fog, and volumetric lighting

The 2D art has been created using software like Adobe Photoshop and Illustrator for creating bitmap and vector images that had been used in the game

The 3D art has been created in Autodesk 3Ds Max the base geometry and UV (the coordinates where the texture sits on the geometry) and after that has been taken into Substance Painter to draw the textures on the 3D object.

The custom shaders have been realized in Unity's ShaderGraph, here I created the base material for the paintings which combines the painting texture with the canvas texture in order to create the illusion that the paintings are drawn on canvas, or cardboard or paper, through this technique I can recreate different painting styles. The glass shader that can be seen through the skylights in almost every room in the game uses a 360 capture of a real outdoor space and has a parallax effect to simulate depth based on the player's position. The prism uses a refraction index, linked with a reflection probe inside the engine to reflect the space around it and deform it based on the color of the base texture. The charcoal burning effect has its emission property animated to glow in and out, and the vegetation shader uses two-sided render on the object's faces.

Visual Effects have been created with the help of Unity's Shuriken Particle system using 2D textures in order to create various composite effects like fog, mist or even volumetric light these textures based on a set of parameters can resemble almost anything, using this modular approach means that with the same texture I can further create a variety of different visual effects.

All the assets above have been integrated into unity to be tested and reviewed, the exports have been chosen based on compatibility and information that the respective containers can hold. For 2D textures, I used PNG files in order to have an alpha channel where it was needed and for 3D files, I used FBX to export because this format keeps the material information and I can easily make modification to the base mesh which the engine remembers the assigned materials and I don't need to reapply them again.

A mix of static and realtime lights has been used to illuminate the levels. Static Lightmaps have been generated once all the assets didn't suffer any more modifications meaning that once an object is static the engine traces the light and shadow information into a texture that after it applies it over the original texture of the geometry reducing this way the number of calculations for each light ray and improving performance. This technique does

not apply for moving objects, wherein the case of a moving platform for example mixed lighting was used so that all the objects in the range of the light source that would move will be affected by realtime lighting and those which were static would instead use a lightmap.

The lighting process requires many iterations, each scene having its particularities where each individual light source must be adjusted in order to achieve the desired effect, also the light baking for my game took around 30-50 minutes calculated on the GPU and another 20-30 minutes to write that information on the geometry.

Code Development:

To create the necessary flow of the game the main mechanics had to be coded and tested for functionality in the game engine as well as the compatibility between them.

Gravity Change We went through different options and prototyping each and one of them, at first, we tested rigidbody and character controller. We used rigidbody because it was the only feasible way to implement it. A script was created in order to switch between the players normal and the one on the object you change gravity to, this action happens while pressing “Spacebar”. The next step was to check what surface is under the player and automatically change the normal of the player accordingly with the surface he stands on, this gave us the ability to use convex surfaces like spheres and pipes and allow to move on them freely. We also created a script on certain objects that doesn’t copy the normal in order to restrain the surface on which the player can walk, especially on stairs so that he could walk on them straight.

Our portals use a camera that renders what the player sees from portal A to the point where portal B is placed, basically, there are two cameras that each move how the player moves. They use a custom shader that is placed on the plane that acts as a portal it uses a render texture in order to project on the plane of portal A what camera B sees, it also contains a script that doesn’t render some objects with a certain tag, the portal frame for example.

Upon entering the portal collider, A, the script creates a clone of the player at portal B and instantaneously switches between them after crossing the portal A threshold making the crossing of portals seem seamless. After the player exits the collider of Portal B both the player and camera clone are destroyed in order to improve performance.

Player Interaction is resolved by using two scripts, one that sits on the player and gives the information that while pressing E an interaction is supposed to happen and the other sits on an object with a certain tag allowing the player to interact with that object, in the case of one painting which consists in a jigsaw puzzle the script on that object verifies if each of

the puzzle pieces is in the correct order if done correctly the script destroys that game object and allows the player to advance to the next level

Movement we used a classic control scheme of WASD to move the character forward, backward, and side to side through the environment using the local coordinate system and the forward direction of the player coincides with the camera. On platforms, the player is transported from one point to the other with a script that copies the transform of the object to the player.

We used a first-person camera attached to the player component as a child, this allows the camera to follow the direction in which the player is going and also dictates the forward movement of the player. The Main Camera suffered many modifications in order to accommodate the constant change of gravity and its variables. We ended up using a custom transform which uses the input received from the player character but interprets them in a different way.

For the Player Respawn we used triggers boxes placed at the edge of the level to keep the player from going out of bounds when a trigger is in contact with the player's collider it teleports him to a center point in the level and resets all variables to the normal in order to prevent him gaining mobility and ending up in an infinite fall.

Object Glow using a recast to find an object with a certain tag, if the ray hits the target than we apply a custom glow shader on the object.

Sound Script uses colliders to play sound and after exiting the collider the object is destroyed.

Object Spawn is used to spawn or despawn certain objects in the scene, after triggering a mesh collider the script spawns the object in place, we used this script extensively for optimization purposes, knowing that after a certain threshold the player couldn't go back we would despawn the level behind him and spawn the one in front of him in order to improve performance.

Sound Development:

The sound design of the game has many layers, each one of them has been created accordingly to their usage.

The music has been composed by the two sound designers from the team, the music has a crescendo advancing once with the player and creating a feeling of calm at start and distress through the end. It was recorded digitally in Ableton with a guitar and organ as midi input devices.

After our screenwriter finished the script, we went with the voice actor to a recording studio in order to record the voice over of our main character. The sound has been captured as a mono track and later on trimmed and mastered in Adobe Audition and exported as individual wav files each containing one paragraph of speech. In the game Ellie, the main character has a dialogue between her and her own consciousness, I recorded the same actor with both parts of the dialogue and mastered them individually based on the character that was speaking the script can be found in the Annex.

Foley sounds, Ambiances, and other SFX have been sourced out of audio libraries.

With all the sound assets centralized in the unity project I used different techniques to replay these sounds, the Ambiance and Music use the collision of the player in order to playback the sounds. The voiceover has been triggered as well at key moments in the gameplay. A different script was used to play the footsteps, which have been devised into two arrays one for the left foot and one for the right, choosing at each step a combination with one from each with a random pitch variation between 0.9 and 1.1 in order to create variation.

The sound design has been carefully crafted with the progression of the player in mind.

Once all the visual, auditory, and programming assets at hand I started implementing all of them together in a complete build. The levels of the game have been constructed in stages, with the condition that we will move on to the next stage if the one we worked on was finished. In this way, by the end of the project's deadline, five levels were completed with another 10 in plan for further development.

All assets have gone through the assembly stage which happened in the engine once an asset was ready, for example, the pipeline for one painting would go this way: Once the 3D model of the paintings frame will be finished and the 2D texture as well, they would be imported into the engine where one custom material is used to apply the texture on it. Once the 3D object is imported it is dragged into the scene and the rotation, scale, and position of the object and pivot point are checked, if every one of these variable match the ones in the project the material is applied to the painting frame and check if the UV's have any stretches and if the UV tile is correct. Next, this object is made as a prefab so I can easily instantiate it at a later time and only modify one variable and change the image inside the painting. The prefab is placed in the level and I test it while playing to see if it has any errors. At this time if there are no errors the object is marked as done and I can move to the next one.

IV Testing and Conclusions

Testing has been realized by my team in the development stages and after each major build, I gave the game to some friends, colleagues, and teachers in order to gather feedback and improve the game through this method.

Based on the feedback gathered from the last build I centralized the answers and created the following statistic:

On a test group with 11 people, the majority of 72.8% of them were 23 and 24 years old, coinciding with my target audience, the rest of 27.2% were 22, 26, and respectively 29 years old.

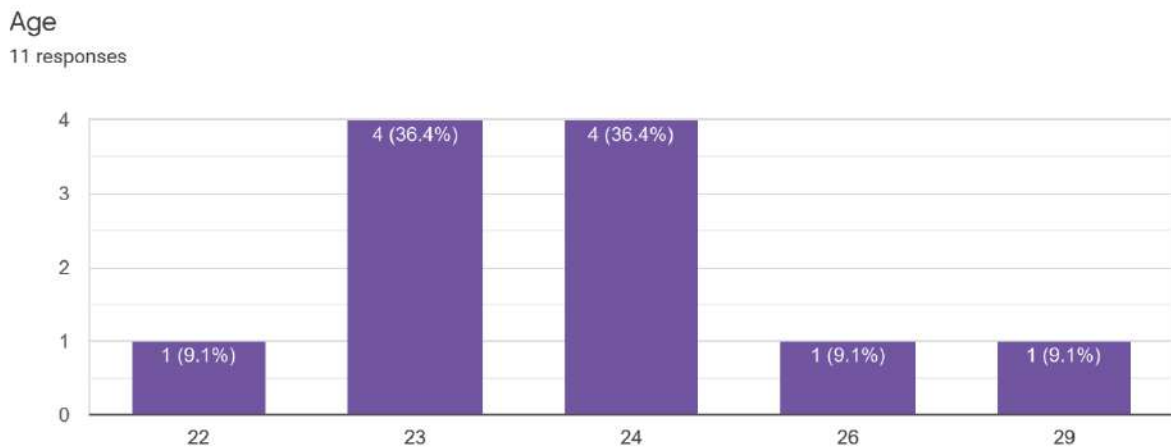


Figure 21 Age Group

From a scale of 1 through 5, 1 representing not understanding games at all and 5 representing understanding them very well, the majority of 72.7% were well acquainted with the concept of video games 9.1% pretty well and 18.2% medium, as a conclusion the

audience was knowledgeable enough in order to give helpful feedback.

How well are you acquainted with video games

11 responses

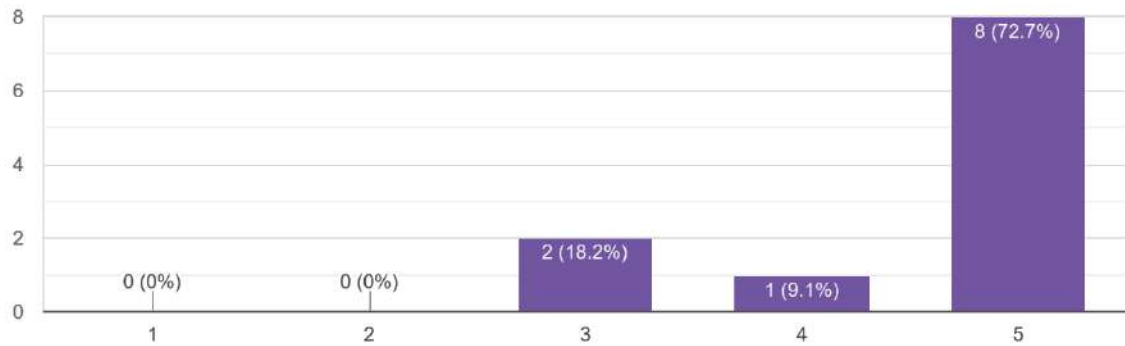


Figure 22 Video Game Knowledge

From the 11 test subjects all of them have enjoyed the puzzles in the game.

Did you enjoy the puzzles in the game?

11 responses

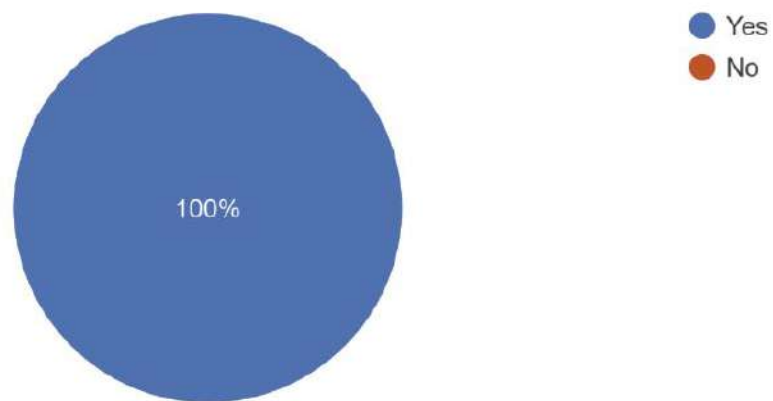


Figure 23 Puzzles in game

The majority representing 81.8% of the people understood all the game mechanics with 18.2% of them which had partially understood them, for this case the game seemed harder.

Did you understand the game mechanics?

11 responses

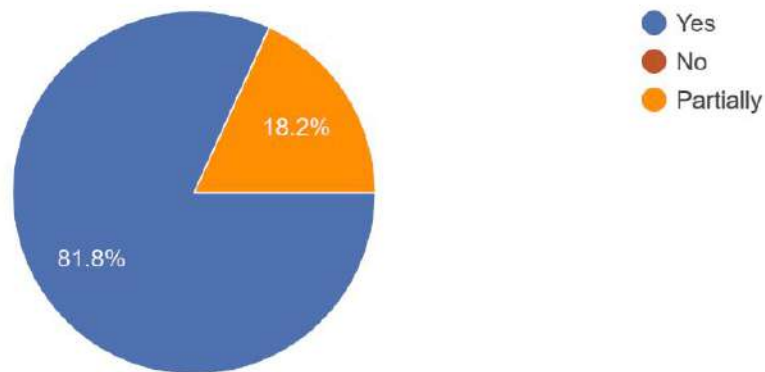


Figure 24 Game Mechanics

All of the participants in the study wanted to play more of the game. Meaning that they were imprisoned by the concept, idea, and gameplay.

Will you like to play more of it?

11 responses

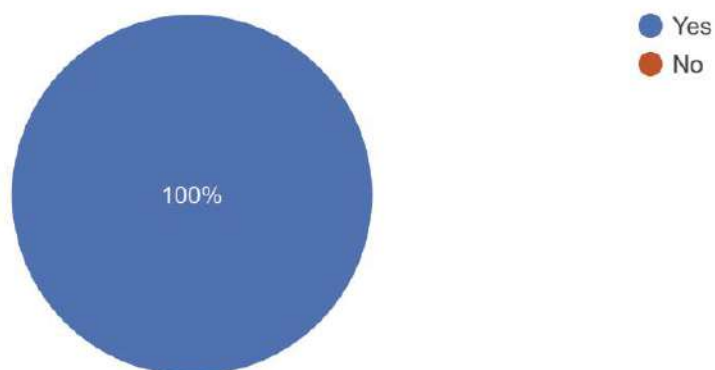


Figure 25 Play More?

Table 2 Game Fell

NR	WHAT FEELING DID YOU HAVE AT THE START OF THE GAME?	WHAT FEELING DID YOU HAVE AT THE END OF THE GAME?
1	Neutral	Frustration
2	Caught between reality and daydream of a gallery	A little bit of frustration and release
3	Neutral	Exited
4	Fear	More fear
5	Curious and challenged	Victorious
6	Exploration	Completion.
7	Not sure	Good, that I managed to finish it.
8	Pettiness	Exaltedness
9	Indifferent	Anxiousness
10	Excitement	A feeling of accomplishment
11	A good sense of adventure	Intrigued

The main goal with these questions where to see if the game had an impact on the player's state, from the beginning of the game to the end. The statistic showed that at the beginning players had various types of emotion ranging from positive ones, to neutral and negative. By the end of the game, all of the participants had had a change in how they were feeling, some of them went from neutral to positive, others from negative to more negative emotions while others went from negative to positive emotions. 54.55% of them had a fulfillment after finishing the game.

On a closer review of each player's responses, a correlation has been found between the complete understanding of game mechanics and frustration in the end. Meaning that the ones who better understood the mechanics enjoyed the game more.

The feedback was very useful in creating an experience everyone can understand, based on the answers I made design modifications and created a more user-friendly experience, sometimes you can't see everything that is in front of you and a simple questionnaire can be a powerful tool for game design.

Also testing it on various devices gave feedback in optimization and minimum requirements for the game to run at an optimal framerate

After all the testing and improvements have been completed, the game is ready for the next stage in which I need to publish it, create a marketing plan, localization, community engagement, platform distribution, and other elements that can improve the overall sales of the game.

Conclusions

In the thesis Expanding human perception through puzzles in video games, by reviewing books, scientific articles, games, and internet databases I created a video game that followed the premise How can we design a game that can change the player's visual perspective? To achieve this I incorporated game mechanics, optical illusions, and impossible objects in the game environment under the form of puzzles that the player can solve by exploring the maze-like levels.

By developing this game, I came to the following conclusions:

- A game is formed from rules, a system, they wish to interact with it and extend this in a pleasurable activity to us.
- Goals are a big part of games. Creating a challenge for the player is vital, in order to engage him with the game a clear goal and a way to solve this goal must be provided.
- When teaching a new mechanic to a player a repetition must occur in order to make the player understand completely.
- Form follows function.
- A puzzle is a mental challenge that makes you stop and think.
- Perception is the top-down way where our brains organize and interpret that information and put it into context.
- In order to create a believable 3D space characteristics like depth, distance, lighting, and proportions must be taken into account in order to immerse the player.
- One very important skill while researching a game is the ability to play it both as a first time player and as a game designer as well.
- Once an art direction is set this must be kept uniform through the entirety of the game.
- The difficulty of the entire game is controlled by the difficulty curve.
- Game mechanics are the core of a game, however, in order to fulfill the design of the game, mechanics have to be chosen to sustain the goal of the game.

- A game designer cannot predict all the ways in which the players will use these mechanics and neither the players in some points, giving freedom to the player to experiment with the gameplay elements is a risky but rewarding experience
- The development process can be described as a collection of skills, plans, ideas, and passionate people working towards a common goal.
- To create the necessary flow of the game the main mechanics had to be coded and tested for functionality in the game engine as well as the compatibility between them.
- The sound design has been carefully crafted with the progression of the player in mind.

The conclusions I have reached based on the research and game development process, have formed a more in-depth idea of how a puzzle game should be created. By keeping the flow and progression of the player in mind, introducing him into a virtual game world, that generates emotion, and playful experience. In order to achieve his goal, the game must communicate the necessary tools he can use through the medium of game mechanics, storytelling, and interaction.

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Annex

Game Design Document



Revision: 2.0.0

GDD Written by: Păun Andrei

Overview

Theme / Setting / Genre

- Narrative First Person Puzzle Game,

Core Gameplay Mechanics

- Gravity Change
- Object Interaction
- Portal Teleportation

Targeted platforms

- Steam VR
- PlayStation VR

Monetization model

- Premium paid 29\$

Project Scope

- Game Time Scale
 - Cost - None
- Development time 2 Years
- Team Size
 - Core Team
 - Andrei Păun
 - Technical Artist, Game Designer, Level Designer
 - Part Time
 - Dani Cezat
 - Programmer, Game Designer
 - Part Time
 - Monica Pascu
 - Screenwriter
 - Part Time
 - Florin Voicu
 - Programmer

- Part Time
- Sergiu Agachi
 - Programmer
 - Part Time
- Ana Buretea
 - 2D Artist
 - Part Time
- Nicolae Prodromou
 - Composer, Sound Designer
 - Part Time
- Ionuț Crava
 - Composer, Sound Designer
 - Part Time

- Student Licenses, No other Costs

Influences

- Escher's Art
 - I was inspired by Escher's optical illusions and wanted to explore the three dimensional aspect of them
- Antichamber
 - This was a huge influence in the game's genre. The intriguing well designed puzzles made me
- Manifold Garden
 - Art Style and Gravity change mechanic are great ways in which I intend to explore

The elevator Pitch

Narrative first person puzzle game inspired by Escher's illusions, aiming to place the player in a VR environment, full of mind-bending challenges intriguing puzzles following the story of a young artist redefining her style.

Project Description

Galerist is a narrative puzzle game in which a young artist seeks to overcome her fears and anxieties, in a dreamlike space filled with illusions to be solved.

The use of clever game mechanics and well thought level design recreates the feeling found in Escher's most famous paintings.

The project aims to create a game with the idea of collaboration in mind, in order to complete the task at hand a team was constructed with members from two universities.

Our goal is to develop and release a game in two years and experience the whole development process from concept to practice.

What sets this project apart?

- The puzzles
- Art Style
- Sound Design
- Concept

Core Gameplay Mechanics

- Gravity Change
 - Gravity change gives the player the ability to change the surface on which he walks
 - Approach a wall, press "Spacebar" and you will have your gravity changed to the wall, and can walk on it.
- Object Interaction
 - Object interaction gives you the ability to change the object's state, or gravity
 - Approach an object press "E" and change his properties
- Portal Teleportation
 - This is a passive mechanic, used in order to teleport the player to another point on the map
 - It is used to create impossible spaces like rooms inside walls that are only accessible from one side

Story and Gameplay

Story

A young artist with depression and a lot of self-doubt, tries to overcome her frustrations and anxieties, discovering more about herself, art style and why she is trapped in this place inside of her mind. As she emerges more and more in her subconscious mind the space and logic of reality fade away, she becomes more in touch with her inner self and manages to find peace and realizes why she loves art so much.

The story unfolds in a non linear manner, the Narrator (Ellie) reveals her thoughts and weaknesses as he discovers the space around her.

Script (A few Inserts)

Ellie: I've seen enough,

I have to go right now

I have a lot of work to do

Where's the exit door, or just the exit

Consciousness: Ha, what about going left, something seems to be over there.

C: Escher refused to paint the cover of Rolling Stones

E: Call me Ellie, please

E: Here lies the painting, which we first contradicted

This painting should not have been here, Stupid painting!

C: Doomed to walk up a flight of stairs forever

Doomed to be part of a tessellated... Forever

C: Look closely at the painting

He's constructing a world of chaos

It should look like your mind

E: This isn't my mind

In my mind are dreams, and my beloved muse and friends

And I'm surrounded in love not in pain

Gameplay

You play as Ellie, wandering through a gallery, your goal is to find a way out while at the same time, yourself, you move from room to room, each one getting harder to enter until one point where everything kind of makes sense.

In this journey of yours, you will encounter mind twisting puzzles, impossible objects and beautiful paintings some that even have a secret meaning inside them. The voiceover completes the actions you are making alongside the changing music depending on the atmosphere with peaceful ambience in the background.

You use “W, A, S, D” to move, change the gravity with “Spacebar” and interact with other objects by pressing “E”

Assets Needed

- 2D

- Textures

- Concrete, Flooring (Marble, Tiles), Paintings, Glass, Skybox

- 3D

- Environmental Art Lists

- Walls, Ceiling, Skylights
- Props, Lamps, Frames,
- Stairs, Railings, Impossible Objects.

- Sound

- Sound List Ambient

- Outside

- Factory
- Port
- Forest
- Rain Fall

- Inside

- Gallery
- Waterfall

- Murmuring voices
 - Wind
- Sound List Player
 - Character Movement
 - Steps
 - Interaction Sound
 - Door Opening
 - Voiceover
 - Studio Recording
 - In game Integration
- Code
 - Character Scripts (Player Pawn/Player Controller)
 - Player Movement
 - Gravity Change
 - Moving Player with platform
 - Stair Movement
 - Object interaction
 - Ambient Scripts (Runs in the background)
 - Object Spawn / Despawn
 - Sound Loop Script
 - Main Menu and Loading screen
 - Object Rotating
 - Occlusion Optimization Script
 - Object Glow Interact
 - Footstep Script
- Animation
 - Environment Animations
 - Stairs Moving

- Platforms Rising
- Round Spheres Moving on wall
- Prisms Rotating

Schedule

- Implement Mechanics
 - One month
 - Implement Gravity Change
 - Implement Object Interaction
 - Merge the two mechanics
- Create Environment First 3 Levels
 - Three Weeks
 - Create first region
 - Create second region
 - Create third region
 - Merge the regions
- Finish Tutorial Level, Lv1, Lv2
 - Two Weeks
 - Merge all Sublevels
 - Debug
- Test and Polish
- Refine Mechanics
 - Two Months
 - Improve Gravity Change
 - Remake Portals
- Test and Polish
- Create Environment Next 2 Levels
 - One Month
 - Create region 4
 - Create region 5
- Merge All Regions
- Shading
 - Two Weeks
 - Create Master Shader

- Apply Materials on all Geometry Surfaces
- Bug Testing
 - Two Weeks
 - Debug Stairs
 - Debug Gravity + Portals
- Debug Occlusion
- Lighting
 - One Week
 - Create Environment lights
 - Create Ambient Lights
 - Bake Lighting
- Final Build
 - One Week
 - Make last Tweaks
 - Build Game

Gantt Chart Galerist

Paun Andrei

Project Start Date:

11/10/2019

Legend:

On Track

Low Risk

Med Risk

High Risk

Milestone Description	Category	Assigned To	Progress	Start	No. Days
Crearea Echipei Pentru Proiect	On Track	All	100%	11/10/2019	1
Stabilirea rolurilor Echipei	On Track	Paun	100%	11/15/2019	1
Definire Mecanic si Gameplay	On Track	All	100%	11/17/2019	1
Crearea Proiectului si Revision	On Track	Sergiu	100%	11/19/2019	2
Definirea Stilului Artistic	On Track	Ana	100%	11/14/2019	10
Implementarea Schimbare Gratuite	High Risk	Sergiu, Dani, Florin	100%	11/21/2019	5
Construcția Primului Puzzle	Low Risk	Paun	100%	11/26/2019	4
Crearea Asset Primul Puzzle	Med Risk	Paun, Ana	100%	11/25/2019	7
Asamblarea Primului Puzzle	Low Risk	Paun	100%	12/2/2019	2
Testarea	Med Risk	All	100%	12/4/2019	3
Rezolvarea Bugurilor și Minor Tweaks	High Risk	Sergiu, Dani, Florin	100%	12/4/2019	4
Finalizarea Primului Puzzle	On Track	All	100%	12/8/2019	1
Implementarea Portalilor	High Risk	Sergiu, Dani, Florin	100%	12/10/2019	5
Construcția Puzzle II	Low Risk	Paun	100%	12/15/2019	4
Crearea Asset Puzzle II	Med Risk	Paun, Ana	100%	12/12/2019	7
Asamblarea Puzzle II	On Track	Paun	100%	1/10/2020	2
Testarea	On Track	All	100%	1/12/2020	3
Rezolvarea Bugurilor și Minor Tweaks	High Risk	Sergiu, Dani, Florin	100%	1/14/2020	4
Merge puzzles	On Track	Paun	100%	1/18/2020	3
Finalizarea Prototipului	On Track	All	100%	1/21/2020	1
Testarea	Med Risk	All	100%	1/21/2020	4
Balansarea	High Risk	Sergiu, Dani, Florin, Paun	100%	1/25/2020	3
Rezolvarea Bugurilor și Minor Tweaks	Med Risk	Sergiu, Dani, Florin	100%	1/28/2020	2
Definirea Ultimatarilor Nivele	Med Risk	Paun	100%	2/14/2020	1
Arbitrarea Taskurilor	Low Risk	Paun	100%	2/15/2020	2
Construcția Puzzle III	Low Risk	Paun	100%	2/17/2020	4
Crearea Asset Puzzle III	Med Risk	Paun	100%	2/21/2020	10
Asamblarea Puzzle III	High Risk	Paun	100%	3/2/2020	2
Testarea	Med Risk	Paun, Dani	100%	3/4/2020	3
Refacerea Portalilor	High Risk	Dani	100%	2/24/2020	14
Rezolvarea Bugurilor cu Gravitația	High Risk	Dani	100%	3/9/2020	8
Balansarea	Med Risk	Paun, Dani	100%	3/17/2020	4
Construcția Puzzle IV	Low Risk	Paun	100%	3/19/2020	3
Crearea Asset Puzzle IV	Med Risk	Paun	100%	3/21/2020	8
Asamblarea Puzzle IV	Med Risk	Paun	100%	3/31/2020	2
Merge All Puzzles	High Risk	Paun, Dani	100%	4/2/2020	4
Testarea	Low Risk	Paun, Dani	100%	4/6/2020	10
Optimizarea Jocului	High Risk	Paun	100%	4/16/2020	8
Bake Lumina	High Risk	Paun	100%	4/24/2020	6
Finalizarea Jocului	High Risk	Paun, Dani	100%	4/30/2020	8

