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Science4Pandemics Serious Game Design

Scene Modeling and Generative Visual Experiments in the S4P Game Context

Dissertation in the context of the Master in Design and Multimedia, advised by Professor Licínio Roque and presented to the Department of Informatics Engineering of the Faculty of Sciences and Technology of the University of Coimbra.

July of 2023

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July 2023

Acknowledgements

To my family, especially my parents, who taught me that hard work is the key to success and for supporting me. To my friends, who were there to help me through this journey and the difficulties that it offered. And finally, to all professors, especially to my adviser, Professor Licínio Roque, who taught me, gave guidance and encouragement through this project. This work was partially funded by the Science4Pandemics project from EITHealth, and by the FCT - Foundation for Science and Technology, I.P./MCTES through national funds (PIDDAC), within the scope of CISUC R&D Unit - UIDB/00326/2020 or project code UIDP/00326/2020.

Thank you all.

Abstract

The use of generative methods and tools are growing in popularity and use in many different fields, these techniques can bring a variety of benefits to the game design and development, allowing game's to be created faster, benefiting both their players and their creators. Our goal in this dissertation is to study and use different generative techniques to visually alter aspects inside a game, which in turn will influence the player's emotions and possibly, how they interact with the game.

We will utilize the **Science4Pandemics** as a base for such experiments. The game was developed with investigative purposes by CISUC (Center for Informatics and Systems of the University of Coimbra). After studying the different ways to classify emotions and how video-games use their visual aspects to influence the players feeling and consequently, behavior, we then proceed to the practical part of this project. We describe the work that was done for the S4P game, analyzing the game design, the assets that were created, how and why we did it. Afterwards, we proceed to the experiments, using the *Regions* that were developed for the game, we apply different generative methods that visually change the *Regions*' elements, thus also changing how players feel when looking at it. Finally, we move onto the evaluation stage, where we develop a qualitative evaluation and a questionnaire, seeking to inquire about the effects of the visual experiments and if they worked or not. Also questioning if the characteristics of the *Regions* designed and modeled for the S4P game, could be recognized or not.

Key-words

Video-games, Modeling, Generative Design, Emotions, Science4Pandemics

Resumo

O uso de métodos e ferramentas generativas está a crescer em popularidade e utilização em diferentes campos, estas técnicas podem trazer uma variedade de benefícios para o design e desenvolvimento de jogos, permitindo que os jogos sejam criados mais rapidamente, beneficiando tanto os seus jogadores como os seus criadores. O nosso objetivo nesta dissertação é estudar e utilizar diferentes técnicas generativas para alterar visualmente aspectos dentro de um jogo, o que por sua vez irá influenciar as emoções do jogador e, possivelmente, a forma como este interage com o jogo em si.

Utilizaremos o jogo **Science4Pandemics** como base para tais experiências. O jogo foi desenvolvido com objectivos de investigação pelo CISUC (Centro de Informática e Sistemas da Universidade de Coimbra). Depois de estudar as diferentes formas de classificar as emoções e como os videojogos usam os seus aspectos visuais para influenciar os sentimentos e, consequentemente, o comportamento dos jogadores, passamos à parte prática deste projeto. Descrevemos o trabalho que foi feito para o jogo S4P, analisando o design do jogo, os *assets* que foram criados, como e porque o fizemos. Depois, passamos às experiências, utilizando as *Regiões* que foram desenvolvidas para o jogo, aplicamos diferentes métodos generativos que alteram visualmente os seus elementos, alterando assim também a forma como os jogadores se sentem ao olhar para as mesmas. Por fim, passamos para a fase de avaliação, onde desenvolvemos uma avaliação qualitativa e um questionário, procurando averiguar os efeitos das experiências visuais e se estas funcionaram ou não. Também questionando se as características das *Regiões* criadas para o jogo, puderam ser reconhecidas ou não.

Palavras Chave

Video-games, Modelação, Design Generativo, Emoções, Science4Pandemics

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5.6.1. Briefly describe the Region you see in the figure

5.6.2. In which geographical region of the world do you think this *Region* is located

5.6.3. What type of development does this *Region* have? Is it poor? Do their citizens have a good quality of life?

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1. Introduction

This initial chapter contextualizes the project and explains the different motivations and objectives that led to its creation and further development.

1.1. Science4Pandemics

The project *Science4Pandemics* gathers multiple european partners (UC, FSJD, ISGlobal, Penta, Sanofi, GSK, etc.) that aim to disseminate the necessary scientific knowledge so that a common citizen (outside of the healthcare field or that has little information on the topic), may understand and be able to face the different types of epidemics that can one day affect their community. This is done through the propagation of effective tactics and measures to be taken to control or stop the spread and the impact of said epidemics. Among the various methods and tools used to diffuse such information, are the creation, development and distribution of a game that allowed their players to learn about this topic. In this case, the goal is to influence children and young adults, aged between 10 to 18 years old, teaching them relevant scientific knowledge and turning it into a playful activity.

The game, also titled *Science4Pandemics,* is being developed by CISUC (Centre for Informatics and Systems of the University of Coimbra), for research purposes, considering the different possibilities of exploration inside the game, such as: maximizing the efficiency of the different scientific information taught to the player; the application of different generative design methods into the content of the game; seeking to find different ways to streamline; diversify and automate certain parts of the artistic creation of the game.

1.2. The opportunity of procedurally generated content in games

The process of designing and developing a game is something that involves different tasks and fields of expertise. Unlike some types of media, games are interactive, which creates a new dimension to be explored and new factors that must be taken into account when creating them, that can transmit different messages to the player and act differently from any other element in other types of media. It is considered to be a very arduous task to conceptualize and produce a game. It may take years of work, hundreds of people and millions of euros, until a final product may be tangible and later marketed. Generative methods are able to speed up processes during the development of the game, helping designers and developers, but there is a certain lack of use cases and modern games utilizing generative content design in the gaming industry, which can be seen even more clearly when compared to other fields such as typography and text (Sarkar & Cooper, 2020).

1.3. Benefits of procedurally and generative design

With the different benefits brought by generative design, we decided to develop this project with the ambition to speed up the creative aspects of design and development in games. More specifically, to use these benefits in the development of the *S4P* project, by studying the different methods that are used in the many visual fields that comprise the elements of the game as a whole. Then, after applying these methods in our game, we acquire a bigger quantity and variety of assets created in less time, helping the development of the game during the experimentation and also production phase.

1.4. Objectives

With this, we decided to explore the multiple possibilities that the creation of generative content may have in computer graphics, with it being specifically applied in games and even more specifically in the S4P game.

This project focuses on three distinct aspects, which correlate and will build upon one another. First, we aim to describe and analyze the development of the *S4P* game and its characteristics, why and how it was created. Secondly, we study different generative methods and apply them to the assets previously created, to inquire whether they are effective in helping the further development of the game. The goal is to experiment with different visual aspects that may influence the player's perception and or emotional reaction to that part of the game in particular. Finally, we catalog how these different experiments affect the players, trying to understand which emotions correlate to each of the visual changes made.

The S4P (*Science4Pandemics*) is a browser game, developed with pure *JavaScript,* but the images used as in-game *Regions* are designed through the rendering of 3D models, in this case created using Blender. This enables the exploration of different generative concepts, since many of the tools are already semi-implemented inside the software. In other words, we will study and apply different generative techniques to the models and assets created for the Science4Pandemics, that aim to visually influence the player's emotions and interactions towards the images created and, finally, inquire whether these techniques and effects work or not.

This project has potential inside the gaming industry, considering the increasing number of games being produced and the need to be able to do so faster, by researching these topics we make progress in this field and thus help artists, designers and developers. This industry would highly benefit from the utilization of different techniques during the development phase that generative methods bring, which can help automate steps or, at least, speed them up. An example of a process that can be automated, is scattering objects such as trees, rocks and such along a scene, saving time and money. The application of these methods during this step in the development phase would allow the artist or developer to explore different possibilities and ideas in less time and also design a larger amount of assets, creating a bigger visual diversity in the game.

1.5. Visual Aspects: Color, Light, Textures, Movement and Interaction

Amongst the visual elements that comprise a game, five were selected for being considered the most relevant for analysis and exploration. These are **color, lighting, textures, movement** and **interaction**. Each of them are key in building the visual identity of a game, being able to completely change how it is perceived. Each one of these components will be explored and analyzed alone, to understand and explain how they're utilized and how they influence the players.

1.6. Methodology

Regarding the process to develop this project, after careful analysis, we decided that the best approach to this challenge is to divide it into different sections, classify and further analyze each one of them. The sections were divided as such: lighting, color, texture and movement, this way we will be able to deepen each aspect and their effects. More specifically, we will utilize Nigel Cross' process, titled "*Four Stage Design Process*" (Figure 1) that, like most other design models, aims to find a solution to a certain problem. This model has an exploratory approach, investigating different possibilities, researching, brainstorming and then conceptualizing, refining and communicating them.

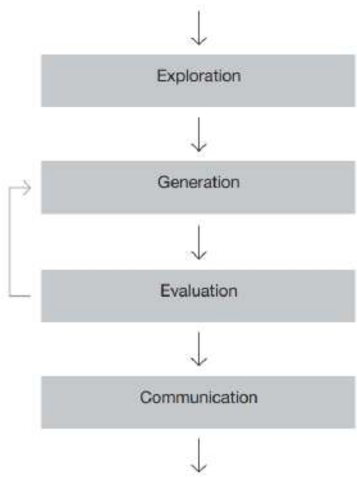


Figure 1: Four Stage Design Process (Nigel Cross, 2011)

As the name implies there are four steps to this design model, which are: exploration, conceptualization, refinement and communication. The first step is to research and brainstorm different ideas and potential solutions, the goal is to gain a comprehensive understanding of the problem and its constraints. The *conceptualization* step involves translating the ideas into different concepts, using sketches, diagrams, programs and any other available tool, to generate as many design alternatives as possible and evaluate their feasibility. *Refinement* involves transforming the prototypes that were created during the conceptualization step into an improved version, working on their functionality, aesthetics and usability. And finally, the *communication* stage is about effectively communicating the design solution, conveying the design intent and rationale to the clients or users.

This method will allow me to research and work simultaneously, studying the multiple facets that were mentioned and test each of their effects, turning it into a non-linear process, always being able to produce new prototypes. In short, this method will bring many benefits to the development of this project, allowing a faster research and test stage and thus the final project itself.

1.7. Work Plan

This subsection describes the plan of development to be followed throughout the project, explaining each of the general tasks that need to be followed in order to achieve our goals and the time period in which they will be tackled.

Even though we began the development of this project in September, considerable work had already been done for the *Science4Pandemics* game, which started being developed in February of 2022 with game design meetings, ideas and planning. And work related to this project began in June of 2022, thus we will identify such tasks and their timeframe. Many other tasks were done during the development of the game, but only the work related to this project will be enumerated and explained.

Division of tasks:

1. Game design and status meetings

Meetings were held to discuss how the game would be developed, what it would involve, different mechanics and every other aspect of the game, after that was decided, weekly meetings were also held to discuss the state of the assigned tasks for each week, for instance modeling assets or prototyping. These meetings were held for the entire duration of the project, even though, nearing the deadline for the delivery, they were less regular.

February 2022 - July 2023

2. Modeling assets

Although much more work other than modeling was done for the game, we will only enumerate this, as it relates to the project itself. This task involves modeling the assets for all of the *Regions* developed for the game. The *Regions* are: *North America*, *North Asia, North Africa, Pacific Asia, Sub-saharan Africa* and *Europe*.

June 2022 - June 2023

3. Write dissertation

Involves the entire process of research and writing of the document itself, since the introduction, state of the art research and documentation of the different results obtained through the experiments.

September 2022 - January 2023
February 2023 - July 2023

4. Experimentation

This task pertains to the process of researching, planning and developing the experiments, which are one of the main goals of this project.

4.1. Lighting Experiments

Development of all of the lighting experiments in Blender, using different techniques to change the light affecting the scene.

March 2023 - April 2023

4.2. Movement Experiments

Development of all of the movement experiments in Blender, using different techniques to simulate the movement and how crowded a region can be.

March 2023 - April 2023

4.3. Texture Experiments

Development of all of the texture experiments in Blender, using different techniques to procedurally change some of the textures affecting the scene.

April 2023 - May 2023

4.4. Color Experiments

Development of all of the color experiments in Blender, using different techniques to change the overall color palette in the scene.

April 2023 - May 2023

5. Testing

This task is about researching qualitative evaluation methods, how to better extract the answers we think are most important from the experiments, developing and applying these tests.

May 2023 - June 2023

1.8. Gantt Diagram

This section aims to organize the time used in each of the tasks previously described, by using Gantt's Diagram (Figure 2).

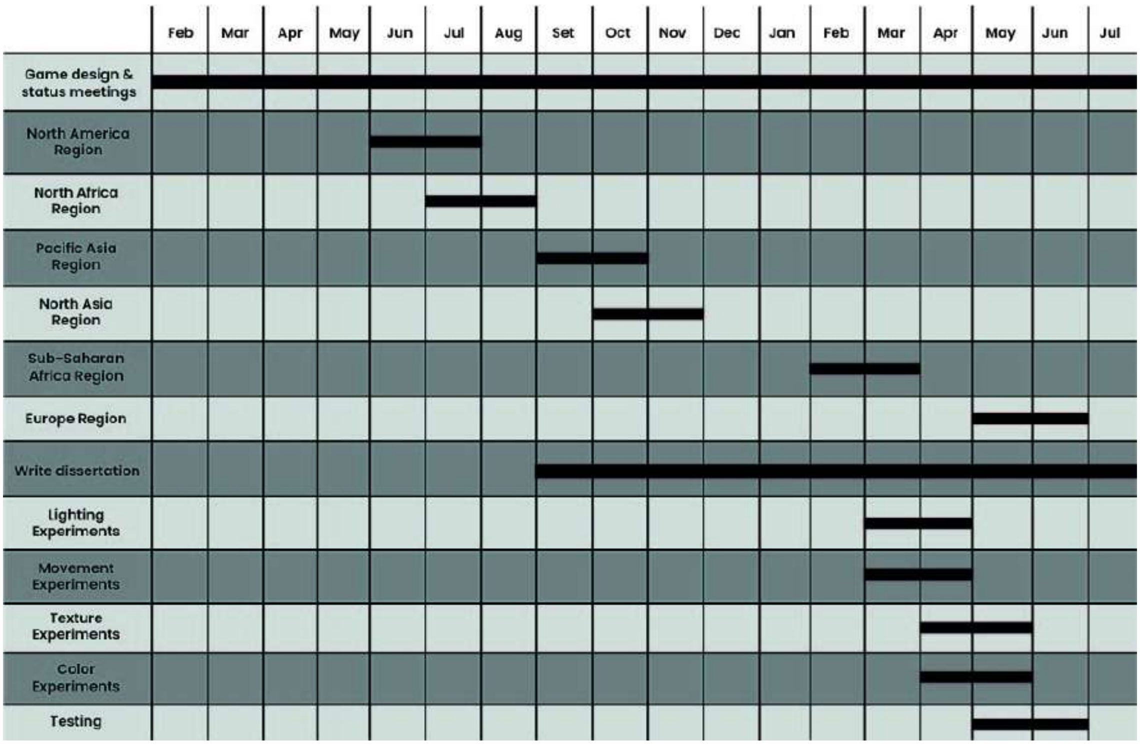


Figure 2: Gantt Diagram with the task plan to be followed

Expected Results

Our goal with this project is to be able to further prove the usefulness of generative methods during the design and development stage of a game, to help their creators increase their productivity. We also aim to catalog how different visual aspects of the game can influence players emotions, evoking a variety of feelings and behaviors from them. After careful study, research, application and testing of the methods and theories described above, we hope to genuinely contribute to the process of creating games and 3D scenarios in general.

2. State of the Art

To understand and evaluate the viability of new projects, it's crucial to study existing projects in the field that may involve similar methods, ideas and results. With that in mind we will divide the aspects explained in the previous chapter in different categories, classify, study and analyze their influences in the final product.

2.1. Emotions and their perception

In this section we will study different methods on how to classify and catalog emotions, and how they impact and influence humans.

2.1.1. Classifying & Measuring Emotions

Before we address how different forms of media can evoke a variety of emotions and how their creators can use such emotions to deeply influence their users, we will discuss what emotions are and categorize them.

The term "emotions" can be confusing and hard to conceptualize and study empirically. Due to its nature being so intercultural and interpersonal, gaining fashion as a colloquial term in modern society and used informally, it has never gotten a formal, consensual scientific designation from the scientific community. Only isolated attempts to create concepts that better describe them, without being affected by the multiple connotations from society's natural language (Cattell, 1990). The question "What is an emotion?" rarely generates the same answer from different individuals or cultures (Scherer, 2005). For the purposes of this research, we will use the model created by psychologist Paul Ekman in the 70s, who identified and organized the spectrum of human reactions and feelings into six basic emotions, which are: ***happiness, sadness, fear, disgust, anger*** and ***surprise***. The proposals brought forth by Ekman changed substantially since he first laid out his theories and opinions about the different emotions that a human being can feel, said so himself in the book "Handbook of Cognition and Emotion" (Ekman, 1999). There he explains his theory and the characteristics that distinguish these basic emotions, such as: ***distinctive universal signals***, mentioning how facial expressions are crucial to the formation of attachments in infants; ***emotion-specific physiology,*** showing that: "there is evidence for distinctive patterns autonomic nervous system (ANS) activity for anger, fear and disgust." (Levenson et al, 1991); ***universal antecedent events***, associating fundamental life tasks and emotions, proposing that such emotions evolved to deal with such tasks (Ekman, 1999).Ekman's work was widespread in the psychology community, pushing other professionals and researchers also to work on their own theories.

Another proposal for categorizing emotions was made by Robert Plutchik, who put forth Plutchik's Wheel of Emotion (Plutchik, 1980). This wheel, not unlike a common color wheel, organizes emotions into different positions along its 360 degrees, allowing the emotions to be combined and form other feelings. According to him, the basic emotions work as building blocks so that more complex emotions can be born. Joy and trust, for example, can be combined and create love (Plutchik, 1980). In Plutchik's Wheel there are a total of eight core emotions, grouped on polar opposites, they are: sadness and joy, anger and fear, expectation and surprise, acceptance and disgust.

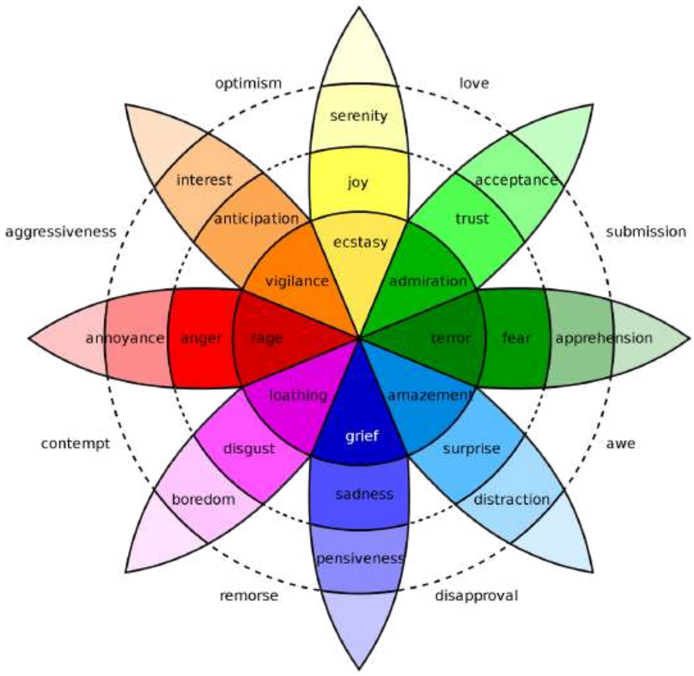


Figure 3: Plutchik's Wheel of Emotion (Wikimedia Commons, 2011)

As the wheel shows (Figure 3), the core emotions are in the middle circle, each layer represents the intensity of the emotion felt, the farther away from the center the less intense the emotion gets. The combining emotions can be observed in between each "petal" of the circle. This circle creates a total of 32 emotions and the possibility for more to be inserted, describing more or less intense emotions that could be put into each core category.

Another model that was created to describe and classify emotions is the PAD Emotional model, created in 1974 by psychologist Albert Mehrabian and James A.Russell. Since its conception it has been widely used in psychology research to understand the underlying physiological and psychological mechanisms of emotions (Mehrabian & Russell, 1974). It works as describing emotions in three dimensions: *pleasure* (P), *arousal* (A) and *dominance* (D). According to this model each emotion can be classified along these dimensions, where *pleasure* refers to a degree of positivity or negativity in the emotion, *arousal* refers to the physiological activation or stimulation associated with the emotion and *dominance* refers to the degree of control or power associated with an emotion (Mehrabian & Russell, 1974). Figure 4 represents how emotions could be placed along these different "axis".

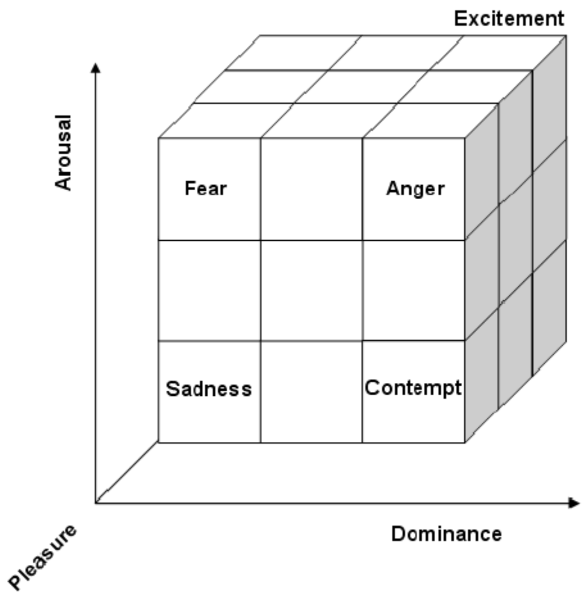


Figure 4: PAD Emotional Model Chart Example (Mehrabian, 1994)

Many studies have been conducted to investigate emotions by using the PAD model. For instance, researchers found that warm colors like orange or red, were associated with high levels of arousal and dominance, while cool colors like blue and green were associated with high pleasure and low levels of dominance (Mehrabian, 1994).

All of these methods are important to our project, since they give us insight on different views and how to possibly approach the problem. Although they will all be taken into consideration, we decided that for the qualitative evaluation that was carried out in order to examine the experiments, Plutchik's wheel was the most viable model to be followed. This model offers a variety of emotions, which also encompass the ones mentioned in the other two models. Ekman's model, for instance, has the advantage of being simple and easy to follow, since it only possesses six emotions, but the wheel allows us to also see these emotions on a spectrum, which may not be feasible with the six basic emotions model.

2.1.2 Influences of aesthetic perception

In Donald A. Norman's book: "*Emotional Design: Why we love or hate everyday things*" (Norman, 2003), he explains that human beings possess three different levels of processing information that their senses capture, these being the **visceral, behavioral** and **reflexive,** each more intellectually advanced than the latter. Reptiles, for instance only possess one level that being the visceral, which allow them to identify a possible danger from a nearby predator. Dogs on the other hand have two levels, visceral and behavioral, allowing them to understand commands, or to “think” on a logical basis, being able to overtake physical obstacles, like barriers or doors that may be found between them and whatever captured their interest. Humans have all three levels, allowing them to reflect and think about how previous actions made us feel (Norman, 2003). These reflections can generate positive or negative feedback. Norman and his colleagues at department of psychology in Northwest University were able to ascertain different behaviors, objects, shapes and sounds that cause these feedbacks. It was observed that well-lit places, temperate climate, sweet tastes and smells, bright and saturated hues, melodic and calm sounds, smiling faces, attractive people (although beauty and its standards may be relative from person to person, the thought of an attractive person, whatever that may be is what causes the positive feedback), symmetrical objects, shapes with curves, those affect positively the human being. Meanwhile their direct opposites usually cause a negative effect, for example: loud sounds, tall heights, objects extremely close to the viewer, extreme heat or cold, pointy objects, strong lights and crowds.

After this research they were able to conclude that, regardless of culture or taste, certain characteristics can be inherently perceived as pleasant or unpleasant to human beings (Norman, 2003).

2.1.3. The Impact of Emotions in video games

To feel intense emotions whilst reading a book, watching a movie or a play is common and happens to everyone, the same can be said for video-games. When watching a character in a game die or reaching the climax during the gameplay, can bring a variety of emotions to the player. These emotions can be felt even stronger in games due to the fact that they result from the player’s own actions, in other words a game is an interactive media and relies on both creator and user to be complete.

After a book is written and published, it will never have its narrative changed, no matter how many times it is read. The beginning, middle and ending of such a book will always be the same. The same concept can be said about other types of media, but video-games have so many different genres that some of them are completely dependable on a player for them to exist as a whole. Sandbox games, such as Minecraft (Mojang, 2011), for example, offer the player an almost infinite amount of possibilities. Each time the player creates a new world, or in other words, a new seed, they come across a different world than the previous, creating a completely new set of possible interactions and actions that they might make, leading to that newly created world to progress and change without ever having a specific ending (Figure 5). Due to these aspects, the games described are very hard to translate into any other format or media.

Figure 5: Minecraft (Mojang, 2011)

Games that heavily focus on narrative have a different emotional weight on their user than other media such as movies or TV shows. They are coined as “playable movies”, characterized by focusing most of its contents into cutscenes or storytelling and not so much on action sequences (actions as in having the player interact with the game) or complex mechanics. One great example of such a game is the acclaimed Heavy Rain (Quantic Dream, 2010), released for the Playstation 3. The story revolves around a series of murders committed by a serial killer, who kidnaps and drowns their victims. The players take control of four main characters, all of whom have a connection to the most recent murder case (Figure 6). The game’s mechanics involve a combination of exploration, quick-time events and decision making, where the players explore different environments with the protagonists, interact with objects and make choices that affect the story’s outcome.

Figura 6: Heavy Rain (Quantic Dream, 2010)

As the story progresses, depending on the players' performance throughout the events, interactions and decisions, they will be able to reach one of a total of 17 different endings to the story, each of them with different outcomes to the lives of the protagonists. When making such choices and directly seeing the results of their actions in the character's lives, the players are able to create a deeper connection to them, more than they probably would for character's of movies or books (Isbister, 2016).

For the player to feel these strong emotions toward any kind of game, character or event, several factors are necessary. In this case, it is the interaction of the player-protagonist that leads to a stronger emotional bond (Isbister, 2016). Along the next chapter we will discuss the different visual factors that can create this emotional attachment or a change in the player's perception.

2.2. Visual Elements that influence the player's perception

In this section we will analyze the different visual elements that are generally used in video games to influence the player's emotions and their perception of different characters, scenarios, maps, scenes and more, focusing on how they can affect the emotions discussed previously.

2.2.1 Geometric Shapes

The basic geometry that makes up the objects and characters present in any game is created to send a message to the players, influencing their perception about a character, environment, enemy, NPC or even dialogue. We will now study how and why they are created and used inside video-games.

In ancient civilizations, artists already used different shapes to influence their audience to feel a certain way (Solarksi, 2017). The basic geometric shapes originate all of the other possible existing shapes, which are then used in every artistic field; these "primary" shapes are: the triangle, the square and the circle. The human mind naturally associates such primary shapes to different emotions and feelings (Solarksi, 2017). A triangle or triangular shape, for example, is usually associated with aggression or danger, while a circle or ellipse is reminiscent of pacific and calm emotions.

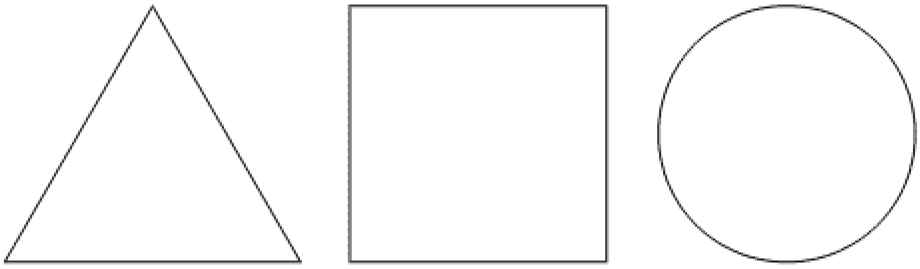
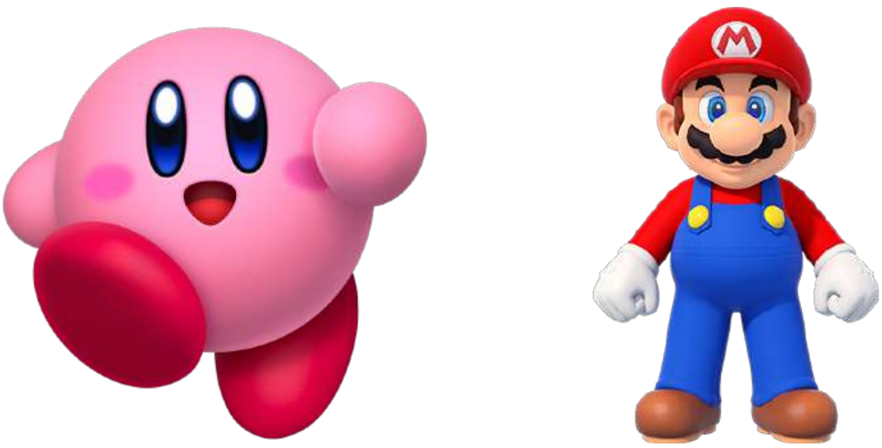


Figure 7: Three basic shapes, triangle, square and circle

Games have different elements that contribute to creating the experiences and stories we play. The different shapes and how they are used are one of these many aspects. Chris Solarski mentions in his book “*Interactive Stories and Video Game Art*”, a total of eight of those aspects, which are: “***poses and character shapes, lines of motion, environment shapes, pathways, dialogue, composition, audio and player gestures.***” (Solarski, 2017)

When analyzing the aspects described by the author, we can think of many examples where the primary shapes may be associated and thus used to influence and change the perception of the players. The most obvious and notable use at first glance is perhaps the creation of characters and environments, which can also be observed in other fields, like paintings, for example, where we can distinguish shapes in environments and composition.

In video games we can also observe such techniques being employed very clearly. When looking at protagonists or characters that are considered to be pacific and friendly, circular and smooth shapes can be seen in the characters' silhouettes, representing this friendliness, or maybe even quadrangular and rectangular shapes, used to promote a strong and robust feeling. In Figures 8 and 9, due to their round shapes, we can see that Kirby and Mario (Nintendo) were designed to promote a friendly and peaceful feeling, which is exacerbated by the company's art style of choice.



Figures 8 & 9: Kirby and Mario (Nintendo)

On the other hand, antagonists, enemies or any type of character that may pose a threat to the player, have a triangular silhouette, making use of pointed shapes to symbolize danger to the player. We can see such an example in Bowser (Nintendo), who even though has a round and sturdy overall shape due to the nature of Nintendo's cartoon-like artstyle, can still give the feeling of aggression through his horns, claws, teeths, spikes and angry brow (Figure 10).

Figure 10: Bowser (Nintendo)

In environments and scenes, the same logic can be applied and easily observed. In levels and areas where the player is exposed to danger, where enemies reside or any kind of challenge is given to them, we can usually observe menacing structures with the objects surrounding such areas having triangular shapes (Figure 11). In contrast to that when the players are in safe areas, we find sturdy and inviting structures, creating an immediate contrast between safe and unsafe areas (Solarski, 2017). The pathways leading to such areas are also subject to this logic, dangerous zones will have narrow entrances, sharp curves and low visibility, completely different from open roads where the vision expands to the horizon.

Figure 11: Ganon's castle (Nintendo, 1998)

Although the correlation between elements is important, throughout the book, Solarski gives too much importance or glorification to some aspects, which does not make sense in some cases. One of these aspects is the dialogue, which, according to the author, is created and designed to be “triangular”, “circular” or “rectangular” (Solarski, 2017). It is possible to associate different personalities in characters to different types of dialogue and how that character communicates, but it is important to note that the dialogue is written to make sense and contribute to the narrative as a whole, not to follow a certain “shape”.

Even though we do not completely agree with this association of dialogue and shapes, the use of primary shapes is still an extremely important factor to take into account when trying to convey feelings and influencing the player to behave, think and feel a certain way.

2.2.2. Lighting

Inside a game, the lighting is one of the most important visual elements, since it can affect an entire scene and all of the other elements present. With a minor change in the lighting’s parameters, such as its color, intensity, angle or position of its source, the player’s perception of the scenario will be considerably different.

In any 3D modeling software or game engine, there are many types of lights that can be used. Even though their names may differ from one software to another, its characteristics are the same, since they derive from real sources of light, observed in the real world. These types of lighting can be grouped into four categories, which are: *directional* or *ambient*, *focal*, *area* and *point* light

Directional Light

The directional light affects the whole scene, imitating the effects of a light source like the Sun, which is so distant that its rays reach the objects with the same angle, meaning that if a scene has a directional light positioned with a 15º angle, the objects will have the same “amount of light” affecting them. As we can observe in Figure 12, the cube and the sphere are influenced only by directional light.

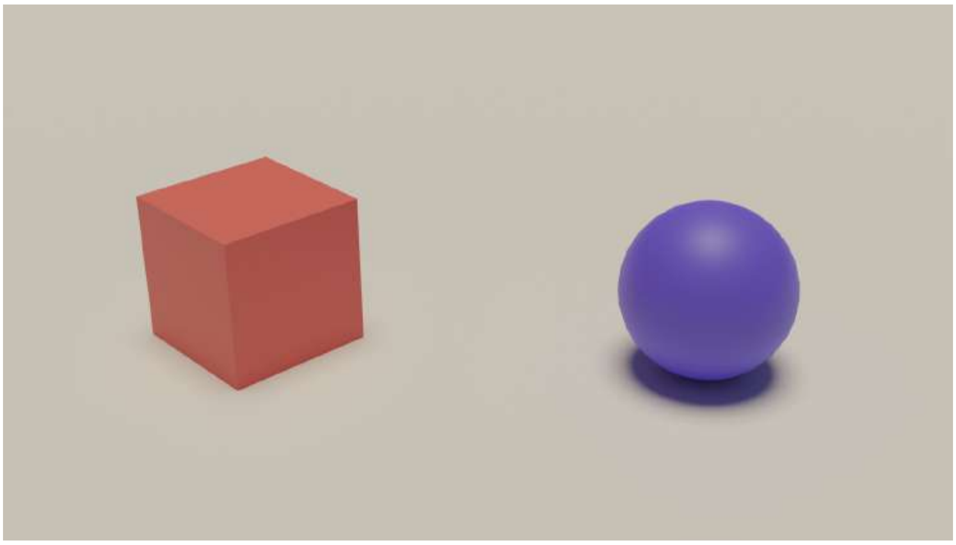


Figure 12: Cube and sphere being affected by directional light (Blender, 2023)

Focal Light

The focal light or spot light, has its source from a single object and has a direction, angle and size of focus. These lights imitate lanterns or light poles that emit light in a single direction. In Figure 13, we can observe the source of this light closer to the sphere, thus exerting a stronger effect on it, leaving the cube in a darker space.

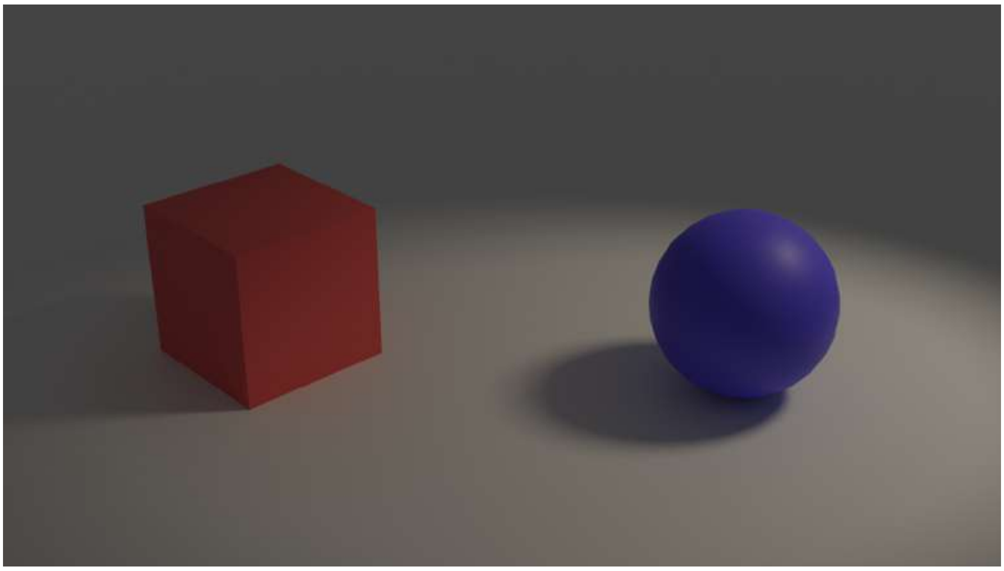


Figure 13: Focal Light coming from the right (Blender, 2023)

Area Light

The area light is used to simulate light coming from surfaces, such as windows, neon lights, a television or maybe even an overcast sky. Similar to the focal light, but with diffuse borders, contrasting with the focal light, which is more acute in this sense

(Blender Organization, 2023). As can be observed in Figure 14, even though the two objects are being affected by the same light, each of them creates a different shadow on the plane.

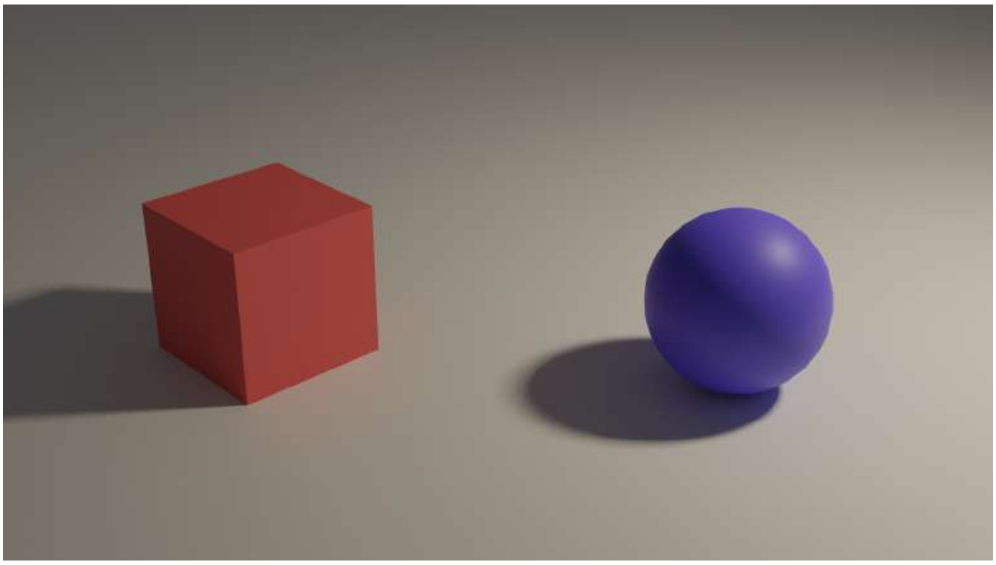


Figure 14: Area Light coming from right side(Blender, 2023)

Point Light

Point light creates an omnidirectional point of light that radiates in every direction equally, many times used to replicate candles, torches, lamp posts or even stars in a starry sky. Figure 15 shows the light positioned between the two objects, exerting light in every direction.

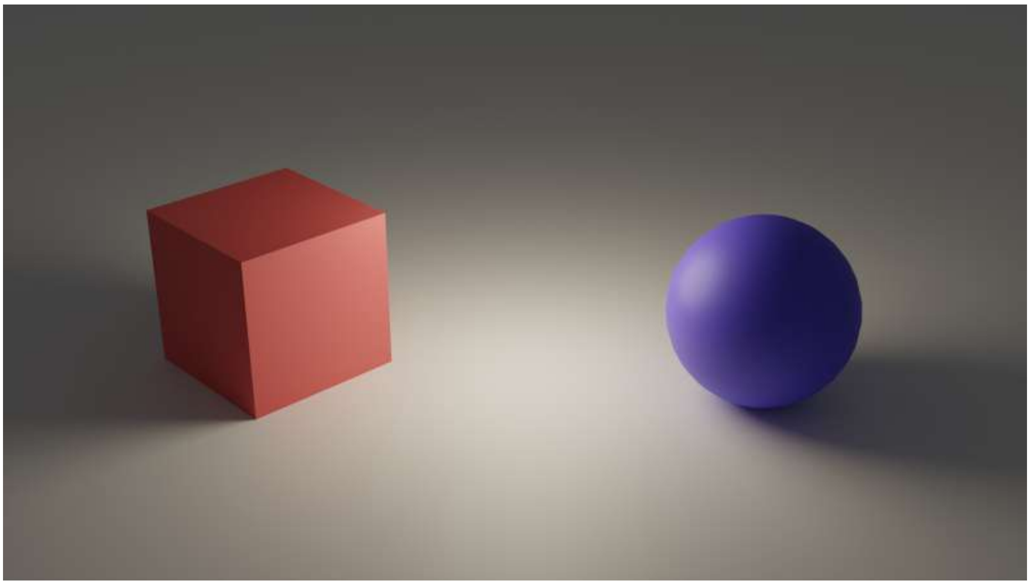


Figure 15: *Point Light* afetando dois objetos (Blender, 2023)

Most lighting in games are carefully created and used with a specific purpose, we will discuss a few examples of the use of lighting in games and their results. In Slender: The Eight Pages (Parsec Productions, 2012), the player has a flashlight as their only reliable light source to traverse the dark forest in which they find themselves, having to manage its batteries to try and avoid the monster (Figure 16). As the player progresses through their goal, the natural lights around them such as the moon and the dim lamp posts that are found in their surroundings, will slowly fade, leaving only the player and their lantern, leaving the players feeling helpless against the darkness and the monster, also making it more difficult to explore and accomplish their objective.

Figure 16: Slender: The Eight Pages (Parsec Productions, 2012)

In Journey (ThatGameCompany, 2012) a yellowed, strong directional light is used to define the desert's hot and arid atmosphere, while a bright point light shines in the distance on top of the mountain, contrasting the overall lighting of the scene, helping to indicate the pathway that the player must take to reach their objectives (Figure 17).

Figure 17: Journey (ThatGameCompany, 2012)

2.2.3. Color

Color directly affects the way people perceive and feel. It can be classified with three parameters: hue, saturation and value. Creating a near-infinite number of possible colors, due to this fact, each time a person thinks about the color “red”, for example, it will be different from any other red that another person may think about. Still, many people make the same color-emotion association. For example, when asking someone to associate the emotion "love" to any color, odds are that the first to come to mind is the color red. Due to cultural or associative reasons, each color influences the human brain, connecting it to some kind of emotion.

There are many theories that try to map the effects of color in human beings. Goethe for example, was a pioneer when it comes to categorizing color, assigning to each a “positive attribute” and a “negative attribute” (Goethe, 1810), associating then, certain emotions inside these colors (Table 1).

Color	Positive Att.	Negative Att.	Emotion
Yellow	Purity, Pleasant	Unpleasant, Dirty ("unreine")	Happiness (“Freude”)
Yellow-Red	Energetic	Annoying	Power
Red-Yellow	Energetic, Caloroso, Passive		Happiness (Glück)
Blue	Comfort	Void, Coldness	Sadness
Red-Blue	Active	Agitated. Restless	Discomfort
Blue-Red	Even more active	Even more agitated, restless	Same as “red-blue”, but more negative
Red	Charm, Grace, Dignity		Faith
Green	Calm, Neutral		Calm

Table 1: Goethe’s Color Summary

The different combinations of colors were also explored by Goethe, who proposed to explain the meaning of each one singularly, but also how they can match together, giving birth to the circle of colors (Figure 18). In it we can see a spectrum of colors and different hues that enter a category of a certain emotion. For example “reason” can be identified both in the orange and red-pinkish tones.

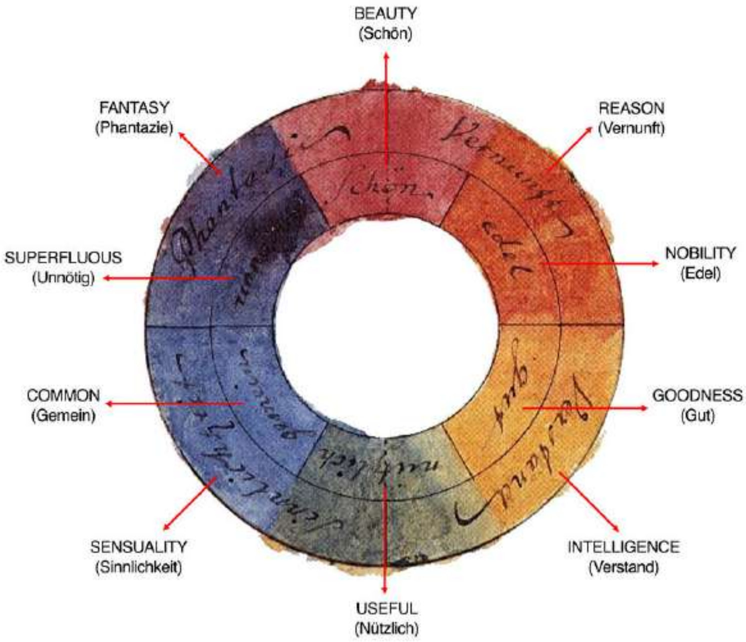


Figure 18: Goethe's Color Circle (Theory of colors, 1810)

Other authors and researchers of this field have also explored this topic, formulating tables, categorizing each emotion and developing theories. Many of the prominent studies are based on Goethe's work and achieve similar conclusions (Palmer & Schloss, 2010).

Josef Albers' work on the other hand, argues that the emotional effects of colors are not universal, but rather depend on individual and cultural associations (Albers, 1963). He notes that red, for instance, is associated with passion and anger in western cultures, while in Eastern cultures, it represents good fortune and prosperity. Blue, can also be seen as calm and serene, while for others can evoke sadness and coldness. Albers emphasizes that observation and experimentation are key in the understanding the effects of color in human emotion and mood, encouraging artists and designers to use different colors in different contexts and paying attention to the subtle variations and nuances that these can have in the subjects mood and behavior (Elliot & Maier, 2014).

Although the study of the effects of color in human mood can be a difficult topic for scientific discussion, games and other media make use of specific types of color palettes to help reinforce certain feelings. Animal Crossing: New Horizons (Nintendo, 2020) uses very saturated and non-realistic hues, pushing the artstyle to a cartoony and childish look, making use of the bright blue and green tones to appear almost magical and whimsical (Figure 19). The color choice, along with other visual elements helps to give the player a feeling of relaxation and sells the game's premise, which is to entertain, with very little difficulties or challenges and provide a pleasant experience.

Figure 19: Animal Crossing: New Horizons promotional Image (Nintendo, 2020)

Horror games like Alien Isolation (Creative Assembly, 2014), on the other hand, use a colder color palette, with grayish hues and darker tones, trying to give the player a feeling of fear, loneliness and helplessness. In Figure 20 we can observe that the metallic tones in the scene, along with other elements like the diffuse blue lights and fog, help to build the game's atmosphere of fear.

Figure 20: Alien Isolation (Creative Assembly, 2014)

2.2.4.Textures

There are different types of textures used in games. Image based textures are nothing more than 2D images or patterns that are applied to the surfaces of 3D models to give them a more detailed appearance, either being realistic or stylized (Figure 21). They are mapped onto the 3D object by using UV mapping, which means assigning different 2D coordinates to the vertices in the object's surface, these coordinates in turn correspond to specific pixels in the texture, allowing it to be correctly applied to the model (Bridson & Müller-Fischer, 2007).

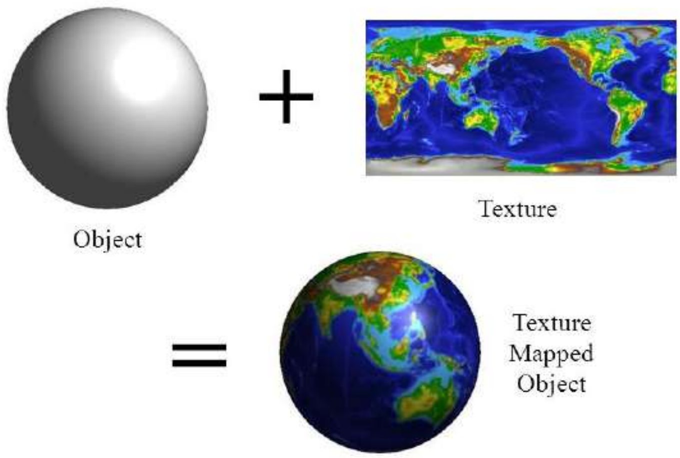


Figure 21: Texture Mapping example (Wikimedia Commons, 2019)

There are many techniques used to create these images, such as using real photos and transforming them into usable textures through photogrammetry, painting these textures directly onto the 3D model through specialized softwares, such as Photoshop, Substance Painter, Quixel Suite and also create these textures procedurally, using a software like Blender, for example, which uses different types of nodes to allow the user to create high-quality textures. These textures can have a wide variety of complexity, ranging from stylized images with simple colors to highly detailed, realistic textures that use normal maps, height maps and other specialized texture types (Bridson & Müller-Fischer, 2007). Textures are a core aspect of modern video-games, since their quality and realism can greatly enhance the visual development of the game's world. In this document we will focus on the different uses of procedural textures, since they are generative and will be used during the practical development of this project, and how these different textures can affect the player's perception of certain objects and environments in general.

Procedural Textures, which are computer-generated textured, created algorithmically, are different from image-based textures since they are generated through mathematical algorithms and functions (Perlin, 1985), generally used due to their various benefits like: *flexibility*, since they can be generated at any resolution, making them highly adaptable and easily modified by adjusting the parameters in the function; *Efficiency* due to the fact that they are generated on the fly by the computer and do not need to be stored in it, unlike image based-textures, which take up a lot of memory or storage space; *Non-destructiveness*, since they are created through algorithms, they can also be modified and edited without affecting the original source, making them even more flexible and non-destructible. These textures are usually used in organic materials, like rocks, trees, water and clouds and can also be used with different purposes, other than being applied to objects. Many games also use procedural textures to generate terrain, Minecraft (Mojang, 2011) uses Perlin Noise, a type of texture that creates organic looking patterns, in its terrain generation, in this case in its mountains and caves. No Man's Sky (Hello Games, 2016) uses this technique in different aspects of the game, from planet and terrain generation to the creation of textures for those planets and the creatures that inhabit them (Figure 22), in Spore (Electronic Arts, 2008), players are able to create their own creature and guide them through the various stages of evolution, procedural textures are used to create the different body parts of such creatures, which allows for a limitless variety of combinations.

Figure 22: A snapshot of No Man's Sky and its textures (Hello Games, 2016)

Textures are a core element in game design and can make or break certain aspects of the gameplay, helping characters, elements in the environment and sometimes the level itself, fulfill its purpose. Different types of textures can be associated directly to certain types of emotion through touch. Iosifyan and Korolkova explore how haptics play an important part when designing products and environments for human interaction. By empirically classifying how different textures affect people's moods, the researchers created a table, which we will use in this project.Table 2 is a shorter version of the one that can be found in their work, containing the materials that we will most likely use in our game and thus, this project.

The values seen in each cell were obtained through multiple methods, explained in Iosifyan and Korolkova's article, which scientifically categorize feelings from each material and also investigate how alexithymia, which is characterized by having significant challenges in recognizing, expressing and describing one's own emotions, is related to the intensity ratings of the basic emotions (Iosifyan & Korolkova, 2019). It represents how strongly the test participants relate to any of the six basic feelings when touching certain materials. The values inside the round brackets are interquartile ranges, while the values on the outside represent the median range.

	Happiness	Fear	Disgust	Anger	Surprise	Sadness
Clay	–	1(2)	2(2)	–	3(1.75)	–
Glass	2(3)	1(3)	–	–	2(2)	2(3)
Wood	2(3)	–	–	–	2(3)	1(3)
Wooden Block	2(2)	–	–	–	1(3)	1(3)
Marble	–	–	–	–	1(2)	2(3)
Concrete	2(3)	–	–	–	1(3)	1(3)
Brick	–	–	–	–	1.5(3)	2(3)
Tile	2(3)	–	–	–	2(2.75)	1(3)
Granite	–	2(3)	–	–	1.5(3)	2(4)

Table 2: Modified version of the Emotional Ratings of Textures (Iosifyan & Korolkova, 2019)

Although Table 2 is based on haptics and not the visuals of the materials, this will also prove useful for this project's practical aspect. We achieve similar results through the visual modification of such materials, thus helping to reinforce specific feelings onto the player.

2.2.5. Movement

Movement is a core element when it comes to heavily impact a player's emotions and perception of the game, as it can represent different situations. Different types of movement can elicit different emotional responses in players, such as excitement, fear or tension (Wolf & Mortensen, 2010).

Drastic movements, for example, tend to create a sense of urgency and danger, while slow movements can represent calmness and relaxation. Not only movement, but perspective and camera movement can also be used to influence the player's perception of the game and how they feel emotionally. In Mirror's Edge (DICE, 2008), the player's movement matches the game's dynamic and tone, with fast-paced and fluid movements, inspired in parkour, designed to create a feeling of freedom and excitement (Figure 23).

Figure 23: Screenshot of Mirror's Edge zipline system (DICE, 2008)

In the Dark Souls (FromSoftware, 2011-2016) franchise, known for being notoriously difficult, we can notice the player has weighty and sometimes even sluggish movements when compared to monsters and enemies that surround them. These slow animations contribute to the feeling of danger and create a sense of weight and impact, which results in each movement or input done by the player, feeling significant (Figure 24).

Figure 24: Dark Souls Remastered screenshot (FromSoftware, 2018)

2.2.6. Interaction

In this section we will exemplify how the player's interaction can change when modifying the aspects mentioned beforehand and how game designers use these changes to emotionally influence the player.

The game Zelda: Ocarina of Time (Nintendo, 1998) perfectly accomplishes the act of changing the players perception and thus, influencing them emotionally. Throughout the game, the main character, Link, goes on many adventures in different areas of the world, one of them being *Hyrule,* capital of the kingdom, in which Princess Zelda resides. With the passing of the missions, Link enters and leaves the city many times, visiting the various areas that exist inside it. The player then builds an image that represents Hyrule itself in their head, which can only be described as a happy place, full of citizens dancing, different side quests and mini-games that can be played, with vegetation blooming full of life and color, where the sun shines bright and a clean, and a well-structured city can be seem. All of these elements are carefully crafted and put there to give the player the message that Hyrule is happy and prospering (Figure 25).

After a key moment in the game's plot, Link is cursed and magically hibernates for seven long years, being rendered incapable of helping the friends he made along the journey. When he finally wakes up, the player leaves the temple in which they were cursed, only to come across a desolate place, dark and gloomy (Figure 26), completely beyond any expectation that the player might have. Even though it still is the same Hyrule, with the same disposition of buildings and elements in general, with the visual changes that occurred, the player immediately realizes that they are in a completely new area that can be explored again.


Figures 25 and 26: Zelda Ocarina of Time (Nintendo,1998), Temple of time before and after the timeskip

It is possible to immediately identify the aspects discussed throughout this document and notice all of the changes that each of them has in the surrounding environment. The bright and strong sunlight was replaced by clouds and purple very weak light, as if a great darkness enveloped the whole world. With the light change we can also notice the color change, the blue sky turned gray, the trees and fields are dead and also have a grayish color.

The textures used in the Temple's facade give a feeling of abandonment and decay. The mountain is also darker, has a noisier texture and the ground has completely lost any brightness, turning gray and dead.

The movement, which was a constant presence before (Figure 27), seen in dogs, chickens and people dancing, turns into an empty plaza, filled with enemies that are static most of the time (Figure 28).

Figures 27 e 28: Zelda: Ocarina of Time (Nintendo, 1998), Hyrule market before and after timeskip

All of this leads us to the last aspect, which is the interaction of the player itself. Due to the different interpretation of visual space around them, the way they will explore and move around the area will be completely different from when they did it previous times. The changes also create an emotional weight to the player. Upon seeing the desolate and completely destroyed world, different from which they were expecting, they realize that it was their own actions, or lack of them, that caused this result.

In Limbo (Playdead, 2011), the game starts out with a completely black and white color palette, with little to no information given to the players about what they have to do or what is their mission. The more the players progresses through the game's puzzles and survive different types of enemies (Figure 29), the more they find about the main character, a little boy in search of his lost sister.

Figure 29: One of Limbo's promotional images (Playdead, 2011)

As they reach later stages into the game, the color palette slowly starts to change into a slightly saturated hue, representing how they are closer to their goal and giving them hope and happiness (Figure 30).

Figure 30: Limbo reaching the final stages (Playdead, 2011)

In Hellblade (Ninja Sacrifice, 2017), the visuals change to match the player's mental state. To help reinforce the game's themes of mental illness and trauma, as the players experience different types of hallucinations and delusions, the world around them becomes increasingly distorted and surreal, creating the feeling of unease and discomfort (Figure 31).

Figure 31: Snapshot of the player having hallucinations in Hellblade (Ninja Sacrifice, 2017)

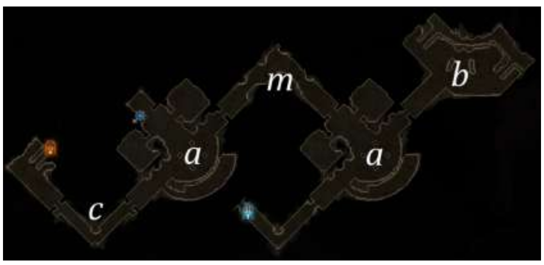
2.3 Generative Content Design

In this section we will explore different examples that have successfully used generative design in video games, analyze their advantages and disadvantages, and the techniques used to develop the design itself.

2.3.1. Level Architecture

Level Architecture is an important concept regarding **PCG** (*Procedural Content Generation*), being one of the first uses of generative design in games. Nowadays, computers are capable of processing immense quantities of information and data, generating complex and realistic graphics and heavy games, many times spamming over 50GB of computer storage. But this was not always the case, in the 90s many developers turned to PCG to overcome the problems posed to them by the limited computational power, and to be able to design worlds and levels that would never fit in a computer storage from the 80s or 90s (Barreto, Cardoso & Roque, 2007). Even though the reason for this use of generative design is no longer as relevant, it didn't stop designers, artists and developers from seeking creative solutions for the problems that they found. Genres like *roguelikes, dungeon-crawlers* and *metroidvanias* are known for having diverse, modular levels, created procedurally that can be different through each gameplay, offering a completely new experience to the player every time they play.

Diablo III (Blizzard Entertainment, 2012) can be classified as a *RPG, dungeon-crawler,* famous for its great diversity in the areas that the player can explore. During its production the developers designed and created modular assets that could be reutilized and reorganized, thus creating a new level faster and with more diversity.



Figures 32 e 33: Diablo III (Blizzard Entertainment, 2012), Map diversity

Figures 32 and 33 represent a single area within the game, but each possesses a different composition. This happens because they represent a different saved file, demonstrating the capacity for map recomposition in the game, where each module can be joined together via bridges, doors and entrances.

Hades (Supergiant Games, 2018), also modular design for generative map creation. In this game the player explores each room that is found inside a certain "level" of the Greek hell, each one with its defining, unique characteristics. Eduardo Gorinstein, one of the game's level designers, explains in a Twitter post, how each level was thought out and built: "Each biome had a set of design principles to guide its design.[...] For Tartarus we wanted medium-sized rooms that are almost always completely walled in, making it forgiving for players…" (Gorinstein, 2020). Ed also mentions how each biome or "level" has specific assets that are used to "build" the room in which the player will enter: "You'll notice that the design kit included: traps, pillars, tables, urns, exits." In Figure 34, we can see how the assets are positioned along the area of the map.

Figure 34: Hades (Supergiant Games, 2018) behind the scenes (Ed Gorinstein, 2020)

After studying these games, we can see that by simply using modular design, the ability to reposition these modules and by assigning different parameters to the structures that compose these worlds, maps or scenes, designers are able to quickly create an almost endless amount of content (Togelius et al, 2016). The use of PCG when building the world is highly beneficial, as it allows these developers and artists to save time and money during the development stage of the game, while also providing more playable content to the players.

2.3.2. Generative Design in Science4Pandemics

Generative or procedural tools have already been utilized during the development of the game Science4Pandemics. With the software used for such development, Blender, we are able to procedurally scatter any objects along different surfaces. This is a good tool to use in the creation of forests, parks or places of this sort. This is done to avoid scattering object by object, which takes a long time and can look very artificial, since a human can't manually and realistically place trees, bushes, rocks, grass and different types of vegetation to create a believable environment.

The Geometry Nodes tool allows us to connect nodes that are able to transform the geometry of different objects. In the first region created for the game, the *North America Region*, we first researched different types of trees that existed in the *Region* and then modeled a stylized version of what we found out to be the most common (Figure 36).

Figure 36: Trees modeled for the North America Region in Blender (Science4Pandemics, 2022)

After placing all of the trees' models inside a *collection* (Blender's nomenclature for a folder), we select the object, preferably a flat surface, on which the trees will be scattered, in this case a plane, representing the ground and add an instance of geometry nodes to such an object. Figure 37 shows the initial Geometry Nodes composition, with only Input and Output groups. Geometry Nodes works by reading nodes from left to right, meaning that the order and disposition of the nodes will affect the end result.

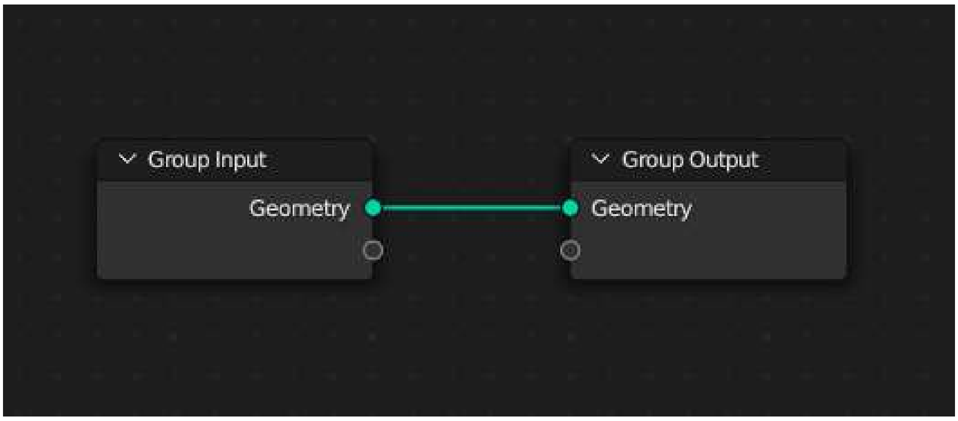


Figure 37: Standard Geometry Nodes (Blender, 2022)

We must first understand the logic of scattering objects through this plane. Geometry nodes allow us to scatter points along any form of geometry; this will, in exchange, replace our plane with multiple instances of small points along its boundaries, by using the *Distribute Points on Faces* node. To bypass this issue we use the *Join Geometry* node to output both the initial geometry and the points we've created. After that we must simply use the *Instance on Points node* to distribute any kind of objects inside a *collection* that we want, along the points on the plane. We then use the *Collection Info* node to select which *collection* should be instanced along the plane and use a *Random Value* node, with very small values along the Z axis, to guarantee some height difference between the trees, contributing to a more realistic look to the forest. Then we adjust the Density values, to determine the forest density, distributing more or less trees along the planes. Figure 38 shows the final setup for the creation of the forest with Geometry Nodes.

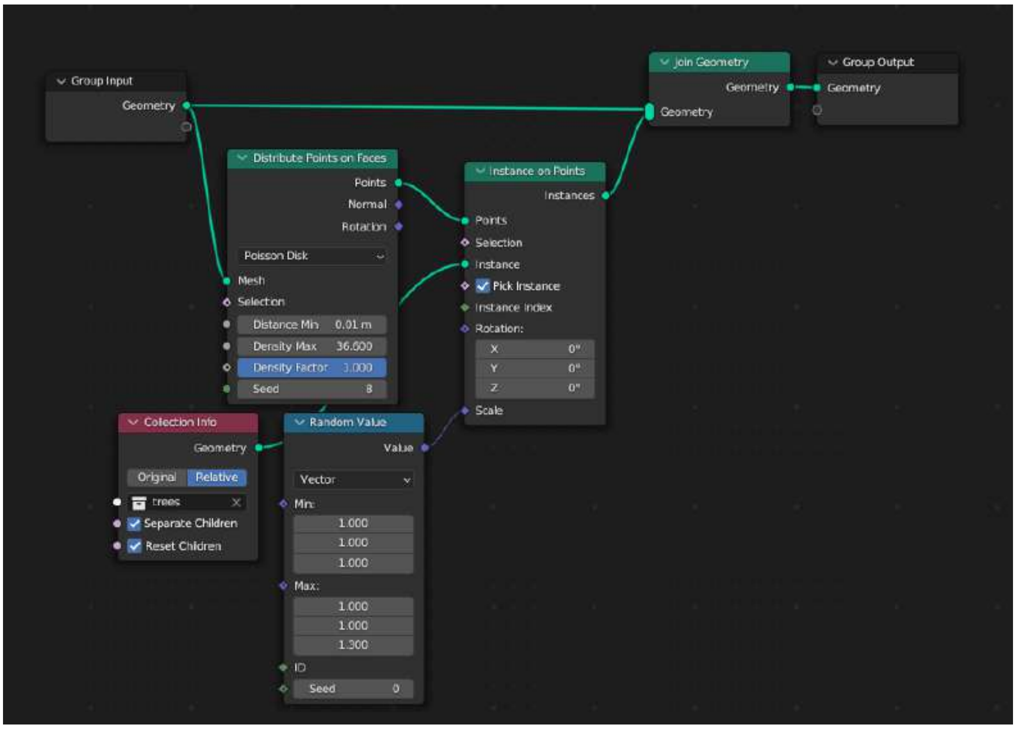


Figure 38: Node Setup for scattering trees (Blender, 2022)

2.4. Conclusion of the State of the Art

This section aims to conclude the state of the art chapter, summing up the key research findings related to our goals.

We began this chapter by researching different forms of classifying emotions, trying to understand the best way to apply these classifications to our experiments. We then reached the conclusion that the Plutchik's wheel was the best way to evaluate our experiments, since it offers a balance of being easy to use and also has a broad spectrum of emotions for our testers to select.

Afterwards, we proceeded to research how games use the visual aspects to influence the players' emotions. We used multiple practical examples of the use of **lighting**, **color**, **texture**, **movement** and how they can affect how the player **interacts** with the game. With that we moved to studying the many ways that generative methods can be applied in games, also using practical examples to demonstrate how effective they can be.

With the research done, we can now associate some of the visual aspects that we experimented upon, with the different emotions that we have studied and will be influenced. Table 3 shows the association between the different aspects and emotions, if there is one. For instance, we know that the night is commonly associated with fear and sadness, such as the color blue, while bright sunlight is associated with happiness. Each cell on Table 3 represents some kind of experiment that was done for the visual aspects selected. This allowed us to organize what we learned, as well as what to expect from the evaluation that was done. They are presented and analyzed in the later parts of this dissertation.

	Lighting	**Movement**	**Texture**	**Color**
Joy	Sunset, Sundown	Moderate	-	Red, Yellow
Sadness	Night, Cloudy	None	-	Blue, Purple
Fear	Night, Cloudy	None, Crowded	-	Blue, Purple
Anger	-	Crowded	-	Red, Yellow
Anticipation	-	-	-	Yellow
Surprise	-	None	Noisy	Green, Yellow
Trust	Sunset, Sundown	Moderate	Noisy	Yellow, Blue
Disgust	-	-	-	Green, Purple

Table 3: Association between emotions and experiments

After properly researching these topics, we moved on to the practical part of this project. Using everything we learned and applying it to the experiments and evaluation that was developed.

3.Design Proposal

In this section we will discuss the development and design process of the Science4Pandemics game and the steps taken to achieve the results that were obtained. We will explore many of the different ideas and prototypes that were created for the game, to explain the thought process behind its creation. We will then move to the experimentations and evaluation of the experiments.

3.1. Initial Iterations

Throughout the development of this dissertation, multiple versions of the game were released, each one of them implementing the ideas that were discussed during the design process. This process changed over the course of the semester, when the team realized that many of the ideas were not achievable, didn't make sense in the game or that we did not have enough time and resources to implement them. Our focus was always to consider if the ideas were interesting enough to engage the players and also if it would be possible to implement them in a realistic time-frame. Although the game suffered changes since its first conception, many of the core elements remained the same, being only modified so that they could fit the current state of the game's mechanics and logic.

During the game design meetings with the S4P team (S4P Game Design Document, University of Coimbra, 2022), the genre of the game was one of the first decisions that we made. Since the partners collaborating with us had very specific ideas about the information that they wanted to be in the game, we had to find a way to make this information as engaging and entertaining as possible, so that the players would be interested in playing and learning more. With some discussion, the team agreed on the idea of a resource manager-like game, where the player would have to manage a *Region*, which is being affected by a disease. Our partners chose a total of five possible diseases, which are epidemics that affect our modern society, to help spread information on the methods to avoid and treat them. The diseases are *covid-19, malaria, ebola, cholera* and *HIV*. The player would then have to make different choices, managing their money, researching methods to ward off the disease and protect the citizens that live in the region. By failing to properly manage it and allowing the populace to perish, the player would then lose. Otherwise if the player successfully manages to maintain the citizens in the *Region,* healthy and keep the disease in check, they will progress through the game, unlocking even more *Regions* to administer, increasing the difficulty (S4P Game Design Document, University of Coimbra, 2022). The idea of multiple *Regions* culminated then in another aspect of the game, the multiplayer. In this mode, multiple

Regions are already unlocked and players can join a team of four and manage them together by communicating and exchanging resources.

The format of the game was a cause of debate and discussion. Using an open-source game engine like Unity was the initial choice, for obvious reasons, using a game engine to create a game offers various benefits during the development process, as it ensures cross-platform compatibility, allowing the game to work on different devices; the possibility of richer visuals, since they provide advanced rendering techniques, tools and features; easier asset and resource management, as these systems are designed to help developers manage and optimize resources. But after considering whether it was ideal to have an app as a final product, mainly due to the problems that this can cause during the distribution process, the idea of having a browser game was considered. With the two options having both strong and weak points, it was a matter of discussing and trying to find the better one out of the group. After such discussion it was then decided that the browser format was more beneficial for our team.

Along with the browser format, it was decided that the team was going to use an open-source library for *javascript*, called *threejs,* which allowed and facilitated the use of 3D assets inside the site itself. Despite the team's efforts, the results achieved using this library were non-satisfactory. As Figure 39 shows, the lighting has non-realistic effects on the objects, not casting shadows as it should and generating a strange gleam, even on non-metallic models.

Figure 39: First iteration of a region using *threejs* (Science4Pandemics, 2022)

After such results, the team decided to utilize pure JavaScript for the development of the game's functionalities and Blender to create the visual aspects of the many *Regions* that exist in it. That way the visuals of the game can be created three-dimensionally and use the image rendered in Blender, inside the browser itself as the representation for the *Region*. In Figure 40 we can see the one the very first iterations of an unfinished *Region* in blender.

Figura 40: Initial iterations of a *Region* in Blender (Science4Pandemics, 2022)

3.2. Regions

During the game design process, one central question which was always debated was: “Where will the game be situated? Where inside the game will the player be?”. This question led directly to the creation of the term “*Regions*”, which doesn’t apply directly to the concept of a town, state or country. Each one of these *Regions* has different characteristics that can influence the development of an epidemic, such as population, density, DHI, size and climate, thus making them more or less susceptible to different diseases. There is a total of ten different regions inside the game, which were based on real life locations of different geographical areas of the world, they are: **North America, Central America, South America, Europe, North Africa, South Africa (Subsaarian), North Asia, Central Asia, Pacific Asia and Oceania** (S4P Game Design Document, University of Coimbra, 2022). In figures 41 and 42 we can observe the visual difference between two distinct *Regions*. While the *North America Region* appears cooler, less dense and more developed in terms of infrastructure, the *North Africa* one, can be perceived as much warmer, denser and less organized. This not only helps with the visual diversity of the maps where the player will spend most of their time in the game, but also serves as visual aid, helping them learn which diseases are more likely to appear in different climates and infrastructural conditions. Figures 41 and 42 show the final iterations of the *North America* and *North Africa Regions*, respectively.

Figura 41: Final iteration of the North American *Region* (Science4Pandemics, 2022)

Figura 42: Final Iteration of the North African *Region* (Science4Pandemics, 2022)

The *Regions*' visuals changed gradually, as we experimented more and more with different color palettes, types of vegetation and architecture for the first *Region*. We quickly realized that many of the elements can be reutilized, such as the streets that permeate them, or buildings that are common between different geographical locations, leading us to create modular assets. This would not only help to create each *Region* faster, but also help us to develop each module with a believable scale, since this way we could compare different elements in each module. In Figure 43 we can see that the street module is quite different from its first iteration, which can be seen in Figure 40**,** where the saturated green used for the grass was drawing too much attention and the module was completely occupied by only the street itself, with no details, such as lamp posts, trash cans, benches and other elements that can be found in an urban landscape. In the final version, the amount of space that the street occupies was decreased so that it makes sense near the rest of the elements surrounding it. We also added trees, lamp posts, grass and a walkway, helping build believability throughout the whole region.

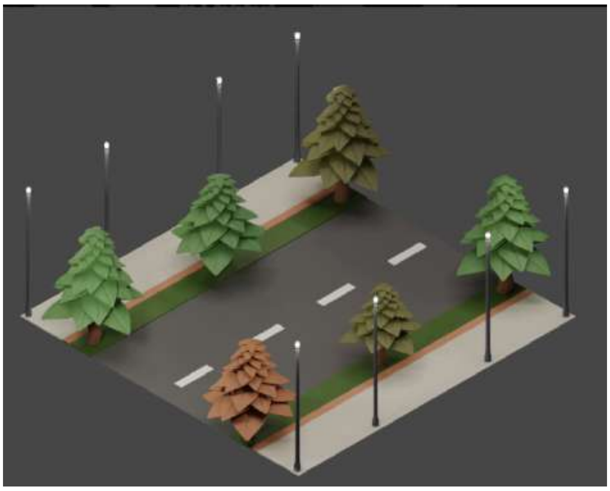
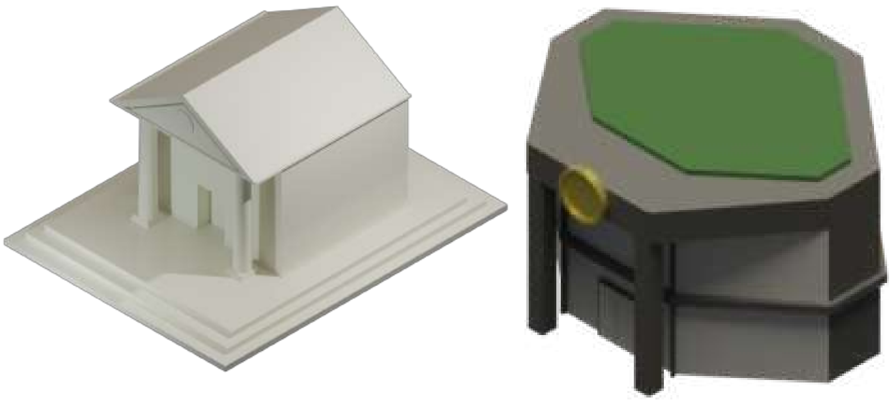


Figure 43: Final version of street module North America Region (Science4Pandemics, 2022)

3.2.1. Buildings of Interest

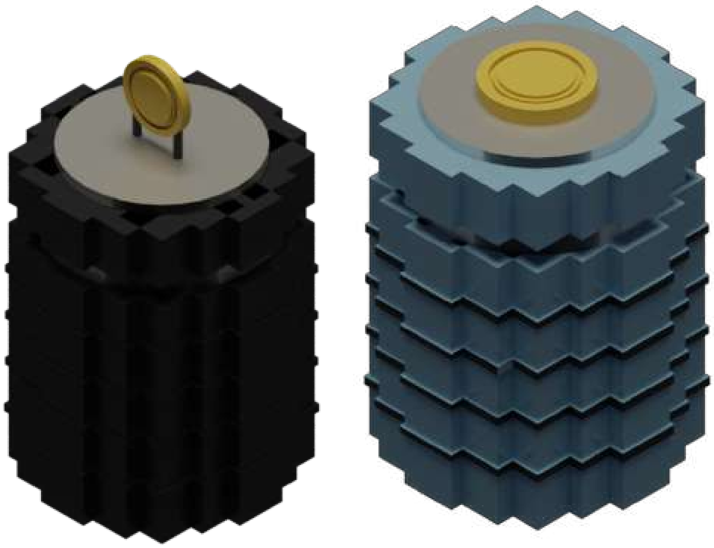
Inside every *Region* there are multiple interactive buildings, where the player performs different actions throughout the game, which will directly influence the current state of their *Region*. There are a total of ten different interactive buildings, named *B.o.I,* short for *Buildings of Interest,* they are the: *Region Hall, Bank, Hospital, Laboratory, Water Station, Factory, Media Station, Public Construction Department, Vaccination Center* and *Testing Center* (S4P Game Design Document, University of Coimbra, 2022). Each building has a different purpose, where the player will perform actions regarding different aspects of managing the *Region*. The *Bank* will be used for actions regarding monetary aspects; the *Hospital, Vaccination Center and Testing Center*, for different actions regarding health care and disease prevention; the *Laboratory,* for research aspects; *Media Station,* for disclosure and divulgation actions; *Factory,* for item production and distribution; *Public Construction Department,* for building new *B.o.Is* and also repairing & upgrading the existing ones; *Water Station*, for water treatment of the whole *Region*, which will be key in stopping the spread of certain diseases. The *B.o.Is* are also upgradable, meaning that when the player has enough coins, they will be able to improve the building's capacity and effectiveness, each of them with three possible levels. They also possess a level of conservation, meaning that the building deteriorates over time, losing effectiveness and must be repaired. Although the functionalities for upgrading and deterioration are not yet implemented into the newer versions of the game, they have already been tested and have been partially developed. The visuals for the *Buildings of Interest* were also heavily altered throughout the development and shifted a lot since their conception. Many of them changed completely or were erased, since their use was no longer needed in the game (S4P Game Design Document, University of Coimbra, 2022). In Figures 44, 45, 46 and 47, we can see how different *B.o.Is* changed during the development of this project and the game.

Figure 44 shows the initial concept for the *Bank B.o.I,* which was based on old buildings that have been repurposed many times. As it can be observed the model is untextured, because this version was almost immediately scraped, since it actually resembled a city hall or some kind of political building, rather than a bank and ended up being the base model for the final version of the *Region Hall B.o.I* .The second version (Figure 45) had inspirations from an old bank that the team found in the images gathered for concept art. Although the team thought it could be discerned that the building was indeed a bank, after some tests, the feedback we received from the players was negative. Many thought it represented a building related to agriculture or farming services due to the green color on the roof and the golden coin in the facade was not as perceived as we intended.



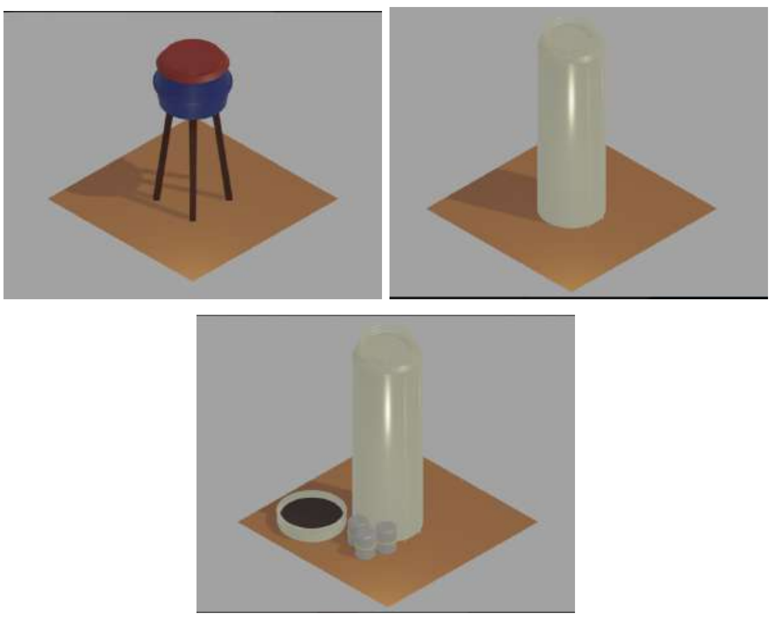
Figures 44 & 45: Different versions of the *Bank* B.o.I *(*Science4Pandemics, 2022*)*

We then proceeded to research for more visual references and decided to go for a more modern and corporate look for the building. The third version (Figure 46) is inspired by a bank from Europe, with taller height and glass materials, it helped us with the concept of a modern bank. The idea of the coin was kept, but the model was enlarged and put at the top, so that it could be discerned from far away and from the perspective of the player. Although we liked the general look of the model and the feedback was positive, the black glass did not receive positive feedback. In the final changes, we set the glass to a “Sky Blue” color (hex code: 80DAEB) and placed the coin laying on the top of the building, thus resulting in the final version of the *Bank B.o.I* (Figure 47).



Figures 46 & 47: Different versions of the Bank B.o.I (Science4Pandemics, 2022)

The *Water Station B.o.I* suffered great changes until we had positive feedback with its final design. Figures 48, 49 and 50, show the first iterations, representing the three possible levels that the *B.o.I* could have. Since the mechanic to upgrade and fix the Buildings of Interest was considered non-priority, we postponed the development of the three building levels, leading us to rethink our concept, giving the building a more developed and detailed look.



Figures 48, 49, 50: Initial iterations for the water station building (Science4Pandemics, 2022)

After more research, we realized that water stations around the world had open wells or containers that purified the dirty water, turning it into drinkable water and redistributing it into the city pipes. We used these details in our new design and created what would quickly become the final design for the *Water Station B.o.I* (Figure 51).

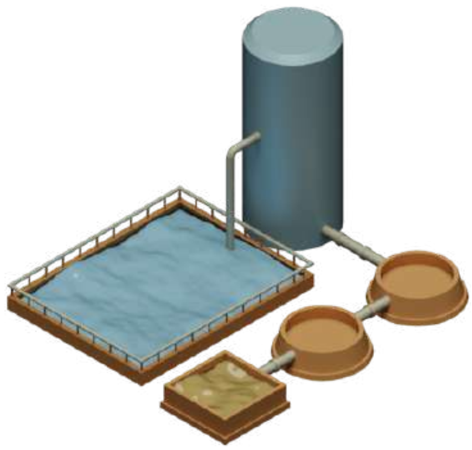
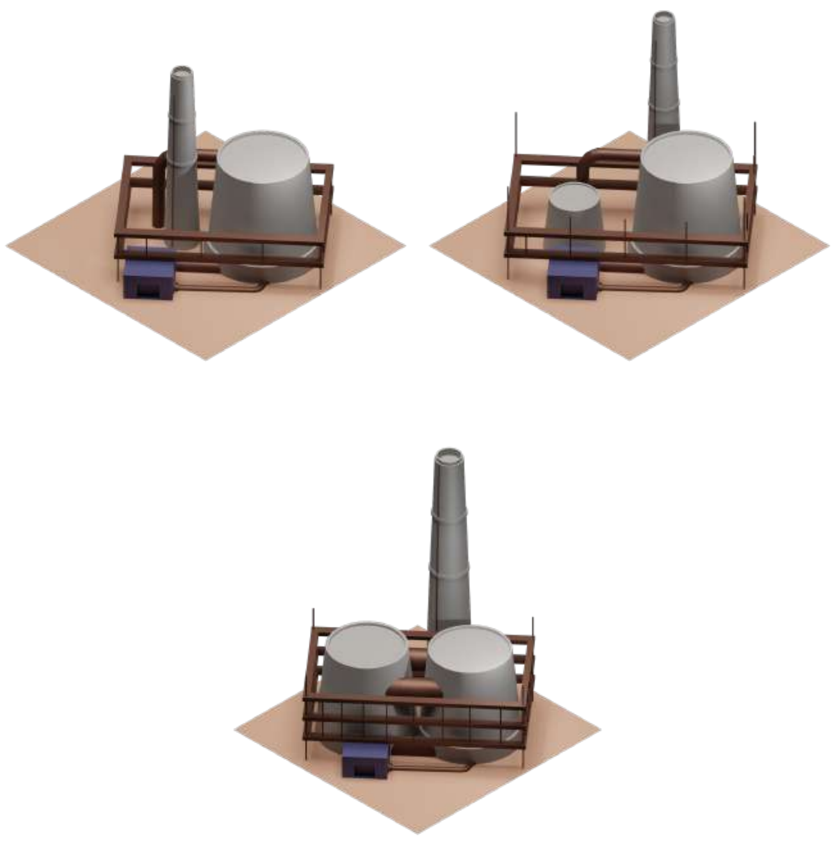


Figure 51: Final Water Station B.o.I design (Science4Pandemics, 2022)

The process was the same when developing the visuals for the *Factory B.o.I.* Since we needed three different, evolving visuals for the first version of the game (Figures 52, 53, 54), we aimed to create a less developed look for the first level of the building, so that the evolution could be visible for the player. The first iterations of the *Factory* had too many details and could not be discerned easily, thus we decided to change it almost entirely.



Figures 52, 53, 54: Initial iterations for the Factory B.o.I (Science4Pandemics, 2022)

After postponing the “upgrade building” functionality, we proceeded to simplify the general design of the building and scale it down so that it looked on par with the rest of the region surrounding it. Figure 55 shows the final iteration of the Factory *B.o.I*

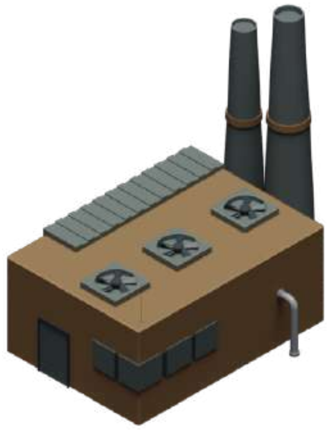


Figure 55: Final Iteration of the Factory B.o.I (Science4Pandemics, 2022)

3.2.2. Non-Interactive Buildings

Besides the *Buildings of Interest* found inside the *Regions*, most of its space is populated by non-interactive buildings, such as houses, parks, gas stations and other buildings that are commonly found in towns around the world, which are crucial to immersing the player inside the *Region*. Each model was carefully designed, modeled, textured and positioned so that we could achieve the characteristics that made sense for each specific area of the game (S4P Game Design Document, University of Coimbra, 2022). As it was mentioned before, a key concept of the game is the fact that different *Regions* possess different variables that make it up, influencing the possible spread and evolution of the diseases present inside the game. We will now go over every *Region* that has been fully developed so far and analyze their characteristics and non-interactive buildings, to understand why they look the way they do.

North America

The *North America Region* encompasses countries like The United States and Canada, so we began by researching prevalent information about these countries. As mentioned before, some characteristics of the countries were key in developing the visuals for the final *Regions*, these were: the climate, population, density and GDP (Gross Domestic Product), which would allow us to estimate how well developed some countries may or may not be, helping us to decide on the overall characteristics that would comprise the scene. With this in mind, when developing *North America*, which was the first *Region* created and the first playable one, we decided to create a balanced and easily manageable map, where the player could learn the basic mechanics, without too many setbacks or hardships. The characteristics for this *Region* were: temperate climate, with a medium density to represent suburban areas and with a high GDP, which translates how well developed the equivalent geographical region in the real world is.

Given what has been said, we could decide on the type of vegetation that existed in the area, the surrounding terrain and also how the weather would be transmitted into the Blender lights. In figures 56 and 57, we can observe surrounding mountains, which are common in this geographical region, and pine trees as the most common type of arboreal life, making up forests and parks. Since it is also a fairly sunny region, we decided to model solar energy panels (Figure 58) that are quite common around Canada and the USA.

Figure 56: North America's Region surrounding mountain (Science4Pandemics, 2022)

Figure 57: North America's Region pine forest (Science4Pandemics, 2022)

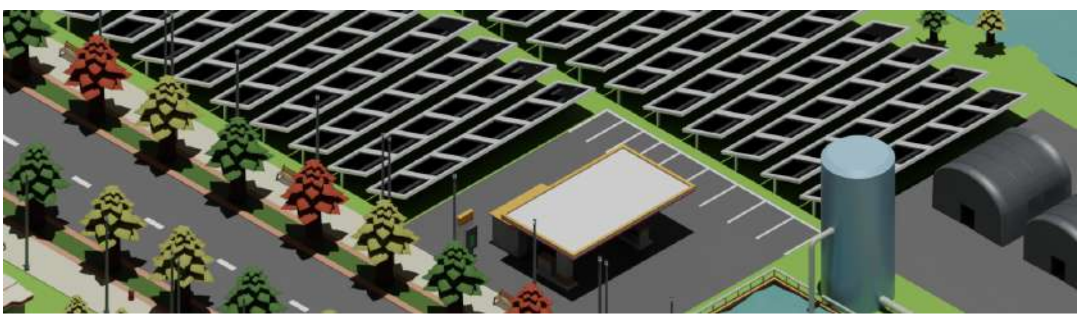
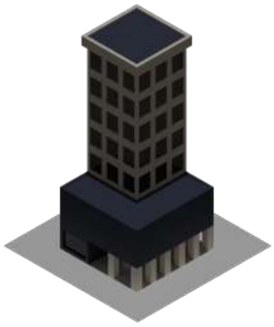


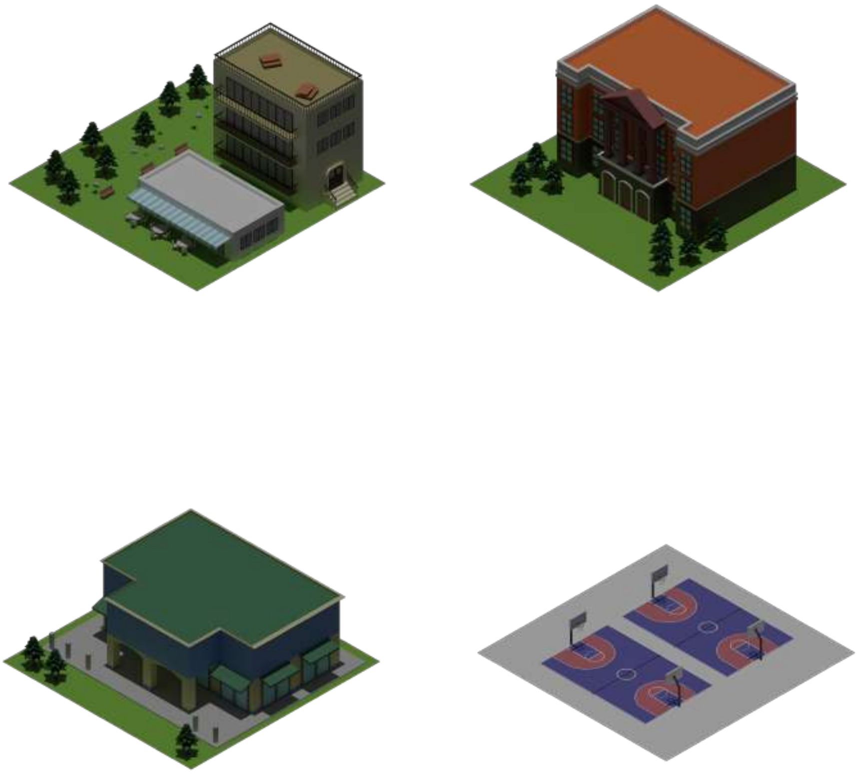
Figure 58: North America's Region solar panels (Science4Pandemics, 2022)

After that we moved on to the general buildings that would populate the area. Since this *Region* is meant to represent a suburban area with a moderate density, we started by modeling houses and apartment complexes (Figures 59 and 60), then placing them around the overall area of the map.

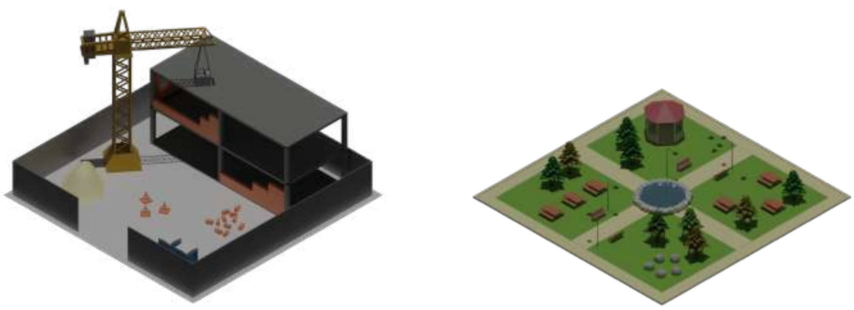
Figures 59 & 60: Houses and building 3D models (Science4Pandemics, 2022)

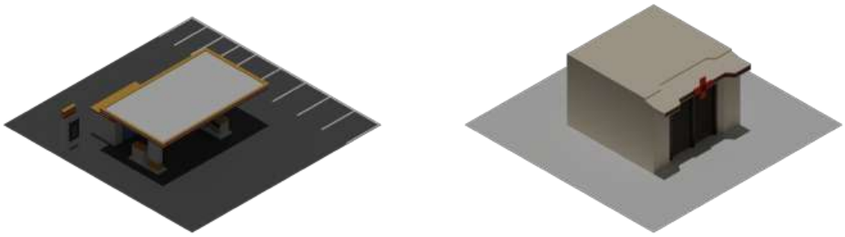
Then we thought about common buildings that could be found around cities and suburban areas like pharmacies, parks, basketball courts, restaurants, schools and shoppings (Figures 61, 62, 63 and 64). We had to decide between a number of buildings that could keep the *Region's* visuals realistic and diverse without compromising too much time, otherwise it would take a long time to develop each of the ten planned *Regions*. The remaining tasks were to model and place the buildings around the area of the map.



Figures 61, 62, 63 & 64: Restaurant, school, shopping center and basketball court modules (Science4Pandemics, 2022)

With an unsatisfactory degree of diversity around the *Region*, we decided to model more buildings like gas stations, construction sites, pharmacies and parks (Figures 65, 66, 67 and 68), trying to achieve even more diversity and believability in the *Region*.





Figures 65, 66, 67 & 68: Construction site, park, gas station and pharmacy modules (Science4Pandemics, 2022)

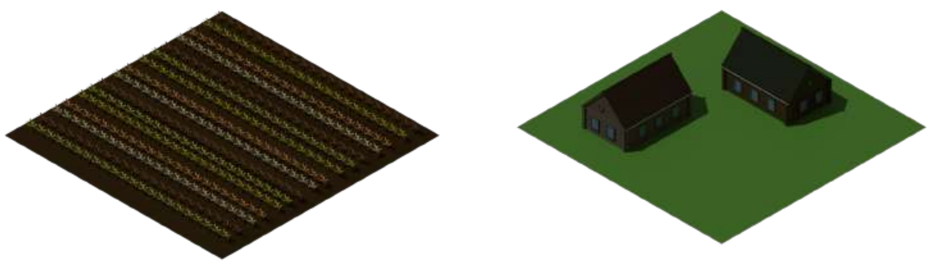
As it can be observed, the final version of each module contains smaller elements like trees, rocks, debris, benches and other, to add another layer of detail to the overall structure. The pharmacy module shown in Figure 67 is a version without the details, which were added afterwards when the whole structure of the map was already organized. Once again, all we had to do was to place the modules on their places, resulting in the original *North America Region* (Figure 69) map.

Figure 69: North America Region final iteration(Science4Pandemics, 2022)

North Asia

For the *North Asia Region* we wanted to transmit a very different mood. This *Region* was mainly inspired in Ukraine and Russia, with their snowy fields and eastern european architecture. Our goal was to represent how this geographical location can have highly populated areas but also vast fields and farmland. We began by drawing the layout of the streets and deciding where the *Buildings of Interest* were going to be placed. This is crucial for the overall layout of the *Region* itself, as it also determines the “slots” where the non-interactive buildings could be placed so that bigger fields, rivers, or residential areas could be created.

After that we began our research on different information on the overall geographical area, no different from the process that was used to create the *North America Region*. In this case we have a very cold region, with a low density in most areas and an average GDP, with fairly even distributed wealth. We then began to place the street models, which are reutilized from the *North America Region*, except for details like different lamp posts and new sidewalks, also placing the *B.o.Is* in the discussed positions in the overall scene. Our first decision was to find a way to create snow and distribute it around the whole *Region*. For this we had two options: we could select the materials that were already created and being used in our scene, and add nodes to it, trying to represent snow. The second option was to somehow scatter a mesh across the entire *Region* that resembled snow and then apply a procedural snow texture one single time to it. The first option offered limited results, since the snow would have no volume, it would just appear along the pre-existing textures. It would also require us to select each material that was already created and re-create the texture to each one of them, which takes too much time. Creating a procedural snow texture and mixing it with every other material would be too time consuming and would not produce the intended result. We decided to explore the second option and look for other ways to create snow. We quickly came upon various addons that create meshes and distribute them along any selected object, to which we applied a simple procedural snow material created with *noise textures* and *bump nodes*, which give details to the mesh. This allowed us to quickly add snow to the entire *Region*, instantly helping to characterize it. After that we began actually modeling the assets specific to this map. We decided to start with the rural area, creating modules for small houses and plantation fields (Figures 70 and 71).

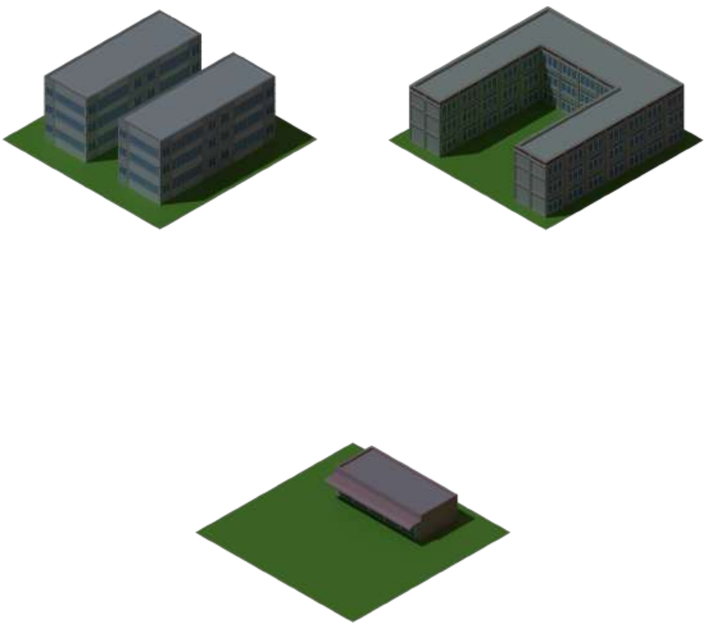


Figures 70 & 71: Rural house and Field assets (Science4Pandemics, 2022)

We created the base models and then made small changes in color, rotation, positioning and minor details on the mesh to create the illusion of diversity without spending too much time on the same asset. We then started to distribute small trees, rocks and lake assets, which were reutilized from the *North America Region*, across the rural area (Figure 72), to add more detail and realism.

Figure 72: North Asia rural area (Science4Pandemics, 2022)

Upon further research for visual references, it was clear that eastern european architecture has a very characteristic style and many of the buildings are actually just blueprints of one another, making it very easy for us to quickly populate the scene by reutilizing assets. We proceeded to focus on the urban area of the map, designing residential buildings, schools and stores, which can be observed in Figures 73, 74 and 75.



Figures 73, 74 & 75: Residential buildings, school and store models (Science4Pandemics,2022)

We used some of the previous assets from the *North America Region*, like the park, gas station, construction site, parking lot and pharmacy, then placed the buildings and added details we were left with the result shown in Figure 76.

Figure 76: North Asia first iteration (Science4Pandemics,2022)

Although we received positive feedback with the assets that populated the scene and the general look of the *Region* itself, the lighting was too warm and the snow was so little that it gave the impression that it was melting off. We decided to tweak these small details to amplify the cold look of the *Region*, which resulted in the final iteration of the region (Figure 77), which is used in game.

Figure 77: North Asia final iteration (Science4Pandemics,2022)

North Africa

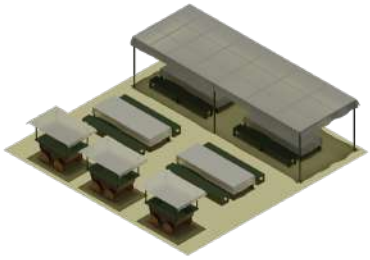
Once again, we started by searching for visual references of the actual geographical location. This *Region* possesses a tropical climate, with high density and a varied GDP, with a low percentage of citizens hoarding a larger part of the region’s wealth, while the rest of its population live in sub-optimal conditions. Taking inspiration from countries like Egypt, Angola and Morocco, our goal was to show that kind of disparity in the final iteration of the *Region*. For that we separated the map in two different parts: the “poor” and the “rich” area and began placing the streets and Buildings of Interest. We started by searching for some type of building that would stand out and immediately reminiscence player’s of this geographical area, which took us to the very specific architecture of mosques which are common religious buildings in this region of the world (Figures 78 and 79).

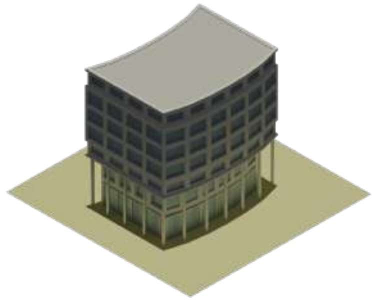
Figures 78 & 79: Mosque and Palm tree model (Science4Pandemics, 2022)

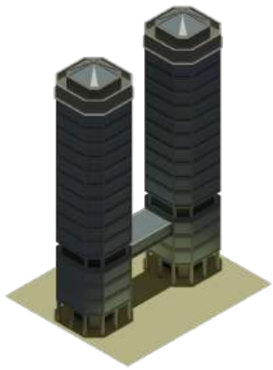
We then placed the mosque on the scene, along with different palm trees and bushes, creating a park area around the building (Figure 80).

Figure 80: Park and mosque (Science4Pandemics,2022)

After that, we continued to work on the “rich” area of the map, modeling big, luxurious residential buildings, that are usually found close to the coast and placed them in the desired position across the *Region*, always making sure that there were enough details and small assets like trees or benches to add more realism to the scene. On the visual reference that was found, there were also multiple street markets, with tents, carts and vendors, which helped us comprise the high density characteristic of the *Region* (Figures 81, 82 and 83).

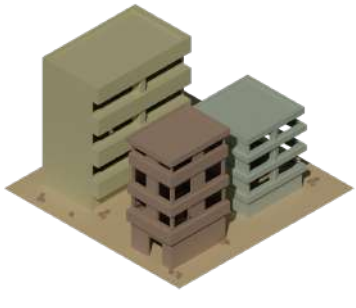






Figures 81, 82 & 83 : Market, rich building, rich building 02 models (Science4Pandemics,2022)

After carefully placing all models in their positions, it was time to model the "poor" area of the region, which we began by researching poor neighborhoods that exist in the countries of inspiration for the map. We then modeled and placed the assets (Figures 84 and 85) on the other side of the *Region*, thus representing the disparity that exists in it.



Figures 84 & 85 : Poor neighborhood North Africa (Science4Pandemics,2022)

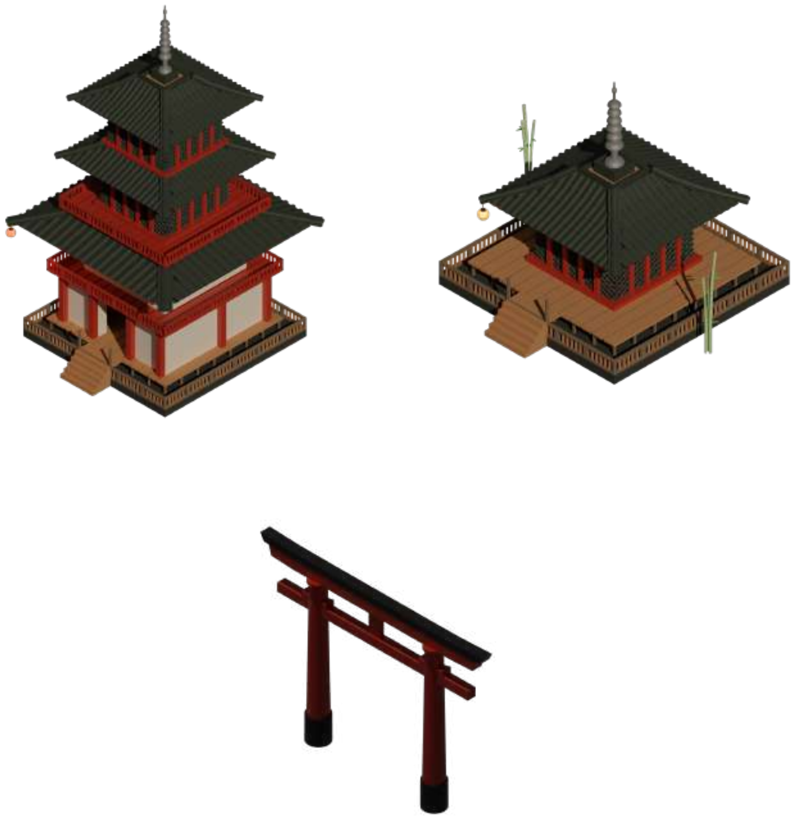
With this, we had to continue to place the modules around the region, adding minor details and reusing modules that are common between *Regions* to help populate the scene and the *North Africa Region* was completed. Figure 86 shows the final iteration of the *North Africa Region.*

Figure 86: North Africa final iteration (Science4Pandemics,2022)

Pacific Asia

The *Pacific Asia Region* is characterized by having a temperate climate and high GDP. But unlike other regions like *North America* for example, we wanted to represent that this *Region* could have a very high density, possessing a large amount of citizens in small, confined areas.

This geographical region in the real world possesses a lot of very characteristic details that helped us make it stand out as an oriental scene, such as cherry blossoms, temples and a variety of crowded residential areas. We researched countries like Japan, Korea and The Philippines, to capture the very distinct architecture that can be found in these countries. After drawing the overall position and placing the streets and B.o.Is, we decided to start with some of the most unique types of buildings like the Temples and the Torii Gate (Figures 87, 88 and 89).

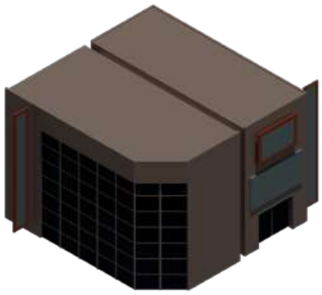


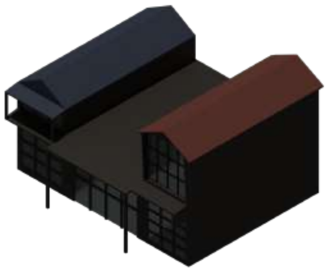
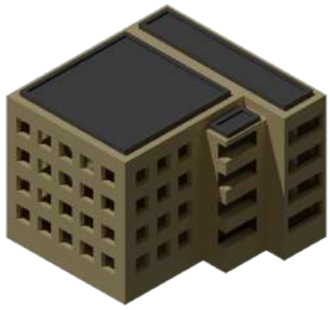
Figures 87, 88 & 89: Tall temple, temple and gate (Science4Pandemics, 2022)

The models' quality was crucial for the overall scene, as these kinds of buildings are remarkably oriental, immediately helping us establish the geographical region of the map. To add even more to this effect, we reused tree models from the *North Africa Region*, but increased the amount of leaves and changed their colors to pink, thus creating cherry blossoms, one of the most common arboreal life and culturally related to oriental countries like Japan. Once again we use the Geometry Nodes Scattering method to distribute these along the general area near the temple, thus creating a semi-rural area or a forest (Figure 90).

Figure 90: Pacific Asia Forest Area (Science4Pandemics,2022)

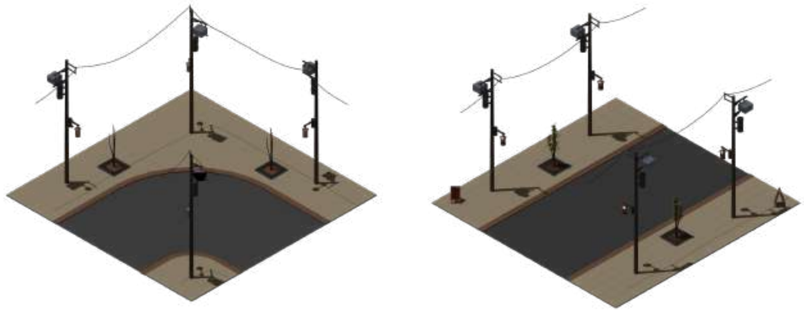
To further enforce the rural oriental ambiance, we modeled japanese-like old houses, and placed them around the rural area of the *Region*. After some research for reference, we found types of buildings that are common in such countries, residential or commercial (Figures 91, 92, 93 and 94) and model these buildings, to create the idea of a dense area, with crowded buildings and streets.



Figures 91, 92, 93 & 94: Arcade, Cherry Blossom, Old House and Tall Building models (Science4Pandemics,2022)

After placing these new models and reutilizing previously modeled assets, such as the construction site, pharmacies, parks and football courts, we decided to go back to the street modules and change some details. After observing the reference, we realized that the North American streets are usually very different from the geographical region we were aiming for. First, the pavement was changed to a slightly darker color and the sidewalk's bricks color was, but most importantly, new lamp posts were added, with energy cables wrapping around them (Figures 95 and 96), which are common in the region and helps to give a feeling of crowdedness.



Figures 95 & 96: Street modules for Pacific Asia Region (Science4Pandemics, 2022)

After some more model placement and final retouches in models, such as changing the textures to ensure more diversity, creating two different assets from the same initial mesh and adjusting the final number of leaves and trees, the *Pacific Asia Region* (Figure 97) was finally completed.

Figure 97: Pacific Asia Region Final iteration (Science4Pandemics,2022)

Sub-Saharan Africa

This *Region* encompasses countries like Ethiopia, Nigeria and Ghana, which all possess a desertic climate, with very dense regions and mostly poor conditions, having a part of its population living without the basic conditions needed. Although that is not the case for the entirety of the countries mentioned, this geographical region has an even more unbalanced wealth and is considered one of the poorest on the planet. Our idea here was the same as the *North Africa Region*, which was to create the visual disparity between the very poor and very rich areas of these countries. We then modeled different houses, trees, restaurants and other assets that could fit the scene (Figures 98, 99, 100 and 101).

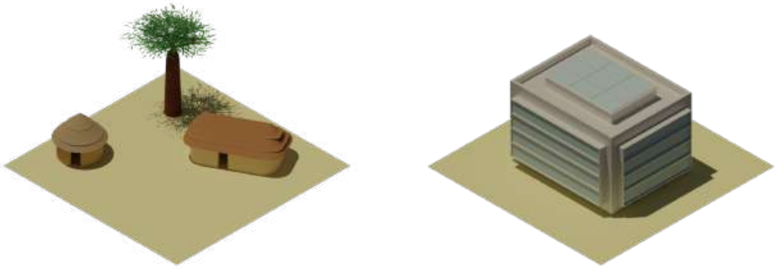


Figure 98 & 99: Poor house and rich house Sub Saharan Africa(Science4Pandemics,2022)

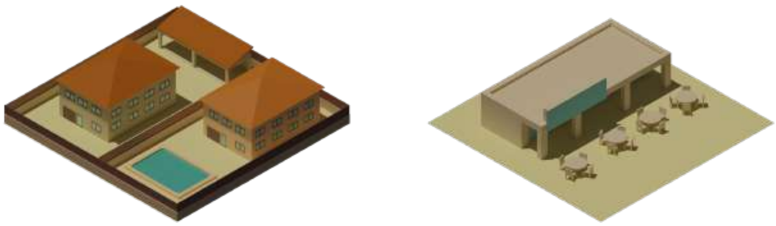


Figure 100 & 101:Rich neighborhood and restaurant assets (Science4Pandemics,2022)

Once again, we positioned the assets along places that would make sense, creating certain areas that visually appear more economically privileged and others, more towards the countryside, less economically privileged. After following the same steps that were described for the other *Regions*, Figure 102 shows the final result.

Figure 102: Sub-saharan Africa final Iteration (Science4Pandemics,2022)

Europe

Even though the European continent is comparatively small in area, due to its geographical location, countries can have very different climates, cultures and quality of life in general, which influences what kind of assets we must model to create a believable environment. To facilitate our work and to ensure that multiple types of regions are included in our plethora of playable maps, we opted to base ourselves on Mediterranean Europe, more specifically, Barcelona. In these countries we can find a temperate climate, depending on the time of the year, with an above average GDP and many areas with a high density, these are the characteristics chosen for the *Europe Region* map. Once again we start our research for reference, to find landmarks or types of buildings, streets or foliage that may be distinguishing for that specific region. Since we already had many common modules that can be reutilized, the only new assets that were created for this region were houses and buildings (Figure 103 and 104), resembling an average neighborhood in this geographical area.

Figure 103, 104: European house and block assets (Science4Pandemics,2023)

We also reutilized the cherry blossoms in the Pacific Asia Region, changing the color of the leaves to a green/ yellow color, replicating an oak tree, very common in Europe and created vast parks with vegetation and walking spaces for the people of the area (Figure 105).

Figure 105: Europe region park (Science4Pandemics,2022)

The rest of the *Region* is made up of assets like parks, gas stations, restaurants, pharmacies, construction sites and other modules, which were used previously to help us populate other regions, allowing us to quickly create the *Europe Region* (Figure 106).

Figure 106: Europe Region final iteration (Science4Pandemics,2023)

4. Generative Visual Experiments

This section will tackle the experimentation on the different *Regions*. By using different generative methods, we will visually alter characteristics inside the scene, such as: *lighting*, *movement*, *texture* and *color*. Our goal with these experiments is to change the way players feel about the affected *Region,* evoking different emotions and thus, possibly altering the way they interact with it.

4.1. Lighting Experiments

The Science4Pandemics game only possesses two types of lighting, directional and point light, used to replicate the different weather conditions and lamp posts respectively. With the aspect of lighting, finding a way to procedurally change the lights was a challenge.

For the first experiments, we used the *North America Region* and applied different HDRIs to change the overall mood of the scene, trying to give the player a feeling that the map was different. This can be made very quickly by browsing for a free HDRI, downloading it and applying it to the "World" setting in Blender, which then uses the light present in the HDRI image as the light in the scene itself.

Figure 107 shows the standard settings for the World Output, which directly affects the background of the scene that the user works in and a standard scene (Figure 108), seen by the user when opening Blender. The background node emits no light and only turns the background the same color as the node displays.

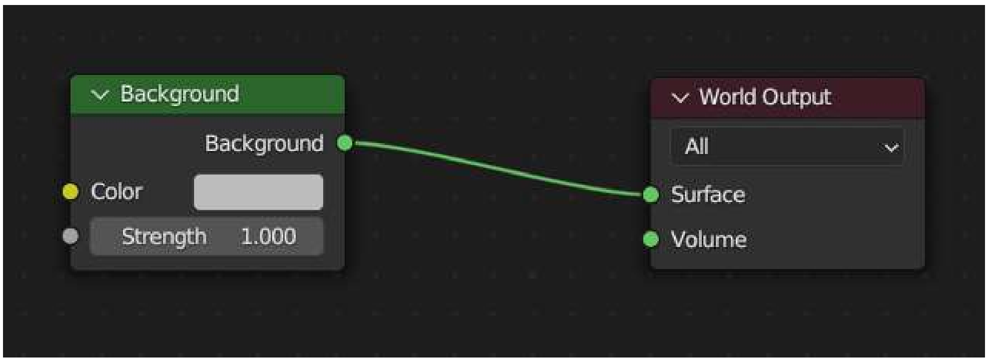


Figure 107: Standard world settings in blender (Blender, 2023)

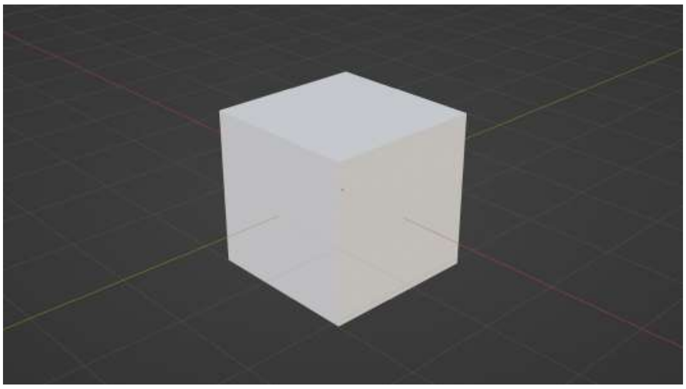


Figure 108: Initial standard scene in Blender (Blender, 2023)

In the original rendered image for the *North America Region*, the lighting used was a default "Sun" (Figure 109), which is a directional light, with a strength of 1.5 instead of 1 and a Canary Yellow, with a hex code of FFFF99, instead of pure white.

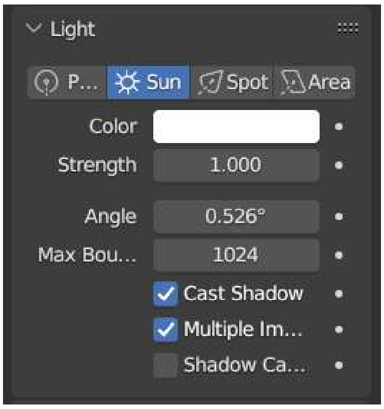


Figure 109: Default Sun Light settings (Blender, 2023)

The yellow, mild light produces the effect of a sunny day in the region, which helps build the interpretation that the region is peaceful and has a temperate climate. Figure 110 shows the original Region.

Figure 110: Original North America Region (Science4Pandemics, 2022)

We then started to experiment with different moods, which could represent a moment inside the game or how a player is supposed to interpret the scene itself. By searching for the node “Image Texture” Blender we could apply a texture to the World in the scene and then simply select the HDRI of our choice, In Figure 111 we can observe the “Image Texture” node with an HDRI image titled “spruit_sunrise_4k”, meaning that the image will produce the lighting and mood of a sunrise. And in Figure 112 we can see the effects of the HDRI lighting in the entire Region and how it can quickly be utilized to generate high-quality lighting instead of using the directional “Sun”.

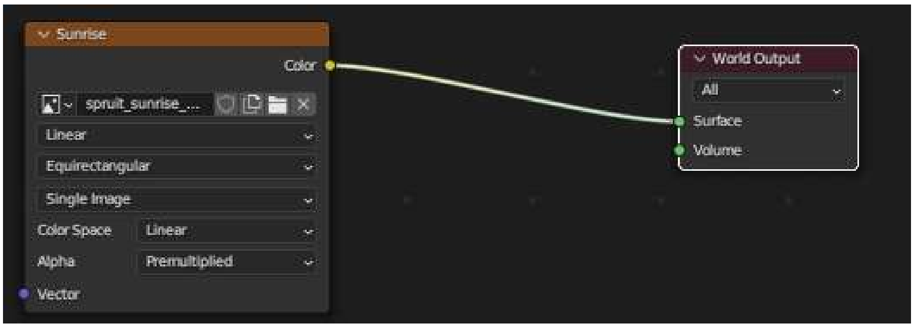


Figure 111: Image Texture Node labeled as “Sunrise” (Blender, 2023)

Figure 112: Sunrise North America Region (Science4Pandemics, 2023)

Figures 113, 114 and 115 show more results that were obtained using the same method, but using different HDRI images, trying to carefully pick one that would completely change the overall mood of the scene, reminiscing the player of another, opposite emotion.

Figure 113: Night North America Region (Science4Pandemics, 2023)

Figure 114: Cloudy North America Region (Science4Pandemics, 2023)

Figure 115: Sunset North America Region (Science4Pandemics, 2023)

Our goal is to use these different moods. created through the lighting change, to try and evoke different emotions on the player. To further investigate the results of each HDRI used we decided to also apply these same images to different *Regions*. The selected *Regions* were *North Africa* and *Pacific Asia*, this is because they naturally evoke different feelings in players, even in their original in-game visuals. In real life, these geographical locations also have very different characteristics and pre-concepts created by different people all around the world, which results in them having certain emotions connected to these *Regions*.

Figures 116, 117, 118, 119 and 120 show the original *North Africa Region* and then with the HDRI applied, in the same order as the previous *Region*.

Figure 116: Original North Africa Region (Science4Pandemics, 2022)

Figure 117: Sunrise North Africa Region (Science4Pandemics, 2022)

Figure 118: Night North Africa Region (Science4Pandemics, 2022)

Figure 119: Cloudy North Africa Region (Science4Pandemics, 2022)

Figure 120: Sunset North Africa Region (Science4Pandemics, 2022)

We then proceeded to apply these HDRI images to the *Pacific Asia Region*, once again, utilizing the same methods and with the same purpose. Figure 121 shows the original *Region*, while Figures 122, 123, 124 and 125 show the results.

Figure 121: Pacific Asia Original (Science4Pandemics, 2022)

Figure 122: Sunrise Pacific Asia Region (Science4Pandemics, 2022)

Figure 123: Night Pacific Asia Region (Science4Pandemics, 2022)

Figure 124: Cloudy Pacific Asia Region (Science4Pandemics, 2022)

Figure 125: Sunset Pacific Asia Region (Science4Pandemics, 2022)

Although the results offered with the use of HDRIs instead of traditional lights were satisfactory and offered good results as a way of evoking different moods through the use of simple images as light source, we could not consider this an application of generative methods, which is one of the goals of this project, since this is obtained, as it was shown in the figures observed previously, by basically creating one single node and applying different textures to it.

With this, the lighting variations experiments are complete and even though the techniques used to achieve such results cannot be considered “generative”, it was still interesting to analyze how different concepts behind the lighting can completely change how a scene looks and feels.

4.2. Movement Experiments

In the Science4Pandemics game, movement means life, since it is a representation that the *Region* itself is healthy and has a population. Through these variations we hope to be able to represent how empty or full any *Region* may look and feel, and how these characteristics affect the player's perception of that place. Through the scattering of models of cars and people across the *Region's* streets and parks, we will represent crowded places and buildings to gauge how the player feels when that *Region* is clearly alive and when it is not. The movement variations will be classified into: empty, moderate and crowded, describing how much movement will be present in that scene.

Blender has two techniques for scattering objects around meshes, one is the Geometry Nodes functionality, already previously explained in this document and the second is the particle system, which although, is older than the later, still works and can be used to speed up the process of populating a scene. In this instance, we will use geometry nodes, following the same process that was explained earlier. We must first organize our scene to start the object distribution, in this case streets, parking lots, parks, courts and any other planes must be separated from any meshes that they may be joined with. For instance, let's take the "corner street" module as shown in Figure 126.

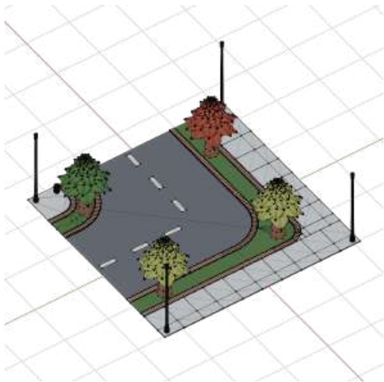


Figure 126: Street module (Science4Pandemics, 2022)

As we can observe, since the mesh was imported from another blend file, the objects that make up this module, such as the trees, lamp posts, street, grass and bricks, have been merged into a single mesh, but we only want to scatter the car models along the roads and not the sidewalk or over the trees. To solve this we must simply select the faces we want to separate, click "shift + p" and select the separate option, now we must also complete the same operation for the other streets modules found in the *Region*. For modules like parking lots, where the whole area could possibly have vehicles we can simply start to apply the Geometry Nodes logic.

No differently from the technique used for scattering the trees in the forest that was shown previously, we must first create an empty Geo Nodes instance in the mesh we want to distribute the cars. To save time, we can reuse the nodes created for the forest, but instead of selecting the *collection* that contains the assets for the forest, we select the "cars" *collection*. As a final touch we remove the random value connected to the rotation parameter, since multiple cars in random directions would not make sense.

Figure 127: Street module with cars scattered(Science4Pandemics, 2022)

When we observe the module up close (Figure 127), we can see different, small errors that are unavoidable when working with these kinds of generative methods, such as a cluster of cars that seen to be clipping, or a car that goes outside the boundaries of the street, luckily for us, the actual camera will encompass the entire region, making these small details virtually invisible. After that we apply the same logic in modules where people can walk or have some kind of activity. To achieve a certain level of extremity when representing a crowded city, we tune up the values for the quantity of points distributed along each plane, increasing the amount of cars and people, Figures 128 and 129 show the results for a crowded and a moderate *North America Region*.

Figures 128 & 129: North America Crowded and Moderate movement variations(Science4Pandemics, 2023)

Not unlike the rest of the regions that we chose to experiment with the variations, we proceeded to apply the same techniques to the *North Africa Region* and the *Pacific Asia Region*, the results can be observed in Figures 130, 131, 132 and 133.

Figures 130 & 131: North Africa Crowded and Moderate movement variations(Science4Pandemics, 2023)

Figures 132 & 133: Pacific Asia Crowded and Moderate movement variations(Science4Pandemics, 2023)

Although these methods are very repetitive, when it comes to quickly populating a scene with different models, they are crucial. They allowed us to alter each module individually, applying different instances of the objects we wished to scatter, with a great amount of control over said objects, instead of placing multiple single objects around the scene, which would consume a large amount of time and unnecessary effort. These methods are not perfect though, as was mentioned the details such as the precise positioning of each scattered model cannot be controlled, thus possibly resulting in clipping or unrealistic behavior depending on what asset is being scattered. In the cases where we used these methods, since the camera was positioned far away from small objects, the clipping is not visible and even though some minor details might be noticeable, it does not matter as it is the overall feeling of emptiness or crowdedness that we were trying to achieve.

4.3. Texture Experiments

For the textures, we carefully discussed which materials should be subject to the variations before starting them, since each *Region* is such a big scene and possesses a variety of textures, it was not viable to try and apply modifications to all of them. We decided that the materials that affect big parts of the *Region*, like the streets or the ground textures, were the key to making a big difference in the overall mood of the *Region*, without spending too much time. After that we had to decide which type of variations would be made on said materials. Since the Science4Pandemics game has a cartoony and simplistic look in its design choices, the geometry and materials, we decided to add more details to the materials themselves.

As they stand on their base form, the materials are composed simply of the standard "Principled BSDF" node, with variations in their colors (Figure 134), resulting in very basic looking materials that work in the artistic context of the game.

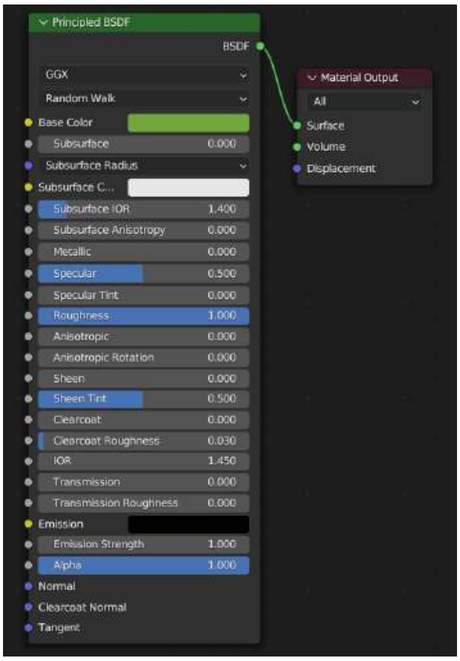


Figure 134: Base ground texture (Science4Pandemics, 2022)

Due to the reasons mentioned above we decided that adding simple details to increase the level of realism of the materials, could greatly alter the overall look of the scene. Both the "ground" and "street" textures received similar treatment. First we decided to add more details to the textures by adding a "noise texture" node to its color parameter, which creates a noise pattern along the entirety of the area of the material. To better control this noise texture we also add a "color ramp" node, allowing us to add different colors to both the area where the noise exists and where it doesn't. To represent the different bumps and for extra detail we also plug a "bump" node to the Normal slot and to the "noise texture" node, creating the illusion of height where the noise is. Finally we add a "mapping" and a "texture coordinate" node to better control the position of the texture that is being applied on the mesh. Figure 135 shows the final material for the ground texture and Figure 136 shows how the ground mesh looks with it applied.

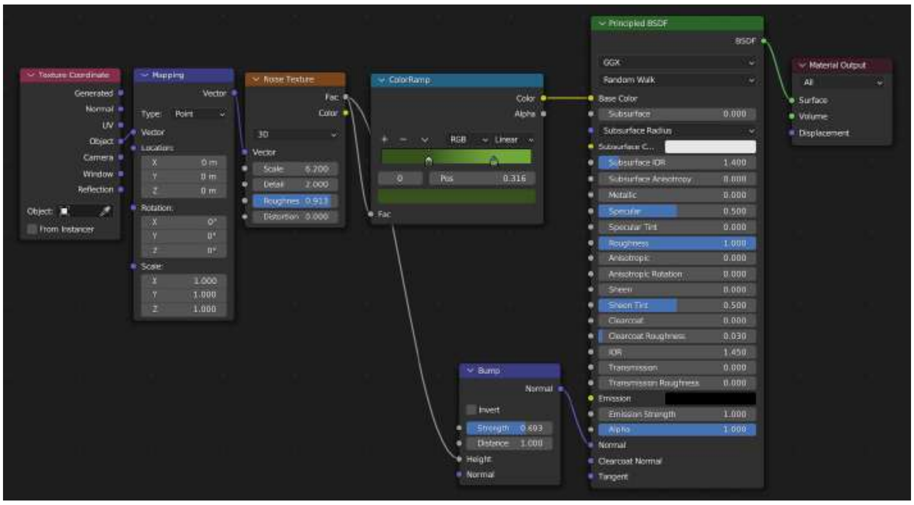


Figure 135: Final ground texture (Science4Pandemics, 2023)

Figure 136: Detailed view of the altered textures (Science4Pandemics, 2023)

After adjusting different parameters, such as the scale and roughness of the noise texture, the height of the bumps created and the overall colors of the ground, all that was left was to replicate the same process for the street texture and then apply it for the remaining of the "ground" and "street" modules. Figures 137, 138 and 139 show the *Regions* with the new textures.

Figure 137: North America texture variations (Science4Pandemics, 2023)

Figure 138: North Africa texture variations (Science4Pandemics, 2023)

Figure 139: Pacific Asia texture variations (Science4Pandemics, 2023)

Procedural textures are already a common generative method, widely used in the gaming industry, with different benefits and disadvantages. In this case, since the textures created were simple and did not require a large time to be developed, we were able to design a material that has a fair amount of detail with almost no computational weight whatsoever that can also be used in a large part of our *Region*, a better option than using image textures.

4.4. Color Experiments

Since color is a byproduct of other components and is affected directly by them, being more a concept than an aspect, we decided to leave it for last. Our idea was to change the overall mood of the scene by affecting all of its elements color's, this way we could test whether the perception of the scene was different or not. We decided to apply a simple, but effective experiment to achieve quick results and a great variety of images so that, when testing, we could have a variety of perceptions from the testers.

Our idea was to apply colored "filters" to the original images, these "filter tests" will be done through the use of a directional light that has been used previously, trying to simulate weather effects that are virtually impossible in real world conditions. This way we will be able to observe what kind of emotional reactions the players would have when playing under these visual conditions. For this experiment we decided to use, as said previously, colors that represent near impossible or actual impossible weather phenomena that lead to unusual effects in the atmosphere, for that we chose the following colors: Purple, green, blue, red and yellow. We then started the testing with the original strength of the Sun, altering only its color. Once again, the Figure 140 the original North America *Region,* with the standard "Sun" Light affecting it.

Figure 140: Original North America Region (Science4Pandemics, 2022)

When applying the colors we quickly realized that the extreme weather effects that we were looking for, could not be achieved with the mild light that was used in the original. We also tested with a strength of two, but still did not feel satisfied and decided to go for a more extreme and unrealistic strength, increasing it to 10. Figures 141, 142, 143, 144 and 145 show the results of the filter in the *North America Region*. The specific HEX code for the colors used are respectively purple: 8400C6; green: 4EC600; blue: 0050C6; red: C6000C; yellow: F0A000.

Figure 141: North America Region Purple Filter (Science4Pandemics, 2023)

Figure 142: North America Green Filter (Science4Pandemics, 2023)

Figure 143: North America Blue Filter (Science4Pandemics, 2023)

Figure 144: North America Red Filter (Science4Pandemics, 2023)

Figure 145: North America Yellow Filter (Science4Pandemics, 2023)

We then proceeded to apply the same tests to the *North Africa Region* and the *Pacific Asia Region,* Figure 146 and 152 show the original results from each region and Figures 147, 148, 149, 150, 151, 153, 154, 155 and 156 show how the filters affected them.

Figure 146: North Africa Original Region (Science4Pandemics, 2022)

Figure 147: North Africa Purple Filter (Science4Pandemics, 2022)

Figure 148: North Africa Green Filter (Science4Pandemics, 2022)

Figure 149: North Africa Blue Filter (Science4Pandemics, 2022)

Figure 150: North Africa Red Filter (Science4Pandemics, 2022)

Figure 151: North Africa Yellow Filter (Science4Pandemics, 2022)

Figure 152: Pacific Asia Original Region (Science4Pandemics, 2022)

Figure 153: Pacific Asia Purple Filter (Science4Pandemics, 2022)

Figure 154: Pacific Asia Green Filter (Science4Pandemics, 2022)

Figure 155: Pacific Asia Blue Filter (Science4Pandemics, 2022)

Figure 156: Pacific Asia Red Filter (Science4Pandemics, 2022)

Although simple, the experiment offered interesting results , since the effects created were able to quickly alter the entirety of the *regions* and thus the possible emotional response from the players. Although simple, this method can also be considered parametric (Gerber, 2007), since it only uses the different values from the standard Directional Light node and was able to create effective results within a short amount of time.

5. Evaluation

In this section we will explain the methods used to create the evaluation and analyze its results, with the goal to ascertain the effects of the experiments on the *Regions.* And to determine that the design of said *Regions*

5.1 Evaluation Procedure

This section is devoted to gathering the results obtained in the previous sections and evaluating them based on different criteria. With these evaluations we aim to first inquire whether the visual variations that were made along the Generative Visual Experiments section, had the desired effects and influences in the player's perceptions of the affected Regions. And second to investigate if the multiple visual and stylization choices that were made along the development process of the *Regions*, actually worked as planned. This means that we will try to discover if, for instance a *Region* like the *North America* map, can be identified as having characteristics of said area in the real world.

These evaluations will be conducted through a questionnaire, which is divided into two different parts, each one focusing on the two purposes explained in the paragraph above. The first section will be a comparison test, using Plutchik's wheel of emotions, which was mentioned previously in this document. Our goal with this part is to get the testers to compare the original images and the altered ones, to ascertain which emotions contained in the wheel resonate the most with them. Each experiment or variation comprises one question in this section and each question possesses four different scales that the participants must assign. These scales are different emotions from the strands of Plutchik's wheel (Figure 157), containing emotions that are on opposite ends of that segment (Plutchik, 1982). The emotions on the scales range from: joy to sadness; anticipation to surprise; fear to anger; trust to disgust. They range from values one to seven, which means that, for instance when selecting "one" in the first scale, we would be assigning to that variation, a very strong feeling of joy, transforming it into "ecstasy" as is shown in Plutchik's wheel. Similarly if we select "seven" that would be equivalent to "grief" and "four" represents "neutral", meaning that the tester has no inclination towards either emotion in the spectrum.

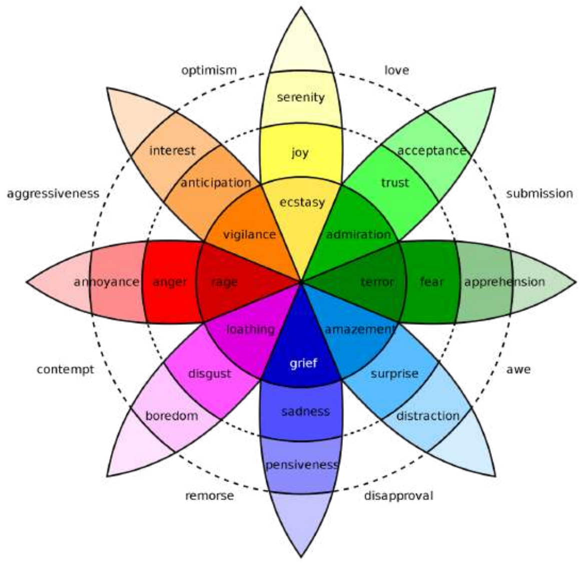


Figure 157: Plutchik's wheel (Wikimedia Commons, 2011)

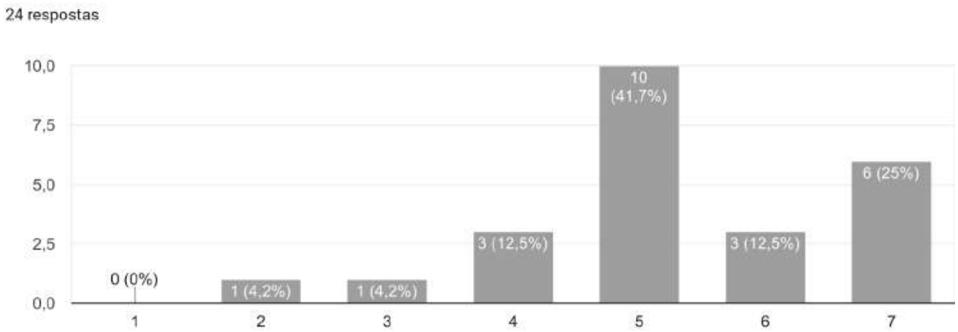
The second part of the questionnaire consists of simple questions such as: "In which geographical region of the world do you think this *Region* is located?" and "What type of development does this *Region* have? Is it poor? Do their citizens have a good quality of life?". Since the *Regions* were created with specific references and thus characteristics, this serves as a test to ensure that these characteristics have come through to the players. The evaluation analysis will be organized similarly to how the experiments were laid out, we will examine each result from each category of variations and then analyze the written results, following the same order as the experiments were set up.

With the core of the evaluation methods now explained, we can proceed with the analysis. After distributing the tests to different people, some that had previous background in the area of design or games and some with no background in this area whatsoever, we gathered 24 test results, from testers aged 16-26, with around 50% being male and 50% female. We will now analyze the different results from said tests.

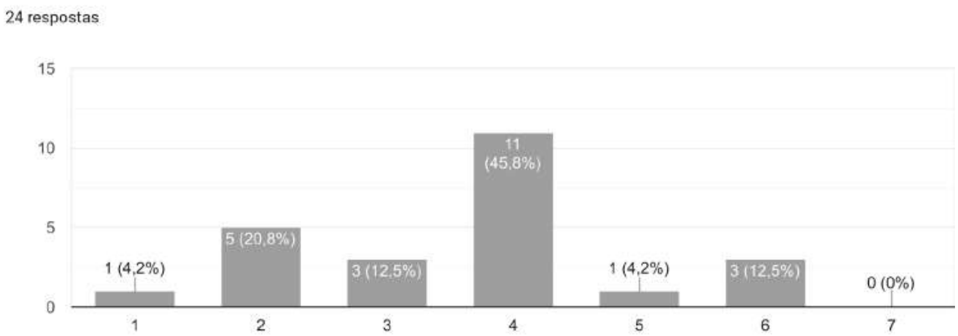
5.2 Lightning Variation Results

There were a total of four different lighting variations, which used Night, Cloudy, Sunrise and Sunset HDRIs, organized respectively in that order. Graphs 1, 2, 3 and 4 show the results for the *Night North America Region*.

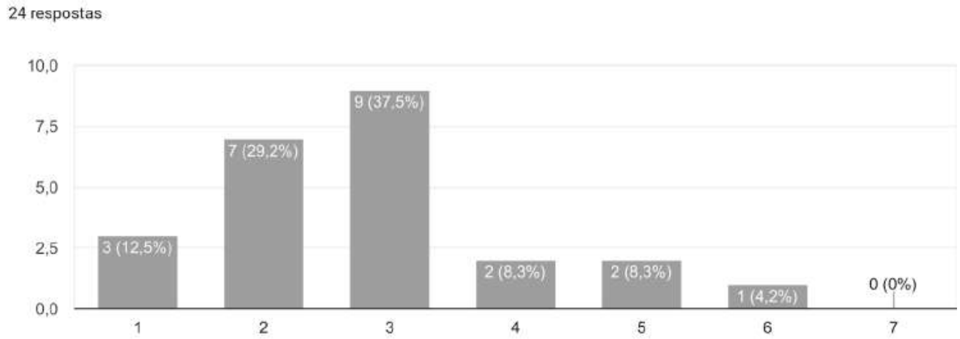
Figure 158: Night North America Region (Science4Pandemics, 2023)



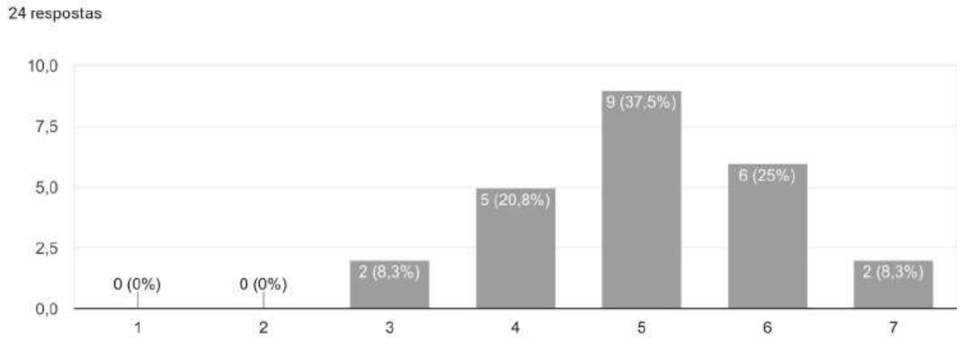
Graph 1: Night North America Joy (1) to Sadness (7) scale (Science4Pandemics, 2023)



Graph 2: Night North America Anticipation (1) to Surprise (7) scale (Science4Pandemics, 2023)



Graph 3: Night North America Fear (1) to Anger (7) scale (Science4Pandemics, 2023)

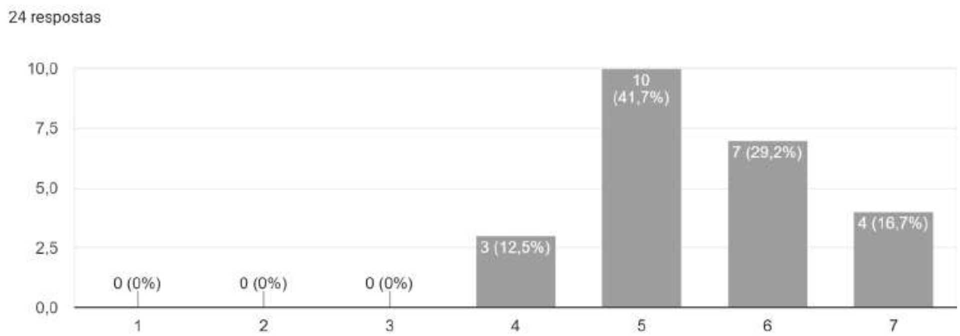


Graph 4: Night North America Trust (1) to Disgust (7) scale (Science4Pandemics, 2023)

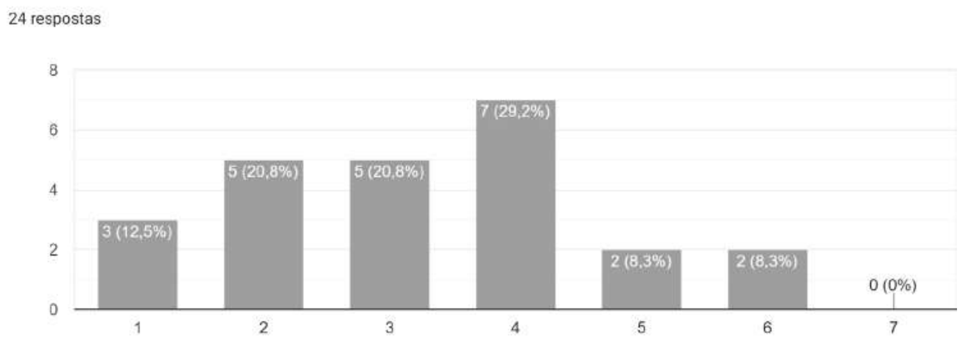
In the *Night* variation of the *North America Region* (Figure 158) we can observe some very predominant feelings, like "*sadness*", "*fear*" and "*disgust*", which comprise around 40% of the results. The nighttime, as we studied, is often culturally associated with some sort of sadness or fear, due to the somberness and lack of light that it usually provides, meaning that these results are within our range of expectation. We can also observe some outliers in the first scale (Graph 1), where two different testers assign the feeling of "*joy*" at different intensities. The second scale (Graph 2) also shows that most participants don't feel any type of "*anticipation*" or "*surprise*" when looking at the image, but tend to lean towards the "*anticipation*" side of the scale, even though it is on a weaker intensity. The last scale (Graph 4) shows unexpected results, since the nighttime is not usually associated with any form of disgust, leading us to believe that the results would mostly be a "four" on the scale, but over 50% of the testers assigned feelings of disgust on different intensities to the image. This may simply be due to the misconceived feeling that it is better to feel something towards the image presented rather than nothing (assign some emotion rather than neutral), or maybe by looking at the opposite side of the scale and rejecting the feeling of "trust" when in a nighttime setting, the testers decided to assign the emotion on the opposite side of the scale, which is not necessarily the opposite emotion.

We will now move onto the other *Night* variation of the other *Regions*. Starting with the *North Africa* chart results, to inspect whether the results differ or not.

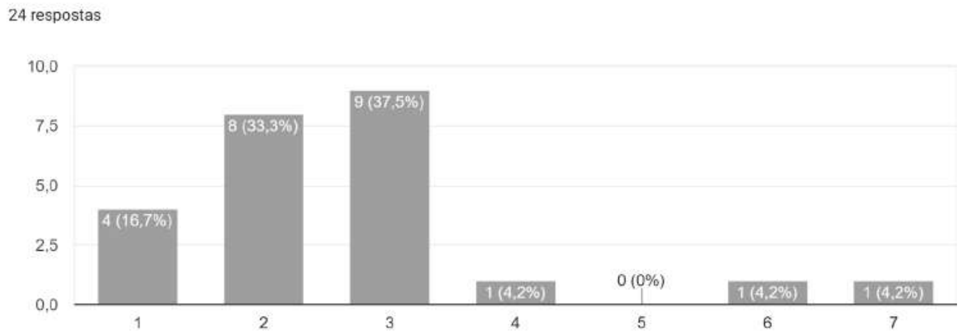
Figure 159: Night North Africa Region (Science4Pandemics, 2023)



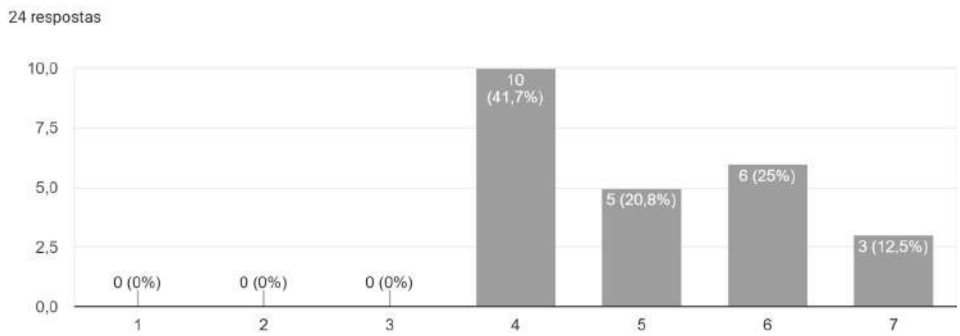
Graph 5: Night North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 6: Night North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



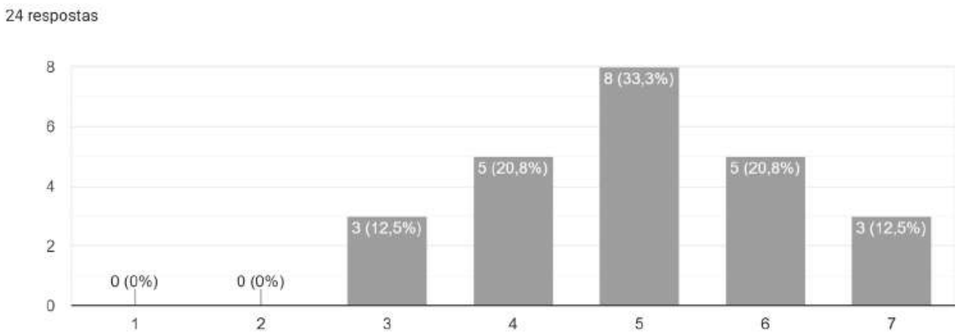
Graph 7: Night North Africa Fear to Anger scale (Science4Pandemics, 2023)



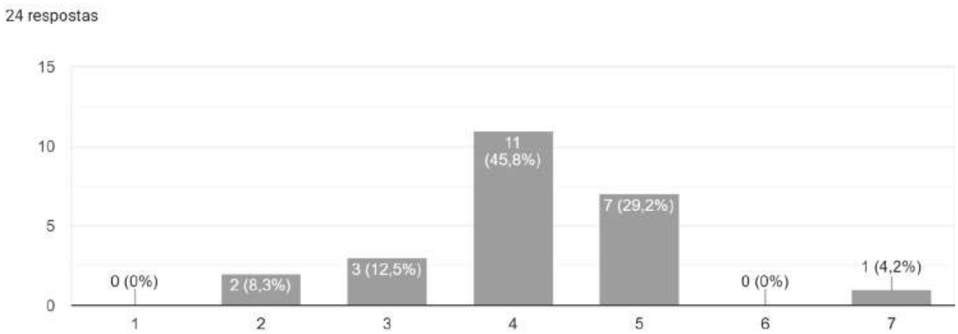
Graph 8: Night North Africa Trust to Disgust scale (Science4Pandemics, 2023)

In the *Night North Africa Region* (Figure 159) we can immediately observe uneven distributed results, weighting more towards one side of each scale (Graphs 5, 6, 7 and 8), with little to no outliers in the results. As expected, the feelings of "*sadness*", "*anticipation*", "*fear*" and "*disgust*" (the latter continues to be unexpected, but matches with the results found in the *Night* variant of the *North America Region*), all considered negative feelings, brought by the thought of the darkness that this environment creates. Lastly, we will analyze the *Night* variation for the *Pacific Asia Region*. Using the same methods as previously, analyzing the graphs and comparing results.

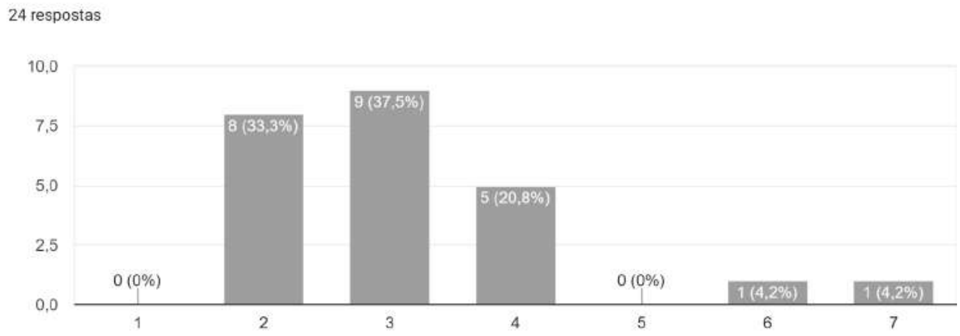
Figure 160: Night Pacific Asia Region (Science4Pandemics, 2023)



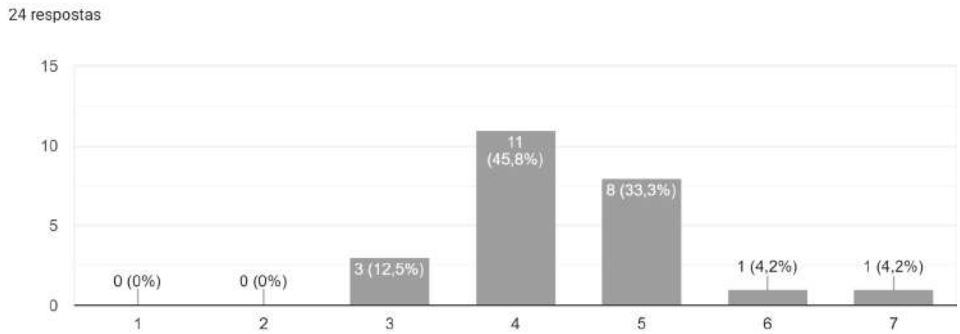
Graph 9: Night Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 10: Night Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 11: Night Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)



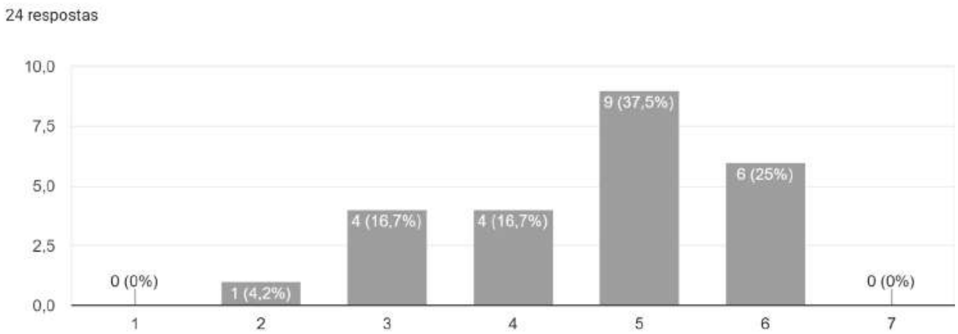
Graph 12: Night Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

In Figure 160, the trend continues, with negative feelings being more popular on all four scales (Graphs 9, 10, 11 and 12), but with a few curious cases. The first scale (Graph 9), for instance, out of the three *Regions* analyzed, is the one with more "positive" & "*neutral*" options, with a total of 12.5% feeling slight "*joy*" and almost 21% of the testers having no feelings whatsoever. This may be due to the tiredness of completing the questionnaire and thus assigning a somewhat more random value to the same type of image? Or maybe this region inspires less sadness due to some element present in it? The second scale (Graph 10) also presents curious results, again, out of the three *Regions*, it is the only one that weighs more toward "*surprise*" rather than "*anticipation*", with around 30% and 20% of votes, respectively. Which begs the question that was made in the previous paragraph, is there some element or reasoning in this *Region*? Or is it mere tiredness and coincidence?

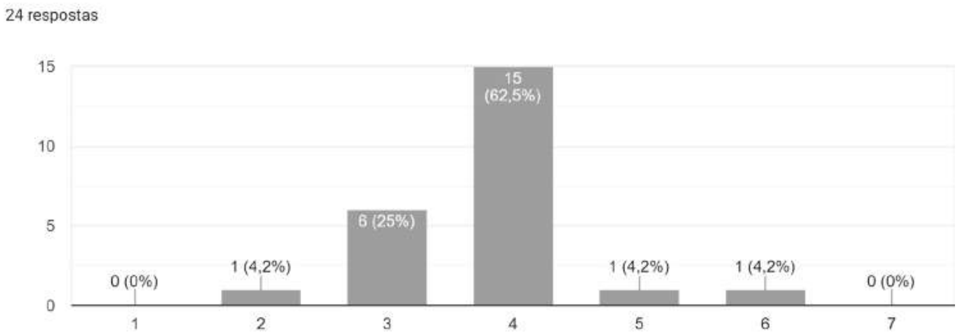
The *Night* variation *Regions,* created overall expected results, with *sadness* and *fear* being the most popular emotion among testers, with many of them also selecting negative emotions such as *disgust.* The night is usually correlated to the unknown and thus, may be evoking predominantly fear or sadness. We will now move on to the

Cloudy variations, starting with the *North America Region.* Following the same process as for the previous variations.

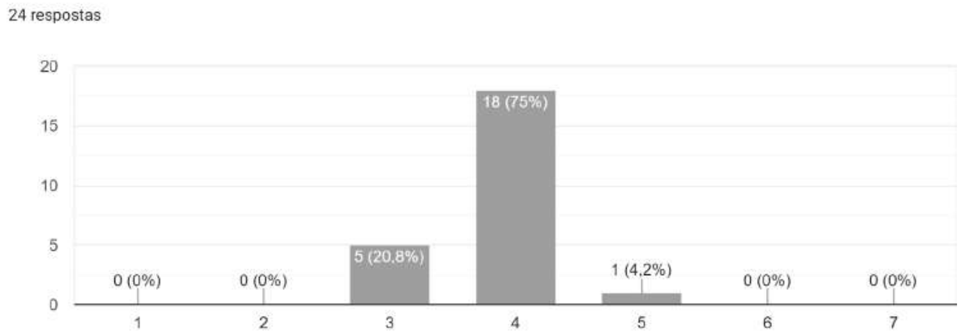
Figure 161: Clody North America Region (Science4Pandemics,2023)



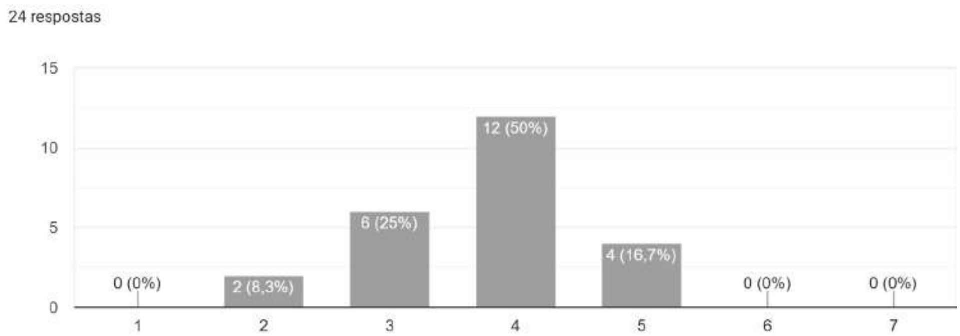
Graph 13: Cloudy North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 14: Cloudy North America Anticipation to Surprise scale (Science4Pandemics, 2023)



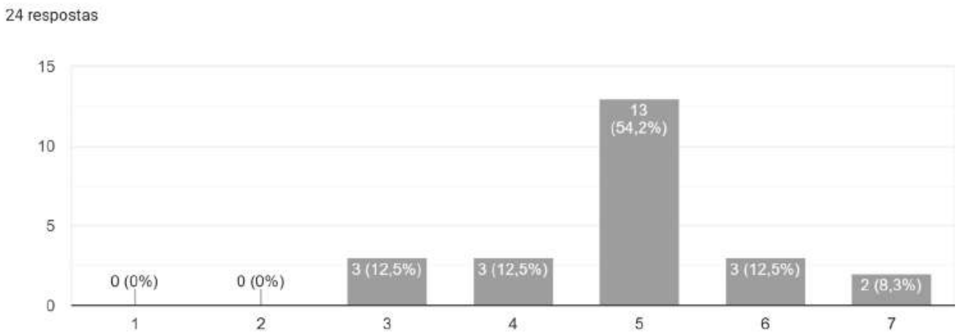
Graph 15: Cloudy North America Fear to Anger scale (Science4Pandemics, 2023)



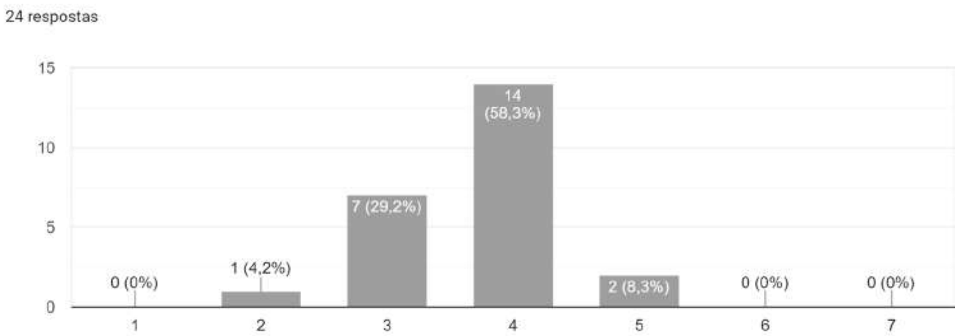
Graph 16: Cloudy North America Trust to Disgust scale (Science4Pandemics, 2023)

The *Cloudy* experiments offered a more desaturated scene as a result, with grayish hues and a hazy overall feel to it. Graphs 13, 14, 15 and 16 refer to the answers in the *Cloudy* variation of the *North America Region* (Figure 161), which are quite even in all scales, with the "*neutral*" option comprising around 50% of the overall results (sum of the four different scales) and very little intense options chosen. Only in the first scale (Graph 13), do we see more negative feelings as the trend, where the testers lean towards the "*sadness*" margin, making up 62.5% of the votes between "*joy*" or "*sadness*". We can also observe that around 20% of the testers feel a more positive feeling in this kind of setting, making the positive feelings more common than in the *Night North America Region.* Next, we will analyze the results for the *Cloudy* variation of the *North Africa Region.*

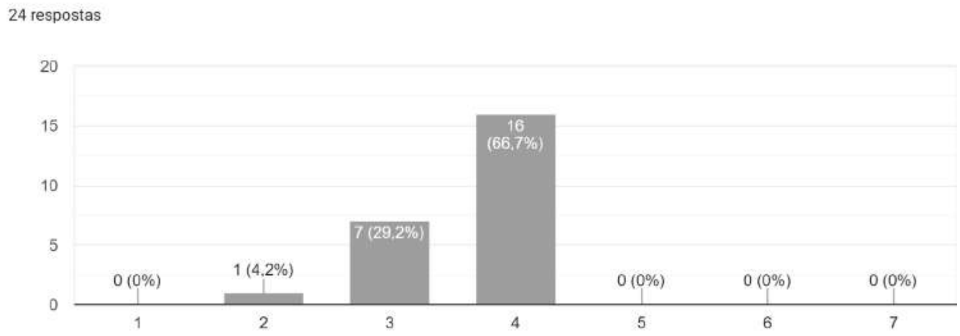
Figure 162: Cloudy North Africa (Science4Pandemics, 2023)



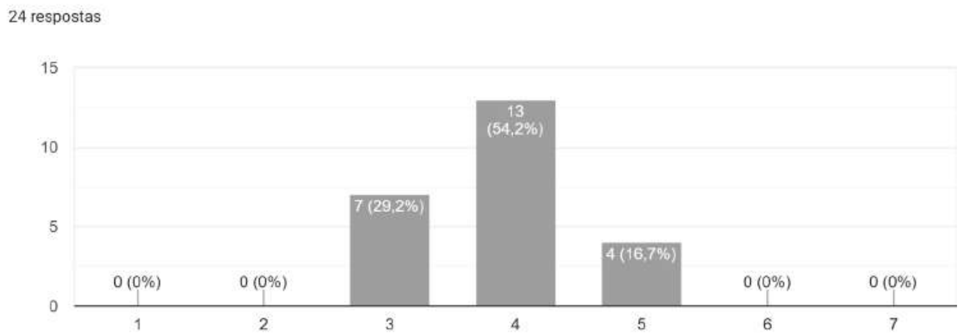
Graph 17: Cloudy North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 18: Cloudy North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



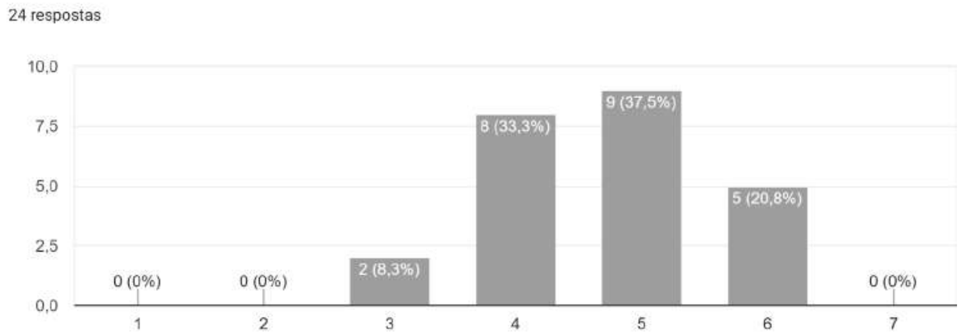
Graph 19: Cloudy North Africa Fear to Anger scale (Science4Pandemics, 2023)



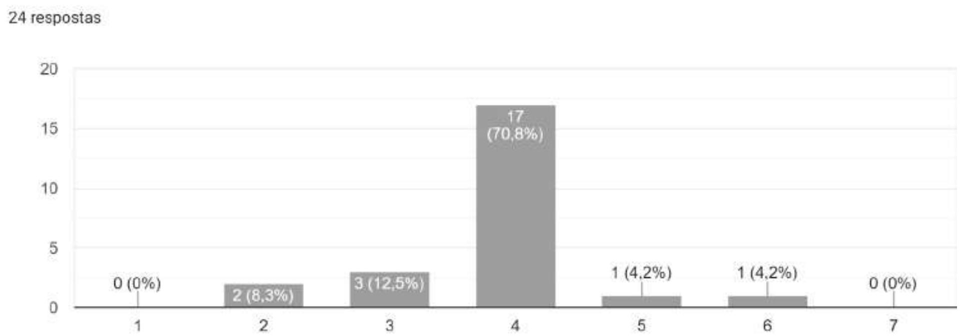
Graph 20: Cloudy North Africa Trust to Disgust scale (Science4Pandemics, 2023)

In Figure 162, we see over 50% of the testers assigning a "*neutral*" option, with the remaining votes being mostly distributed across low intensity emotions, be it positive or negative. In the second, third and fourth scale (Graphs 18, 19 and 20) we can observe that, although most testers feel no emotion toward the variation, when they do it is on a low intensity. On the first scale (Graph 17) "*sadness*" is the trend, with 75% of the votes when considering different intensities, this number is smaller than the previous experiment in the same region, the *Night* variation of the *North Africa Region* (which had around 87% of total testers feeling "*sadness*" to some degree). It is also important to note that, once more there were 3 participants that felt a slight joy when looking at the new image. We will now analyze the final *Cloudy* variation, the *Pacific Asia Region.*

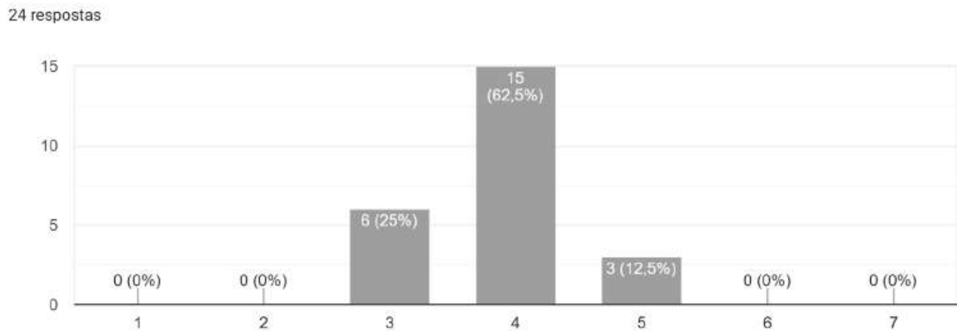
Figure 163: Cloudy Pacific Asia (Science4Pandemics,2023)



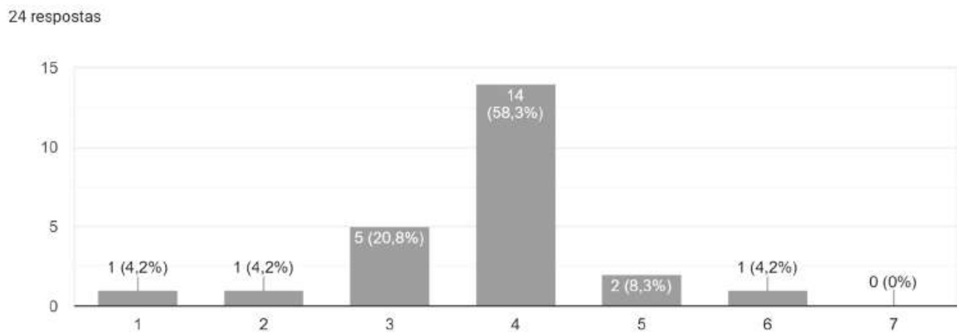
Graph 21: Cloudy Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 22: Cloudy Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 23: Cloudy Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)



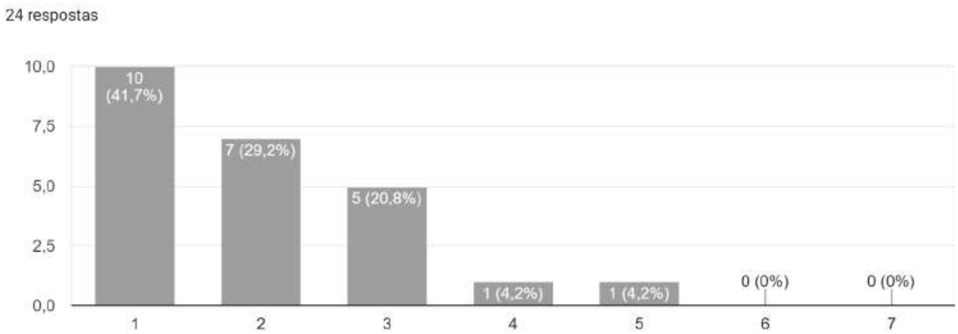
Graph 24: Cloudy Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

The results offered by the *Cloudy* variation in *Pacific Asia* is, in general, no different from its *Cloudy* variation counterparts, with "sadness" being the only predominant feeling overall, having almost 60% of votes (Graph 21). The remaining scales (Graphs 22, 23 and 24) show that most testers feel nothing when looking at the image, with "*neutral*" being by far the most popular option, with 70%, 62.5% and 58.3% and the remaining emotions on all scales, not possessing a significant amount of votes.

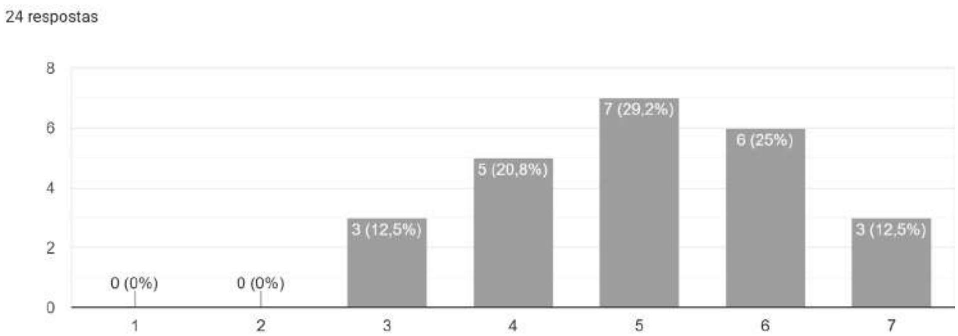
Overall, the *Cloudy* variations had a clear effect on the testers, which is *sadness*, possibly caused due to the lack of sunlight and grayish hues that this experiment brought. The emotion was the most voted out of all three regions, with *anticipation* and *fear* also having minor effects on the participants, an expected result, since they can also be considered negative emotions, related to sadness.

With this, we will move on to the *Sunrise* experiments, once again, starting with the *North America Region*, analyzing each graph to determine what emotions were felt more strongly.

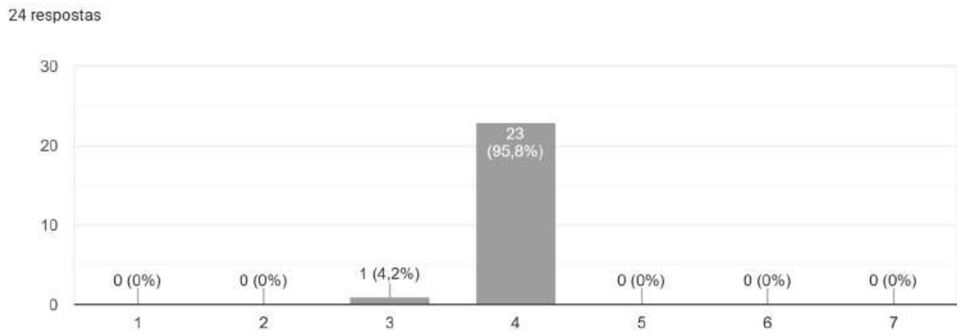
Figure 164: Sunrise North America Region (Science4Pandemics, 2023)



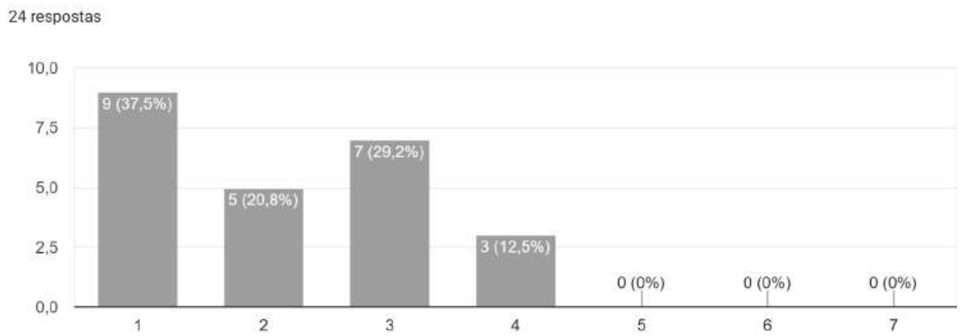
Graph 25: Sunrise North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 26: Sunrise North America Anticipation to Surprise scale (Science4Pandemics, 2023)



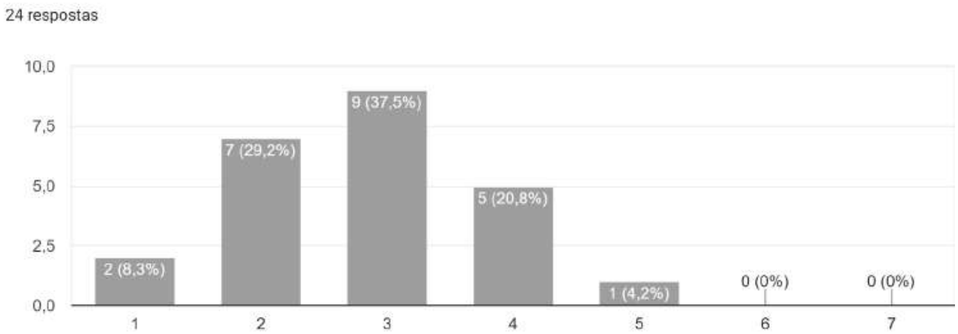
Graph 27: Sunrise North America Fear to Anger scale (Science4Pandemics, 2023)



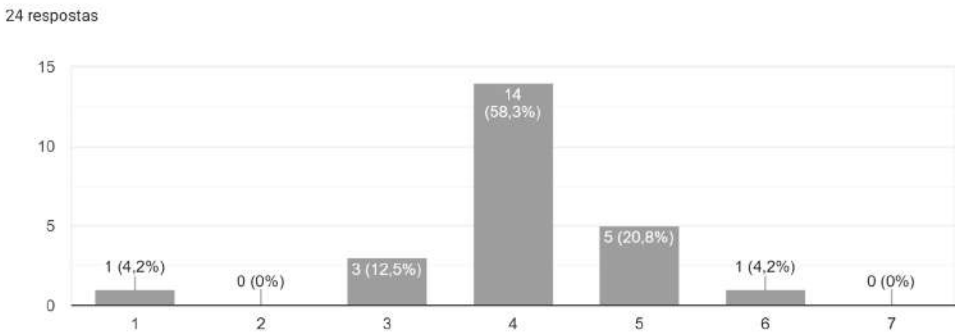
Graph 28: Sunrise North America Trust to Disgust scale (Science4Pandemics, 2023)

In the *Sunrise* variation for the *North America Region* (Figure 164), we can clearly observe a series of positive emotions prevailing. "*Joy*" has 22 votes on Graph 25, totalling over 90% of votes. "*Surprise*" and "*trust*" are also very predominant in their respective scales (Graphs 26 and 28), with 66.7% & 87.5%. Overall a very emotionally positive *Region*, since in the third scale we observe an astounding 95.8% of votes in "*neutral*", assigning neither "*fear*" nor "*anger*" (Graph 27) to the *Region.* We will now analyze the results caused by the *Sunset* experiments in the *North Africa Region*.

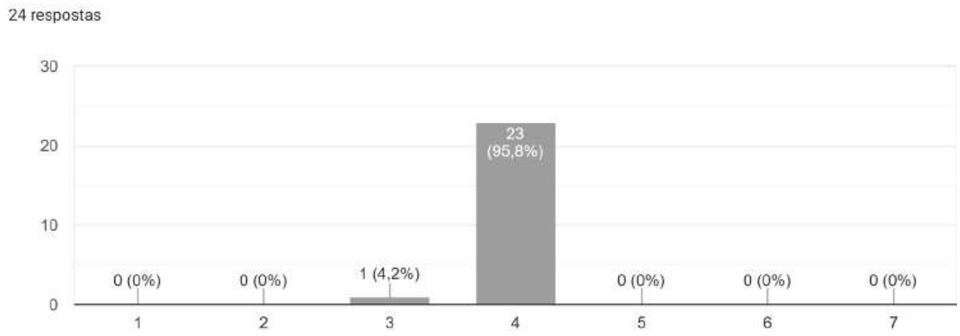
Figure 165: Sunrise North Africa Region (Science4Pandemics, 2023)



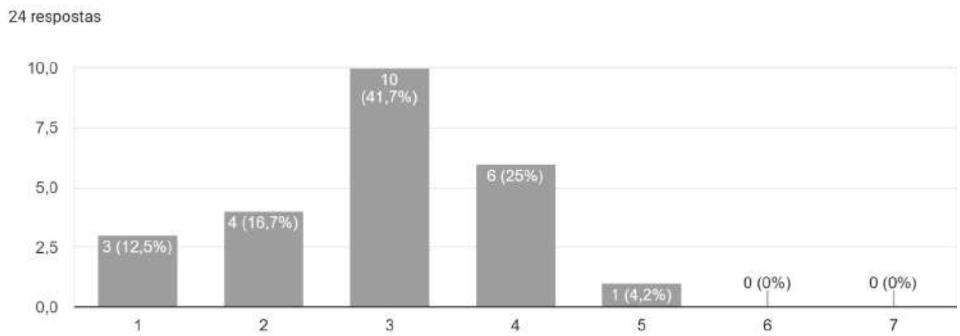
Graph 29: Sunrise North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 30: Sunrise North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



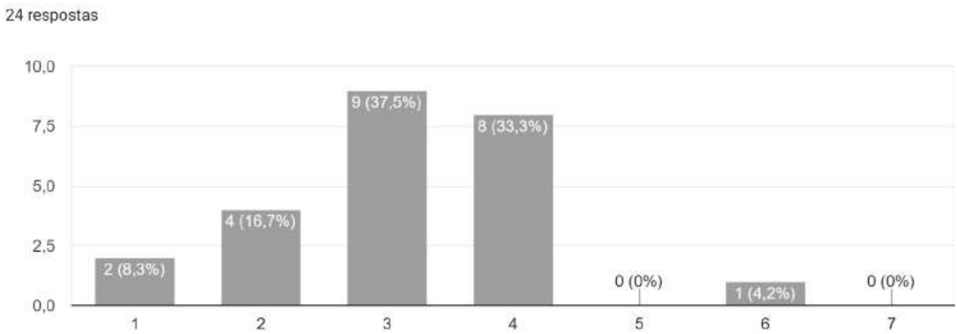
Graph 31: Sunrise North Africa Fear to Anger scale (Science4Pandemics, 2023)



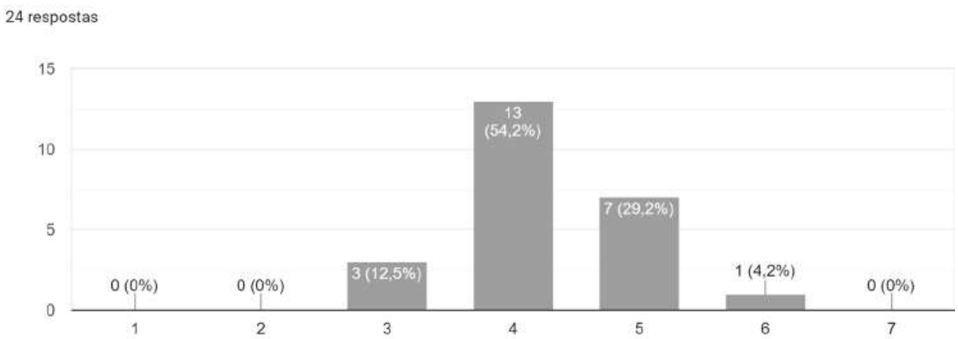
Graph 32: Sunrise North Africa Trust to Disgust scale (Science4Pandemics, 2023)

In Figure 165 the positive trend continues, as we see a preservation of "*joy*" in different intensities (Graph 29), with 75% of the votes, a slight decrease from the previous *Region*, but still very significant. We also see a preservation of "*trust*", with 71% of the votes (Graph 32), again a minor decrease, but not as much as "*surprise*", which now has only six votes (Graph 30) in comparison to the previous *Sunset* variation of the *North America Region*, which had 16. The second scale (Graph 31) still shows us the same results as the *Sunset North America Region*, with "*neutral*" possessing 23 total votes. And in Graph 31, testers still do not relate to either "*fear*" or "*anger*", making it an emotionally positive *Region*. For the final variation of the *Sunset* variations, we will analyze the *Pacific Asia Region*.

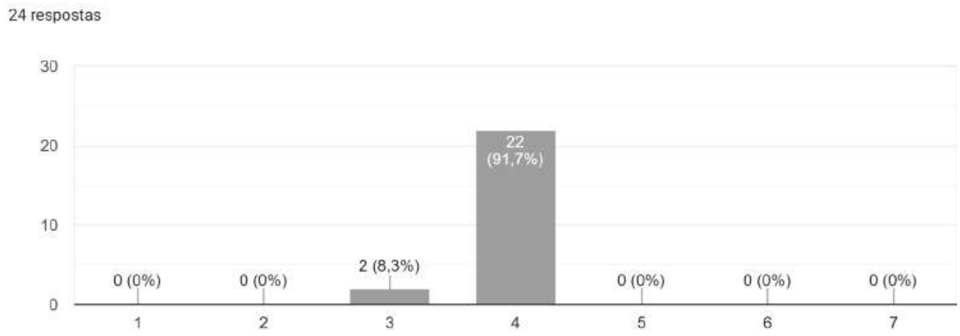
Figure 166: Sunrise Pacific Asia Region (Science4Pandemics, 2023)



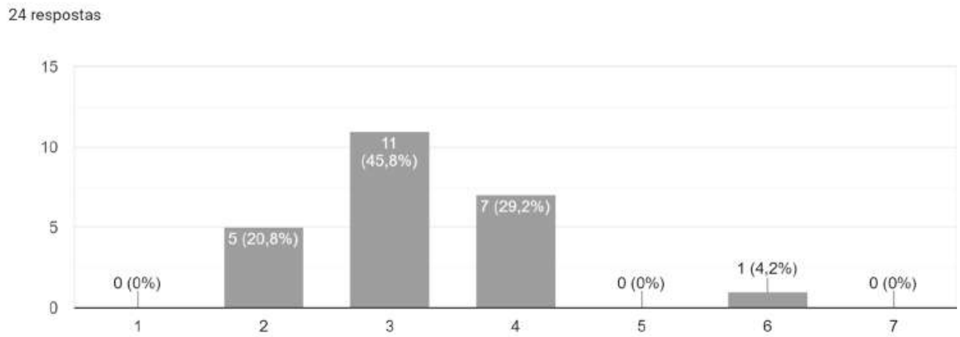
Graph 33: Sunrise Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 34: Sunrise Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 35: Sunrise Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)



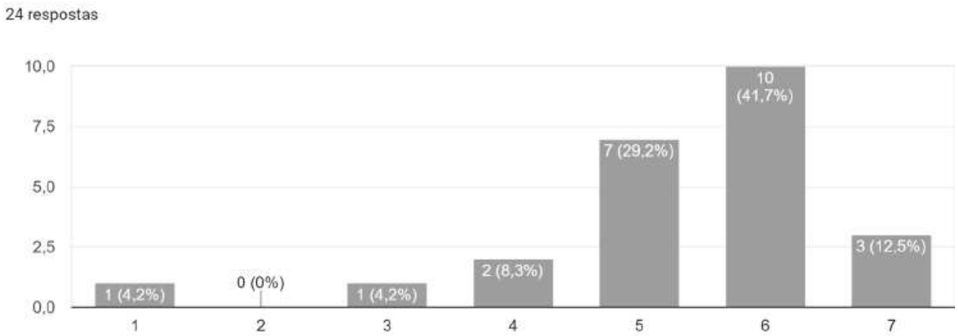
Graph 36: Sunrise Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

In the Figure 166, "*joy*" continues to be the most popular option, this time possessing 62.5% of the votes (Graph 33), which, once again is a decrease from previous *Regions,* this time we can observe that a fair amount of testers feel nothing when looking at the image, with 33.3% of them selecting the "*neutral*" option (Graph 33). "*Trust*" also continues to be a popular option (Graph 36), with a small decrease, totalling 66.6% of votes and more "*neutral*" results. The third scale (Graph 35), once again obtained 22 "*neutral*" votes, with no significant number of testers relating to either "*fear*" or "*anger*". And, as Graph 34 shows, "*surprise*" continues to be a popular option, but as prevalent as "*neutral*".

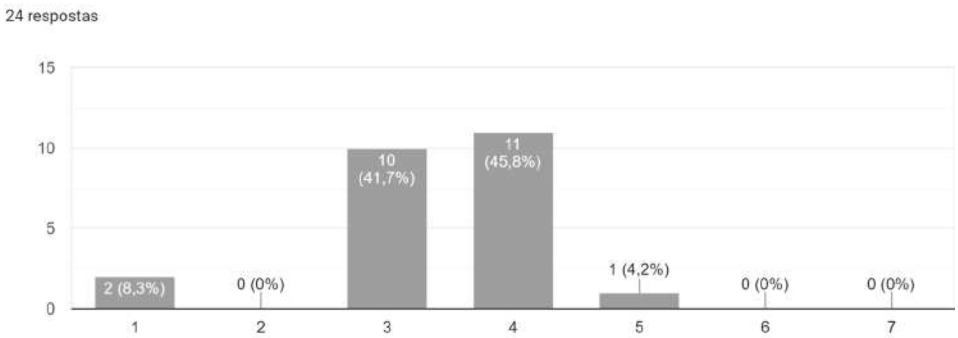
The *Sunrise* variations of all three *Regions* obtained very positive emotions, with *joy* and *trust* being the most popular options and also, a very important fact, which contributed to the positivity of the emotions felt, was that there were almost no votes in either *fear* or *anger.* The bright beams of light and the overall visibility and clarity of the lighting used in this experiment, is most likely what invoked these positive emotions in the testers. We can also consider these results expected, since, as we studied, bright and warm sunlight is often related to positive emotions.

We will now analyze the results obtained by the *Sunset* variations, starting with the *North America Region*.

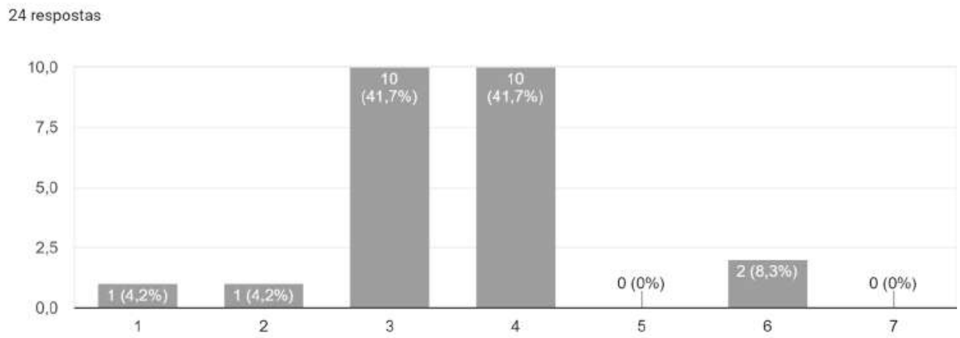
Figure 167: Sunset North America Region (Science4Pandemics, 2023)



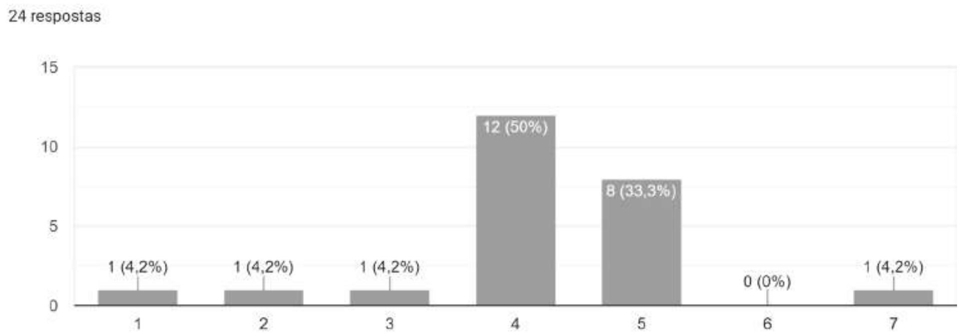
Graph 37: Sunset North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 38: Sunset North America Anticipation to Surprise scale (Science4Pandemics, 2023)



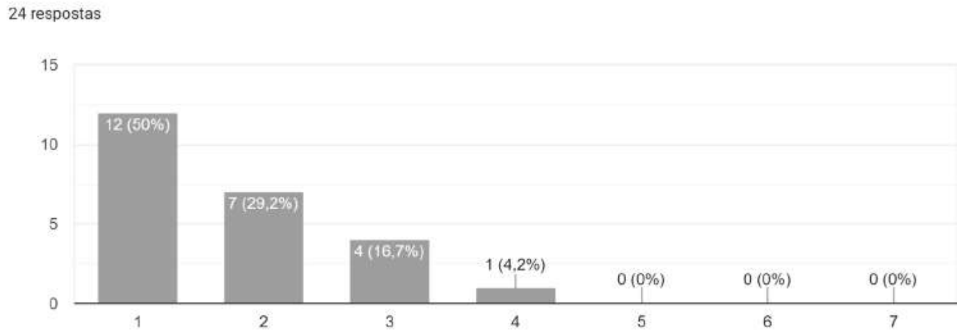
Graph 39: Sunset North America Fear to Anger scale (Science4Pandemics, 2023)



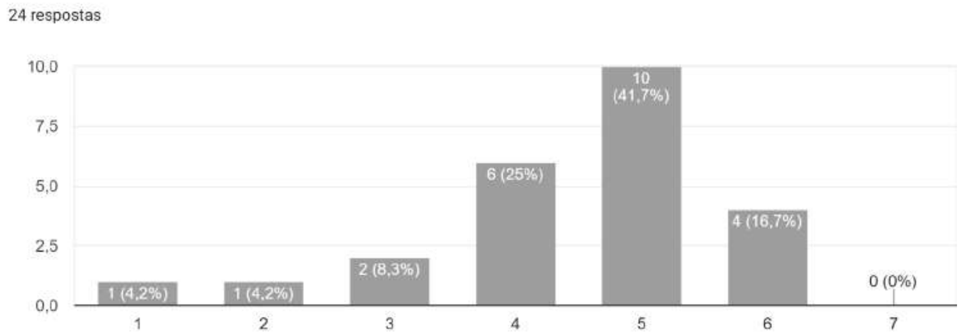
Graph 40: Sunset North America Trust to Disgust scale (Science4Pandemics, 2023)

In Figure 167*,* testers seem to lean towards negative emotions, like "*sadness*", "*anticipation*" and "*fear*" (Graphs 37, 38 and 39) in different intensities, with 83.4%, 50% and 50%, respectively. It's worth noting that in Graphs 38, 39 and 40, the "*neutral*" option is also popular among testers, with at least 40% in the scales. We will move on to the *Sunset* variation of the *North Africa Region*.

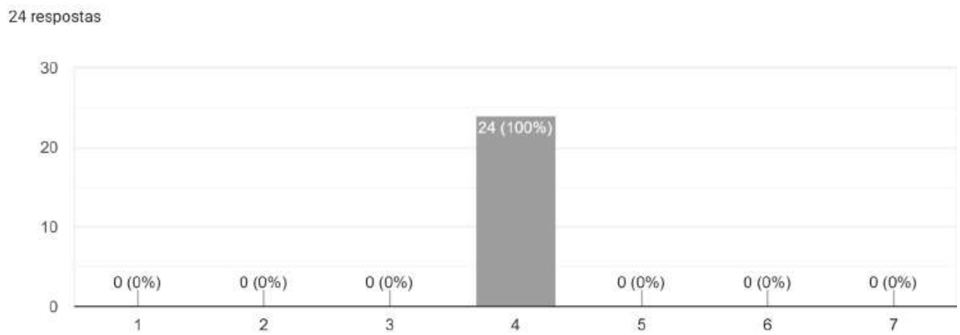
Figure 168: Sunset North Africa Region (Science4Pandemics, 2023)



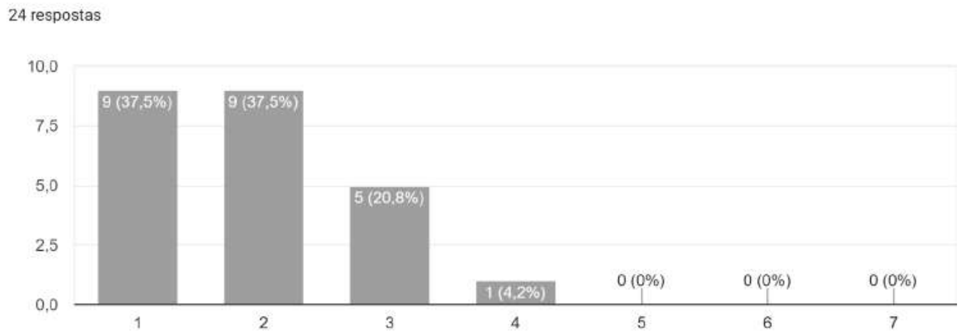
Graph 41: Sunset North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 42: Sunset North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



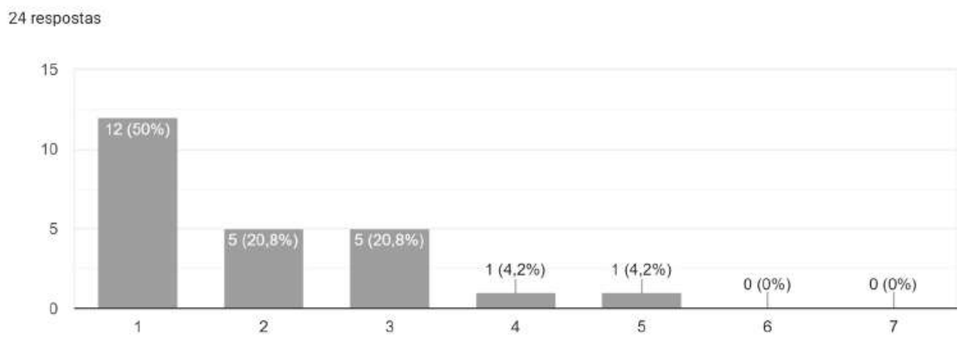
Graph 43: Sunset North Africa Fear to Anger scale (Science4Pandemics, 2023)



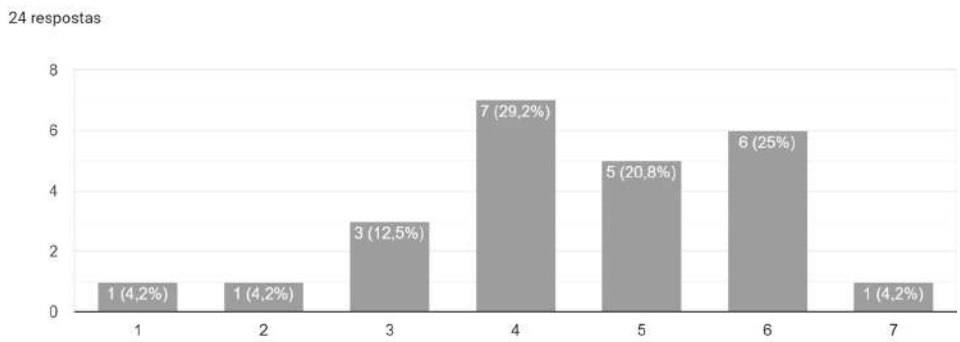
Graph 44: Sunset North Africa Trust to Disgust scale (Science4Pandemics, 2023)

Interestingly, Figure 168 possesses opposite results from the previous *Region,* with mostly positive emotions. In Graph 41 and 44, there is a whopping 95.8% of votes to different intensities of "*joy*" and "*trust*". Coincidentally, all votes in Graph 43, all votes are "*neutral*", completely distancing the image from both "*fear*" and "*anger*". Finally, "*surprise*" also prevails in its scale (Graph 42), with almost 60% of votes. Lastly, we will analyze the *Sunset* variation for the *Pacific Asia Region*.

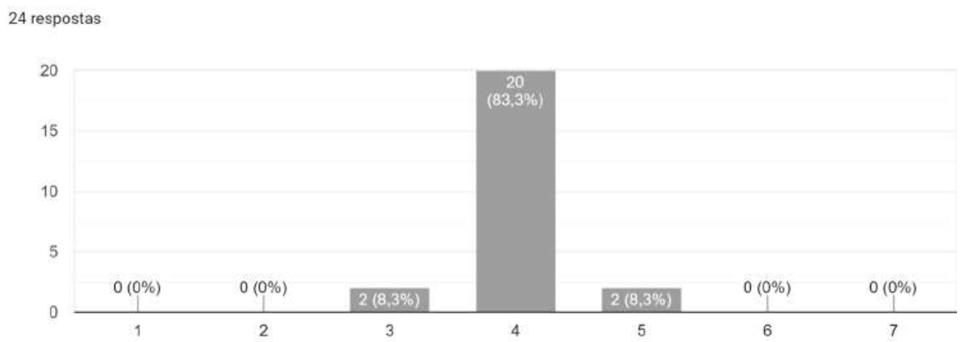
Figure 169: Sunset Pacific Asia Region (Science4Pandemics, 2023)



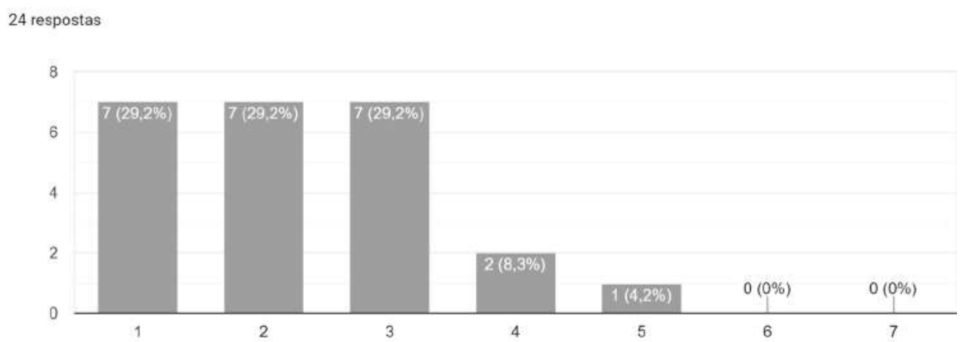
Graph 45: Sunset Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 46: Sunset Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 47: Sunset Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)



Graph 48: Sunset Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

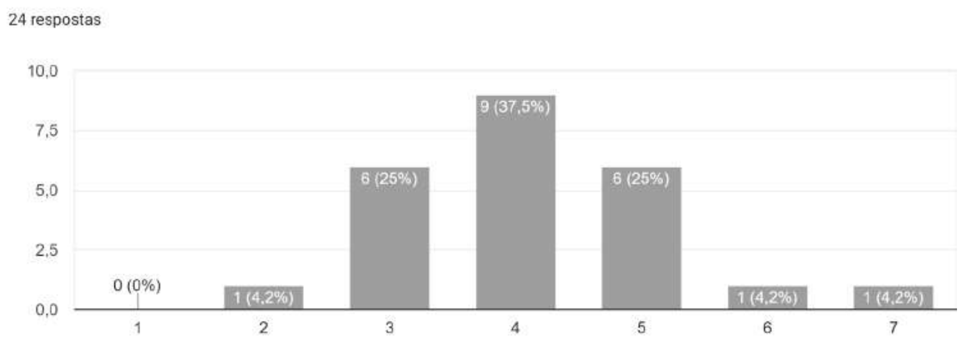
This variation (Figure 169) possesses similar results to the previously analyzed *Region,* with "*joy*" and "*trust*" (Graph 45 and 48) being the most popular emotions, with 91.6 and 87.6% of votes, respectively. Graph 47 shows us that testers still distance themselves from both "*fear*" and "*anger*", with 20 of the participants selecting "*neutral*", instead of any other option. And lastly, "*surprise*" is also the most popular in its respective scale (Graph 47), with 50% of votes, but with more distributed results across the spectrum.

The *Sunset* variations had very interesting and somewhat contradictory results. We see that the *North America Region* obtained a very negative set of emotions overall, with *sadness* and *fear* being by far the most popular emotions selected. While in both other *Regions,* we saw completely different emotions, with *joy* and *trust* being the most popular. Maybe, due to the overall ambiance present in the original *North America Region,* the sunset lighting transformed it into a grayish region, with dim lights, possibly evoking these negative emotions on the testers. While the other regions possess a slightly lighter environment, thus not suffering from the same effect.

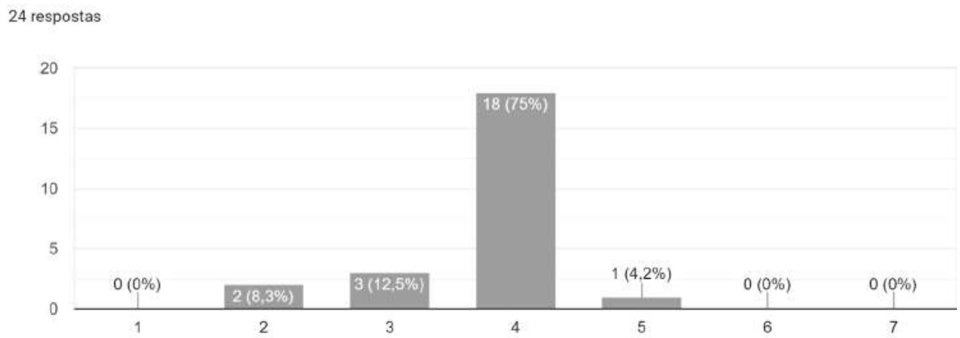
5.3. Movement Variation Results

The *Movement* variations produced two different results for each *Region*, moderate and crowded, we will start by analyzing each "*moderate*" variation for the *Regions* and then move on to their "*crowded*" versions. The first *Region* that we will analyze is the *North America Region*.

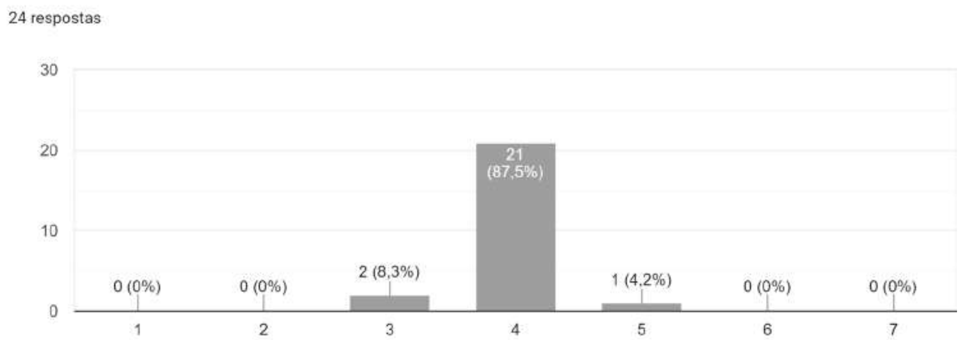
Figure 170: Moderate North America (Science4Pandemics, 2023)



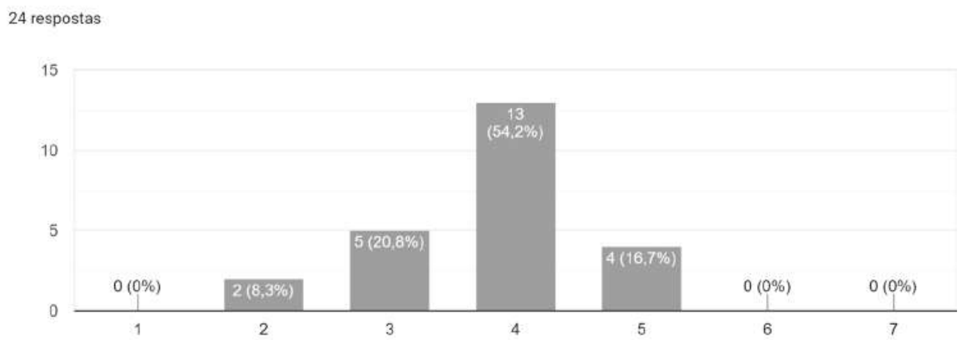
Graph 49: Moderate North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 50: Moderate North America Anticipation to Surprise scale (Science4Pandemics, 2023)



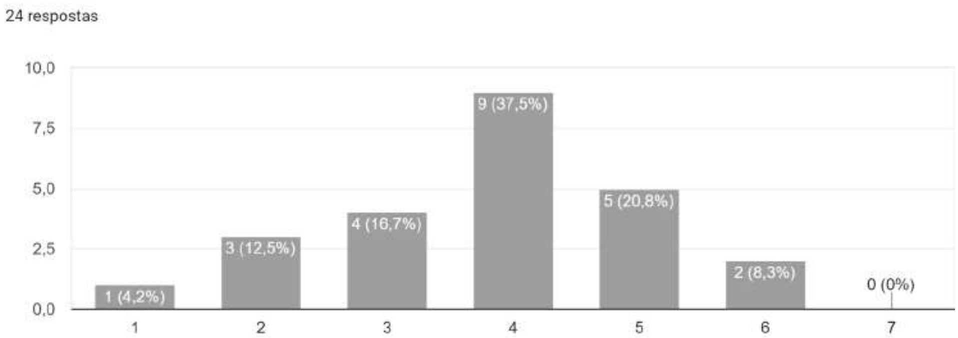
Graph 51: Moderate North America Fear to Anger scale (Science4Pandemics, 2023)



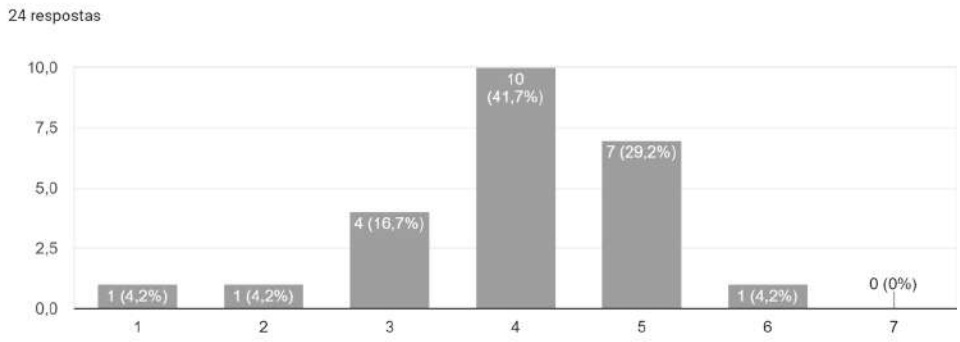
Graph 52: Moderate North America Trust to Disgust scale (Science4Pandemics, 2023)

Unfortunately, the results obtained from the *Moderate* variation in the *North America Region* (Figure 170), did not offer very interesting results, with over 63% of the overall votes (Graphs 49, 50, 51 and 52) being "*neutral*". The first scale (Graph 49) offers some balance in the results where "*joy*" and "*sadness*" have the same number of votes. This may have happened for a number of reasons, such as: the variation simply did not cause any effective influence on the testers, maybe due to the low intensity of the changes made in *Region*; The changes could not be clearly noticed in the image provided to the participants, which is likely since the test can also have been done through a smartphone, significantly decreasing the size of the images created. We will move on to the *Moderate* variation of the *North Africa Region*.

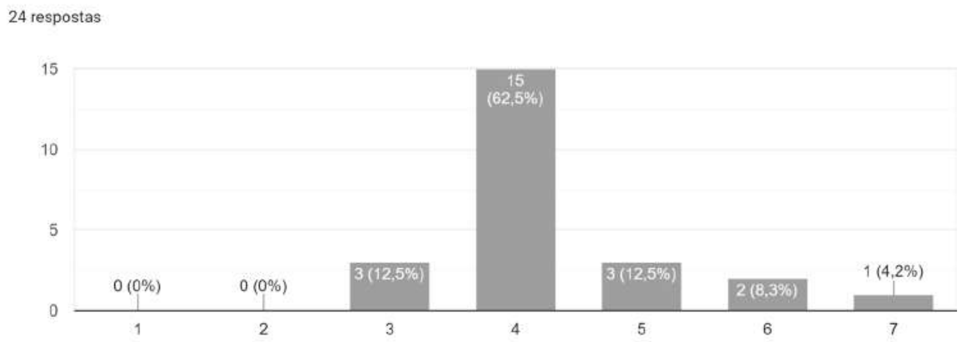
Figure 171: Moderate North Africa Region (Science4Pandemics, 2023)



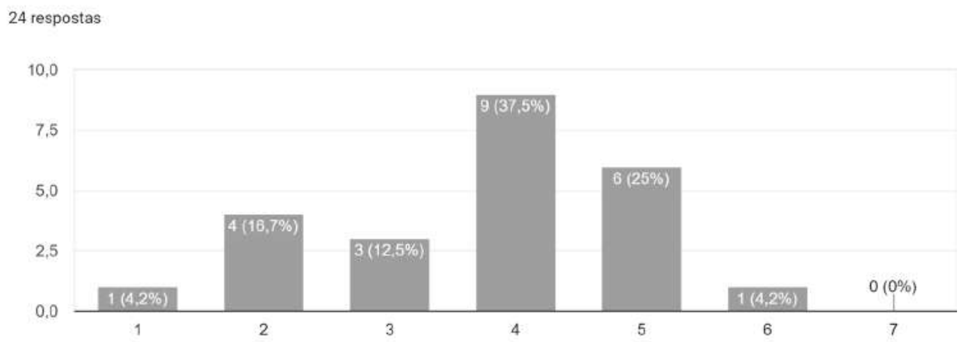
Graph 53: Moderate North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 54: Moderate North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



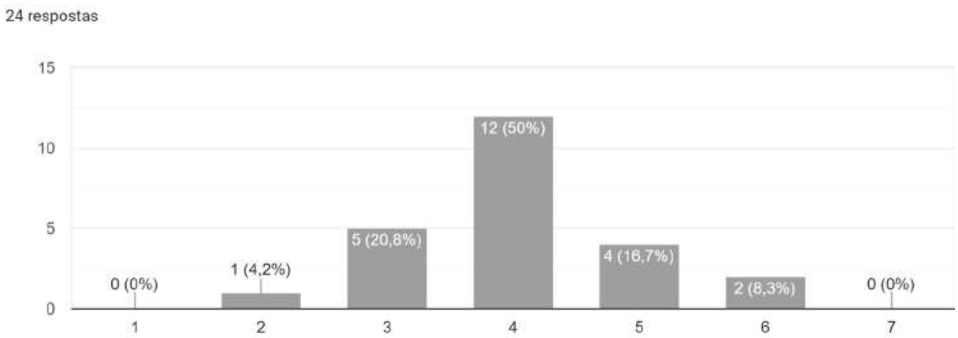
Graph 55: Moderate North Africa Fear to Anger scale (Science4Pandemics, 2023)



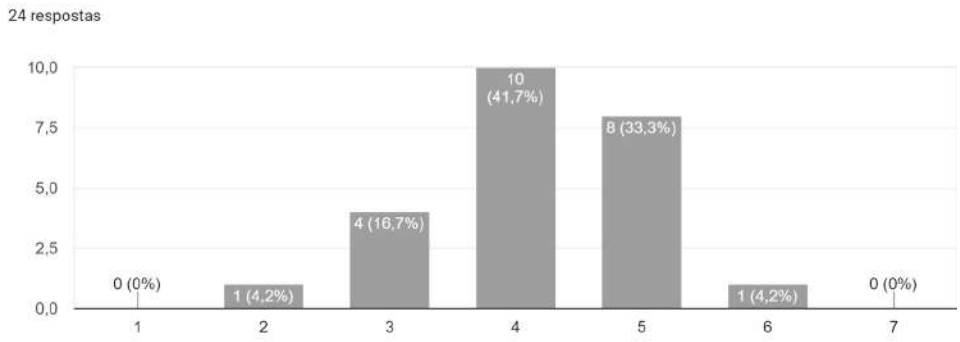
Graph 56: Moderate North Africa Trust to Disgust scale (Science4Pandemics, 2023)

Although the "*neutral*" option continues to be prevalent among the scales, in Figure 171 we can extract more information from the results. Testers don't seem to feel strongly towards any of the emotions in the second scale (Graph 54), where "*neutral*" has over 40% of the votes, with the remaining 60% of them scattered around the scale. The remaining scales (Graphs 53, 55 and 56) also have evenly distributed results, where the "*neutral*" option is still the most popular, always maintaining some sort of balance, although "*anger*" prevails over its counterpart "*fear*" in the second scale (Graph 54), possessing seven votes. As mentioned, all scales have overall balanced results, with no emotion being selected considerably over their counterparts on them, and always maintaining a high percentage of "*neutral*" votes, which might indicate that the experiments did not have any strong effects on the testers. Lastly, we will analyze the *Moderate* variation in the *Pacific Asia Region*.

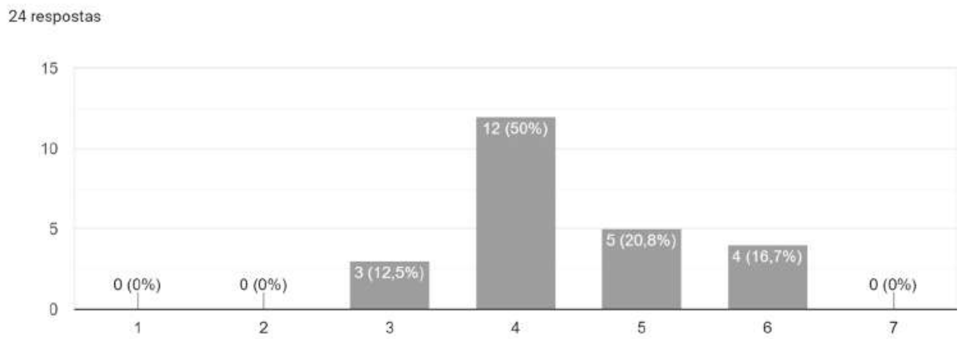
Figure 172: Moderate Pacific Asia Region (Science4Pandemics, 2023)



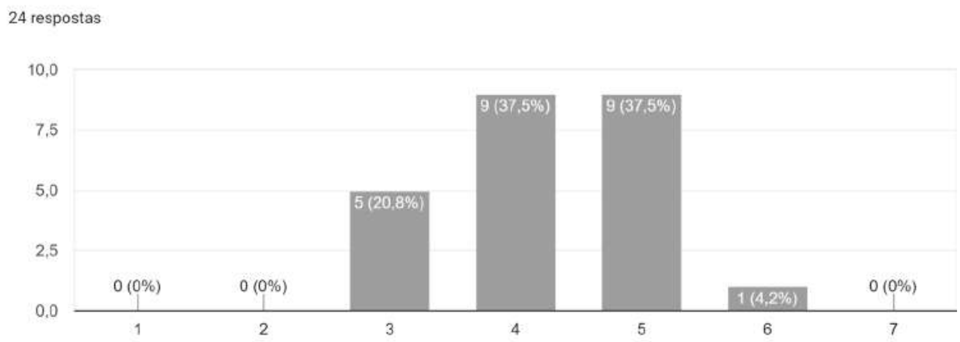
Graph 57: Moderate Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 58: Moderate Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 59: Moderate Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)

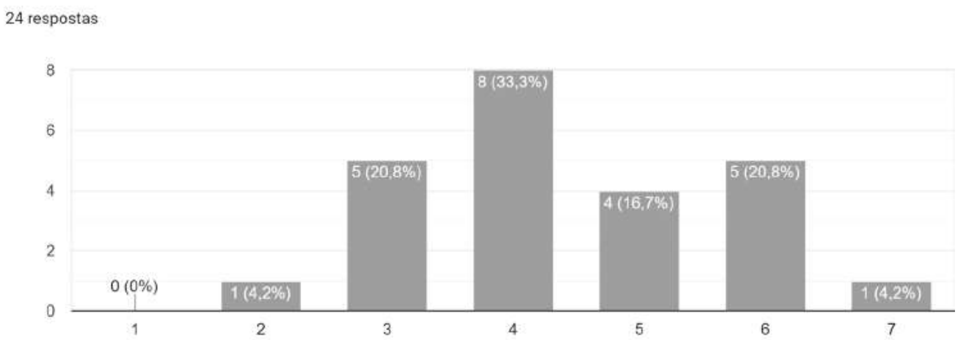


Graph 60: Moderate Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

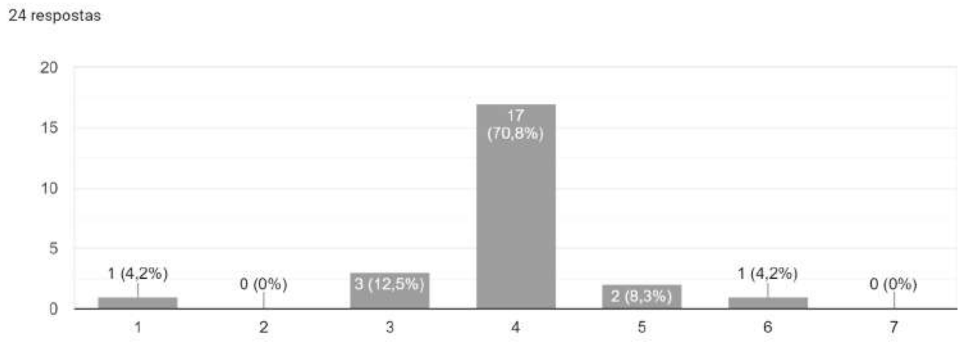
Here we see a continuation of the "*neutral*" trend (Figure 172), with most of the scales predominantly having votes on said option and the rest of the testers more scattered around different emotions. On the first scale (Graph 57) for instance, the participants are equally divided between "*joy*" and "*sadness*", while on the second (Graph 56) and third (Graph 57) scales, "*surprise*" and "*anger*" have minor advantages over their counterparts, both with 37.5% votes. On the last scale (Graph 58) though, we see that “*disgust*” has out-voted “*neutral*”, thus making it the strongest emotion in this modified *Region*.

Overall, the *Moderate Movement* variations , had minor impacts on testers, with “*neutral*” being by far the most popular vote and a few noticeable emotions prevailing over others, such as “*sadness*”, “*surprise*” and “*disgust*”, but maybe due to the small visual changes on the original images, this experiment did not produce major reactions. It is possible that seeing the *Region* moderately populated is just what could be considered “normal”, thus not invoking any sort of emotions on the participants. We will now analyze the results obtained from the *Crowded* variations, starting with the *North America Region*.

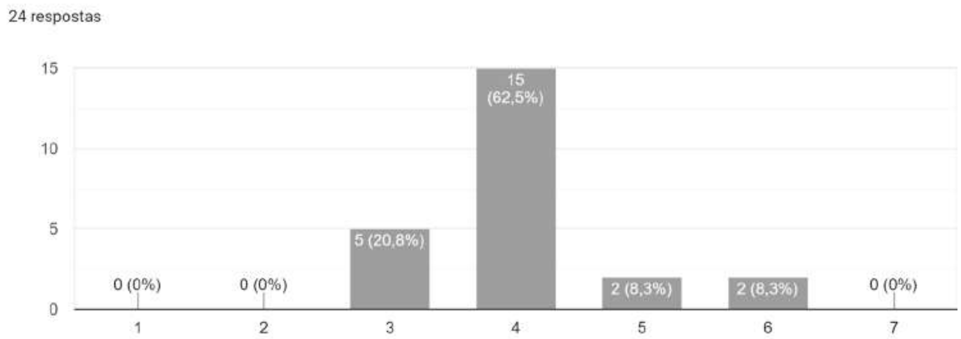
Figure 173: Crowded North America Region (Science4Pandemics, 2023)



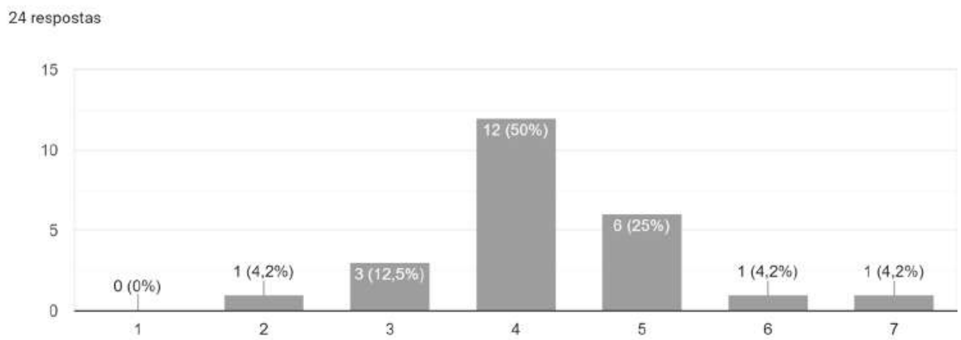
Graph 61: Crowded North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 62: Crowded North America Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 63: Crowded North America Fear to Anger scale (Science4Pandemics, 2023)

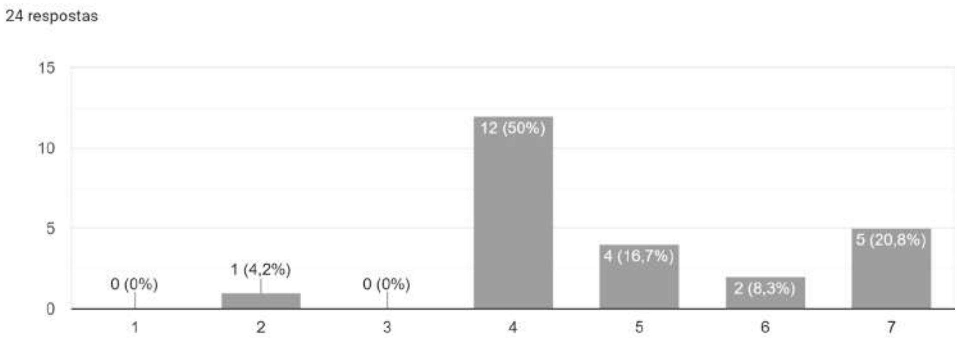


Graph 64: Crowded North America Trust to Disgust scale (Science4Pandemics, 2023)

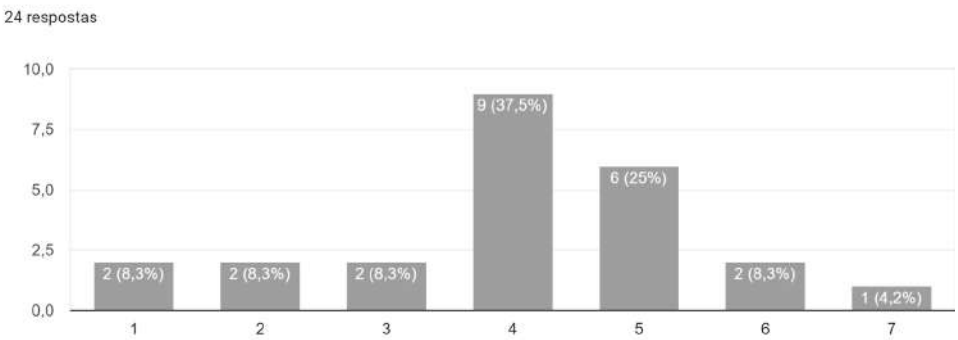
In Figure 173, we observe that, not unlike the previous movement experiments, the "*neutral*" option is most prevalent across all scales (Graphs 61, 62, 63 and 64), with the votes being distributed almost evenly. The only emotion that can be considered significant here is "*sadness*", having around 42% of votes. On the second and third scales (Graphs 62 and 63) we see an even result among both spectrums, and on the fourth scale (Graph 64) "*disgust*" has slightly more votes than its counterpart, with

33.4% of participants selecting the emotion to some intensity. We will move on to the *Crowded North Africa Region* variant.

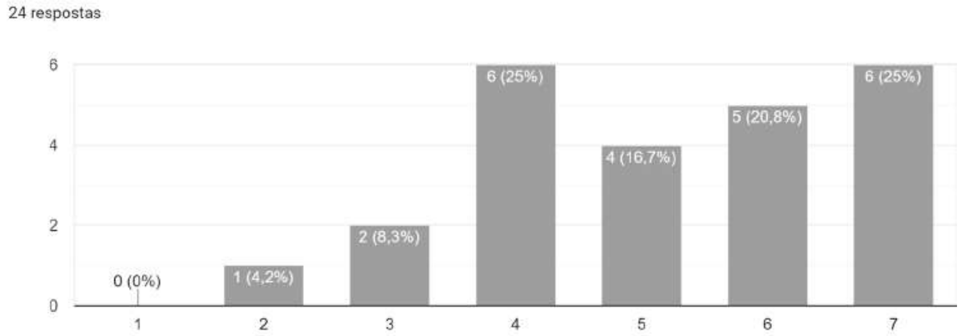
Figure 174: Crowded North Africa Region (Science4Pandemics, 2023)



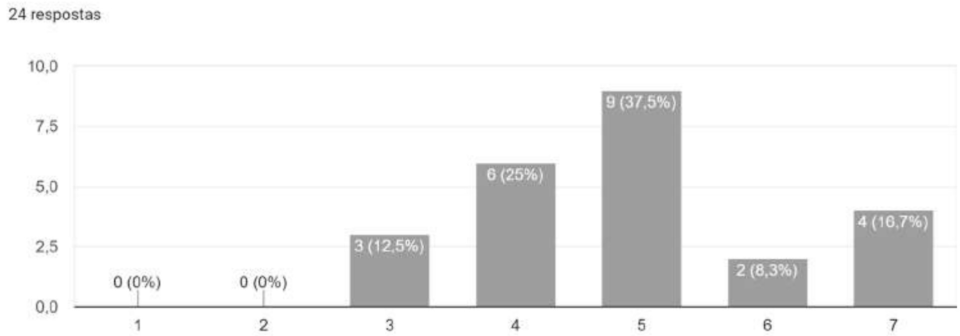
Graph 65: Crowded North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 66: Crowded North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



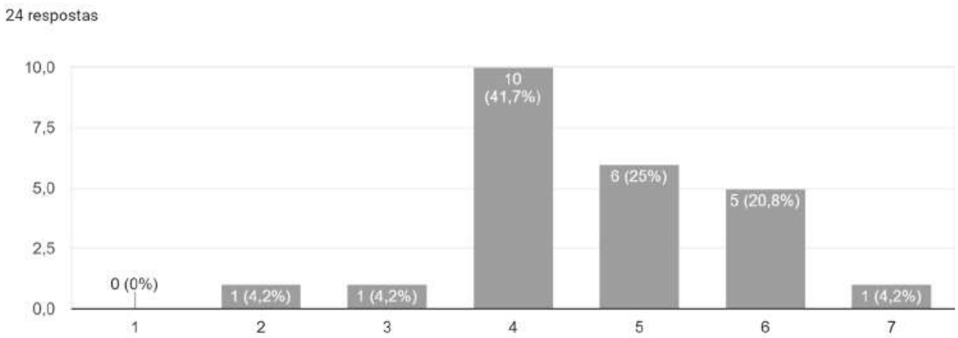
Graph 67: Crowded North Africa Fear to Anger scale (Science4Pandemics, 2023)



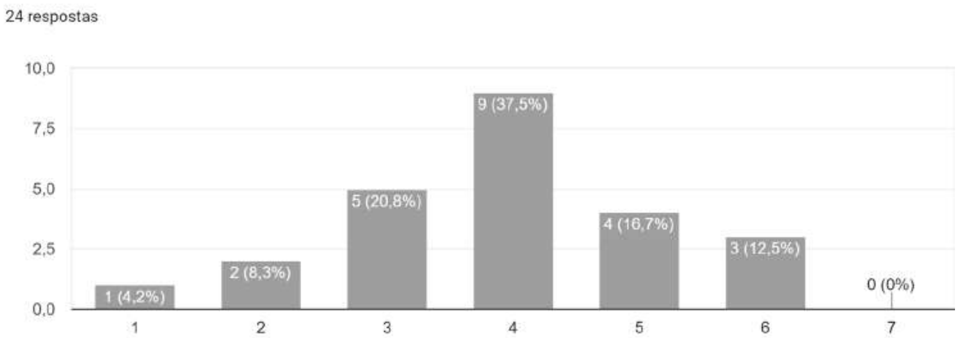
Graph 68: Crowded North Africa Trust to Disgust scale (Science4Pandemics, 2023)

For the first time in the movement experiments, we see certain emotions being assigned more times than "*neutral*". Here in the *Crowded North Africa Region* (Figure 174), "*anger*" and "*disgust*" have over 60% of votes in their respective scales (Graphs 67 and 68). "*Surprise*" is also very prominent, with 37.5% of votes (Graph 66). We can still see, though, a large number of votes in "*neutral*", which has 50% of votes in the first scale (Graph 65) and over 25% in the remaining ones. Finally, we will analyze the *Crowded* variant of the *Pacific Asia Region*.

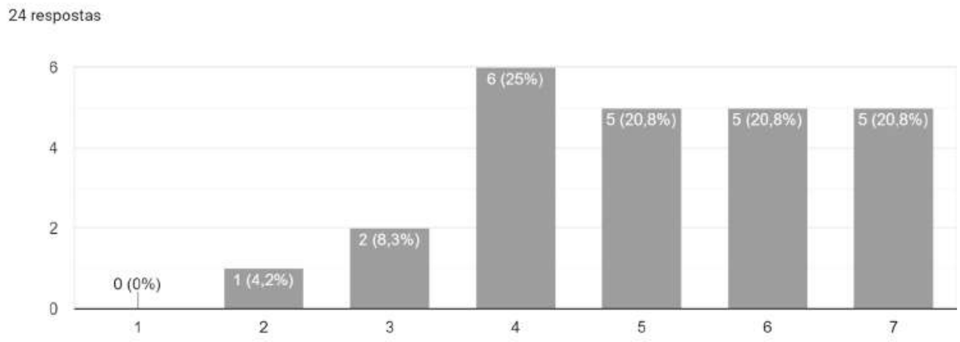
Figure 175: Crowded Pacific Asia Region (Science4Pandemics, 2023)



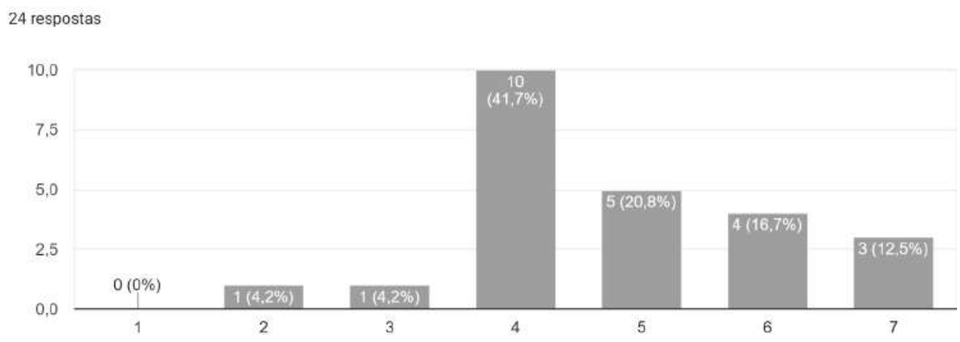
Graph 69: Crowded Pacifica Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 70: Crowded Pacifica Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 71: Crowded Pacifica Asia Fear to Anger scale (Science4Pandemics, 2023)



Graph 72: Crowded Pacifica Asia Trust to Disgust scale (Science4Pandemics, 2023)

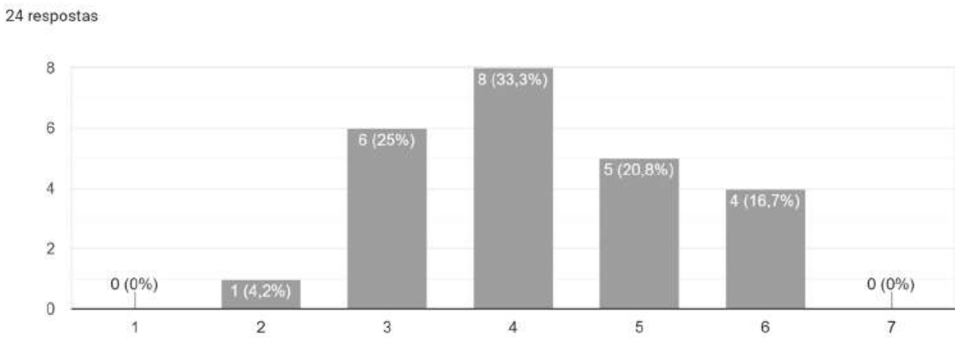
In the *Crowded Pacific Asia Region* (Figure 175)*,* we see a slight rise in the number of "*neutral*" votes (Graphs 69, 70, 71 and 72), when compared to the last *Region* analyzed, but a preservation of "*anger*" and "*disgust*", with 62.4% and 50% of votes (Graph 71 and 72), respectively. "*Surprise*" is no longer the most prevalent emotion on its scale (Graph 70), where we can now observe that "*anticipation*" and "*neutral*" have risen, with 33.3% and 37.5%, respectively.

The *Crowded Regions have* slightly more interesting results than the previous movement experiment, with less "*neutral*" options and emotions like *disgust* and *anger* being more prevalent. Maybe the visual variations made were not enough to result in any strong feeling from the testers. Or perhaps, the crowded *Region* simply does not make an impression on them. Still, with this analysis, we were able to reach a conclusion that was expected, which is a mix of negative feelings when reacting to an over-crowded place.

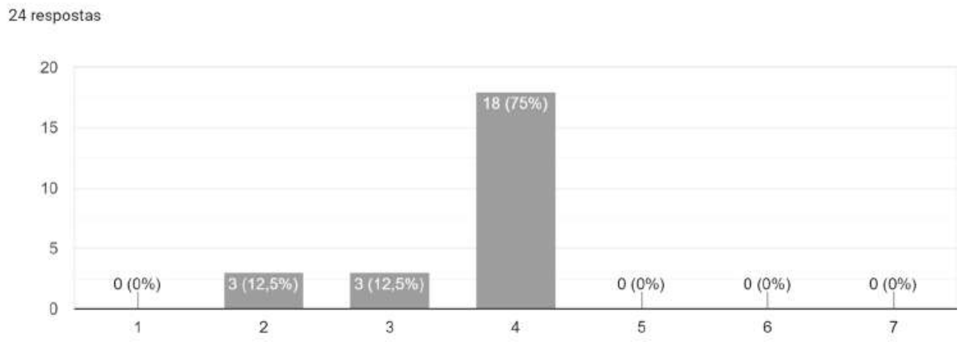
5.4. Texture Variation Results

Out of the four different types of experiments that were done, the textures were the shortest ones, simply due to the fact that it took longer to complete a single variation, requiring us to create and apply procedural textures to the assets that were changed. This led to the creation of the "noisy" *Regions*, which possesses textures with a great amount of noise texture and strength. We will begin by analyzing the results obtained from the *North America Region*.

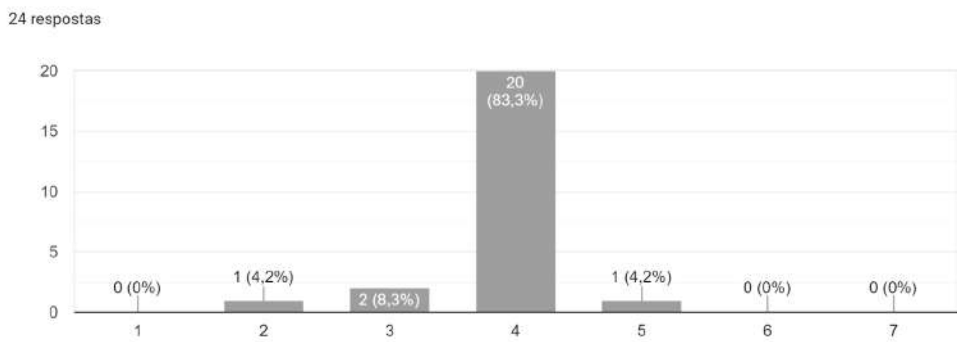
Figure 176: Noisy North America Region (Science4Pandemics, 2023)



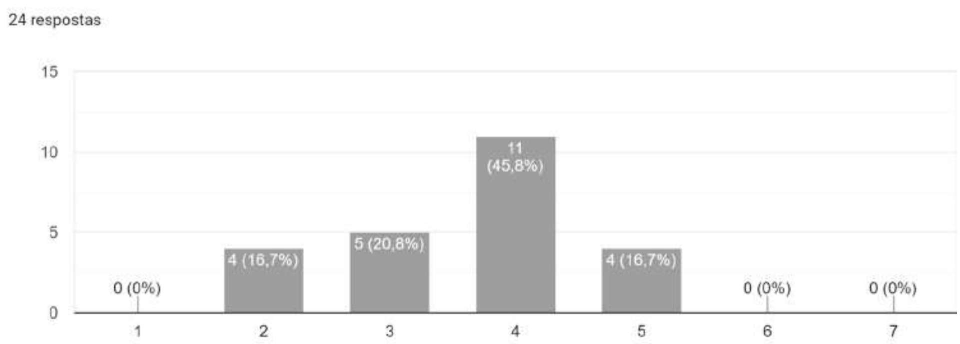
Graph 73: Noisy North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 74: Noisy North America Anticipation to Surprise scale (Science4Pandemics, 2023)



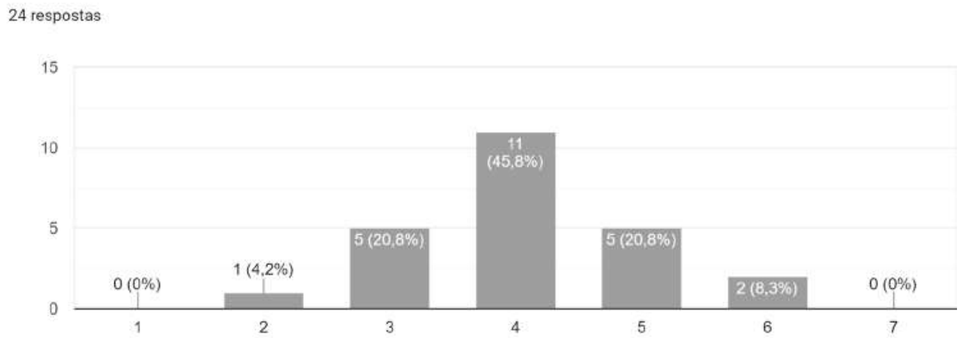
Graph 75: Noisy North America Fear to Anger scale (Science4Pandemics, 2023)



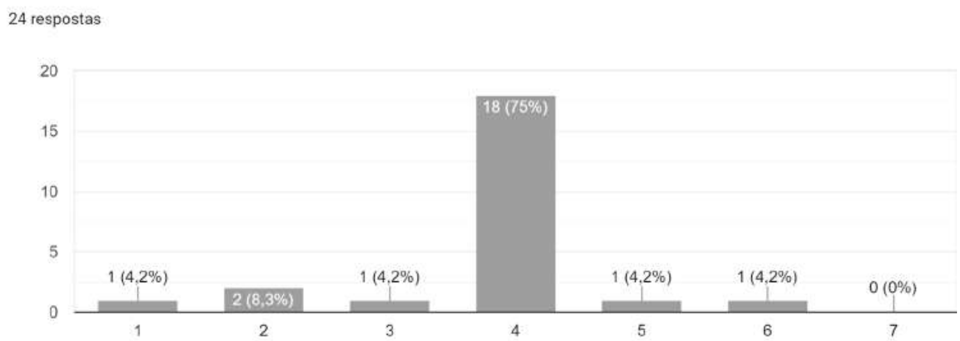
Graph 76: Noisy North America Trust to Disgust scale (Science4Pandemics, 2023)

Figure 176 shows mostly "*neutral*" results, with over 80% of votes on the third scale (Graph 75). Even though there are a number of testers that feel no particular emotion when looking at the image, we can still analyze and discern some data from the graphs. For instance, testers seem to be torn between "*joy*" and "*sadness*" on the first scale (Graph 73), with 7 and 9 votes, respectively. On the second and third scales (Graph 74 and 75), participants show no affinity to either spectrum of emotions, with neutral having 75% and 83.3% of votes. And finally, testers lean towards "*trust*" rather than "*disgust*", but "*neutral*" still prevails over both (Graph 76). With this, we will analyze the *Noisy* variant of the *North Africa Region.*

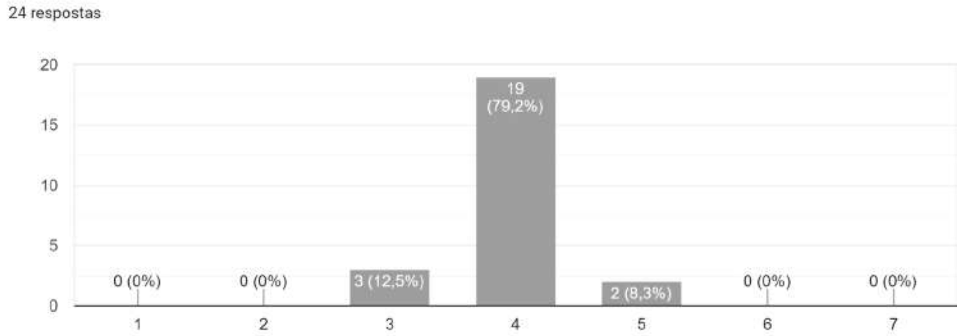
Figure 177: Noisy North Africa Region (Science4Pandemics, 2023)



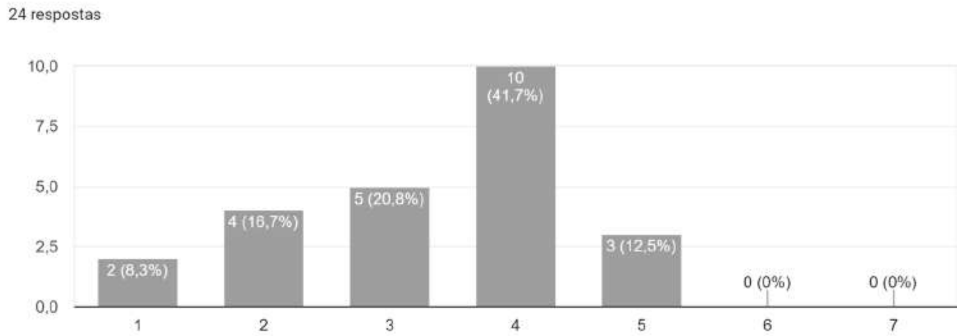
Graph 77: Noisy North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 78: Noisy North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



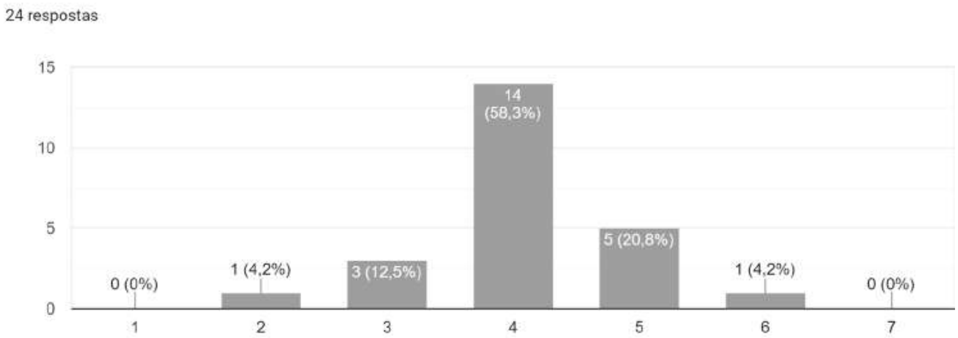
Graph 79: Noisy North Africa Fear to Anger scale (Science4Pandemics, 2023)



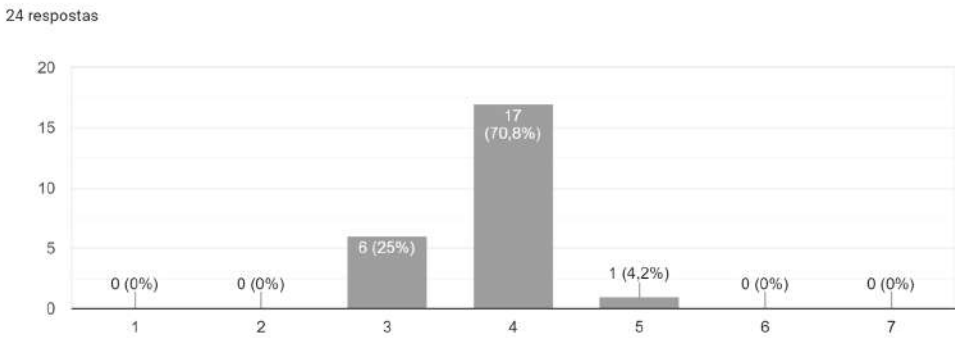
Graph 80: Noisy North Africa Trust to Disgust scale (Science4Pandemics, 2023)

We see a continuation of the "*neutral*" trend here, in Figure 177, with it being the most prevalent option in all four scales, possessing over 50% of overall votes. testers on the first scale (Graph 77) are still torn between the two opposite spectrums "*joy*" and "*sadness*", having 6 and 7 votes respectively. The second and third scale (Graphs 78 and 79) still possess the highest number of "*neutral*" votes, with almost 80% of participants selecting said option. And finally, Graph 80 shows us an interesting result, with "*trust*" being the most selected emotion, at almost 46% of votes. Finally, we will analyze the *Pacific Asia Region* variant.

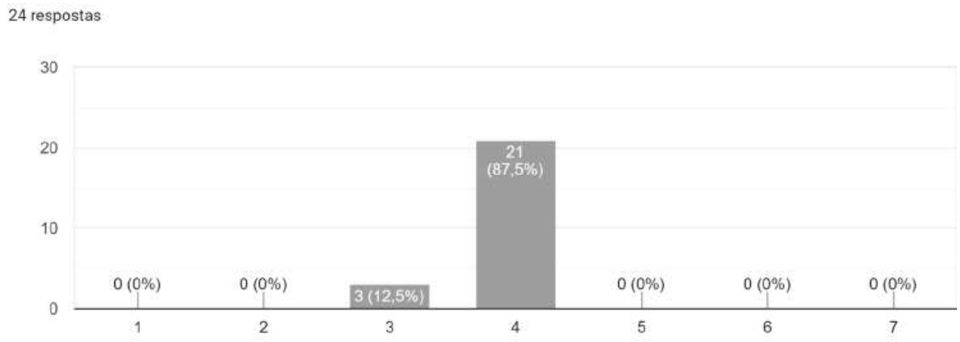
Figure 178: Noisy Pacific Asia Region (Science4Pandemics, 2023)



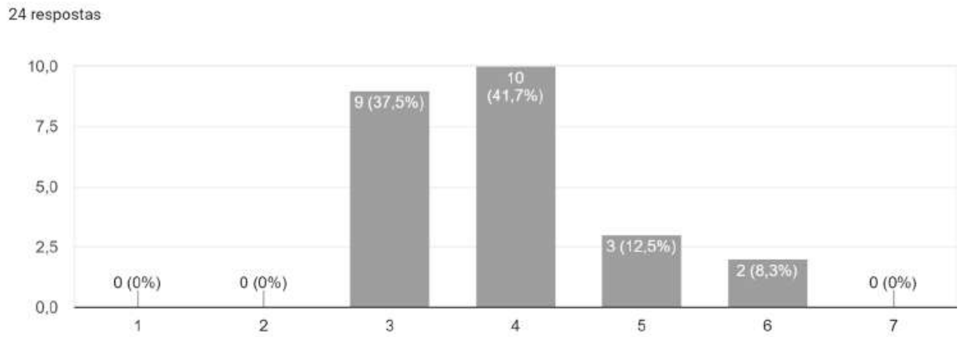
Graph 81: Noisy Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 82: Noisy Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 83: Noisy Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)



Graph 84: Noisy Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

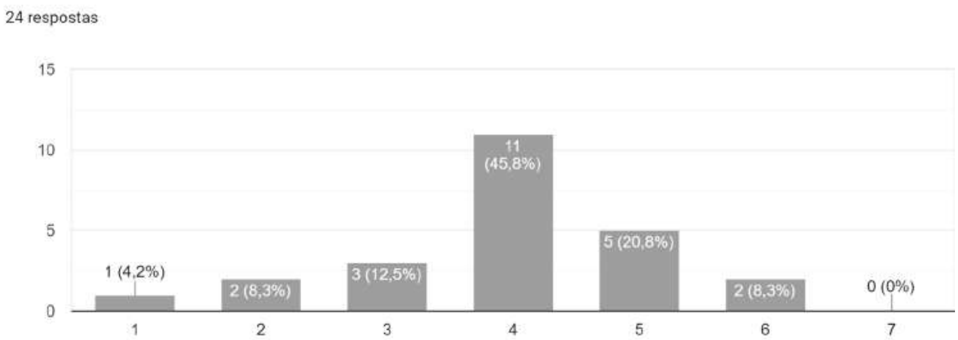
In the *Noisy Pacific Asia Region*, the trend continues, as "*neutral*" has the highest number of votes out of all three *Noisy Regions* and testers do not feel strongly towards any of the emotions shown to them, with the remaining votes being almost equally distributed along the spectrum. "*Sadness*" and "*anticipation*" both have 25% of the votes in their respective scales (Graphs 81 and 82). "*Trust*" is the most predominant emotion, with 37.5% votes, still not as much as "*neutral*" in its respective scale (Graph 84). And on the third scale (Graph 83), we can see almost 90% of votes on "*neutral*".

The texture experiment did not have any significant effect on the testers, with no discernible change or influence in the testers perception of the scene. This may have been due to the size of the image provided in the test, which, due to the configuration of the media utilized, could be visualized in detail by the participants, thus making the changes practically invisible. Unfortunately, we could not reach any new conclusions after the experiments, which is why we consider it a failure.

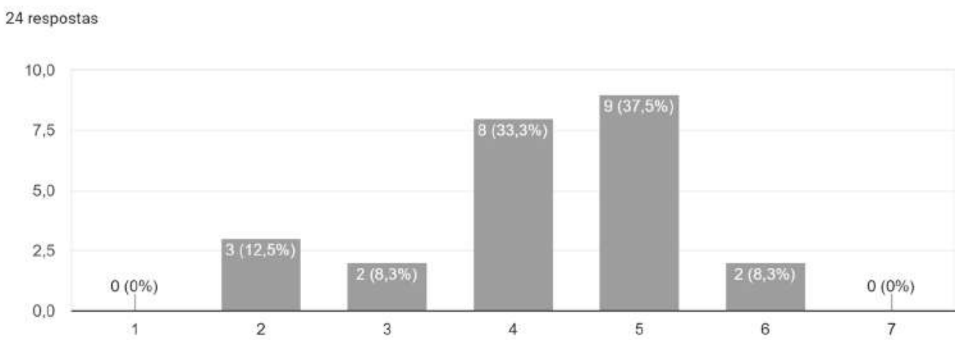
5.5. Color Variation Results

The color experiments, out of the four types of variations, were the most extensive ones and arguably offered the most dramatic changes in the *Regions* along with the lighting experiments. There were five different types of color filters used, each one having a different color to affect the entire *Region*, which were: red, green, blue, yellow and purple. We will begin with the *Red* variant for the *North America Region*.

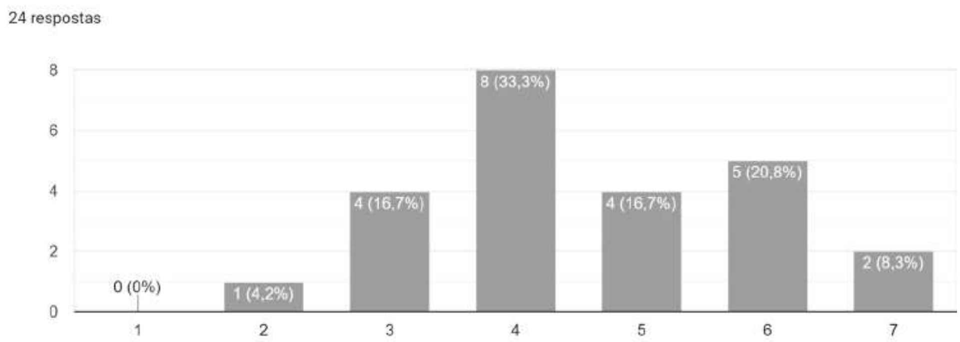
Figure 179: Red North America Region (Science4Pandemics,2023)



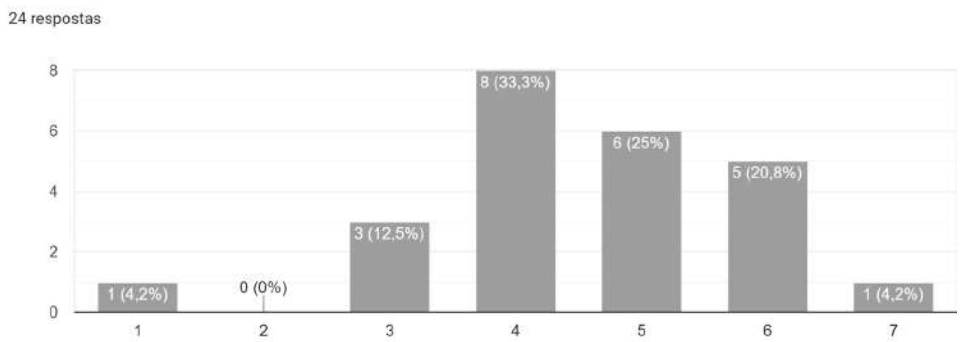
Graph 85: Red North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 86: Red North America Anticipation to Surprise scale (Science4Pandemics, 2023)



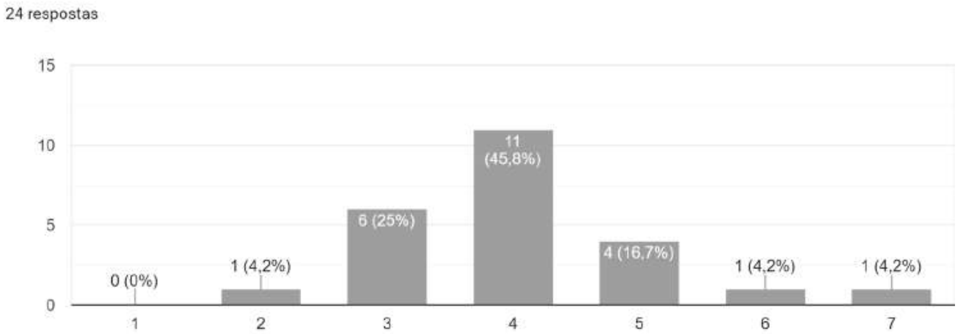
Graph 87: Red North America Fear to Anger scale (Science4Pandemics, 2023)



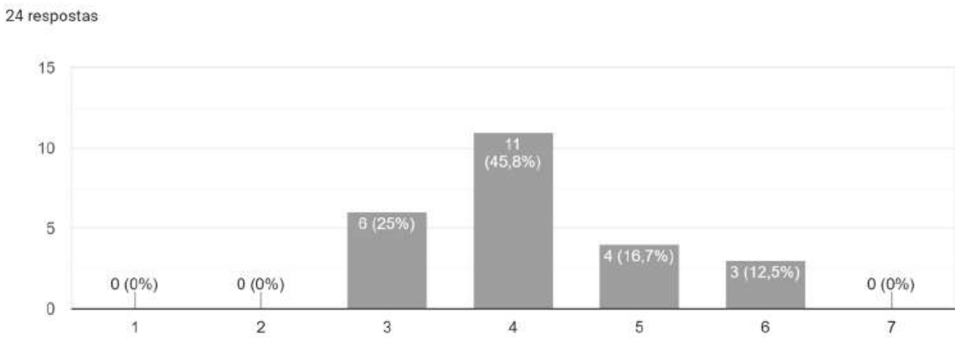
Graph 88: Red North America Trust to Disgust scale (Science4Pandemics, 2023)

Figure 179 offered interesting results, we can see a spike in different degrees of "*anger*", "*disgust*" and "*surprise*", summarizing around 50% of votes in their respective scales (Graphs 86, 87 and 88). We can also observe that the "*neutral*" option continues to be the most popular among the four scales and interestingly, testers were completely divided between "*joy*" and "*sadness*" in their respective scale (Graph 85). With this, we can move on the *Red* variant of the *North Africa Region*.

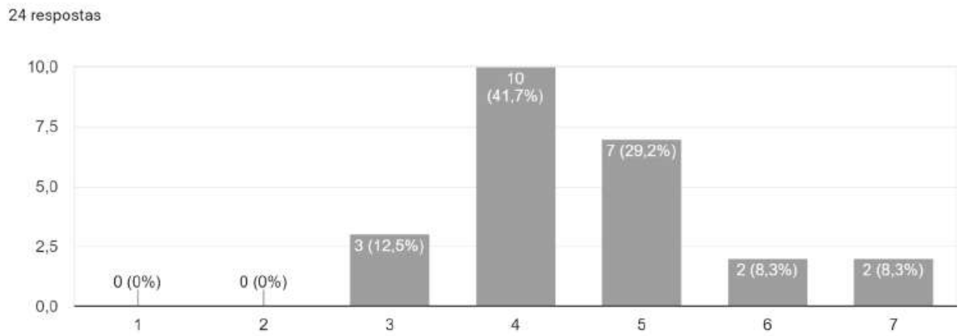
Figure 180: Red North Africa Region (Science4Pandemics, 2023)



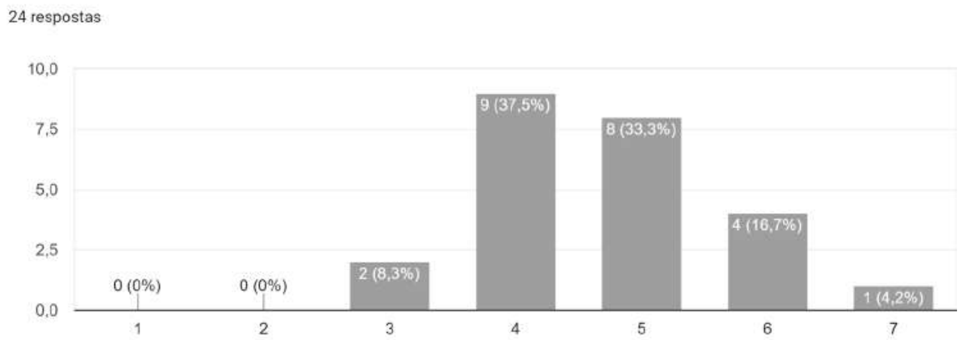
Graph 89: Red North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 90: Red North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



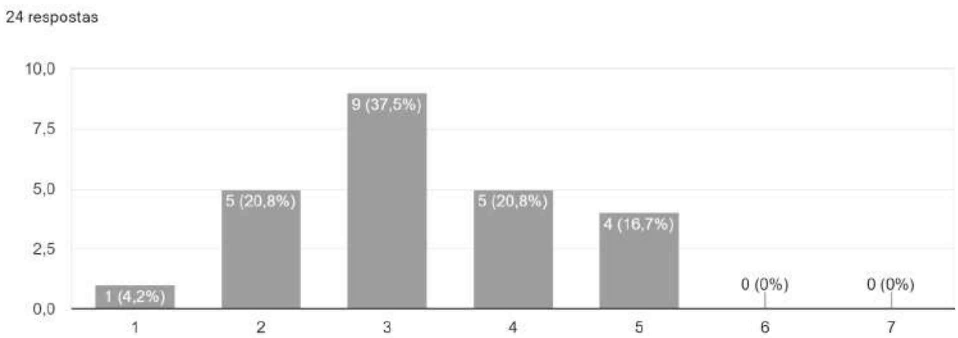
Graph 91: Red North Africa Fear to Anger scale (Science4Pandemics, 2023)



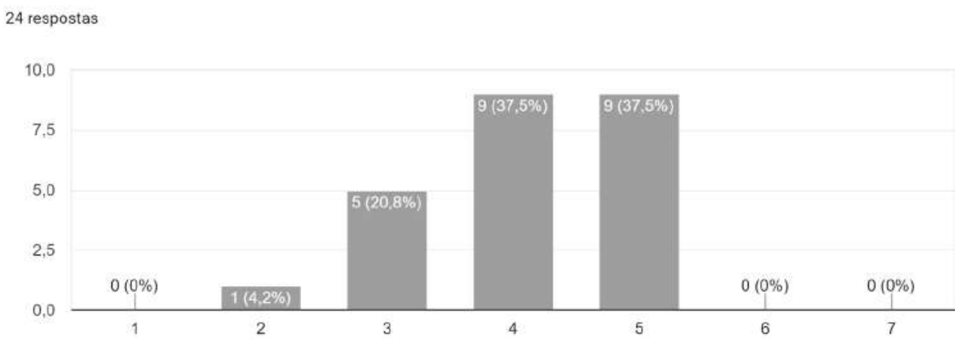
Graph 92: Red North Africa Trust to Disgust scale (Science4Pandemics, 2023)

In the *Red North Africa Region* (Figure 180) we can observe similar results, with the most common feelings being "*fear*" and "*disgust*" (Graphs 91 and 92), but still not as popular as the "*neutral*" option, with testers still divided between feeling "*joy*" or "*sadness*" (Graph 89). In this *Region*, though, the second scale (Graph 90) is very well balanced, unlike the previous *Red Region*, where "*surprise*" had twice as many votes as its counterpart "*anticipation*". Finally, we will analyze the last *Red* variant, the *Pacific Asia Region*.

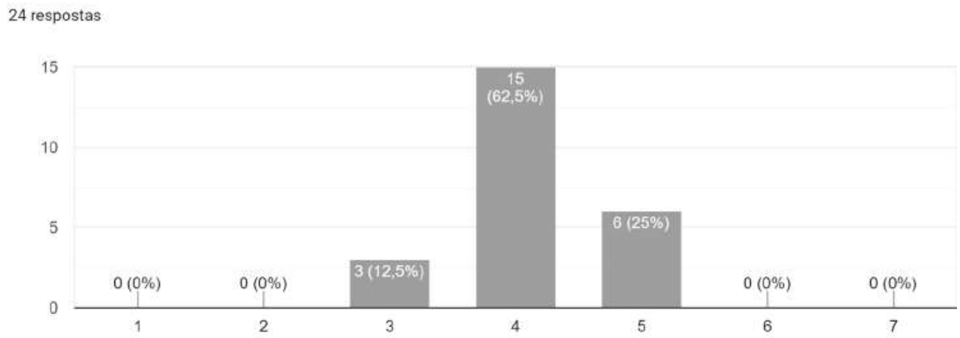
Figure 181: Red Pacific Asia Region (Science4Pandemics, 2023)



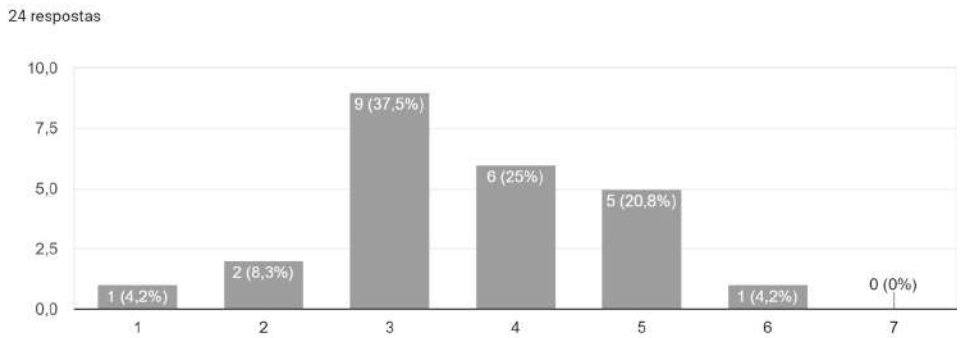
Graph 93: Red Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 94: Red Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 95: Red Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)

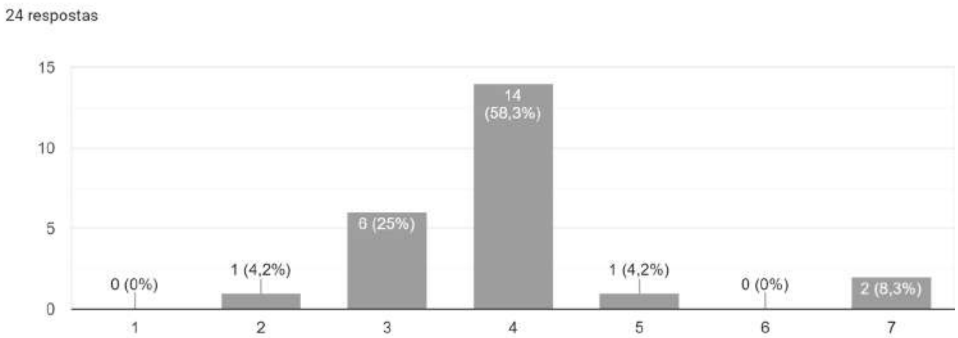


Graph 96: Red Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

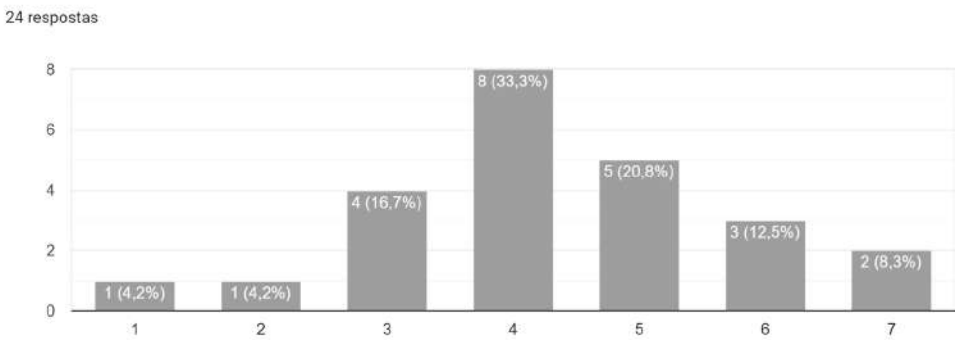
The results obtained from this region are very different from the others. In the *Red* variation of the *Pacific Asia Region* (Figure 181)*,* we see a considerable decrease in "*anger*" and "*disgust*", with the most popular option in the third scale (Graph 95) becoming "*neutral*" and surprisingly, "*trust*" in the fourth scale (Graph 96), an opposite reaction from previous regions. We can also observe another opposite reaction, where around 63% of testers feel "*joy*" to some degree (Graph 93), which, in previous regions, obtained about 25% and 30% , respectively. On the second scale (Graph 94), "*surprise*" and "*neutral*" are tied, with 37.5% of votes.

The *Red* variations seems to have caused an overall rise in "*anger*" from most testers, which can be directly connected to the color red. It was interesting to see how an unusual reddish atmosphere also caused a feeling of disgust in the participants, while also lowering their trust. With that said, the final region that was experimented on, offered completely different results from the previous two. This may have been caused by the original atmosphere in the standard region, which had a pinkish tone to its color palette, due to the cherry blossoms scattered around the map, making it so that the region after the experiment, had its pinkish atmosphere intensified. Thus causing the "*anger*" to go down and low intensity "*joy*", which is classified as "*serenity*" in Plutchik's wheel, to go up. Even though that is the case for the Pacific Asia Region, we can still connect the color red to negative emotions, especially anger and disgust, which are very popular choices amongst participants. We will now analyze the *Green* variants, starting with the *North America Region*.

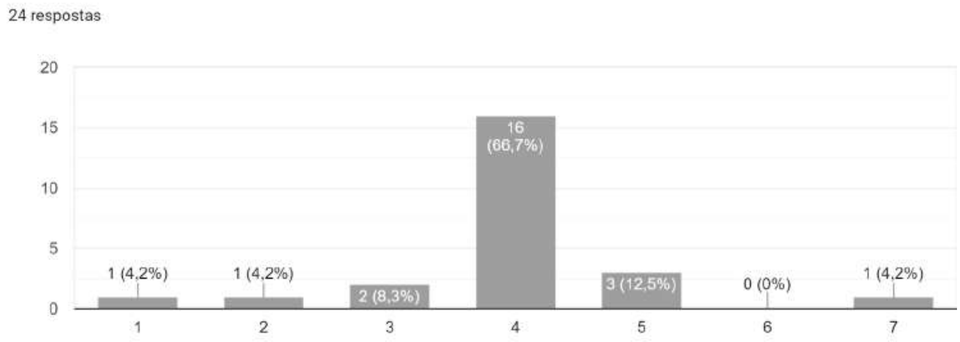
Figure 182: Green North America Region (Science4Pandemics,2023)



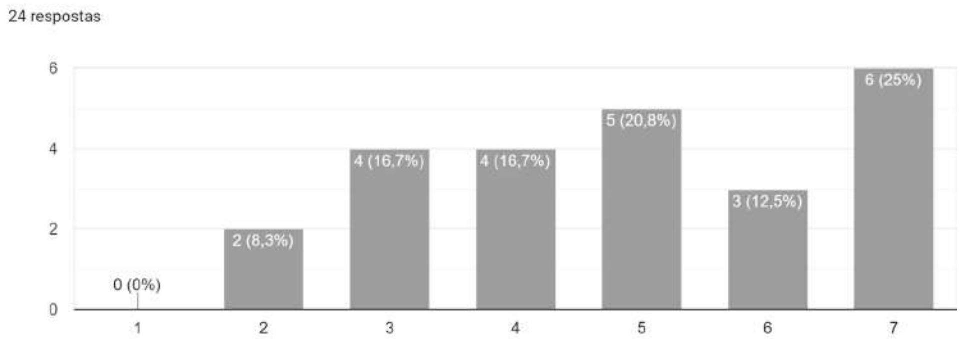
Graph 97: Green North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 98: Green North America Anticipation to Surprise scale (Science4Pandemics, 2023)



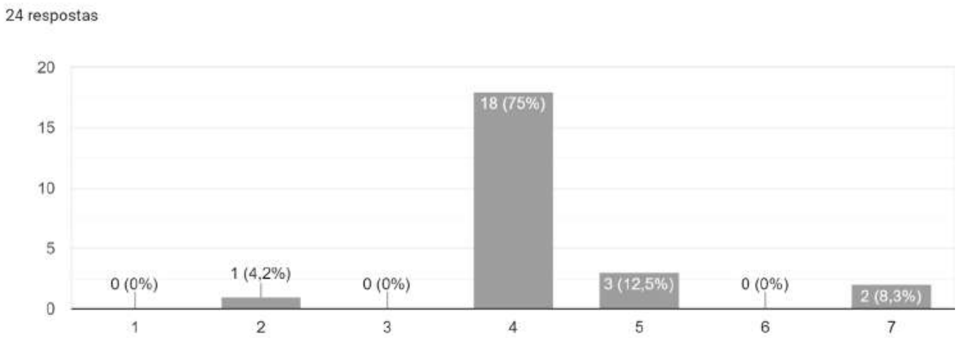
Graph 99: Green North America Fear to Anger scale (Science4Pandemics, 2023)



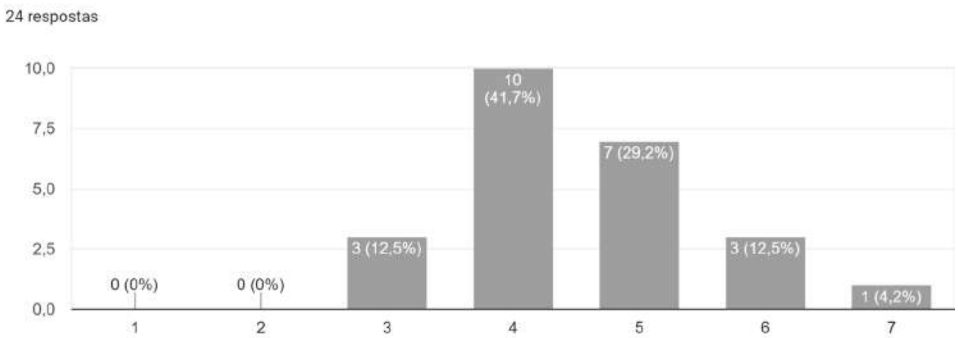
Graph 100: Green North America Trust to Disgust scale (Science4Pandemics, 2023)

The *Green North America Region* (Figure 182) had very scattered results all across the board, with the first three scales (Graphs 97, 98 and 99) having the most votes as "*neutral*" and very balanced feelings. For instance in the third scale, both sides have the same amount of votes, which is four testers feeling "*fear*" and other four feeling "*anger*". The fourth scale (Graph 100) shows the most expected results, showing that participants feel a very intense emotion of "*disgust*", with six total votes on the maximum degree, meaning "*loathing*" in Plutchik's wheel and a total of 58.3% in the "*disgust*" side of the scale. We will now move on to the results obtained from the *Green* variant of the *North Africa Region*.

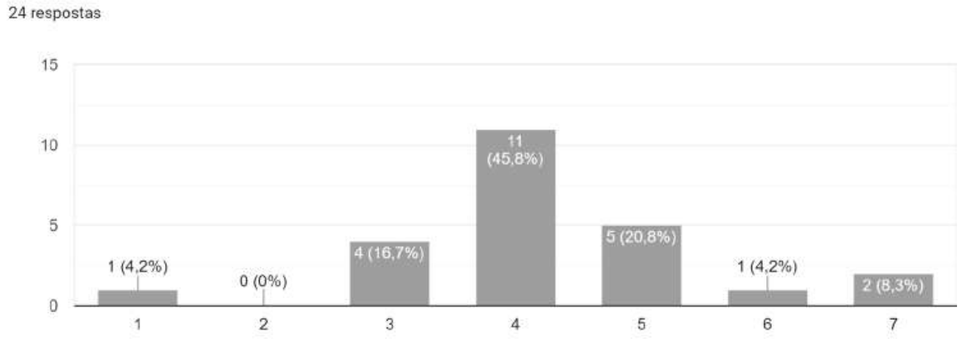
Figure 183: Green North Africa Region (Science4Pandemics, 2023)



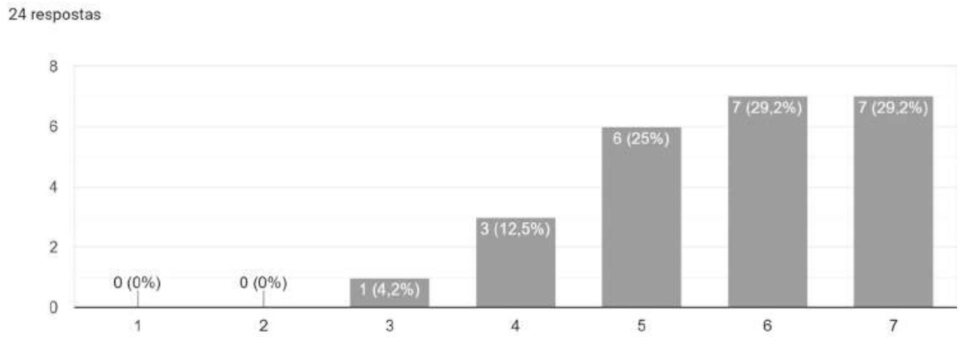
Graph 101: Green North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 102: Green North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



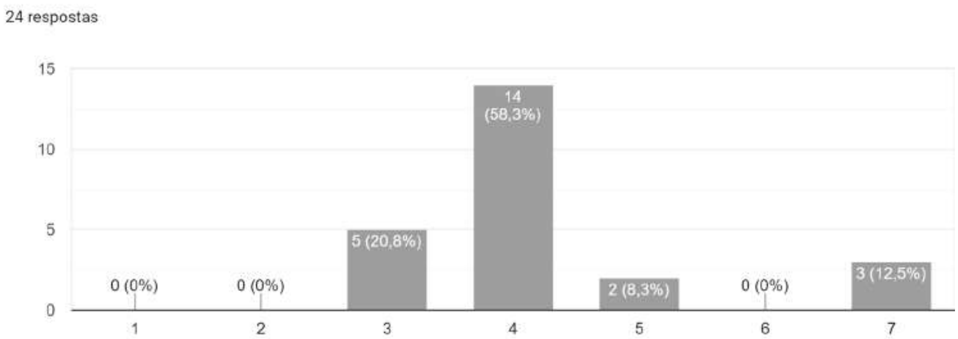
Graph 103: Green North Africa Fear to Anger scale (Science4Pandemics, 2023)



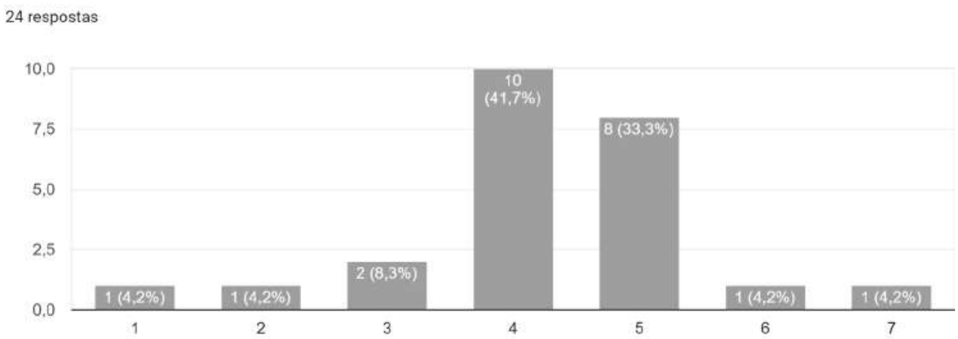
Graph 104: Green North Africa Trust to Disgust scale (Science4Pandemics, 2023)

We see similar results in Figure 183*,* where the first three scales (Graphs 101, 102 and 103) show very balanced results, with lots of testers assigning the "*neutral*" option and the last scale with completely one-sided responses, where they feel an even stronger intensity of "*disgust*", with 83.4% feeling it to some degree (Graph 104). In this region though, it is interesting to point that Graph 102 saw a significant increase in the number of "*surprise*" responses, with a total of 11 participants choosing such options. Which may be caused due to how intense the green filter contrasts the previous yellow, warm atmosphere of the region. We will now analyze the last *Green* variant, the *Pacific Asia Region*.

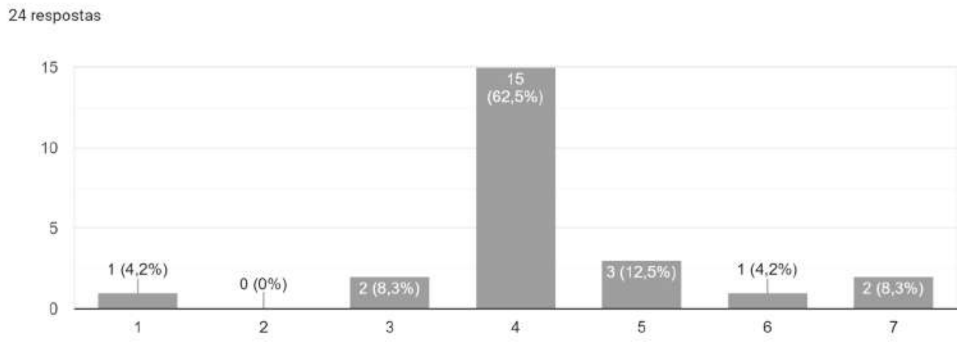
Figure 184: Green Pacific Asia Region (Science4Pandemics, 2023)



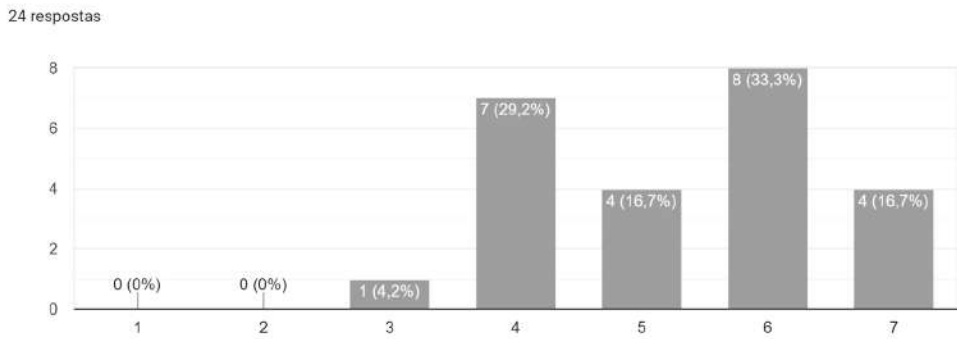
Graph 105: Green Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 106: Green Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 107: Green Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)

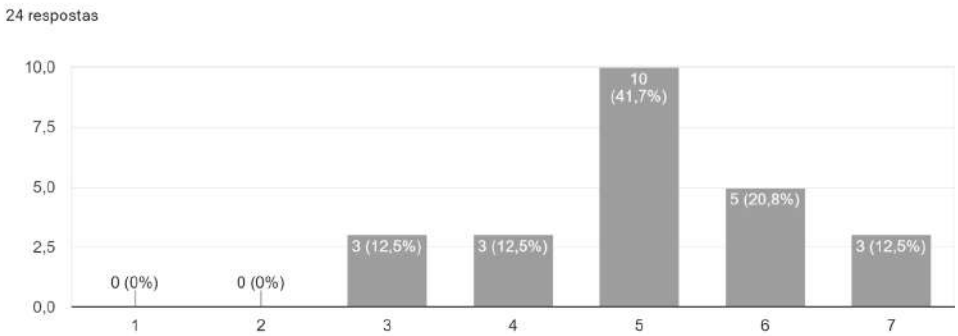


Graph 108: Green Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

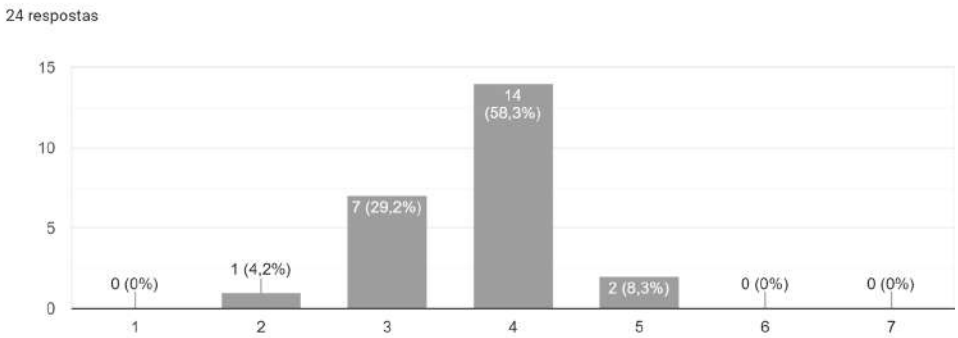
In the *Green* variant of the *Pacific Asia Region* (Figure 184), results continue to follow the pattern as we see the scattered results (Graphs 105, 106, 107 and 108), with the exception of “*disgust*” and “*surprise*”, which have around 67% and 42% of votes, respectively. Even though these continue to be the most select emotions, the most popular option continues to be “*neutral*”, comprising almost 50% of total votes across all scales.

Overall, the *Green Regions* specialized in evoking a feeling of *disgust*, which, as we observed in previous chapters of this document, is very commonly associated with the color green when used in certain ways. Turning the atmosphere into this color may have helped testers associate the town with some kind of mist or compound affecting the air, which would be likely, since the color is also associated with organic and poisonous things or substances. With this, we can proceed to the next color, *Blue* and its variants, starting with the *North America Region*.

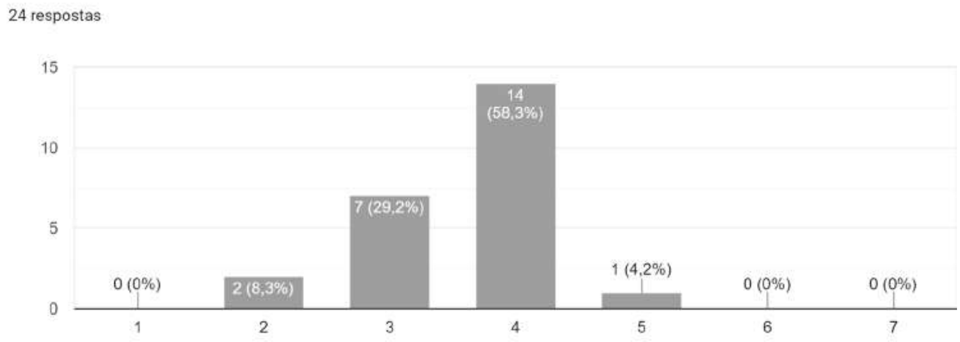
Figure 185: Blue North America Region (Science4Pandemics, 2023)



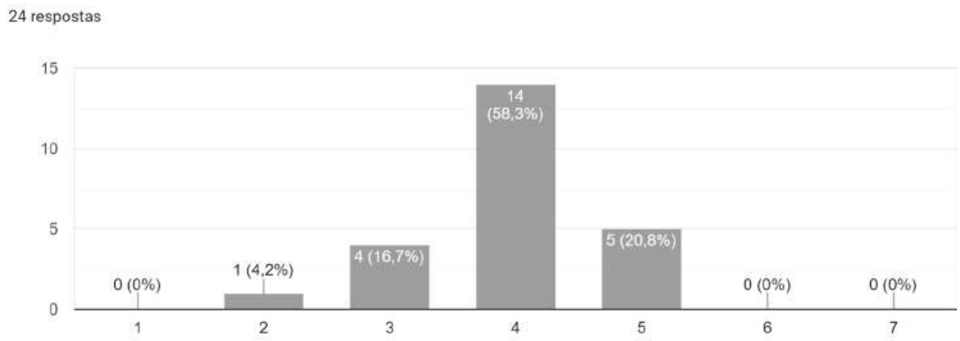
Graph 109: Blue North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 110: Blue North America Anticipation to Surprise scale (Science4Pandemics, 2023)



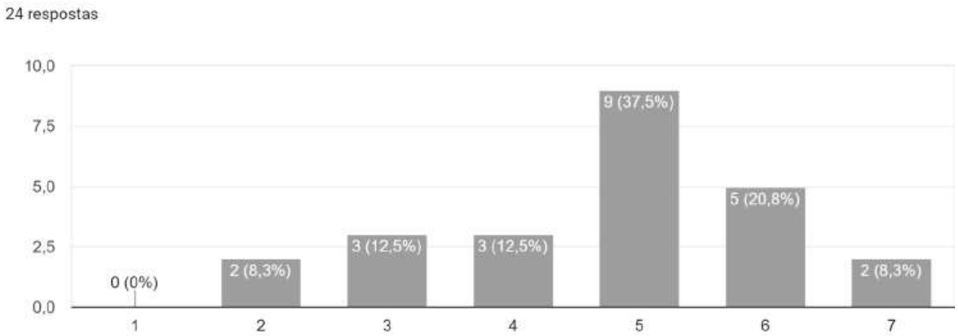
Graph 111: Blue North America Fear to Anger scale (Science4Pandemics, 2023)



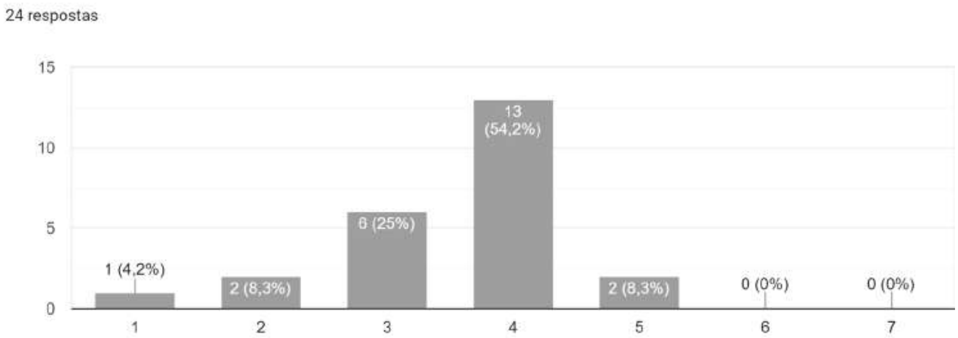
Graph 112: Blue North America Trust to Disgust scale (Science4Pandemics, 2023)

In the *Blue* variant of the *North America Region* (Figure 185)*,* results were as expected, since blue is commonly associated with sadness to different degrees, we can observe that the most selected option was "*sadness*", with 75% of votes in the first scale (Graph 109), as usual there are some testers that feel the opposite when looking at the image, voting in the "*joy*" option. The second and third scales (Graphs 110 and 111) show some more distributed responses, with the most popular option being "*neutral*" and most of the remaining votes being assigned to "*anticipation*" and "*fear*", with 33.4% and 37.5% respectively. Which was not expected, since fear is not commonly associated with this color, which, as we studied, is considered "calming". This leads us to think that a combination of aspects in the Region led to this emotion, such as the lack of people in the streets, paired with the coldness caused by the *Blue* filter, may have evoked fear in the participants. *Anticipation,* though, can be interpreted as longing for something, turning this emotion into a close relative to *sadness,* which is more expected. And finally, the last scale (Graph 112) shows completely even results, with "*neutral*" being selected by over half the testers. With this we will move onto the *Blue* variant of the *North Africa Region*.

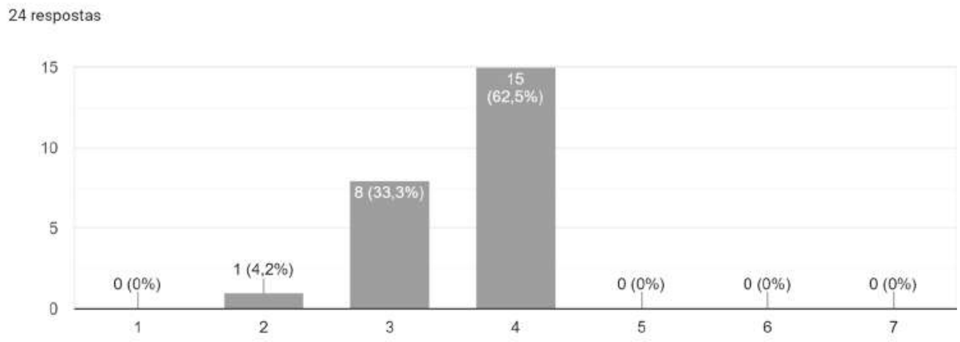
Figure 186: Blue North Africa Region (Science4Pandemics, 2023)



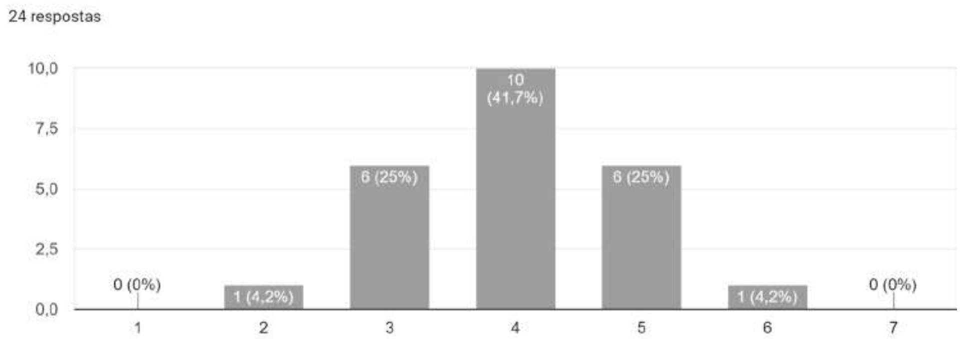
Graph 113: Blue North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 114: Blue North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



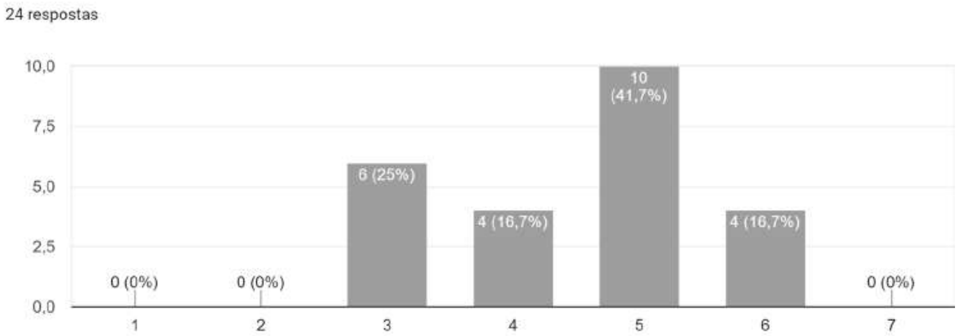
Graph 115: Blue North Africa Fear to Anger scale (Science4Pandemics, 2023)



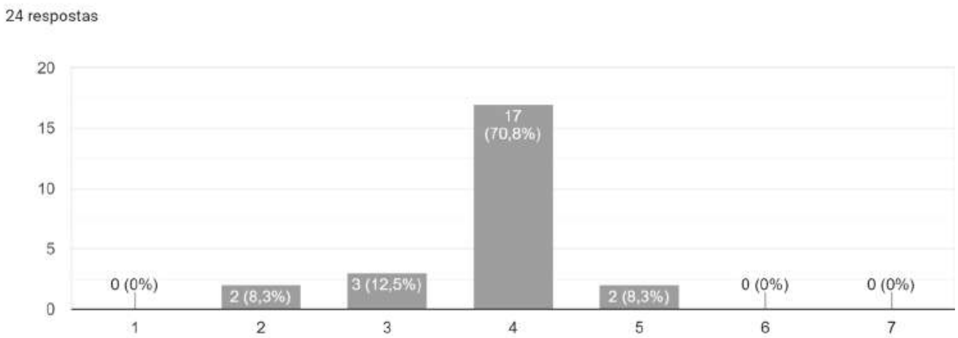
Graph 116: Blue North Africa Trust to Disgust scale (Science4Pandemics, 2023)

This *Region* (Figure 186) follows a similar pattern, where "*sadness*" is the most popular option, having 66.6% of total votes (Graph 113) and "*anticipation*" and "*fear*" being the most popular in their respective scales, both with 37.5% of votes (Graphs 114 and 115). In the *Blue North Africa Region* though, testers feel more strongly on the fourth scale (Graph 116), which possesses an even bigger number of votes both to the "*trust*" and "*disgust*" spectrum, each with 29.2% of votes, almost a 50% increase from the previous *Region*. Although there is a significant increase, "*neutral*" continues to be the most selected option in this scale, with around 42% of the votes. Lastly, we will analyze the *Pacific Asia Region*.

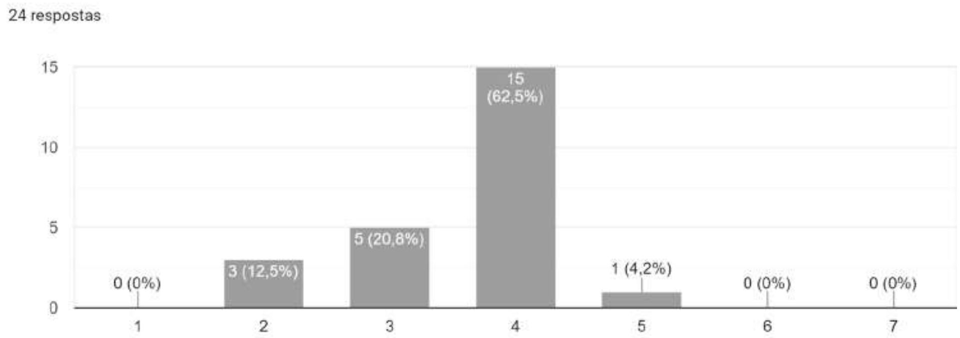
Figure 187: Blue Pacific Asia Region (Science4Pandemics, 2023)



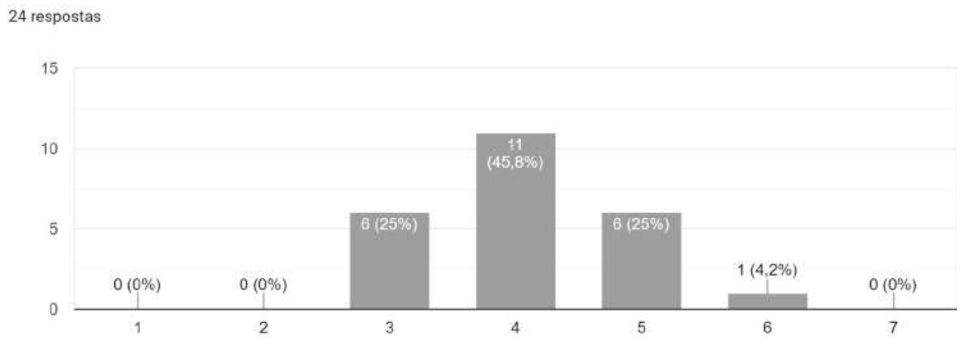
Graph 117: Blue Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 118: Blue Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 119: Blue Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)

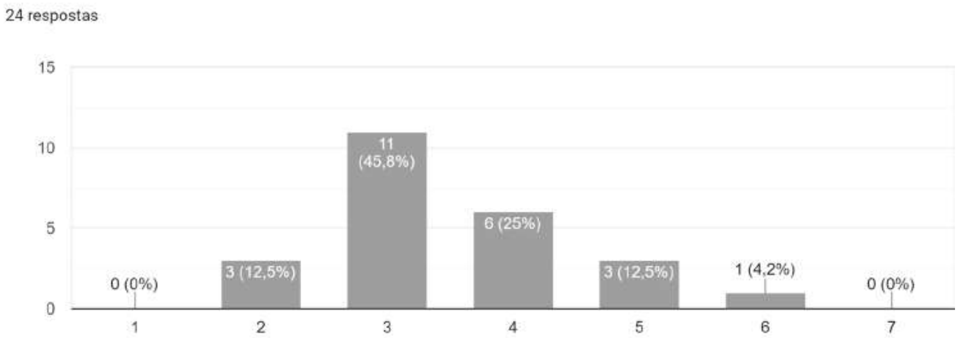


Graph 120: Blue Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

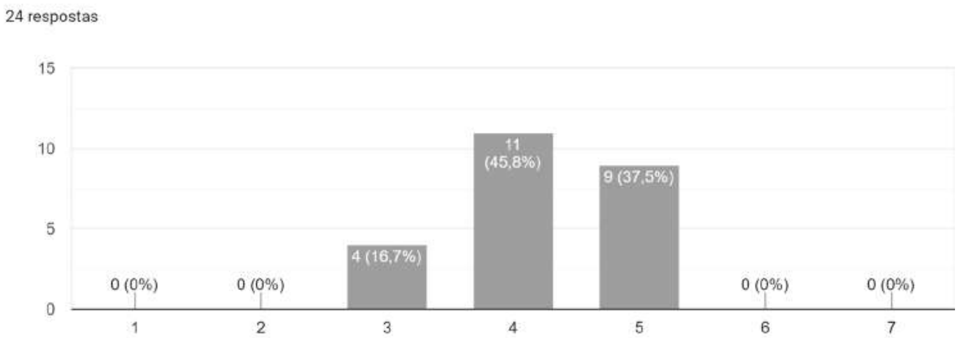
The *Blue* variant of the *Pacific Asia Region* (Figure 187) continues the "*sadness*" trend, with 58.4% of the votes, although it is worth mentioning that this *Region* possesses the biggest number of testers assigning "*joy*", making up 25% of the total votes on the first scale (Graph 117). The number of "*anticipation*" votes is smaller than both previous regions, with "*neutral*" having 70% of the votes on the second scale (Graph 118), and the percentage of "*fear*" is still around the same, at 33.3% (Graph 119). Although the difference is small, this time around, participants seem to lean more towards the "*disgust*" side (Graph 120), which is interesting, since a negative emotion like so, contradicts the big number of outliers selecting "*joy*" in the first scale.

The *Blue* variants had interesting results, with the commonly associated coldness of the color, mostly evoking a feeling of *sadness* and *fear* on the testers and, as we have seen in all previous experiments, there were also outliers such as "*joy*", which is an opposite of *sadness* and a balance between, for instance, *trust* and *disgust,* perhaps indicating a certain indifference overall to these emotions and selecting such option, just for the sake of selecting something other than "*neutral*". We will analyze the next color experiment, which uses a *Yellow* filter, starting with the *North America Region.*

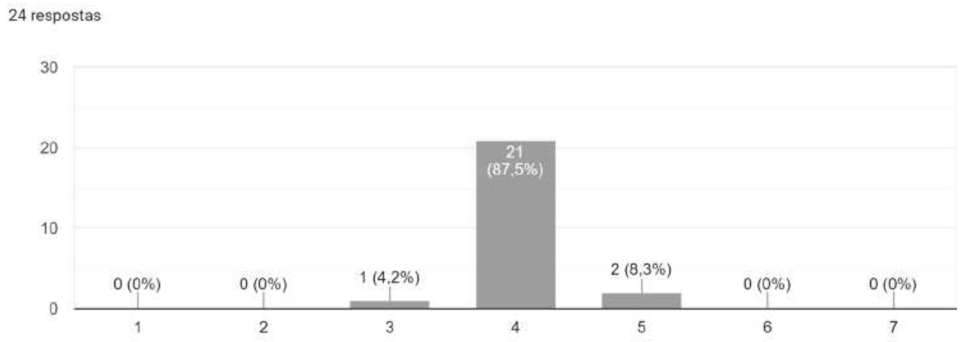
Figure 188: Yellow North America Region (Science4Pandemics, 2023)



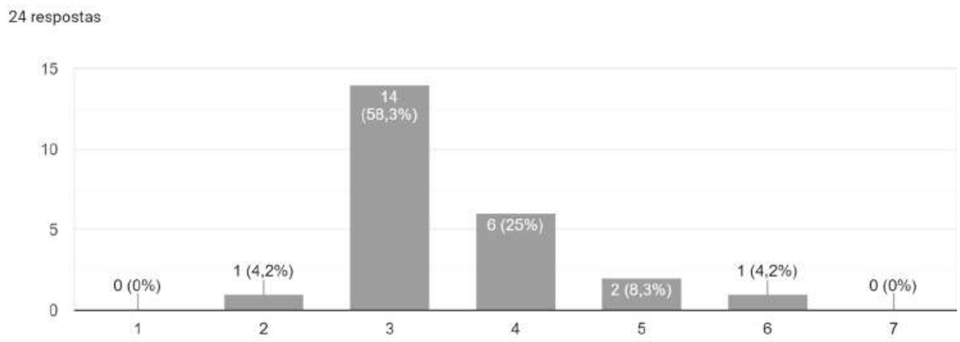
Graph 121: Yellow North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 122: Yellow North America Anticipation to Surprise scale (Science4Pandemics, 2023)



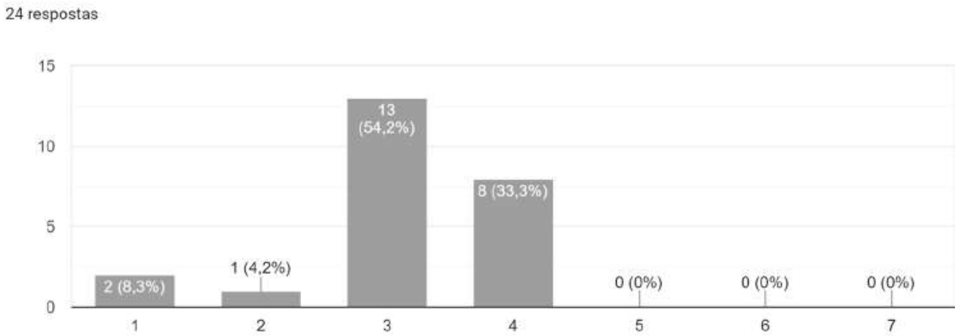
Graph 123: Yellow North America Fear to Anger scale (Science4Pandemics, 2023)



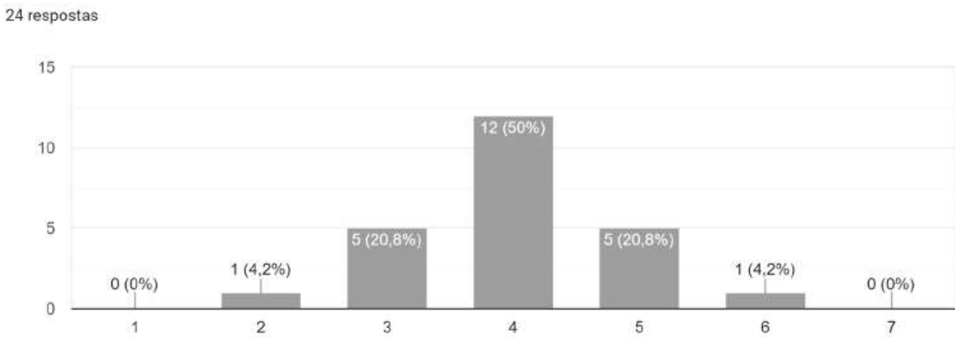
Graph 124: Yellow North America Trust to Disgust scale (Science4Pandemics, 2023)

In the *Yellow* variant for the *North America Region* (Figure 188)*,* we can observe a feeling of "*joy*", with over 50% of participants selecting the emotion in different intensities, but with a considerable amount of votes to "*neutral*", around 25% and a few selecting "*sadness*" to some degree (Graph 121). In the second scale (Graph 122) we can also observe feelings of "*surprise*", but once again, a large number of testers selected the "*neutral*" option. Interestingly, the third scale (Graph 123) offered the most one-sided results out of all the color experiments so far, with 21 votes for "*neutral*", which completely segregates the color yellow from either *fear* or *anger.* Finally, the last scale (Graph 124) shows us that most testers feel some intensity of "*trust*", with about 62% of the votes, rather than the 12.5% of "*disgust*" votes. We will now analyze the *Yellow* variant for the *North Africa Region*.

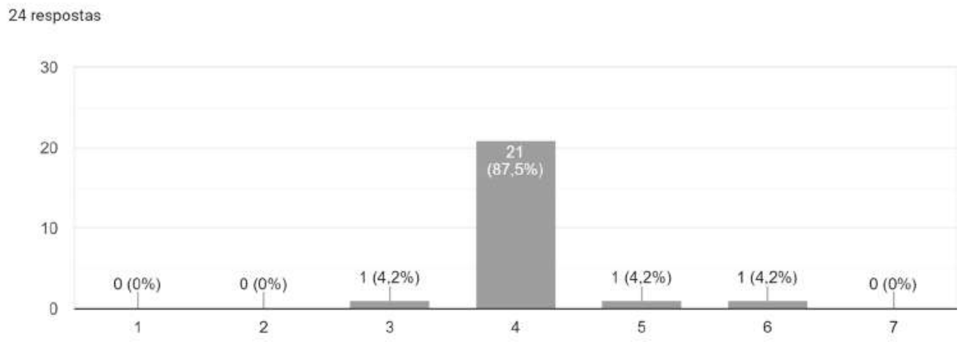
Figure 189: Yellow North Africa Region (Science4Pandemics, 2023)



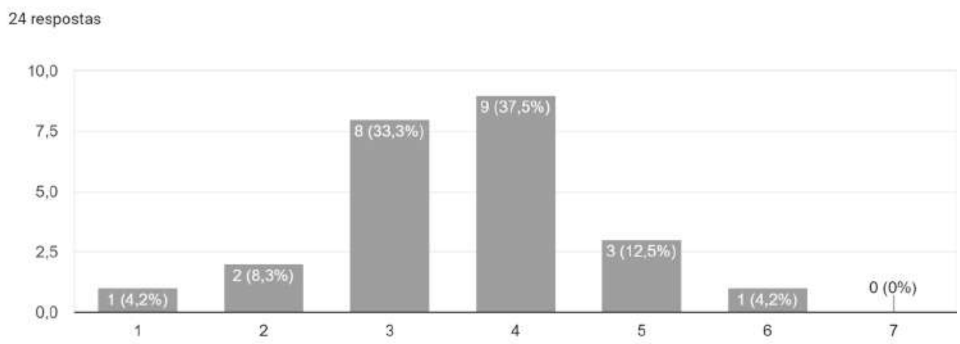
Graph 125: Yellow North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 126: Yellow North America Anticipation to Surprise scale (Science4Pandemics, 2023)



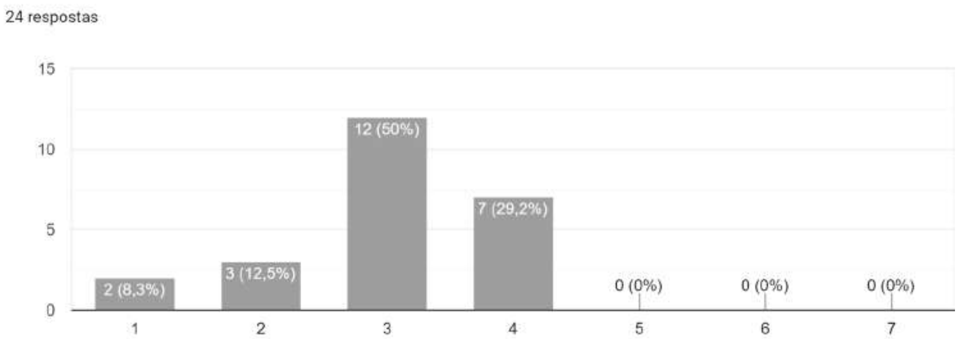
Graph 127: Yellow North America Fear to Anger scale (Science4Pandemics, 2023)



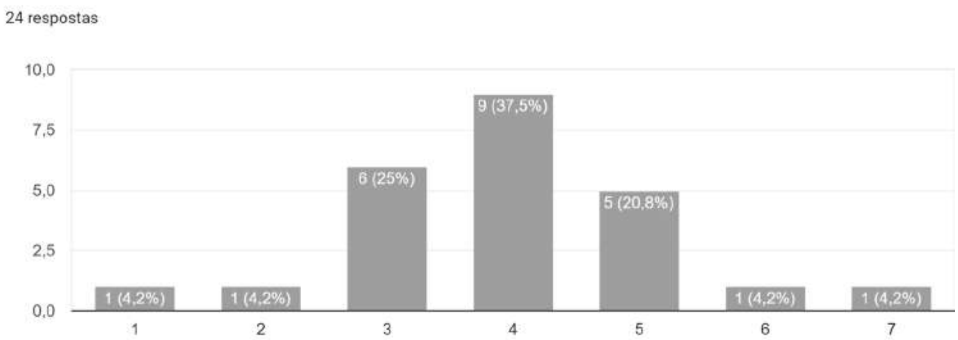
Graph 128: Yellow North America Trust to Disgust scale (Science4Pandemics, 2023)

In Figure 189*,* we can observe a complete prevalence of "*joy*" over "*sadness*", with the former having 66.6% of votes and the latter having a surprising zero votes (Graph 125). In the second scale (Graph 126) we see an equilibrium between the two spectrums and a high percentage of "*neutral*" votes. Once again, we see 21 "*neutral*" votes in the third scale (Graph 127), completely detaching the color from the two emotions present. And lastly, we see a decrease of "*trust*" votes (Graph 128) when compared to the previously analyzed *Region,* and a slight increase in "*neutral*" and "*disgust*" votes. We move on to analyze the last *Yellow* variant, the *Pacific Asia Region*.

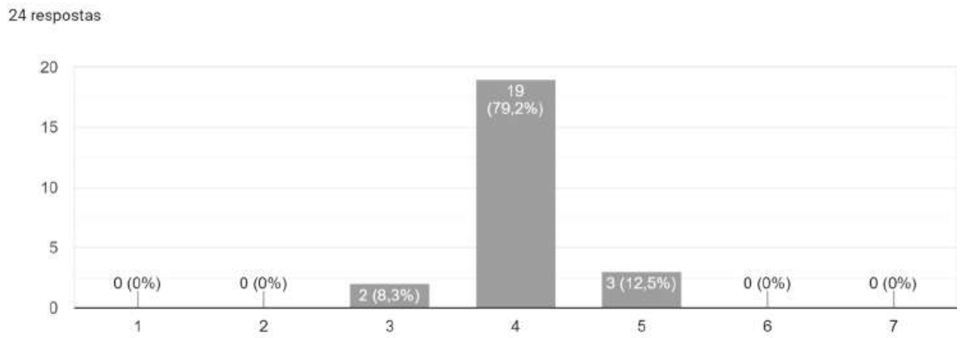
Figure 190: Yellow Pacific Asia Region (Science4Pandemics, 2023)



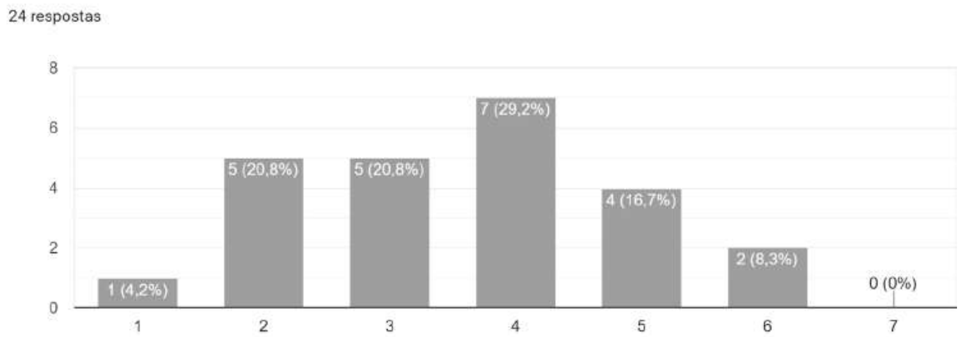
Graph 129: Yellow Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 130: Yellow Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 131: Yellow Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)

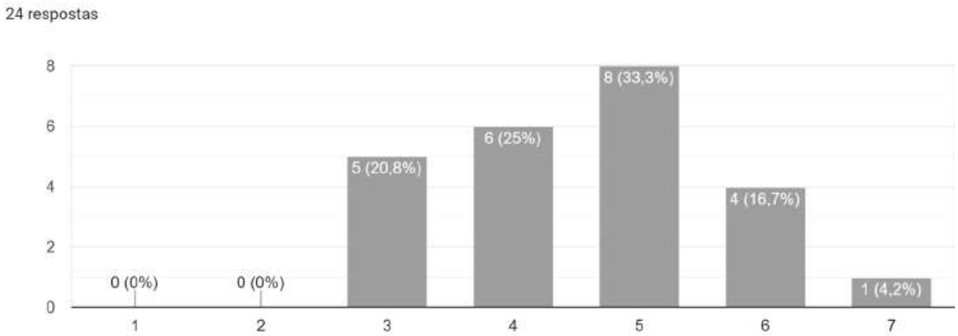


Graph 132: Yellow Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

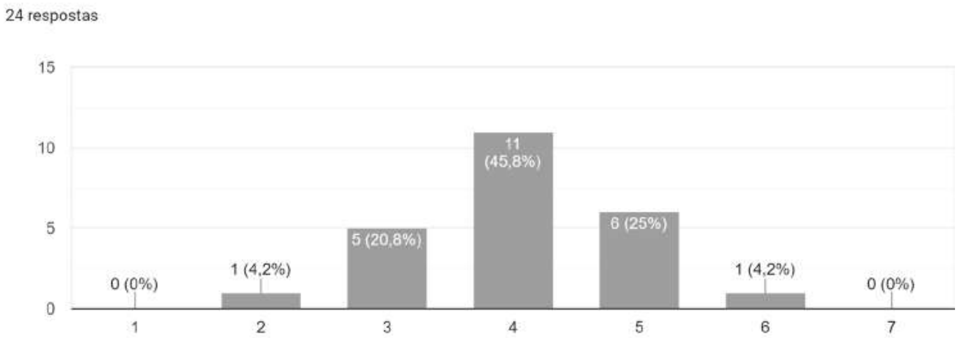
The trend in the *Yellow* variant of the *Pacific Asia Region* (Figure 190) continues as, once again, we can observe zero votes on the "*sadness*" spectrum of the scale and over 60% on the "*joy*" spectrum (Graph 129). The second scale (Graph 130) continues to have an almost complete balance, with over half the votes divided over "*anticipation*" and "*surprise*", and the rest in "*neutral*". On Graph 131, we can observe that the distancing from "*anger*" or "*fear*" continues, as there are 19 votes on "*neutral*" and the rest distributed along the scale. And lastly, the number of "*trust*" (Graph 132) votes remained the same when compared to the two previous *Regions*, but "*disgust*" had a minor increase.

Overall the color yellow evoked *joy* in the testers, having one of lowest amount of "*sadness*" votes so far. It has also brought a small amount of both *trust* and *disgust,* since, as we have analyzed, their votes are very evenly distributed. Arguably the most interesting results were obtained from the third scale, where we discovered that the color yellow has no apparent effect on the tester's *anger* or *fear.* The final color experiment is the *Purple* variant, which we will begin to analyze with the *North America Region*.

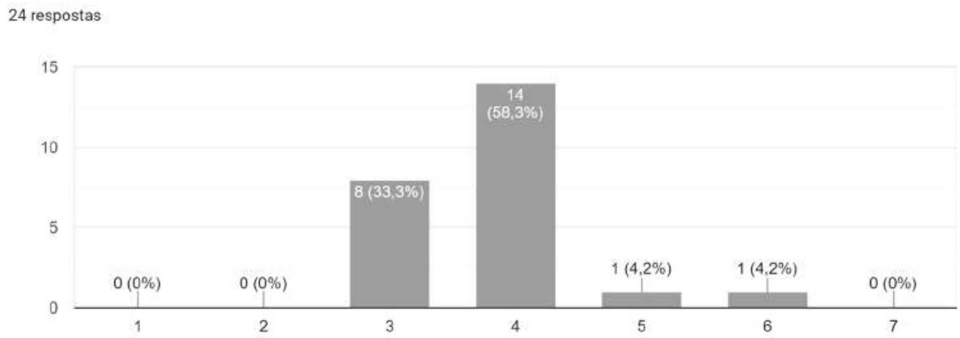
Figure 191: Purple North America Region (Science4Pandemics, 2023)



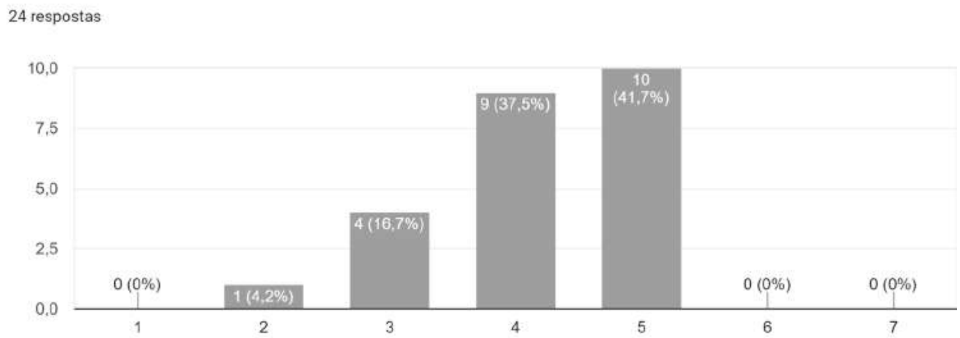
Graph 133: Purple North America Joy to Sadness scale (Science4Pandemics, 2023)



Graph 134: Purple North America Anticipation to Surprise scale (Science4Pandemics, 2023)



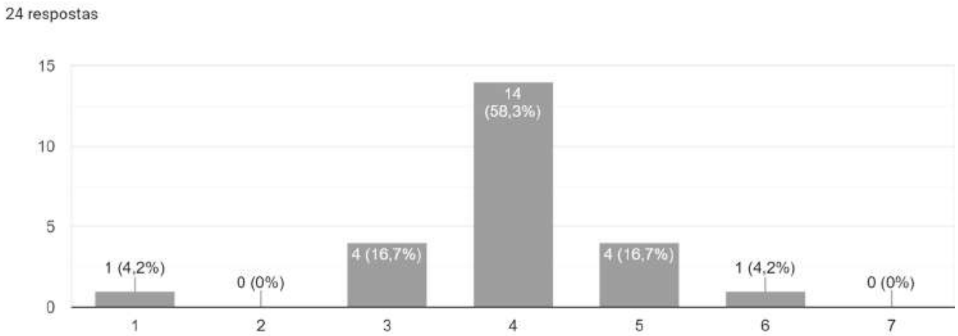
Graph 135: Purple North America Fear to Anger scale (Science4Pandemics, 2023)



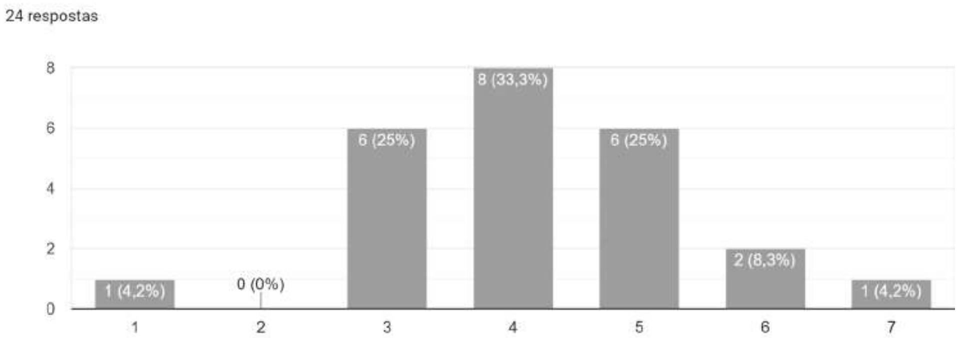
Graph 136: Purple North America Trust to Disgust scale (Science4Pandemics, 2023)

In Figure 191, we can observe two major emotions being assigned by the testers: "*sadness*" and "*disgust*", with 54.2% and 41.7% of votes, respectively (Graphs 133 and 136). It is interesting to note that on Graph 133, "*joy*" also possesses a significant amount of votes, but they are surpassed by "*neutral*" and different intensities of "*sadness*". We can also see a significant amount of "*neutral*" votes, especially in the second and third scales (Graphs 134 and 135). Once again, "*fear*", has 33.3% of votes, but is exceeded by "*neutral*", with 58.4% of them, making it a minor emotion felt by participants. We will move on to the next *Purple* variant, the *North Africa Region.*

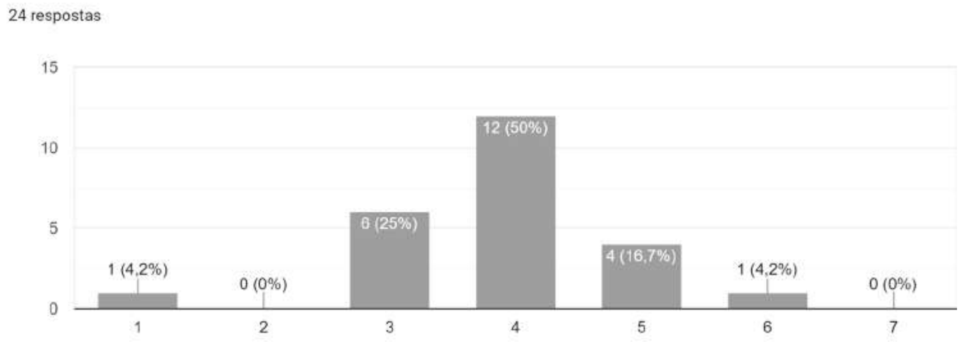
Figure 192: Purple North Africa Region (Science4Pandemics, 2023)



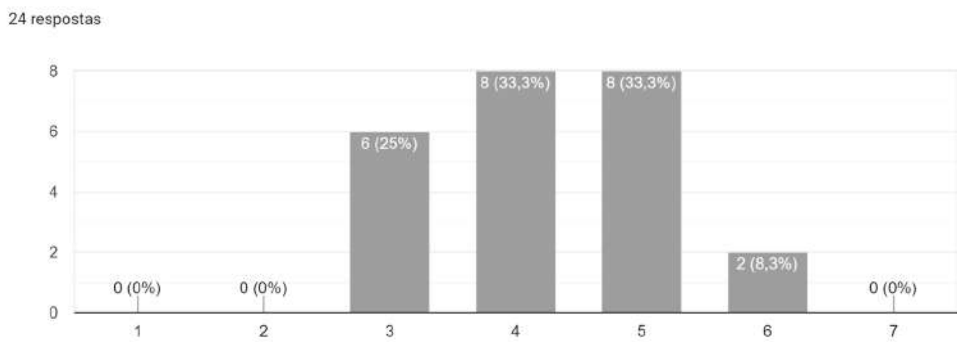
Graph 137: Purple North Africa Joy to Sadness scale (Science4Pandemics, 2023)



Graph 138: Purple North Africa Anticipation to Surprise scale (Science4Pandemics, 2023)



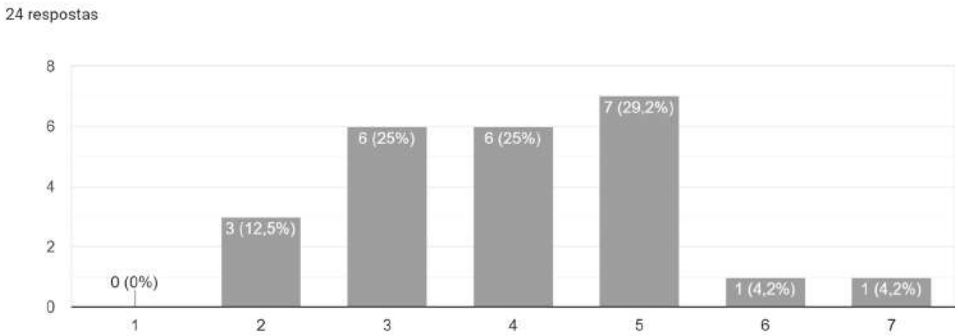
Graph 139: Purple North Africa Fear to Anger scale (Science4Pandemics, 2023)



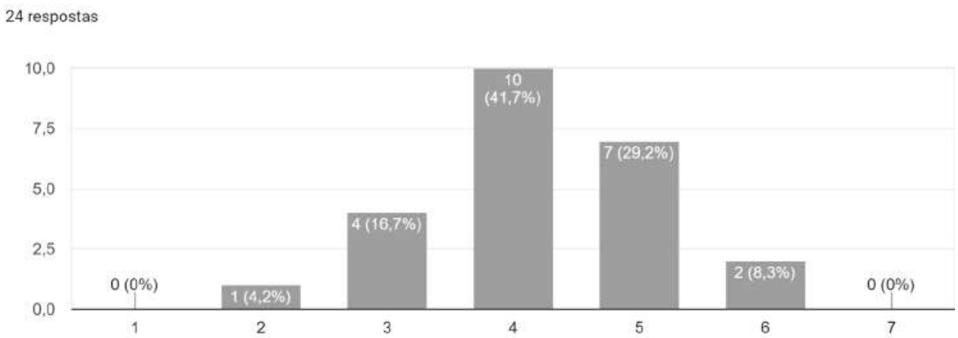
Graph 140: Purple North Africa Trust to Disgust scale (Science4Pandemics, 2023)

In this *Region* (Figure 192), we see varying results from the previous variant. "*Sadness*" is no longer as predominant among testers, with only 5 votes, tying with "*joy*" and "*neutral*" is now the most voted option on Graph 137, with almost 60% of votes. "*Disgust*" continues to be a popular choice, with 41.7% of votes (Graph 140), and both "*anticipation*" & "*surprise*", now have more votes than they had in the previous region, with 29.2% and 37.5% of votes (Graph 138), respectively. The second scale (Graph 139) possesses distributed results, with "*neutral*" being the most popular option. Overall "*neutral*" votes went up and the most predominant feeling is still "*disgust*". We will now analyze the final color experiment, the *Purple* variant for the *Pacific Asia Region*.

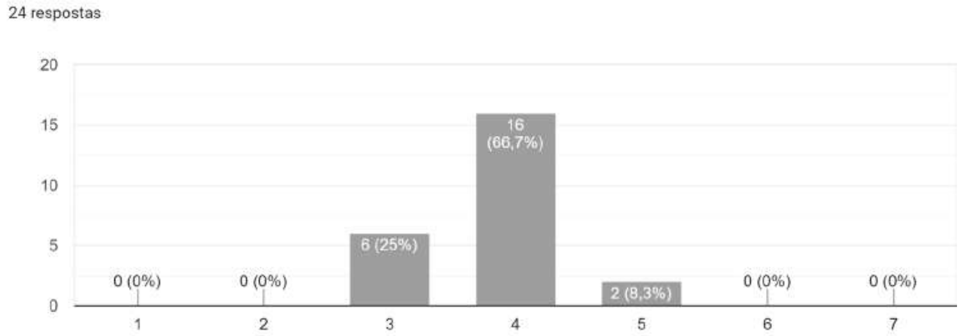
Figure 193: Purple Pacific Asia Region (Science4Pandemics, 2023)



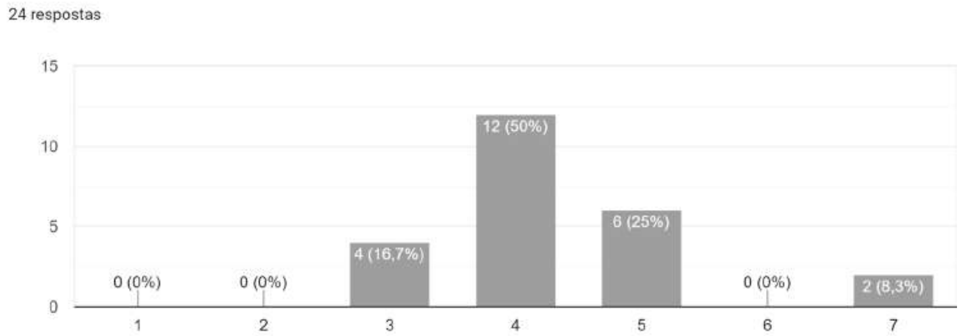
Graph 141: Purple Pacific Asia Joy to Sadness scale (Science4Pandemics, 2023)



Graph 142: Purple Pacific Asia Anticipation to Surprise scale (Science4Pandemics, 2023)



Graph 143: Purple Pacific Asia Fear to Anger scale (Science4Pandemics, 2023)



Graph 144: Purple Pacific Asia Trust to Disgust scale (Science4Pandemics, 2023)

Interestingly, here in Figure 193, "*joy*" has tied to its counterpart "*sadness*", both with 37.5% of total votes and "*neutral*" with the remaining 25% (Graph 141). The levels of "*disgust*" have also dropped (Graph 144), now with only 8 votes, giving space to more "*neutral*" votes. On the second scale (Graph 142), "*surprise*" is now the most selected emotion, with 37.5% of the testers relating to it. Finally, the third scale (Graph 143) continues to be dominated by "*neutral*" and a slight "*fear*", with 66.7% and 25% of votes.

Overall, the *Purple* variants are very interesting, since different regions provoked very different results, which was not the case for other experiments. *North America* possessed a great number of participants relating to *sadness* and *disgust,* while *North Africa* saw a majority of participants not relating to either *joy* or *sadness,* but still a considerable percentage of votes to *disgust.* And *Pacific Asia* divided the testers, which related partially to *joy* and *sadness*, but much less to *disgust.* The color seems to influence people differently, with testers feeling very diverse emotions whilst analyzing the image. It is also important to note that these experiments were in the later parts of the evaluation, meaning that participants were tired and assigned answers more randomly, trying to finish the test as soon as possible, which influences the final results.

5.6. Analyzing the Answers to Open Questions

The questionnaire possesses three different questions for each region. Each one aiming to access different information from said *Regions* that we considered was important to the overall work that was done in the *Science4Pandemics* game.

5.6.1. Briefly describe the Region you see in the figure

The first question given to the testers was: "Briefly describe the Region you see in the figure". This question was meant to inquire whether the overall feeling of the region built, accomplished its purpose or not. It was also a great way to ask for generalized opinions of each *Region,* without directing the participants towards any specific answer.

For the *North America Region*, we aimed to create a calm, suburban region with a good quality of life and after analyzing the answers from each participant, we can understand which characteristics stood out more in the region. Since this is such an open-ended question, there is no "correct" or "incorrect" answer, our goal is to inquire and extract the answers so that we may understand what the participants prioritize when analyzing the *Region.* The answers were varied: "*Small city/ village*", "*A town with roads, trees and buildings with no people or cars.*", "*industrial city*", "*This region has green spaces, a lot of fields to practice sports, schools, hospital, friendly neighborhood* " and "*Busy, polluted* ". It was very interesting to see what the testers thought of the region, most answers were correct, with participants describing a suburban city with lots of vegetation and a good quality of life. Others, though focused on the cluster of buildings that can be seen on the top part of the region, which is comprised of factories, warehouses and solar panels, and thought that the city was mainly industrial, describing it as "*polluted*". One participant also noted how the city is completely empty, with no people, cars or apparent life.

In the *North Africa Region*, our goal was to create a desertic region filled with disparity, where one side has clearly more economical power and quality of life than the other. Filled with luxurious buildings and run-down houses. This time around, answers seemed a bit more polarized than what we aimed for, with some focusing solely on the poor parts and other on the rich parts: "*Seems like a very polluted and unorganized city*", "*Arid, poor*", "City near a desert with extreme wealth and poverty", "*High temperature*". Although there were such cases, most testers pointed out that the city possessed a disparity of wealth and very hot weather, which can be considered a success on our part.

The *Pacific Asia Region* was created to be a developed city with high density, with lots of residential buildings and a more rural zone close to said area, possessing temples and forests. Although they were able to locate the region, most participants actually thought that it was a sparse city, with not so much density. "*It's a city with a temple, tall buildings, a lot of green areas and entertainment facilities*", "*a city with some medium high quality buildings and historical ones too*", "*It's a less dense area,* *even though it appears to be a downtown. I'd say the buildings have commercial purposes*". Despite that, the participants were still able to determine that it was indeed a well-developed region (all actual responses can be found in the appendix).

5.6.2. In which geographical region of the world do you think this *Region* is located?

The second question addresses the geographical location in the real world where that *Region* may be situated, the question is as follows: "In which geographical region of the world do you think this Region is located?". After analyzing the answers for the *North America Region* , the results were not as satisfactory as we wished, with around 14 results indicating options like: "USA", "America", "South of the United States", "Canada" and "North America" out of the 23 results (for some reason Google Forms only registered 23 answers for this question, unlike the 24 overall results), which comprises about 60% of the answers. Other 8 testers described something related to Europe, like "Eastern Europe" or "Small country in Europe" and a single participant answered "Japan".

For the *North Africa Region* we expected more diverse results, since the region built can easily be interpreted as an Middle Eastern country, which although is part of Asia, possesses very similar characteristics to the region we were aiming to develop, due to these reasons, answers involving countries around the geographical area mentioned, will also be considered as a "positive" result. With that said, this *Region* was the most recognized out of the three, with 21 out of 24 results identifying the geographical location as "Africa", "North Africa", "Northern Africa", "Middle East", "Arabia" or "Arab Emirates" comprising around 87% of results. Other answers included: "Brazil", "America" and "Europe", leading us to believe that the great disparity in living conditions and arid climate were very well represented in the overall scene.

At first, we expected the *Pacific Asia Region* to have the best results out of the three regions, this was due to the very characteristic architecture present in the area and, although it also obtained very satisfying results, with 20 out of 24 answers correctly identifying the region, consisting of around 83.3% correct responses, the *North Africa Region* was still the most recognized. Curiously, there were some interesting wrong answers among the responses received, like: "North America", "Braga, Europe" and "London".

After analyzing the results we concluded that the desired characteristics had been accurately represented, with testers easily being able to identify, or at least, name a region with very similar characteristics. Although, as we could also observe, practice was needed, since the first region to be developed did not have the quality and the results we were expecting, even then, some of the participants could still determine the location of the *Region* (all actual responses can be found in the appendix).

5.6.3. What type of development does this Region have? Is it poor? Do their citizens have a good quality of life?

The third and last question's purpose was to investigate whether the development and overall economic conditions of the Region were accurately portrayed. The testers were asked: "What type of development does this Region have? Is it poor? Do their citizens have a good quality of life?" The *North America Region* had acceptable results, with around 50% of total votes saying that the region had a good quality of life. Other 11 testers described something between "medium to good development" or "industrial city, so medium quality of life", which is not completely wrong, but our goal for this *Region's* design was to create a rich region with its citizens having a good quality of life. The last participant pointed that the region was poor, noting that "it seems polluted", bringing us to a total of 50% correct results (which could be considered more if we add some of the "medium quality" answers), showing us that once again, the first *Region* to be developed could have some improvements.

Our goal with the *North Africa Region* was to create a visible disparity, where most of the region is visibly poor, while a smaller portion is rich, meaning that we consider answers like "poor and rich" or "medium, with disparity" as correct. This time, results were far more satisfactory than the previous *Region,* 19 votes described the region correctly, either mentioning the disparity: "The region appears to have both upper-class and poverty-stricken residents. Only a small number of citizens appear to have quality of life." Or how most of its citizens do not possess the wealth necessary to have a decent quality of life: "The quality of life of the citizens depends on their wealthness". The remaining 5 testers did not have the perception of such disparity, describing the region as a "rich region, good quality of life", "all look rich", or as having "good development, good quality of life". With this, the ratio of correct answers is around 80% to the 20% wrong answers, a most welcome result.

Like the first *Region,* the *Pacific Asia Region,* was created as an upper-middle class development, meaning that overall, most citizens have a good quality of life.This broadened the acceptance of correct answers as we decided that "middle class, middle quality of life" to "good quality of life", would be acceptable answers. After analyzing the results, 100% of the participants assigned the correct description to the region, some describing it in more detail: "It's a wealthy area. The temple surely draws attention. I feel it's well developed, and people have a good quality of life", others simply mention the development: "Rich and good quality of life", "developed city, good quality of life in general" (all actual responses can be found in the appendix).

6. Conclusion

In this section we will summarize the work that was developed along the time-frame of this project, along with possible future research and personal reflection.

6.1. Summary

We started this dissertation by contextualizing the problem and explaining how the S4P game and many others, can benefit from the use of generative techniques that allow the developers and artists to speed up the game's development. While also explaining how the different visual aspects that comprise the game can influence the player and how they feel, thus communicating our goal to explore both the different possibilities that are offered by generative methods, but also to understand, experiment and catalog how these visual characteristics can evoke different emotions.

Afterwards we started our broad research on different methods of classifying emotions. Reading articles, books and essays about authors and researchers of the area that proposed theories to explain how the human brain connects color, lighting, shapes, textures and movement to different feelings. Also researching different games that used these methods and techniques, thus using practical examples to represent their utility and effectiveness. This research included many proposals on how to classify emotions, such as the Basic Human Emotions (Ekman, 1999), the Plutchik's Wheel (Plutchik, 1980) and the PAD emotional model (1994). And also different generative techniques that are currently used in games, such as procedural textures, scattering and Geometry Nodes.

Following this research, we proceeded to the practical part of this project, which involved three different parts. First, we began by analyzing how the S4P game was designed, what were the main ideas behind it and the core mechanics, prioritizing the *Regions,* which are a crucial concept for the game and this project itself. We explained how they were created, the different characteristics they possess, like climate, geographical location, wealth, density and population. The different buildings that comprise them, such as the *Buildings of Interest* and the non-interactive buildings and also describing how these buildings were designed and then modeled. The second part of this project's practical development was to conduct experiments using some of the previously developed *Regions.* The goal of the experiments was to use generative methods to visually alter the *Regions* to try and influence the players' emotions. We applied different techniques to alter the *lighting*, *movement*, *texture* and *color*. After that it was finally time to evaluate whether these experiments worked as expected and were able to influence the tester's emotions. And if so, what did they influence and how. We considered the *lighting* and *color* experiments a great success, since they were able to evoke an abundance of different emotions in the participants, which allowed us to deeply catalog what each visual variation caused on them. While the *movement* and *texture* experiments, not so much. The *movement* experiments were able to evoke some emotions in testers, but not enough for us to have the certainty that said characteristics cause said emotions. And the *texture* experiments had no relevant effect whatsoever, leaving the testers to feel the same as they did when analyzing the original image. The last part of this evaluation also inquired the participants if the *Regions* themselves worked as intended, questioning if they could briefly describe it, if they could geographically locate where it was inspired and if they could identify the quality of life in the *Region.* Once again, some were more successful than others, with the *North Africa* and *Pacific Asia Region* being the most recognizable in all aspects, and the *North America Region*, not as much as its counterparts.

With that the project is complete and we can confidently say that we are very pleased with the results obtained. After the analysis, we could see that some *Regions* and experiments were more successful than others. Despite this, we were able to deeply learn about the topics studied and hopefully contribute to artists and developers that wish to use such methods or to know more about their emotional effects on players.

6.2. Future research

We were able to conclude the entire work that was proposed in the beginning of this project, but what we learned can still be used in the further development of the S4P game. Almost half of the initially planned *Regions* are not fully complete, with the research and experience that was gained from this project, we can apply these new techniques to the development of said maps, allowing the team to work even faster and produce more results. We can also use the catalog of emotions that was created and try to apply it in different aspects of the game, not only the *Regions,* such as the HUD, the many mini-games that exist in the game and others. It is also in our goals, to re-develop the evaluation, making some small changes to create a more dynamic experience when completing such a long questionnaire. And distribute it to a larger number of testers, giving us a greater amount of data and thus more insight on the topic.

6.3. Personal reflection

Finally, to conclude this dissertation, it is important to mention that our goal was not to create new generative methods, but rather to study them and ascertain their usefulness in this project and as a whole. And also not to create new theories or proposals about the effect of visual elements in emotions, but rather to study the existing ones and also ascertain whether they can be improved and worked upon. It was very interesting to investigate these topics and a privilege to contribute to the game development field.

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