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Amplifying User Experience on Virtual Reality Through Level Design Based on Environmental Storytelling

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ARLINDO GOMES DE SOUZA NETO

“AMPLIFYING USER EXPERIENCE ON VIRTUAL REALITY THROUGH LEVEL DESIGN BASED ON ENVIRONMENTAL STORYTELLING”

Dissertação apresentada ao Programa de Pós-Graduação em Design da Universidade Federal de Pernambuco, como requisito parcial para a obtenção do título de Mestre em Design.

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For the designers of future universes.

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ABSTRACT

In virtual reality (VR) applications, the number of games that feature complex narratives is still low compared to traditional games; according to Steam data, they are only 4 of the 15 best-selling VR games. We can attribute this fact to the high cost of developing these experiences as they require a lot of testing, research, and experience from the development team. One of the approaches that help teams tell stories is environmental storytelling, which consists of telling stories through the environment to collaborate with the overall narrative being told. Previous work has already demonstrated the effectiveness of environmental storytelling in digital games. However, there is little material relating this approach to VR, a technology notably known for promoting spatiality, immersion, and presence in virtual environments and which could benefit from a refined approach to environmental storytelling. In this work, we propose a classification framework for environmental storytelling approaches and assess the impact of these strategies in a test with 12 players of different gamer types; the experiment consists of users playing four specific segments of a VR commercial game that presents approaches and strategies of environmental storytelling. We conclude that the type of players impacts their reaction to environmental storytelling approaches and strategies. Also, the authors observed behavior patterns throughout the experiments, but further research needs to be done in larger groups to generalize those behavior patterns.

Keywords: Virtual Reality. Environmental Storytelling. Narratology. Level Design. Games. Extended Reality.

RESUMO

Em aplicações de realidade virtual (RV), o número de jogos que apresentam narrativas complexas ainda é baixo se comparado a jogos tradicionais. Segundo dados da Steam, eles são apenas 4 dos 15 jogos mais vendidos em RV. Podemos atribuir esse fato ao alto custo de desenvolvimento dessas experiências por requererem muitos testes, pesquisa e experiência do time de desenvolvimento. Uma das abordagens que ajuda times a contar histórias é o uso de narrativa ambiental, que consiste em contar histórias através do ambiente de forma a colaborar com a narrativa geral que está sendo contada. Trabalhos anteriores já demonstraram a eficácia da narrativa ambiental em jogos digitais, porém existe pouco material relacionando essa abordagem a RV, tecnologia notadamente conhecida pela promoção da espacialidade, imersão e presença em ambientes virtuais e que poderia se beneficiar de uma abordagem mais refinada em narrativa ambiental. Neste trabalho, propomos uma estrutura de classificação para abordagens de narrativa ambiental e avaliamos o impacto dessas estratégias em um teste com 12 jogadores de diferentes perfis; o experimento consiste em os usuários jogarem quatro segmentos específicos de um jogo comercial de RV que apresenta abordagens e estratégias de narrativa ambiental. Concluímos que o tipo dos jogadores impacta no entendimento às abordagens e estratégias de narrativa ambiental. Além disso, os autores observaram padrões de comportamento ao longo dos experimentos, mas pesquisas adicionais precisam ser feitas em grupos maiores para generalizar esses padrões e entender mais a fundo essas relações.

Palavras-chaves: Realidade Virtual. Narrativa Ambiental. Narratologia. Level Design. Jogos. Realidade Extendida.

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1 INTRODUCTION

As virtual reality (VR) technologies evolve, equipment's become more accessible and the number of users grows. According to data from Steam, the most prominent digital gaming platform today, it is estimated that around 1.8 million users have equipment that allow them to access VR content, which corresponds to about 1.96% of the total users of the platform (HEANEY, 2020). We can attribute the low number of users to factors such as: The costs of VR equipment are getting lower, but they are still expensive for occasional users (LIAGKOU; SALMAS; STYLIOS, 2019); The investments on AAA[1] projects are rising, but there are not many of them available(SMITH, 2021); Highly immersive VR setups, are in general are more complex and expensive(LIAGKOU; SALMAS; STYLIOS, 2019).

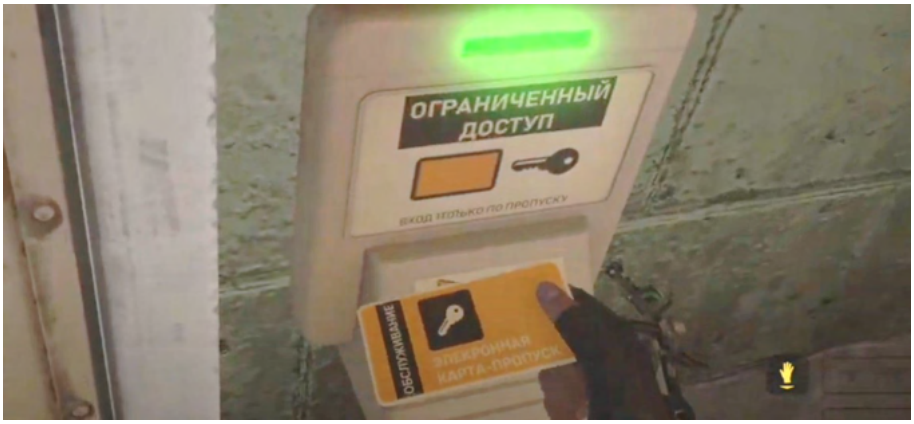
However, as we can see in the case where the launch of Half-life: Alyx (VALVE, 2020) that caused the Valve Index to sold out (LANG, 2020), due to the high demand for the game that was released along with a headset. Situations like this showed us that the guarantee of good content is fundamental in the acquisition of this equipment. Also, many companies are working on the development of headsets that do not need a dedicated computer like Oculus Quest, Lenovo Mirage and Vive Focus.

Bearing in mind these aspects of the VR gaming industry, we can assume that as it develops, the content presented on the platform also evolves, leaving only the physics-based games that populated the platform in the early years as Beat Saber (BEAT, 2017), Tetris Effect (MONSTARS RESONAIR, 2018) and In-Mind VR (NIVAL, 2017). According to Metacritic data, the top ten PC games with the best scores in the last 20 years are heavily narrative-based (GAME..., 2020). Several approaches are used to build these experiences, helping the player to discover all the narrative details, and to absorb the story.

One of the industry's best-known approaches is Enviromental Storytelling (ES), which consists of staging the player's space with environmental properties that can be interpreted with a greater meaning, favoring the game's narrative (SMITH; WORCH, 2010). The story is told with the help of the environment in which the player is inserted; as a sample, we can see in Figure 1 that by combining visual elements developers can

[1] Classification to video gaming products that has high-budget, and that are typically produced and distributed by large, well-known publishers.

Figure 1 – Example of ES in virtual reality.



Source: Trophygamers (youtube).

connect them into context, in that specific case connect the card to its specific lock, according to Jenkins (2004):

> The organization of the plot becomes a matter of designing the geography of imaginary worlds so that obstacles thwart and affordances facilitate the protagonist's forward movement towards resolution.

Even though the VR game market is not as profitable as the traditional games market (SMITH, 2021), the appeal for VR games is high, the immersion provided by the medium allied with the synergy of techniques such as ES can favour highly engaging experiences; more than that, some authors and industry professionals consider environmental narrative to be a crucial part of VR experiences (BUCHER, 2017).

Many researchers analyze how media experiences can awaken our emotions; in VR, several aspects can be associated with this; one of the known approaches to deal strategically with emotions is Emotional Design. According to Norman, Emotions change the way the human mind solves problems. Emotional Design is a system that aims to change how cognitive systems operate. (NORMAN, 2004). In VR experiences, factors linked to affordances, intuitiveness, presence, feedback, and perception are extremely important for these experiences' usability. According to Jessica Brillhart (BUCHER, 2017): the audience's emotional journey through experience and perception, as the user experiences the world, must guide technical decisions in the context of VR narratives. It is not always a matter of generating realistic graphics or having the highest resolution possible. The VR experience comprises several parts, where the interaction is significant compared to other media.

ES can be a powerful tool on the construction of VR experiences, the term was presented on a series of web articles by Don Carson (CARSON, 2000) posted on Gamasutra, where Carson provided examples of his work at Disney theme parks and how they provided their visitors with rich narratives using the complete attraction environment as a narrative asset. Jenkins (JENKINS, 2004) also provided insight on a web article, explaining how games as a media format could benefit from a different narrative architecture, considering the facts that the users have agency in the space where the story is happening and the fact that they are present in the virtual space. Since then, many games have been pointed as success cases for their approaches to ES; We can see as state of the art for ES the games Dear Esther (PINCHBECK, 2008), Myst (CYAN, 1993) and Journey(THATGAMECOMPANY, 2012) games that are solely focused on using those approaches to present narratives (BEVENSEE, 2014).

The fact that those games are focused on delivering stories creates an extensive discussion between narratologists and ludologists (JUUL, 1999), trying to define if they were a game or an interactive movie. It generates another dimension of narrative studies defined as interactive narratives. The concept of narrative could be applied differently according to new approaches and media types. Regarding the application of ES, Bevensee (2014) points out that a more suitable definition of narrative is:

> A selection of staged objects, events, and environmental setting, suggesting a cause-effect relationship or a semiotic relationship from a story theme in non-linear time and space. (BEVENSEE, 2014)

In this work, the main objective is not to investigate the traditional definition of narrative or extend the concept in any manner but to use it as a base for understanding ES approaches on immersive experiences. In that regard, a tool to classify the elements its crucial to provide the research with information about the environment, and its elements. Although there are existing classifications and frameworks on this subject, as presented by Bevensee (2014), Tarnowetzki (2015), Fernández-Vara (2011) and Smith e Worch (2010), none of them focus on classify the elements of ES as parts of a plan for level design, therefore, we propose a framework for understanding and classifying approaches to ES on a strategic level and the lessons learned from the research and experience, that can help developers and designers to apply ES on VR Experiences. Furthermore, on this research we investigate the application of those approaches on VR, a technology known to provide presence and more robust emotional

responses (JERALD, 2015). Combining those aspects, we can assess user experience related to this narrative technique applied in VR and how game designers and development teams can explore ES techniques for particular player types.

The primary motivation for this research is to study and experiment on possible synergies between ES and VR. ES has proven potential in the industry and has been discussed for many years as in Carson (2000), and its potential aligned with VR advantages. However, to the best of our knowledge, there are no works on literature, that explore those two aspects jointly, and also, investigate the association between presence provided by the environment and immersion related to the technology itself (MESTRE et al., 2006). On Table 1 we present the research structure for this work.

1.1 OBJECTIVES

1.1.1 General Objective

Investigate the impact of ES approaches on the behavior of different types of players in VR.

1.1.2 Specific Objectives

1. Learn definitions, techniques and models of analysis in the literature in ES, player profiling and user experience in virtual reality scenarios;
2. Propose a classification framework for different approaches to ES;
3. Gather data through an user experiment on distinct scenarios where we can assess different aspects of ES on the VR experience;
4. Learn and discuss the impacts of ES strategies on the users in virtual environments.

Table 1 – Research Structure

Research Phases	**Objective**
Literature Review	Research on the science databases regarding environmental storytelling, engagement, emotion, presence and design of environments on virtual reality.
Other works analysis	Analysis on frameworks, papers, methodologies that are in some way related to environmental storytelling.
Framework's proposal	Elaboration of a framework to classify and understand different approaches on environmental storytelling.
Data Collection	Experiment applications where users will use a virtual reality product that uses the discussed approaches.
Data Analysis	The data will be analysed considering players' subjective and objective responses to the approaches on environmental storytelling, in order to validate the framework.

2 INTERACTIVE NARRATIVE AND LEVEL DESIGN ON VIRTUAL REALITY

When we think about VR, we naturally talk about the sense of spatiality and presence, the feeling of being present in the environment, the dissociation of the user with the real world, and the immersion provided by this technology (MESTRE et al., 2006). However, we notice that when we talk about those aspects, we are talking directly about the virtual environment, and how the quality of the content inserted in this space is essential for these experiences to be pleasurable and convincing for users at different levels of use in VR.

Dan Archer, the creator of one of the first pieces of journalism in VR, *Harvest of Change*, suggests that immersive narrative is the best model for presenting complexities, ambiguities, and contradictions in prominent stories that take several episodes to be adequately told (KOSKI, 2015).

It is key to the understatement of ES, understanding that it is part of an interactive medium, where players will explore themselves and actively make choices and actions. It is essential to point out that not all games tell stories - they can be very abstract as an art form as dance or music - but most of them have some degree of narrative aspiration that helps them to evoke emotions or to explain core mechanics based on gamers previous experiences (JENKINS, 2004). However, games that focus solely on storytelling, not necessarily can be defined as a cinematic or theatrical experience. Adams brings light to the interaction side and defines its role on interactive media in general; he comments: The whole point of interactive media is letting the player do something on her own. (ADAMS; FAçADE, 2005). So even in virtual theatrical experiences like The Under Presents: Tempest (TENDERCLAWS, 2019), there is a fine mix of traditional narrative and interactivity to portray the story as an experience to the audience.

Jenkins defines a framework for what he calls narrative architecture where he can separate different categories of interactive narrative and present a classification that can be used as a base for ES. The four types are:

- **Evocative**

  This type of narrative is where a familiar aspect is essential for the audience to understand what is being told. For example, games based on movies or recreations

of a specific context (e.g., stranger things (STRANGER..., 2016) try to emulate an 80s setting).

It is interesting to notice that, more than telling a direct narrative, the evocative approach can reinforce a world or bring the users to the context of a specific story but tell a spin-off story with the same elements.

- **Emergent**

  Those narratives surge spontaneously; they are not previously designed; the game gives the players the tools to create their own stories based on what they are developing during the gameplay. That can be applied to any game; even a bug can generate an emergent story. E.g., in In-car simulation games, the users can suffer accidents or perform stunts that will be a memorable personal story.

  However, it can also be applied in other ways; part of the story can be pre-defined, but some aspects can be emergent. Some approaches are commonly observed on Immersive Theater applications, such as The Under Presents: Tempest (TENDERCLAWS, 2019).

- **Embedded**

  Level design is the main playground for the embedded narratives; it is associated with walking simulators (YU, 2020). Those games are based on the environment to tell stories and guide the users directly. Although, in general, they are very structured and pre-defined experiences, they are not centered on challenging the players with complex mechanics.

  We can say that, on embedded narratives, the story and level design must perform together to deliver an experience.

- **Enacted** The player must perform as a character; the environment and game must provide him with information and agency to understand his identity and perform acts and choices. Role-playing games are an optimal scenario to those kinds of narratives, digital or analog, that provide the users with much information to understand the whole scenario before and during the gameplay.

Those definitions in the narrative define strategies for building those stories in games and the main objectives behind them. As stated by Bleszinski (2000): Level

design is as much an art as a science; it requires technical and artistic skills. Level design is often referred to as creating the levels (or stages) of games inside which we had the placement of the architecture and nature itself.

Carson comments that in the context of theme park attractions, the physical spaces convey the stories that set designers are trying to tell; aspects such as color, lighting, and texture can lead to subcontinent responses and a better understanding of context. Thus, Carson indirectly makes a parallel between set designs and level designers; both professionals are responsible for guiding users through the path and presenting the narrative structure with the right pacing and in a transparent way.

It is natural for us to understand walking as an exploration and investigation task; also, when the context message is not correctly propelled through the environment, the user could lose interest or be frustrated with the experience, at that moment, the set or level designer could lose an excellent opportunity to bring the users more profoundly into the story. Thus, according to Carson, part of the art of level design comes from creative ways of inserting information into the environment without appearing artificial and without leaving the impression that something was left to be found (CARSON, 2000). With that in mind, we can consider VR applications, the middle-ground between the 2D screen games and the attractions on theme parks, bringing many new possibilities and supplementing limitations on both mediums. Furthermore, as narratives are one of the main aspects of influencing users' immersion in VR (SLATER; USOH; STEED, 1994), the environment itself can act as a tool for transforming experiences and making them reach a higher level of presence emotional appeal and consequently become more pleasant and attractive to users.

Authors like John Bucher consider the environment in those cases a passive narrative element; according to Bucher (2017), The passive elements organize conflicts and prepare the user so that active elements of narrative appear later and these leave users more engaged and interested over time The dynamics among all the elements displayed for the user, using the environment as essential moderator, is crucial for telling the story with the user's most profound involvement.

2.1 ENVIRONMENTAL STORYTELLING

The term ES was first presented by Carson (2000), and taken into gaming by Jenkins and refined in different strands by Smith e Worch (2010), Fernández-Vara (2011), Tarnowetzki (2015) and Bevensee (2014). This subsection explores the different strategies and points of view regarding approaches and definitions of ES.

According to Smith e Worch (2010), we can define ES as the act of staging the player's space with environmental properties that can be interpreted with a more significant meaning, favoring the game's narrative. The authors defined as environmental narrative characteristics in games:

1. ES relies on the player to associate disparate elements, interpreting them as a meaningful whole;
2. ES fundamentally integrates player perception and active problem solving, which builds investment;
3. ES invites interpretation of situations and meaning according to players' views and experience;
4. ES can help the player navigate an area by telegraphing [1].

ES is a set of approaches that successfully communicate subjectively with players. When we enter virtual worlds, we naturally start looking for information that can help us understand the space and circumstances we are involved in; therefore, they are the first elements to be found and analyzed (BUCHER, 2017). Furthermore, it is an approach that plays a fundamental role in building the players' perception and consequently changes their emotions and actions during the session.

ES is an approach that is directly linked to personification and presence in virtual environments. This approach shows the strong relationship between the virtual environment and VR experiences quality. When placed in a completely new virtual environment, users immediately search for information to guide them about the new world they have entered. The environmental elements are the first images that these users

[1] Telegraphing is a term used in sports, that means unintentionally alerting an opponent to someone's immediate situation or intentions, in that case adapted to environments in which the designers alert the players through cues.

begin to process (BUCHER, 2017). Strategies of ES have great potential to strengthen further the links between the environment and the user in VR.

As much as the authors have presented the most organized and accepted definition concerning the theory of environmental narrative, this material is purely based on previous experiences in the game industry, and little formal literature exists on the subject. Tarnowetzki (2015) points out that the characteristic that ES builds investment lacks a theoretical background and needs more studies to be fully accepted. As a practical approach to ES Tarnowetzki (2015) divided ES into three broad categories, the physical environment, the social environment, and the extra-diegetic environment.

1. The physical environment consists of everything visible or audible during the game experience. Elements that make up a tone for the situations experienced. Examples would be objects, climate and destruction, music (ambient or popular music), and traces in the environment.

2. The social environment consists of all spoken or written information found in the environment. We can cite as examples: player-character dialogues, character-character dialogues, recorded audio of the characters, and messages written by the characters.

3. In the extradiegetic environment, we can insert elements out of the game's real-time experience, for example, original songs made for the game, information that appears in the menus, or even part of the story told in books or manuals.

Meanwhile, other authors propose different concepts but complementary to ES, as is Indexical Storytelling (FERNáNDEZ-VARA, 2011). According to the author, Indexical storytelling is a strategy to build the narrative based on traces and affecting the environment, either the designer or the player. Indexical storytelling applies a user-focused approach to how she understands, experiences, and alters the environment. The author divides the concept into two main aspects: History of the Game World and History of the Player. The Game World is subdivided in:

1. Detective Work: In that subdivision of game world history, the author defines it as ...discovering the history of the game world, what has happened before the player enters the space.(FERNáNDEZ-VARA, 2011) In general, the player becomes an investigator and should reconstruct the events in the environment, exploring cues,

documents and questioning witnesses and suspects to reconstruct the stories in the virtual world. Fernández-Vara (2011) comments that:

> This type of indexical storytelling is constituted by the traces left behind by other agents who have been in the space before. The remains are objects that those agents have modified previously.

2. Signage and Tutorials: Signage and tutorials are the most common approaches to provide fast information to players in a fast way; according to Fernández-Vara (2011): ... it is an explicit type of indication in the Peircean sense[2]—it tells the player where to go or what to do. On that spectrum, we can put plaques, signals, writings on walls, or even a character that practically explains something using the environment.

The last subdivision regards the player story during the gameplay; the author calls it Player Traces. It means that the actions made during the session can be permanent or semi-permanent, or in some cases can have a direct consequence on storytelling as occurs on Dishonored (2016), if players go through phases aggressively and chaotically, the environment becomes grimmer. For example, more rats are present on the streets. According to Fernández-Vara (2011) reinforcement of player, traces is a powerful way to create a stronger bond between the player and the world.

Despite presenting different concepts, Smith e Worch (2010) and Fernández-Vara (2011) converge that when player leaves a persistent mark in the virtual world. They can reinforce the players' feeling of presence and belong (FERNáNDEZ-VARA, 2011; SMITH; WORCH, 2010) on that world.

Beverseen presents a conceptual framework that divides the construction of environments into three layers combined with Ryan (2006) scalar derivation of narrative, as can be seen in Figure 2. Assigning them and providing specific guidelines for each layer, Bevensee (2014) describes the layers as:

1. Natura: solely based on evoked narrative and Ryan's first two items. It is interesting to see if participants will have a story experience or not, given a superficial level of narrative content.

2. Introspection: The process of introspection is occurring for some participants on the first level; this level will be even more focused on setting the main story around

[2] Related to the philosopher Charles Sanders Peirce(PIERCE, 1931)

Figure 2 – Relation of Ryan (2006) scalar derivation of narrative with Bevensee (2014) Environmental Layers.

Source: Author, adapted from *Bevensee* (2014)

the user. This is done by including another character that represents a part of the main character (the user).

3. Causation: This layer is related to embedded narrative elements and the cause-reaction relationship that is key on approaches of ES when the user should pierce together parts of the story.

So far, the presented frameworks have shown us different forms of viewing, understanding, and developing approaches to ES. Smith e Worch (2010), Fernández-Vara (2011), and Tarnowetzki (2015) pointed out broader classifications, focusing on the objectives that the approaches on ES are used to achieve. Meanwhile, Bevensee (2014) goes deeper on psychological aspects and the relationship between narrative and general aspects of gameplay but is still abstract regarding creating, defining, and combining specific approaches to ES.

Based on that, we believe those works are crucial to creating a narrative system that works and pushes players to more profound experiences, and allows developers to portray complex and rich stories. Nevertheless, there is a gap in those works regard-

ing the relationship of level design, world-building, and ES. We see it as an opportunity to clarify the impacts and the principal value of using those approaches in virtual environments.

3 PLAYER'S PERCEPTION AND EMOTIONS ON VIRTUAL ENVIRONMENTS

Researchers in extended realities have always associated these technologies with themes of cognitive science, because these approaches are one of the main pillars of the study in human-computer interaction. Two essential themes in these studies are perception and emotion. According to Jerald (2015):

> Perception is a higher-level process that combines information from the senses and filters, organizes, and interprets those sensations to give meaning and to create subjective, conscious experiences. This gives us awareness of the world around us. (JERALD, 2015)

Perception and emotion are two of the main pillars in studying human-computer interaction, so it is not uncommon to see them associated with research in extended realities. We can define perception as a process of high cognitive level, where information is combined through the senses and is interpreted in sensations, thus creating conscious subjective meanings (JERALD, 2015). On the other hand, emotions are a process of the lower level of cognition; they are more linked to visceral and physiological responses; emotions can alter our perception since they serve as beacons for the appropriate behavior for each situation. According to Norman (2004):

> Emotions are inseparable from and a necessary part of cognition. Everything we do, everything we think, is tinged with emotion, much of it subconscious. In turn, our emotions change the way we think and serve as constant guides to appropriate behavior, steering us away from the bad, guiding us toward (NORMAN, 2004)

Observing these two aspects, we can understand how VR experiences resonate, informing users of good or bad memories. The emotional connection at the end of the VR experience is usually the most remembered, so the memories could be positive if the experience was good. However, the user is not always able to reach this point, if by chance the experience is interrupted by any problem or malfunction, this can create an aversion of the user to the experience, and in the case of new users to the technology, it can cause an aversion to VR experiences in general (JERALD, 2015). In some game projects, developers use approaches of emotional planning inserted at the game level. It uses techniques such as the Emotion Chart (FELTHAM, 2018), where the objective of each section of the game level is planned to induce the user to feel certain emotions that will insert the player into the story.

Perception works through the connection between our senses; at this moment, the coexistence and association between them are crucial for the interpretation of information; in VR, the dissociation between the senses can cause a problem known as *motion sickness*, which can happen when there is the dissociation of the senses with body on the virtual simulation, causing a vestibular conflict, resulting in nausea, headache, nausea, and other issues depending on the user's sensitivity. Something like this can directly affect the user's emotions, making him feel distressed, for example. Another aspect related to the user's perceptual part is the relationship between the principles of presence and immersion, according to Jerald (2015):

> Presence is a function of both the user and immersion. Immersion can produce a sense of presence, but immersion does not always induce presence— users can shut their eyes and imagine being somewhere else. Presence is limited by immersion; the greater immersion a system/application provides then, the greater potential for a user to feel present in that virtual world. (JERALD, 2015)

Another vital aspect for VR experiences is the concept of immersion; it is an objective where the system and the application come together to generate sensory stimuli in users (SLATER; USOH; STEED, 1994). They are divided by Slater, Usoh e Steed (1994) into:

- **Extension:** How many senses are activated by this experience;
- **Combination:** how the senses come together and complement each other within the experience;
- **Ambience:** The tips for the user to discover the experience need to be panoramic.
- **Vivacity:** Is the (technical) quality in which the experience is portrayed;
- **Interactivity:** The user's ability to make changes in the virtual world and appropriate it through the tools provided by the system;
- **Narrative:** The message on which the experience is supported, how events unfold and the rules that govern the virtual world.

The cognitive process is a vast topic that fluctuates across different knowledge disciplines. An interesting way of defining its aspects is the human cognition and reaction

model, which can be classified into four main parts: visceral, behavioral, reflective, and emotional (NORMAN, 2013).

When we analyze these aspects from Desktop vs. VR experiences, the pattern repeats. In the study promoted by Pallavicini et al. (2018), The authors reported that the players, in general, showed a more intense emotional response in VR, data obtained through questionnaires and psychophysiological analysis and that the level of presence in these cases was higher than on 2D screens. We can assume that due to the senses' occlusion, user involvement will inevitably be greater in VR; in the study conducted by Flavian, Sánchez e Orús (2020), authors built an experience simulating a hotel room for potential customers. The results showed that, with the greater integration between humans and devices, they obtained a better perception of personification, especially in VR compared to desktops and smartphones. Narratively speaking, the effects are incomparable, while in a game or film, the user witnesses a discussion between two outsiders. In VR, he can be at the same table between the two people feeling the tension prepared for that moment (BUCHER, 2017). This situation can be crucial for the user to understand the narrative more fully, projecting into the characters' pains.

In contrast, in the study conducted by Diemer et al. (2015), users reported increased presence in a virtual environment when faced with strong emotions; the authors relates this not to the visual and technological quality presented but to the emotional engagement promoted by the experience. Despite studies in dissociating presence and VR technology elements, there are strong correlations between solid emotions and presence (DIEMER et al., 2015). The authors also report that emotions were stronger in neophyte users of technology, showing that aspects such as surprise and novelty count for the impact of the experience of these users.

Jerald (2015) comments that most users tend to remember the final parts of the experience, as when there is the shock of returning to reality. In experiences that end in an emotional peak, they tend to be remembered more positively for their impact on the user. However, when the experiment ends badly, even if the problem was technical, such as high latency or faulty tracking, causing adverse physiological reactions in users, they tend to remember the experience as bad. As a result, many do not feel like trying VR again (JERALD, 2015).

Several interactions extend to the emotional field and trigger nasty reactions; McMahan, Lai e Pal (2016) talks about how interactions with medium fidelity of realism in-

terfere in the user's experience, being low fidelity and high fidelity interactions better—accepted by users in tests promoted by the team. The authors associate this result with the users' lack of familiarity and the need for adaptation when faced with an interaction that is not expected.

Problems like this experience can cause frustration and an increase in the cognitive load, which puts the tool's overall quality for the user. In general, these problems are caused by the breakdown of affordances in the virtual environment and often in confidence in the system, generating bad surprises and sometimes anxiety for putting the player in a pressure situation where he will not know precisely how to act thanks to failures in the system.

Finally, the objective of virtual reality experiences is not to make the player completely comfortable. The restlessness and tension caused by the narrative are crucial devices in generating emotions. They are effective ways of inserting presence in the virtual environment when this is the objective. However, designers and developers must be meticulous because these aspects can be negatively triggered when we have problems with the system, poorly designed interactions, or users with health conditions, aspects that make using VR devices difficult; sometimes, it is impossible to design a solution for everyone. However, it is imperative that users can customize specific settings that make the interaction more pleasant or, in some cases, just possible.

3.1 PLAYER PROFILING AND MODELING

Player profiling methods are growing as the game industry becomes one of the most significant sectors of media consumption. Many approaches have been implemented to understand specific aspects of the players, which games they choose, how they act, and what is important to them to engage in digital games. One of the most known is Gamer Motivation Model (YEE, 2016), constructed by Quantic Foundry, a game analytics company, with a public survey answered by more than 450,000 players; the researchers constructed a profound profile of the respondents and could determine which games they might be interested in. Information that is valuable to gamers and game stores, Steam is testing some of those approaches publicly based on the game library of the user, they access history and a wish list, so they could present a list of suggestions, special offers, and mini trailers (a solution to present a curated group of

games separated by themes quickly).

Drachen, Canossa e Yannakakis (2009) present an approach that goes through behavior analysis during gameplay to construct personas or profiles. They apply an unsupervised learning approach where player session data is tracked and used to automatically understand if they are playing the game as the designers intended to and in which profile that player is located on; this can be achieved through self-organized Maps (KOHONEN et al., 1996). The authors propose that their tool could mitigate real-time problems and allow the game to adapt itself to how players play the game.

Yannakakis et al. (2013) propose a similar technique but utilize metrics, a physiological response, and general game metadata to construct a game model and analyze choices after they happen. The authors present a taxonomy that intends to classify players in various aspects according to their choices and reactions during gameplay. They propose that their approach can be interesting for the freemium game market, where players do not pay for the game. However, pay for additional content or items; information like that could determine what content is more exciting or changes affect players relationships with the games.

Finally, there are approaches based only on questionnaires to analyze players' behavior and create a direct profile, understanding their preferences and habits during gameplay like GAIN (VAHLO; SMED; KOPONEN, 2018) and GTC (VAHLO et al., 2017). Approaches like that can determine the player types without users being submitted to gameplay to obtain answers. Moreover, the information provided regards their previous experiences with any games on any platforms, so research-wise becomes more scalable and flexible in applying on groups of any size.

4 ESC - ENVIRONMENTAL STORYTELLING CLASSIFICATION FRAMEWORK

We propose a framework for the classification of ES approaches, ESC Framework. Subdividing the approaches of ES, we can understand the strategies and how those affect players' performance during gameplay and how they associate with VR immersive approaches. For that, we will put the classification to test on four chapters of Half-Life: Alyx(VALVE, 2020). Moreover, understand how players deal with the strategies created by the developers.

First of all, it is crucial to establish the relationship between the significant elements. *World Building, Level Design, and Environmental Storytelling*.

World building is defined as the process of building an imaginary realm (COULTON et al., 2017). The medium can vary a lot, from fictional books, video games, movies, and anything that sets out a story to be told. The world should provide the narrative a base for the stories to happen. In some narrative approaches, the world is set at the beginning of the narrative - In books, it can happen on a preface or in games as a cinematic showing past events - but the task of presenting a complex world is complicated. It could consume a lot of play time if told entirely at the beginning of the experience. A common approach with games and movies nowadays is to present a situation that explains some aspect of the story world and dilutes specific aspects through the narrative. That way, narrative designers can reinforce the world and present many aspects and details about it, provoking a better understanding of the context and giving meaning to characters and players' actions.

Level design is a job that requires technical and artistic skills (BLESZINSKI, 2000); level design is often referred to as the process of creating the levels (or stages) of games inside of that we had the placement of the architecture and nature itself. The paths that players could or could not take, associate environment to game mechanics, and diverse elements that support the narrative and provide congruence among the different aspects of the gameplay. The levels in themselves are where the games are physically happening, so they are the middle-ground among visual, narrative, and technical aspects of the game; in the case of ES, the level is where those approaches take place and can be strategically placed to provide support for specific objectives, the whole world or even the player's identity.

Finally, ES is a set of approaches and strategies created by developers as game designers, narrative designers, quest designers, level designers, or environment artists. It will depend on the size and structure of the team. Those approaches are indirect ways to present stories to players, and they must resonate with the level design and the *world building* in a way that they must work separately but make sense together as pieces of the same set. So the approaches on ES should have as objective, enhance the player's knowledge of the world, the characters, the level, and the narrative.

4.1 ENVIRONMENTAL STORYTELLING OBJECTIVES

We propose a set of objectives for ES on digital games. As the primary reference for development for those definitions, we had Smith e Worch (2010), Fernández-Vara (2011), and Tarnowetzki (2015). Although the three works state similar aspects regarding the objectives for the ES, in order for the framework analysis to work, we adapt the knowledge from the three of them and divide them differently the overview of the objectives can be seen on Table 2.

Table 2 – Environmental Storytelling objectives.

Environmental Storytelling Objectives	
Reinforce the World	Affordances
	Reinforces the setting
Reinforce Narrative	Micro Stories
	Association of Facts
Reinforce Level Design	Present Limits
	Show Paths
	Introduce Mechanics
Reinforce Characters	Identity
	Association of characters with the context

4.1.1 Reinforce the World

The reinforcement of the world is one of the pillars of the experience of virtual games; all the pieces have to fit to provide the right message to players. Therefore, as main aspects of the world reinforcement, we can present:

- **Affordances:** The affordances of the fictional world are a massive part of the constructions that are better presented practically; how things work in that fictional world is a critical way to communicate how people live there, and it should corroborate visual and psychological aspects of the characters. e.g., the hygiene appliances in a medieval bedroom; how doors work on a spaceship, or how people produce food in a post-apocalyptic world. Thus, affordances are crucial for communicating intrinsic parts of the fictional world and providing the player with a sense of reality, or a living virtual world, as some game developers advertise.
- **Reinforces the setting:** That subdivision can be directly related to the global context of the world, objects, images, or evidence that communicate to the player what kind of fictional world she is inserted e.g., in a post-apocalyptic world, many abandoned cars are resulting from the collapse of the world's fuel supply.

4.1.2 Reinforce Narrative

That is the most prominent use of ES, providing information for the user complementing a global narrative that is being passed through the different agents in the game; some games have their narrative firmly based on ES using those kinds of approaches as What Remains of Edith Finch (GIANTSPARROW, 2017), Gone Home (FULLBRIGHT, 2013) or Myst (CYAN, 1993). So as subdivisions of that aspect, we have:

- **Micro Stories:** Pieces of information serve as complementary parts for a bigger goal; sometimes, they work on previous general information or narrative tropes and cliches (as they are easier to recognize). Those could be evidence of activities of other agents, stains, objects. e.g., scattered objects in a room could mean a home invasion; Big bloodstains on a bed could mean that someone was murdered while sleeping.

- **Association of Facts:** Developers could apply elements in the same context for being associated and decrypted by users, e.g., a destroyed grand piano on a kitchen + debris of fallen walls and ceiling + a hole on the ceiling + overgrew plants; those aspects indicate that the floor above the kitchen fell, probably due to the abandonment of the estate.

4.1.3 Reinforce Level Design

Everyday use of ES corroborates with level design intentions, blocking some passage, guiding the players with environmental elements, or even providing knowledge about mechanics or practical aspects of the world. They can be subdivided into:

- **Present Limits:** These approaches are, in general, to provide limits to the level; it is also related to the use of invisible walls, invisible barriers that level designers use to limit and directional the navigation. e.g., on a trail within a deep forest, the trees on the sides are a natural barrier that communicates the impossibility of getting through this path.
- **Show Paths:** Those are ways to attract user attention to a specific place or element that is key for the continuation of the path; it can be a button, a door, a line on the floor. In general, those elements are presented with visual contrast to enhance the user's search for them, e.g., a door half open indicates that it was open or it could be open; a light on the end of a dark hallway indicates that is something to be seen there; a glowing button on a mid-light environment could indicate that the button will activate something that will change the current situation.
- **Introduce Mechanics:** Among the more complex uses of ES is the creation of invisible tutorials, they can be presented as a Micro story, but they have different purposes; they should make the user learn about something; sometimes, those are tied to other characters too, e.g., a character falling into a hidden trap indicates that in that environment, traps were set before; a corpse seen from far could be used as a sign that something dangerous is ahead and should be noticed beforehand.

4.1.4 Reinforce Characters

- **Player's Identity:** The player must know who he is in that context, and what is his role in that story, at least a little bit, approaches may vary a lot on how to dilute that information about character history, personality traits, and general directives.
- **Association of characters with the context:** The people who live in that world should have specific characteristics regarding their appearance, clothes, or objects they use. Those aspects should corroborate the global narrative or display a parallel situation in the same world. e.g., in a post-apocalyptic setting, people who live in a violent city will probably be among thrash or demolition debris, dress in old dirty clothes, and carry weapons of all types. On the other hand, it would be more obvious to see cleaner characters and fewer weapons, and evidence of violence and destruction in a well-established civilized town.

4.2 ENVIRONMENTAL STORYTELLING CLASSIFICATION

In this subsection, we present the classification categories and their elements; those will serve as a direct classification for the application of ES on virtual games. we propose to divide them into three macro-categories:

1. **Active Investigation:** This category is based on Fernandez-Vara's detective work (FERNáNDEZ-VARA, 2011). The user should be active in uncovering tips and cues and tying the pieces together to progress or discover facts.
2. **World Reinforcement:** This category is based on Smith and Worch's environmental objectives(SMITH; WORCH, 2010). Objects or Texts can serve the purpose of presenting the world.
3. **Direct Communication:** This category is based on Fernandez-Vara's Signage and Tutorials(FERNáNDEZ-VARA, 2011). Information can be directly passed from a video, cutscene, symbol, or text element. Something that is staged but based on the environment.

Those three categories are based on the designer's objective when creating approaches based on ES; some elements can be present in more than one category.

Table 3 – Environmental Storytelling categories and elements.

Environmental Storytelling Classification Framework			
Elements	**Categories**		
	Active Investigation	**World Reinforcement**	**Direct Communication**
Evidences	x		
Cues	x		
Signage		x	x
Architecture		x	
Audio		x	x
Video		x	x
Imagery	x	x	x
Actions	x		x

Also, this subdivision can be improved, and elements can be used in a way that the authors did not imagine. Those elements should be necessarily diegetic; we exclude from the classification extra-diegetic text and UI elements or other elements that are not built on the environment, with the only exception being audio and video elements. As the objectives, the elements could be altered and commonly combined to make a specific approach viable. The elements can be subdivided into Active Investigation, World Reinforcement, and Direct Communication. On Table 3 we show where every element fit on the classification:

4.2.1 Active Investigation

Those elements are necessarily correlated with a micro story or level exploration; they should be an investigation element and be a clue for something to be found or a fact to be discovered.

- **Evidence:** Objects, elements, remains or stains; any passive element related to a micro-story being told;
- **Cues:** Cues that indicate a path or a focal element to a player's progression;
- **Imagery:** Visual elements associated with the narrative provide some hint to the story being told or the characters in it;

- **Actions:** Actions of characters could have a significant effect on the discovery of a specific micro-story. A known habit of the character can be integrated as an element of investigation.

4.2.2 World Reinforcement

Those elements are necessarily correlated to reinforce the fictional world and provide convincing elements for the believability of this world.

- **Architecture, Interior and Product Design:** - Physical inanimate elements that provide a stylistic background to the user's world. Those can be used in an opposite effect as the developers applied on Prey (ARKANE, 2017). The user is presented to an apartment in a modern city, and instants later discover that she is in a starship as a test subject.
- **Audio:** Sound elements that indirectly present aspects of that world. e.g., The sound of chirping birds in a peaceful setting or a howling wolf in a forest setting. We can include here the original soundtrack. They can emulate a time or a specific city or place through lyrics, genre, or instruments used.
- **Video:** Video elements that indirectly present aspects of that world. For example, we have the Night Springs tv horror series inside Alan Wake (REMEDY, 2012) television show that reinforce the similarities with our contemporary world but in an unsettling way, like the experiences the characters on the game are dealing with.
- **Signage:** Some visual symbol or text that reinforces the context of the world or the situation the characters are involved in. As an example, in the series The Last of Us NaughtyDog (2013), the players are constantly presented with the *fireflies* symbol, sometimes associated with graffiti that depicts some of the events that happened in the past.
- **Imagery:**Image elements that indirectly present aspects of that world. e.g., the comic books Savage Starlight on The Last of Us (NAUGHTYDOG, 2013) act as a parody from our real-world comic books, creating a parallel between real and fictional worlds.

4.2.3 Direct Communication

Those are direct hints presented by the developers to help stuck users, guide them more efficiently, or teach mechanics.

- **Signage:** Symbols or text that directly points to a place or reveals answers, e.g., the safe codes on The Last of Us (NAUGHTYDOG, 2020). In general, messages written on paper, we can also consider a world reinforcement element, as the writer presents some contextual elements on the messages.
- **Video:** Video Elements that directly present clues or evidence that should be addressed.
- **Audio:** Audio Elements that directly present clues or evidence that should be addressed, e.g., in Grand Theft Auto V (ROCKSTAR, 2013) characters call directly to the player's cell phones with mission instructions or any related information about where they should be going.
- **Actions:** Sometimes, partners could be the medium for developers to help the player or give information about the current state, e.g., the companions work on The last of us 2. They give instructions when the player is stuck or filling information gaps regarding specific areas or aspects of the world.
- **Imagery:** Visual elements that directly present clues or evidence that should be addressed, e.g., on Bioshock Infinite Irrational (2013) is known for its propaganda posters on the walls of the fictional city that can provide direct instructions about items while reinforcing the setting with the art style and language.

4.3 HOW TO USE

The main objective of this framework is to help researchers when analyzing existing experiences, VR or non-VR, classify and understand the purpose of each element analyzed, being aware of their specific objectives on the scene.

The classification should occur based on the Table 3 subdivisions, we recommend that first of all the researchers build a classification structure, it will be different to each

experience. Below we present a suggestion of organization regarding the Level, sections, objectives and strategies:

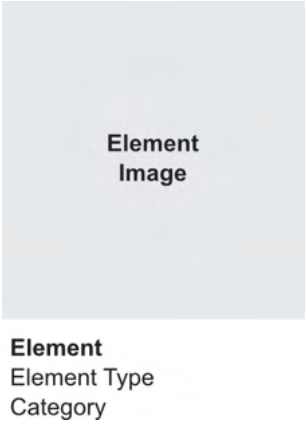
- Entire Level 1
  - Level Section 1
    - Section Objective 1.1
      - Strategy
    - Section Objective 1.2
    - Section Objective 1.3
  - Level Section 2
    - Section Objective 2.1
      - Strategy
    - Section Objective 2.2
    - Section Objective 2.3
- Entire Level 2
  - Level Section 1
    - Section Objective 1.1
    - ...

This is a way to guide the classification into an objective-oriented way, making the elements part of those objectives where the classification begins. It is essential to notice that some elements can combine more them one objective or even have one objective with two approaches simultaneously, they should be classified for each one. It is essential to understand the key objectives of the environment to construct a whole meaning during classification.

On Figure 3, we show a suggestion on how to organize the information, it can be displayed as an imageboard, as we showed on Figures 9, 17, 21 and 23, as a table, image or video, the classification can work in any way the researcher need or could organize and analyse this information.

Strategy definition is an observational aspect of this framework; what we call strategies are a set of generic components used in a specific way to help the environment

Figure 3 – A model for element classification.



Source: Author

to achieve the objectives; they are game design patterns that affect the narrative locally, some of them are pretty common and observed on various games, more on that on Subsection 4.3.1. So those are practical ways to group elements and make them meaningful and even participate in creating micro stories related to the bigger narrative.

4.3.1 Example Strategies

In this subsection, the idea is to exemplify some common strategies of ES that are present in various games -sometimes are direct references to movies or books - and are also cases that show how we can adapt those approaches.

4.3.1.1 Evidence Overload

This case is widely applied in different media; the intention is to present many images, texts, and symbols relevant to the overall story. As we talk about much content, the objectives can vary or be combined inside the same “framing”. On Figure 4, we had three examples:

On 4.a in an image from Get Even TheFarm51 (2017), an investigation game, the board on the scene reunites all the clues players gathered during their exploration and helps them make sense of the findings. On 4.b a screenshot from Bioshock Infinite Irrational (2013), portrays an investigation done by another character. The designers included images, audio, drawings, and texts. To present the users with faces of the characters and pieces of narrative from past moments. On 4.c on Wolfstein(MACHINEGAMES,

Figure 4 – Examples of Evidence Overload

Sources: a. Get even (2017); Bioshock (2007); c. Wolfstein: The New Order (2014)

2014) players are presented with a memorial for World War II fallen soldiers,that is a piece of reinforcing the world and the actual context of the game, it is vital to show specific aspects and compare as this fictional world is an alternative reality to events that happened in our real world history.

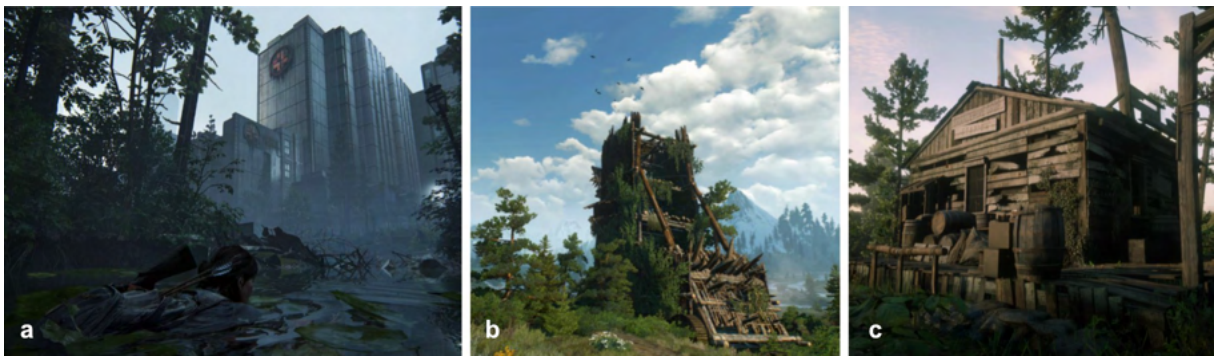
There is also an alternative version of this. A character does a fake exposition of clues to incriminate other characters or plant fake clues to invalidate the real clues. That tactic is known as orgy of evidence the term in itself was presented in the movie Minority Report, but it is present in various games, books, movies, and others.

4.3.1.2 Overgrown, Abandonment and Ruin

In this approach, developers create a contrast between artificial structures and nature. In general, the objective is to show that important events happened in that environment a long time ago. Sometimes elements of other agents can be inserted to reinforce the abandonment feeling on those game levels.

As we can see in Figure 5.a on The Last of Us 2 (NAUGHTYDOG, 2020), developers presented an entire city that was bombed and later abandoned. So they present elements like rivers, waterfalls, and forests, side by side with dilapidated constructions and cars. On 5.b as we can see in the example from The Witcher 3 (CDPROJEKTRED, 2015), the players are presented with elements that do not usually belong to the context they are inserted in; they act as an indicator that past events occurred in that scene, in that case, a big battle. On 5.c in Red Dead Redemption 2 (ROCKSTAR, 2018), we have an example of an abandoned space that is linked to a specific event.

Figure 5 – Overgrown Abandoned location



Sources: a.The Last of Us(NAUGHTYDOG, 2020); b. The Witcher 3 (CDPROJEKTRED, 2015); c. Red Dead Redemption 2 (ROCKSTAR, 2018).

4.3.1.3 Stains as character positioning

A classical way to portray a wounded character, and help to build a micro story with him, is to put bloodstains on the environment, marking a position of a character in a space where he got wounded or was treated for a wound; stains are classic cues to put an agent and an event together on the virtual environment.

Figure 6 – Stains defining character position.

Sources: a.Bioshock Infinite(IRRATIONAL, 2013); b. Kona (PARABOLE, 2017).

We can see two examples on Figure 6, on Figure 6,a, in the initial chapter of Bioshock Infinite (IRRATIONAL, 2013), during the gameplay, the users are presented with a fight scene, and after that upstairs, a bloody hand can be seen on the wall, positioning a wounded character from this fight on the way up. A similar strategy can be seen on the game Kona (PARABOLE, 2017), the players were investigating a medical doctor clinic. As we can see on 6.b, the stains are positioned on the pillow and the bed, suggesting that someone with a severe head wound was lying there.

Stains are a straightforward way to signalize many kinds of events, but in the specific

case of bloodstains automatically puts a living creature in the position, most probably a human character on the scene; it is also a straightforward way to integrate this as facts into a micro story inside the environment.

4.4 USING THE FRAMEWORK AS A DESIGN SPACE

Besides being a classification framework, we can also use ESC Framework to organize the creation of new experiences; using the structure provided on Subsection 4.3 and the classification subdivisions and categories on Table 3, developers can define the Level objectives, sections, objectives and strategies, and also define what elements will be needed to portray the story in an effective and organized way.

As a demonstration of that, on the list below we present an example of how this structure can be used to help organize definition of environmental elements on a level scale:

- **Level 1** - Metro Tunnels
  - **Section Objective 1.1** - Guide users on the path to the left.
    - **Strategy** - Light contrast and sound contrast.
      - **Possible Elements:** Light, wind sound, well maintained signage (implying that is a path still in use)
  - **Section Objective 1.2** - Reinforce to users that they are on an active train line.
    - **Possible elements:** Train sounds, Trains (passing by, sounds of people talking and characters on the platforms.

After that, developers can adapt the model presented in Figure 3 to do sketches on the elements they want on the environment, using this framework as planning for the environmental building.

5 METHOD

The scientific method built to achieve the proposed research objectives will be detailed in this section. It is possible to understand as a scientific method the set of procedures and methods to achieve knowledge on a given subject, making it necessary to identify the operations so that this process is verifiable and replicable by other researchers (GIL, 2008). Where we have as a primary goal to investigate the relationship between users from different profiles and different approaches to ES applied to virtual reality. Here we present the characterization, how we conducted the literature review, how we built the tests, and analyzed the results.

5.1 CHARACTERIZATION

In this research, we intend to use an abductive approach (PIERCE, 1931), where solutions can be developed associating the study areas. Specific use cases can be reached to construct narrative-based VR experiences to obtain specific information about user behavior in those scenarios. This research has a qualitative approach, where we need to obtain personal information directly from users, from their relationship with the virtual reality experience. In other words, The researcher needs to put himself in the user's shoes and try to understand how they perceive their feelings and sensations during the experience (MINAYO, 2012).

Regarding the research classification, we can classify the study based on Vergara (2012) classification. Regarding the ends, the research classifies as:

1. Explanatory research: Was constructed as a compendium of works regarding ES, player profiling, and virtual reality.

2. Descriptive research: Focuses on the relationship between the behavior of users and level design in virtual reality experiences, showing what is essential for every type of user regarding the applied approaches. Presenting those results will help us better understand the object of study.

Regarding the means, the research classifies as:

1. Field Research: As the data is collected where the problems happen, on the virtual environments of the game Half-Life Alyx (VALVE, 2020). The data is gathered from video analysis and questionnaires applied to users who passed through the experiences.

2. Experimental Research: Besides being field research, the game is also a controlled scenario where we can analyze and observe how the users act when confronted with situations provided by the experience. Therefore, further analysis of the data could bring much understanding about the themes we are studying in this research.

5.2 LITERATURE REVIEW

We explored the themes through a literature review to know them better and find their congruences and intersections. To achieve that, we applied the PRISMA approach (MOHER et al., 2009). This method was a valuable tool for organizing and dissecting what has become our base material. Through that, we gathered books, theses, conference papers, and journal articles; non-academic material was also considered, such as GDC (Game Developers Conference) presentations and web articles, presenting empirical experiences from professionals in the industry that should not be ignored. ES and user experience are recurrent themes regarding level design, game design, and interaction on those forums.

For the search on the Scopus database, we created three search strings regarding the main themes of this proposed work, they are:

- **immersion OR presence OR interaction OR framework AND environmental storytelling**

  A string focused on the intersections among ES and aspects regarding the overall virtual reality experience and tools that help creators apply the approaches on the field. This string resulted in 80 results.

- **environmental storytelling AND virtual reality**

  A string focused on the intersections between ES and virtual reality in general. This string returned in 37 results.

- **narrative AND engagement AND virtual reality**

  A string focused on finding congruence between narrative and engagement-centered works on virtual reality scenarios. This string returned in 113 results.

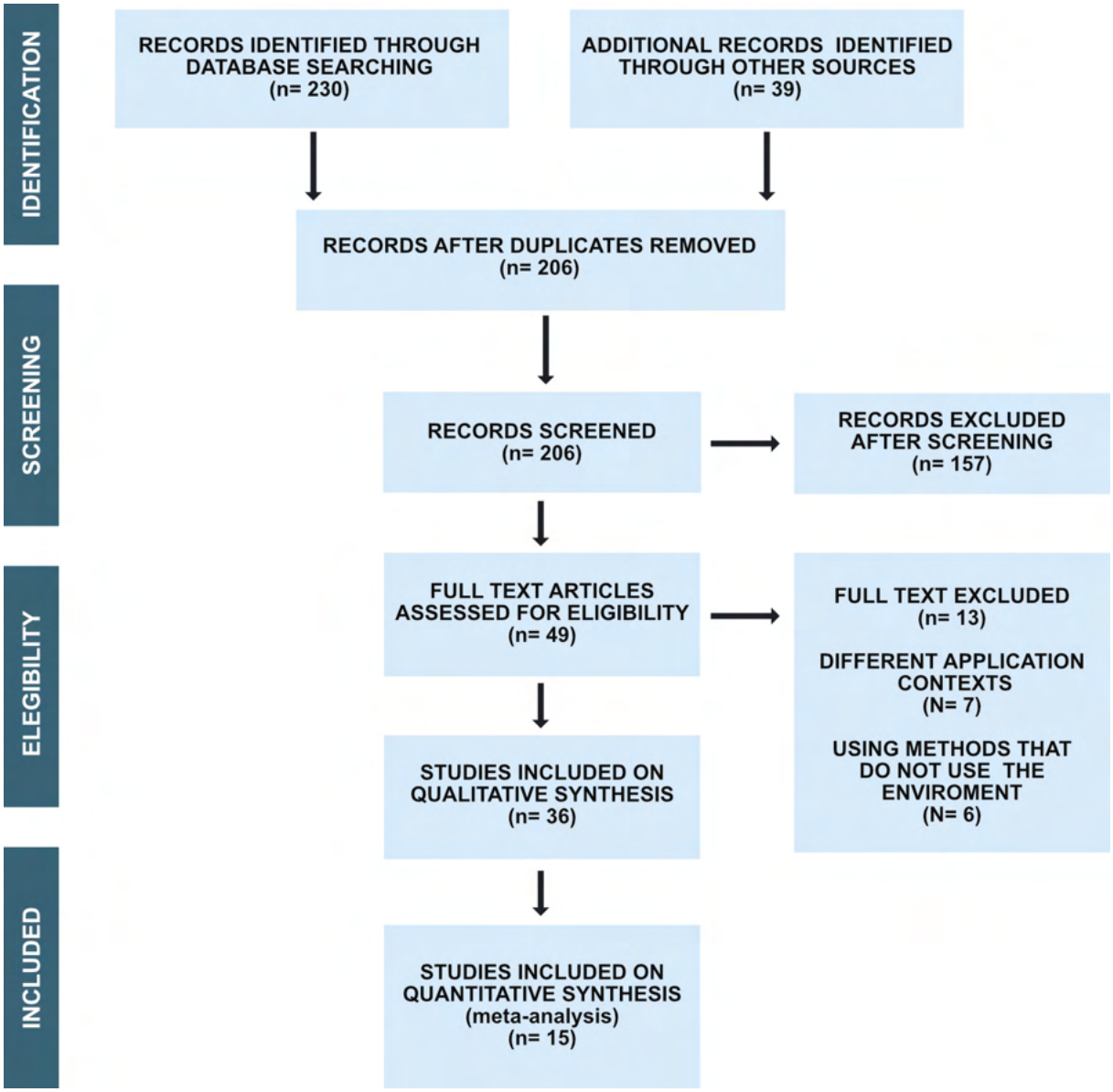
With those, we totalized our findings on 230 works regarding the themes of the work; additionally, 39 works were added from different sources as derived from the papers themselves or found when searching for specific answers and references in general.

Then, we started applying PRISMA(MOHER et al., 2009) with 269 works; after removing duplicates, we had 206 works submitted through the initial screening. 157 works were excluded based on title and abstract, resulting in 49 papers for full-text evaluation of eligibility. From those, 13 papers were discarded for (1) being inserted in different contexts (n=7), e.g., education or training; (2) Use different methods to increase narrative engagement that does not use the environment (n=6).

We finished this step with 36 papers that were included on our qualitative synthesis, after that 15 of them were selected as components for our meta-analysis. In Figure 7 we have a graph that shows the step-by-step process of the PRISMA application.

We gathered 36 works that served in some way as reference and base for the construction of our experiments; with that, we aim to discover what are good and bad solutions, based on user data, when approaching ES in virtual reality.

Figure 7 – Graph with step-by-step PRISMA application for this literature review.



Source: Author.

5.3 DATA COLLECTION

Considering the qualitative aspect of this study, we do not intent to generalize our findings but to understand the phenomena (FLICK, 2009) deeply. To achieve our goal, we gathered a set of questionnaires to be applied pre and post-experiment; those are our primary methods of gathering data directly from users, in addition, applying video analysis with an adapted approach of Mondada (2006), which uses symbols and transcriptions to analyze the input in a *script* format. Instead, we create a timeline to analyze the game sessions individually and use tags and symbols to describe actions

Table 4 – The hints that will be used to help stuck or confused participants.

Gameplay Hints	
Chapter 1	**Chapter 2**
“Look at the handle”	“Look to the input panel”
“You can jump this wall”	“Look to the cage”
“Follow the wires”	“Follow the signs”
Chapter 4	**Chapter 7**
“The key is a card”	“You can unlock this door”
“Read the sign on the blue door”	“You can hide behind that wall”
“Look to the input panel”	“You can jump through”

and choices regarding the virtual environment.

For the tests, the users will play four chapters of Half-Life: Alyx (VALVE, 2020); for the sake of feasibility of the experiments, we implemented a hint system for the moments where users are stuck, lost, or confused during the game session. It consists of specific hints passed through the users after they pass 5 minutes stuck. They are described on Table 4.

As we are presenting the participants with game fragments, it will be tough for them to understand the context, so we need to introduce the actual objectives at the beginning of the session. Those are:

- **Chapter 1:** The introduction of the game will briefly explain the world and the characters.
- **Chapter 2:** You need to solve a puzzle to pass through this section of the quarantine zone.
- **Chapter 4:** You need to solve a puzzle that involves opening two doors and dealing with enemies in order to pass through.
- **Chapter 7:** You need to avoid and guide the enemy away from you, until you get to an elevator on the other side of the level.

5.4 SET-UP

The equipment used in the experiments consists of 1) A Vive Pro Headset kit, with two tracking stations and two joysticks; 2) A computer equipped with an Intel I7 processor, an RTX 2080ti graphics card, 32GB of RAM, and 2TB of storage. The experiments occurred in Voxar Labs, lab inside of the Centro de Informatica of Universidade Federal de Pernambuco; in a play area of 3x3 meters.

5.5 ETHICAL ASPECTS

Accordingly, with Brazillian National Heath Council, Brazillian graduate researchers must submit their research for approval of a health committee from their university; this process is necessary to ensure dignity, autonomy, and safety for the research subjects in scientific research in the country. Therefore, this research was approved by the Research Ethics Committee from Universidade Federal de Pernambuco (UFPE), under the identification(CAAE): 50883521.4.0000.5208, beginning the process on September 24th, 2021, and being approved on April 11th of 2022.

5.6 TEST FLOW

The Pre-Experience Questionnaires will be answered before the day of the meeting; based on that, we will construct their profiles and ask 12 of them - two from each profile described by Vahlo et al. (2017) - to perform the tests on the lab.

They will be oriented to open the game and load a specific game save. For the sake of the study, we will separate the experiences in four tests. They must first play test 1 (chapter 1), which is a way to give them basic instructions and to understand the context. After that, they will be oriented to open the file for Test 2 (fragment of chapter 2), then file for Test 3 (fragment of chapter 4) and the file for Test 4 (fragment of chapter 7).

In the end of each scenario, they answered the Post-Experience Questionnaires, containing psycho-emotional tests, a usability questionnaire, a presence questionnaire, and three open-ended questions. The whole experiment should not last more than 1 hour and a half for each user. Considering that we will use VR applications, the long

exposure can cause undesirable effects for some users, such as headaches, nausea, and pain in the arms.

5.7 PRE-EXPERIENCE QUESTIONNAIRES

The first part is a basic demographic questionnaire, built to give us basic information such as gender, age, VR experience, and weekly game time, which would help us build a basic profile. The questions were:

- What is your age?
- With which gender you identify yourself?
  (options: Male; Female; Others)
- What is your acquaintance with VR experiences?
  (options: Never used; Used once; Rarely; Knowledgeable; Uses daily)
- How many hours do you play games weekly?
  (options: Less than one; 1-3h; 3-5h; 5-10h; 10-20h; more than 20h)
- Do you have any chronic health conditions?
  (options: Prescription Glasses; Diverse ocular conditions (photosensitivity, eye strain or others); labyrinthitis; gastritis; locomotion conditions; concentration conditions; neurological conditions; others)

After that a Player Type Questionnaire will be applied, We selected Vahlo, Smed e Koponen (2018)'s approach to player profiling because we needed to do the profiles before scheduling the tests as we have a limited number of seats, which allows us to select only two players of each type.

Player profiles are a powerful tool that allows us to identify players' behavior, game choice, and engagement, which can help companies and the players themselves (VAHLO; SMED; KOPONEN, 2018). The selected approach was GAIN (VAHLO; SMED; KOPONEN, 2018), a 15-item questionnaire-based profiling tool, allow for focused research picking specific players and analyzing them in specific scenarios; they give us a significant perspective of how they would act when confronted with those scenarios. Moreover, it can

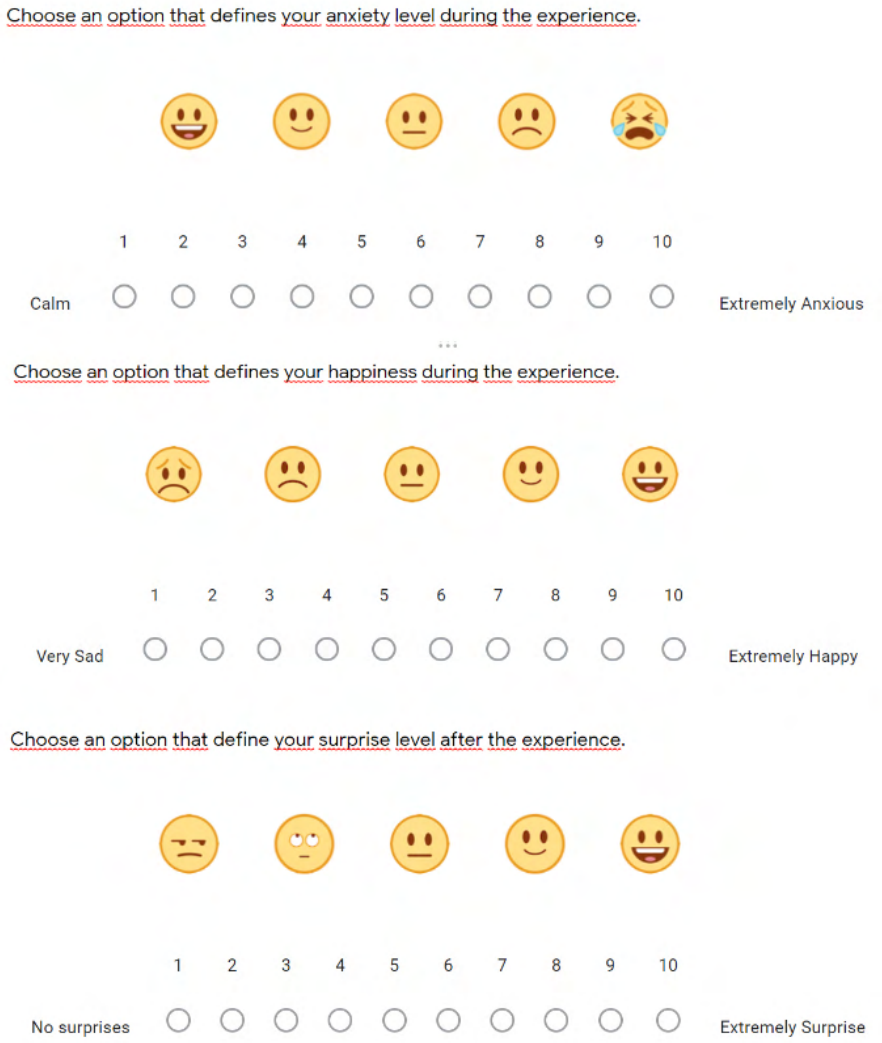
help us predict and understand how world-building aspects of the game can influence their choices and general behavior.

The GAIN questionnaire is based on 15-items, the respondents should classify them on a 5-item Likert scale:

1. Managing and directing cities and their inhabitants;
2. Trading items, weapons, or resources;
3. Generating resources such as energy or money;
4. Killing and murdering;
5. Sneaking and lying traps;
6. Sniping to eliminate enemies;
7. Developing skills and abilities;
8. Exploring the game world;
9. Making meaningful choices in dialogues;
10. Tilting the game environment;
11. Running at a fast speed while avoiding obstacles;
12. Performing in athletics, gymnastics or other sports;
13. Dressing up, applying makeup, and choosing looks;
14. Gardening and taking care of farms;
15. Taking care of and training pets;

After that, players are divided into six subdivisions: Supervisor, Acrobat, Companion, Explorer, Adventurer, and Mercenary.

Figure 8 – VAS-A, VAS-HP and VAS-S representation



Source: Author.

5.8 POST-EXPERIENCE QUESTIONNAIRES

We applied three VAS short tests on post-experience questionnaires - Visual Analogue Scale (AITKEN, 1969; WEWERS; LOWE, 1990). Those are classical tests to measure the psychological moment of the user after the experience, and they are VAS - A (anxiety), VAS-HP (happiness), and VAS-SP (surprise) (PALLAVICINI et al., 2018). Each one consists of one question regarding the emotion described. The user must choose a 1-10 score. We want to know how users see themselves after completing chapters for a general analysis regarding the connection of virtual reality, emotions, and ES. In Figure 8 we present the adaptation made to be further used in our experiments.

In sequence, we will present users to SUS II (SLATER; USOH; STEED, 1994), a test

that focuses on measuring users' presence and immersion within VR environments, which are our targets for enhancement with the application of environmental narrative in these environments.

In the end, we put three open-ended questions regarding what could be better, what the application should not have, and if they had any problem during the experience.

5.9 DATA ANALYSIS

As input for our data analysis, we will have questionnaire answers to gather personal information that we will analyze to understand user behavior, opinions, and choices during gameplay.

Furthermore, we will also have the video of game sessions, capturing the user's audio as additional input. It will be applied an adaptation of Mondada (2006) video analysis method. Where we point timestamps to actions and tags of observation, actions are literally what players are doing on videos. Therefore, we developed the subsequent subdivisions as actions:

- Shooting: When players are attacking enemies;
- Sneaking: When players are slinking, trying to see an enemy in advance, or waiting for the enemies to pass;
- Exploring: When players are actively searching for something, touching things, opening drawers;
- Running: When players are actively running from something or trying to avoid being in one specific position;
- Walking: When players walk from point A to point B.
- Objective: When players perform an action that is a test directive.
- Died: When players lose their lives in the game.
- Hint: When players listen to a hint that will help them achieve the objective;

- Idle: When players are not interacting with the scenario or other characters but are testing some game interaction, on pause, or asking something for the researcher.

Tags are researchers' notes of things that happened during those actions; they are a different way to understand the player's state of mind during those specific parts. As tags, we present the following list:

- Cinematic: When players are watching the cutscenes.
- Game Bug: When a bug caused by a game malfunction happens.
- Hardware Bug: When a bug caused by hardware happens.
- Confused/Lost: When players seem lost or speak, they are lost, reducing their interactions and trying to understand what is happening.
- Testing something: When players test some specific aspect that could be an interaction mode, an object, or a part of the environment.
- Key Element: When players interact with a secondary element that is important in some way for the ES of the scenario.

To analyze deeply and their session times, crucial information to understand the impact of environmental strategies, as we can see as the players see the environment. Finally, we also consider as input the direct feedback from participants during the game sessions, and talking informally after the sessions about the experience.

6 FRAMEWORK APPLICATION ON HALF-LIFE: ALYX

First of all, it is necessary to introduce the game storyline briefly. Half-life:Alyx(VALVE, 2020) is a VR exclusive game developed by Valve; the game is part of a series of games called Half-life. The story happens in a world where a scientific project accidentally opens a portal to another dimension, consequently leaving the way open to an alien invasion. Along with aliens from a planet called *Xen*, there is the *Combine Forces*, a military inter-dimensional organization that travels through planets with the primary objective of conquering them and harvesting resources.

In this chapter, we present the results of the analysis done on sections of the game Half-Life: Alyx (VALVE, 2020). We classified four sections of chapters from Half-Life: Alyx (VALVE, 2020)to apply the ESC framework. The objective is to understand the main strategies and how those impact the behavior of the players during gameplay. The analyzed parts are:

- Chapter 1 – Entanglement: The players are presented to the game world, the core mechanics, and the general story. This chapter is played in its entirety.
- Chapter 2 – The Quarantine Zone (except): The fragment of interest in chapter 2 presents a basic puzzle that can be solved by making coordinated actions with the scenario. In the end, the game shows a password to open a door that leads to the next part; that part of the chapter was chosen because it comprises a dynamic use of ES and presents one of the described approaches that we called evidence overload.
- Chapter 4 – Superweapon (except): Chapter 4 was chosen because it presents exploration as an objective and guides that objective entirely through the environment; on the selected fragment of chapter 4, users must find two cards to open two different doors. In addition, this scenario presents a combat situation, so this is also an aspect that we need to analyze when seeing the sessions and results.
- Chapter 7 – Jeff (except): Chapter 7 presents a scenario where the users must explore and perform actions non-directly described by the game; those mechanics and guidance are constructed through the environment. Meanwhile, they must avoid an immortal enemy.

6.1 CHAPTER 1

In the initial chapter, the players are introduced to the world of the game, its problems, its characters, and the initial storyline of Half-Life: Alyx (VALVE, 2020).In this chapter we highlight three main environmental objectives:

1. Introduce the game world in technology, architecture, geography, politics, and language;
2. Present an extensive set of game mechanics;
3. Introduce the characters.

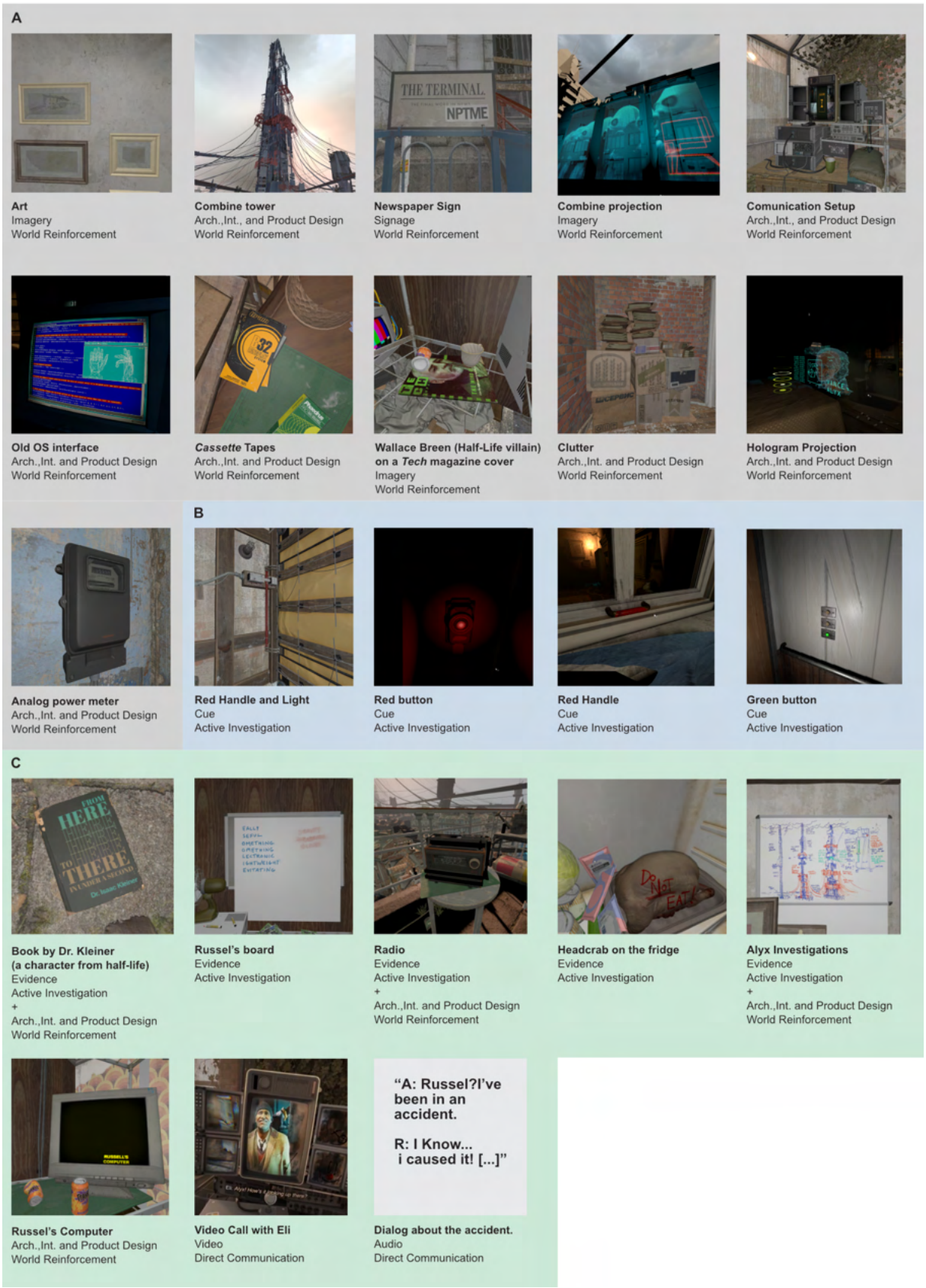
This objective is one of the most complex of the game; even though it is a permanent objective, in the introductory chapters, the developers inserted a lot of information about the new world the players are immersed in, City 17 history in itself presents a huge set of backgroud information for users to discover in-game or through previous games on the franchise. Its architecture style, ruins, and language are an essential part of the huge set of content that composes the city. City 17 is based on eastern European cities in the early 90s as the city stopped progressing after the invasion. A key aspect of the environment is that language presented on the elements which is different depending on the age of the element used to convey the message (e.g., street signs, billboards, newspapers); the oldest objects in City 17 date from before the Combine Forces[1] occupation, so they are written in Russian, while modern elements are written in English, as we can see on Figure 10.

Architecture and urban decay are also shown to enhance personality and construct an identity for City 17, as we can see in Figure 11. Some elements are also presented in conjunction with *Combine* technology, cables, or propaganda, reinforcing the idea of the invasion and cultural obfuscation as we can see on Figure 11.b.

The environment is also in charge of presenting the technological setting of the world; as a raided world, the presence of the invaders causes a constant duality between the advanced alien technology and old human technology, examples of them can be seen in Figure 12.

[1] One of the main antagonists on the game

Figure 9 – Environmental elements of chapter 1 classified by their type and category and divided on three macro objectives: A) Introduce the game world in aspects like technology, architecture, geography, politics and language. B) Present a set of game mechanics. C) Introduce the characters.



Source: Author.

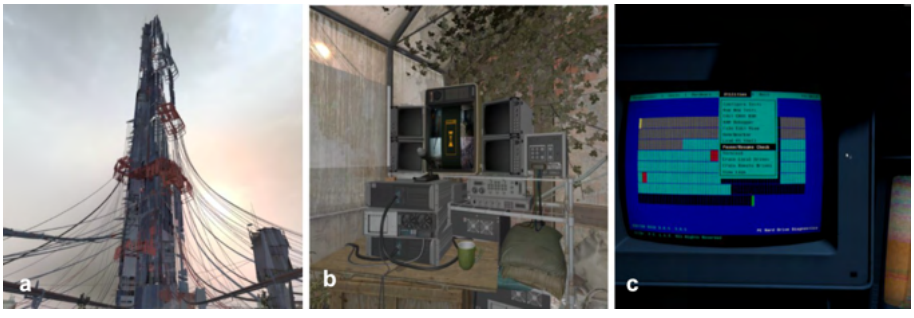
Figure 10 – On the same space (the laundry) we can see assets with different languages, English elements perform a more specific role on micro stories, as the Russian ones are present on elements as signs or general warnings.

Source: Author.

Figure 11 – A. City 17 Urban Elements; B. Urban elements superimposed by Combine elements.

Source: Author.

Figure 12 – A. A megastructure in the center of the city shows the superiority of the invaders over the human population; B. A human communication equipment that looks improvised; C. A Computer interface that reminds us of 90s operational systems.



Source: Author.

Figure 13 – A. Cat sleeping B; The missing cat sign. A note from a neighbor saying: *maybe you should spend more time worrying about all the missing people.*

Source: Author.

This environment presents a micro story that acts as world reinforcement. In the first moments of the game. It is possible to see a cat sleeping on a chair on the neighbor's balcony; later on in the laundry, we can see a sign for a lost cat, with a handwritten note of an upset neighbor, as we can see in Figure 13.

Here we see a case where the designers used a micro story to communicate two facts; people still have pets besides the extreme living conditions. Many people are missing, probably due to the violent approach of the *Combine Forces* against the citizens.

In Figure 9.a above, we can see a classification of sample elements based on the proposed framework.

In this first chapter, the designers needed to show fundamental mechanical interactions through the environment to make clear how specific mechanics work in the game or guide users through the level. Those can be seen classified in Figure 9.b.

The introductory chapter also aims to present the characters, their personalities, and habits. At that moment, the core characters are presented: Alyx Vance, Eli Vance, and Russel; for that, the designers presented some micro stories to introduce them. The first moments of the game presented a place that is like a hideout for Alyx, where players can see various elements that can communicate Alyx's personality as a person that likes to read, listen to music and draw, as we can see in Figure 14.

Players are also introduced to Alyx plans and analyses of the *Combine* tower, as we can see in Figure 15. The environment presents several drawings and a camera that points to the tower. On the second half of the chapter, the players are introduced to Russell's lab, presenting a micro story to solve a quick puzzle. Various cables can be seen entering a cabinet, and a light can be seen under the cabinet, as showed in

Figure 14 – A. A resting spot where the character relaxes reading and listening to music. B. A pet bug. C. Indicatives that the character likes to draw can be seen in some spots of the environment

Source: Author.

Figure 15 – Investigations of Alyx Vance regarding the Combine tower.

Source: Author.

Figure 16 – Puzzle that grants access to Russel's lab.

Source: Author.

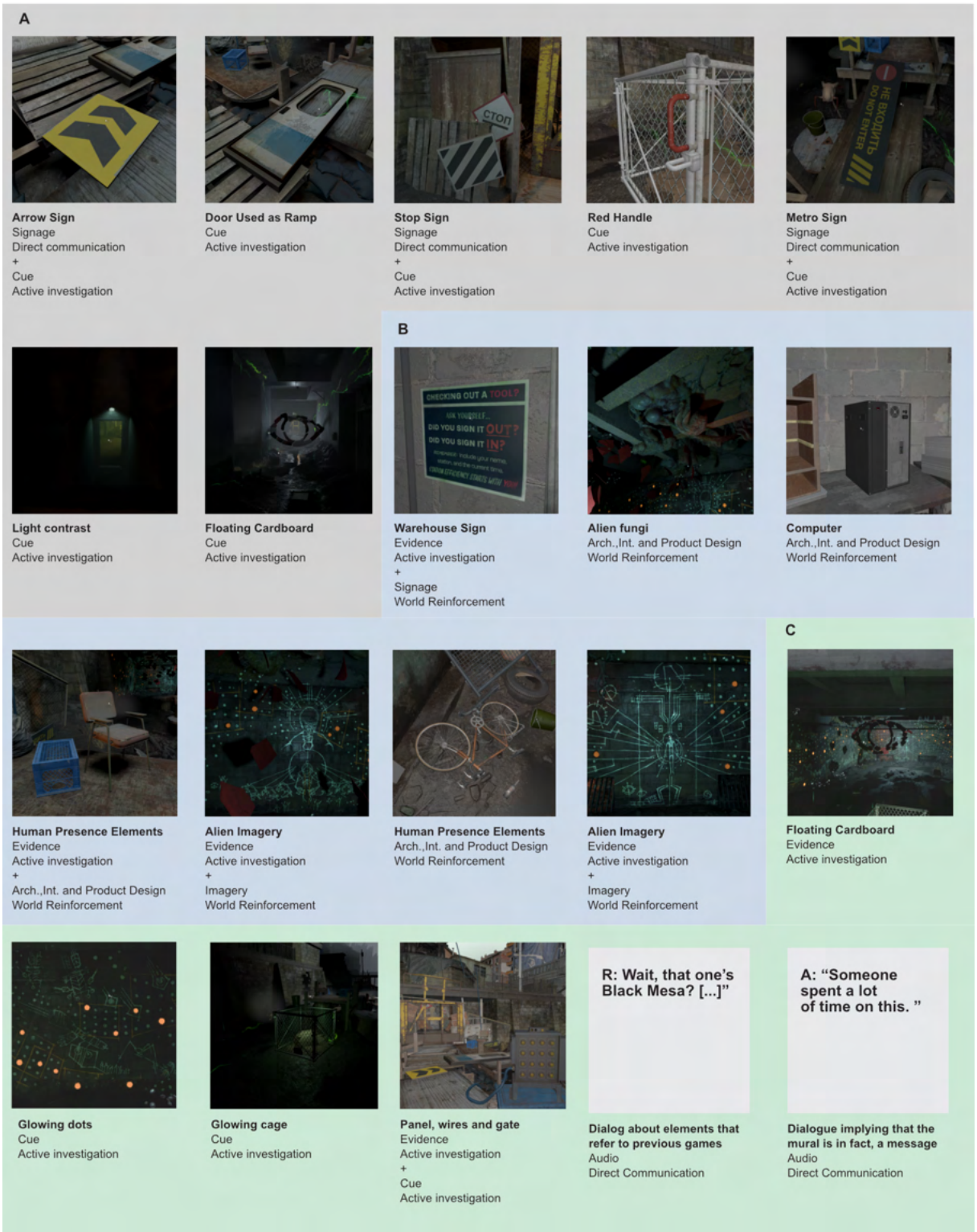
Figure 16. In order to solve the puzzle, the player must find and press the red button that provides access to the lab. 9.c presents samples of elements that corroborate the objectives of the present characters.

6.2 CHAPTER 2

In this chapter, we can find environmental elements that present three objectives:

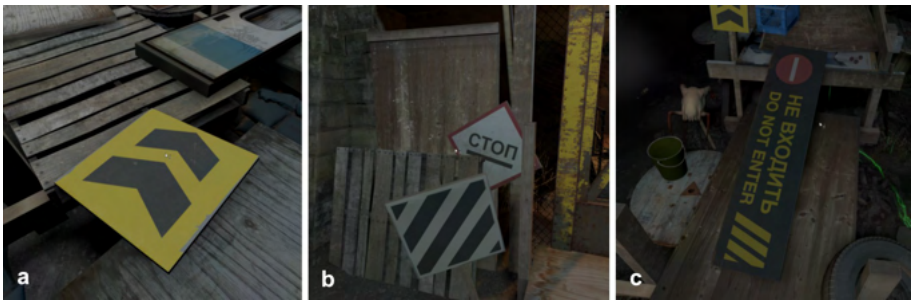
1. Guide players through environmental exploration;
2. Introduce the world's history;
3. Present the puzzle's answer to the players.

Figure 17 – Environmental elements of chapter 2 classified by their type and category divided on three macro objectives: A) Guides players through environmental exploration; B) Present an introduction on world history; C) Presents the users to the puzzle's answer.



Source: Author.

Figure 18 – Examples of guiding elements are a) Arrow signage indicating a path; b) The universal symbol of stop and the slanting bar's sign that generally represent restrictions on traffic context; c) A ramp with a marked spot and another arrow.



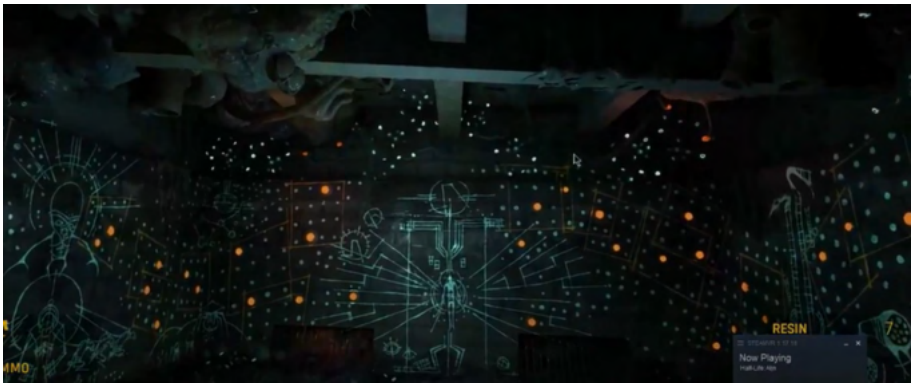
Source: Author.

The elements presented in Figure 18 are posed to guide the players to a specific position, in general, using common traffic signs. The design of the environment makes use of such elements, contextualizing the idea that other agents posed those objects to guide the player's character through the story. The element of Figure 18.a actuates as Signage + Cues, combining them to guide players and provide direct communication. Elements of Figure 18.b also actuate as Signage + Cues, signaling that the player should stop and pay attention to something the same way as the original traffic sign. On Figure 18.c we also saw an application of the Signage + Cues, with additional detail, of the red circle that can lead to an interpretation of this sign as *this is the spot*. It is crucial to notice that all of those signs are defined as cues because they were posed as visual cues; they are not elements in their natural condition. Those elements can be seen classified in Figure 17.a.

On this game chapter, the players are presented with a massive illustration, dot codes, and growing fungi. The characters also speak through audio, complementing specific information that new players to the franchise may not know and providing old players time to recognize the drawings' patterns and creatures. In that case, the *Vortigaunts* are introduced, an alien race explored by the *Combine Forces*. As we can see in Figure 19, the players are presented with an strategy described previously in subsection 4.3.1.1, the Evidence Overload; players are presented with much information associated with previous knowledge. That information is passed through visuals and audio. The visual elements here can be classified into evidence under the category of active investigation, as the complementary audio information can be classified into direct communication. Those elements can be seen classified in Figure 17.b.

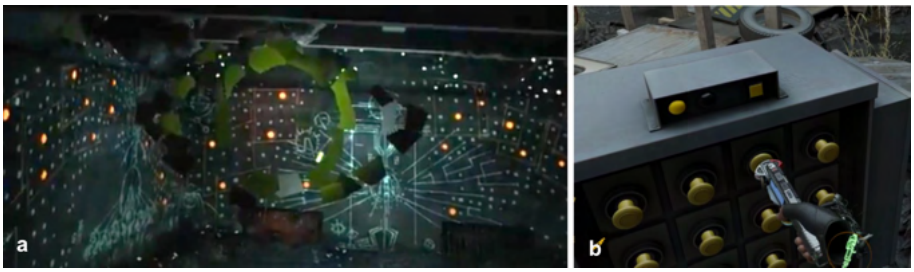
Now players are led to the answer of the puzzle through an environmental cue, as

Figure 19 – Mural with a the brief explanation of *Vortigaunts* history on earth.



Source: Author.

Figure 20 – Mural with the brief explanation of Vortigaunts history on earth. a) The answer is given by the floating cardboard; b) The interface where the password should be entered



Source: Author.

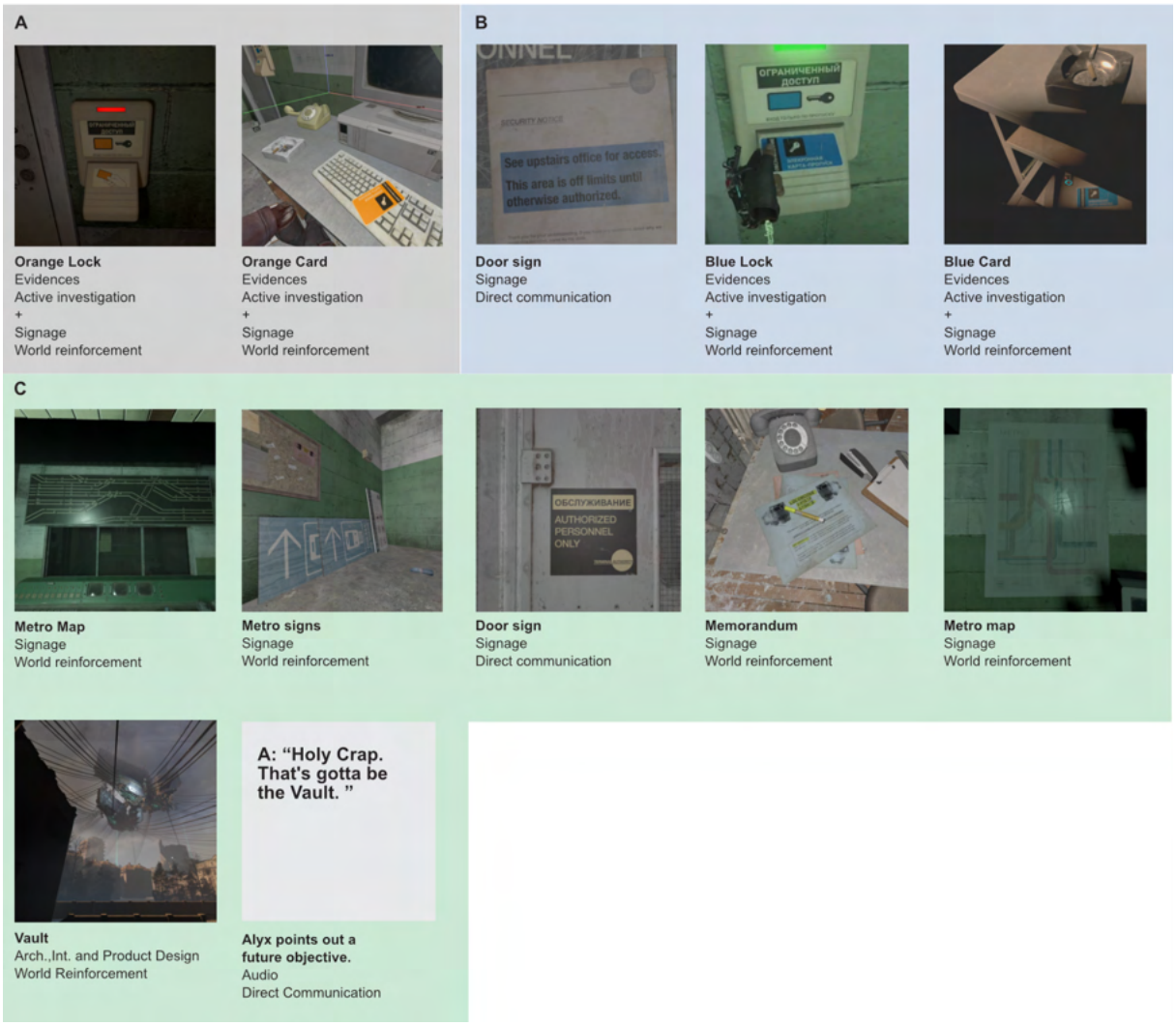
we can see in Figure 20. The password to the door shown right in front of the user as he enters the area is written on the wall in plain sight. That element is shown in Figure 20.a an can be classified as evidence under the category of active investigation. Figure 20.b shows the password interface. Those elements can be seen classified in Figure 17.c.

6.3 CHAPTER 4

In this fragment of the chapter, the main objective is to find two cards, to open two doors; on that level, we also have the presence of enemies, so we can see how those can affect the exploration flow and overall strategies of ES in VR. So this fragment presents three objectives:

1. Guide users to find the orange card and open the orange door;
2. Helps users find the blue card and open the blue door;

Figure 21 – Environmental elements of chapter 2 classified by their type and category and divided into three macro objectives: A) Guide users to find the orange card and open the orange door; B) Help users to find the blue card and open the blue door; C) Reinforce the use of the environment as an office and train station in contrast with the alien structures and creatures



Source: Author.

3. Reinforce the use of the environment as an office and train station in contrast with the alien structures and creatures.

The cards and the door that can be seen on the Figure 22.a and Figure 22.b are themselves elements of Signage; there is a clear visual connection between them, regardless of the context they will be found. However, in this specific case, the primary objective of the locks is to guide users to find their respective cards, so they act as evidence on an active investigation category. Those elements can be seen classified on Figure21.a.

The objective is the same, but the presented problem is much more complex; the

Figure 22 – The visual relationship between the cards and their respective doors a) users must find the orange card; b) the players should use their cards to open the matching door

Source: a.Author b.Trophygamers (youtube).

blue card needs more exploration and understanding of many critical mechanics of the fame. Therefore, the developers include a note on the blue door to explain where the blue card must be. Those elements can be seen classified in Figure 21.b.

It was noted that, the designers inserted various elements to compose the environment as a train station and office; this is presented on notes, posters, and a diverse set of objects present in the environment, as we can see in Figure21.c.

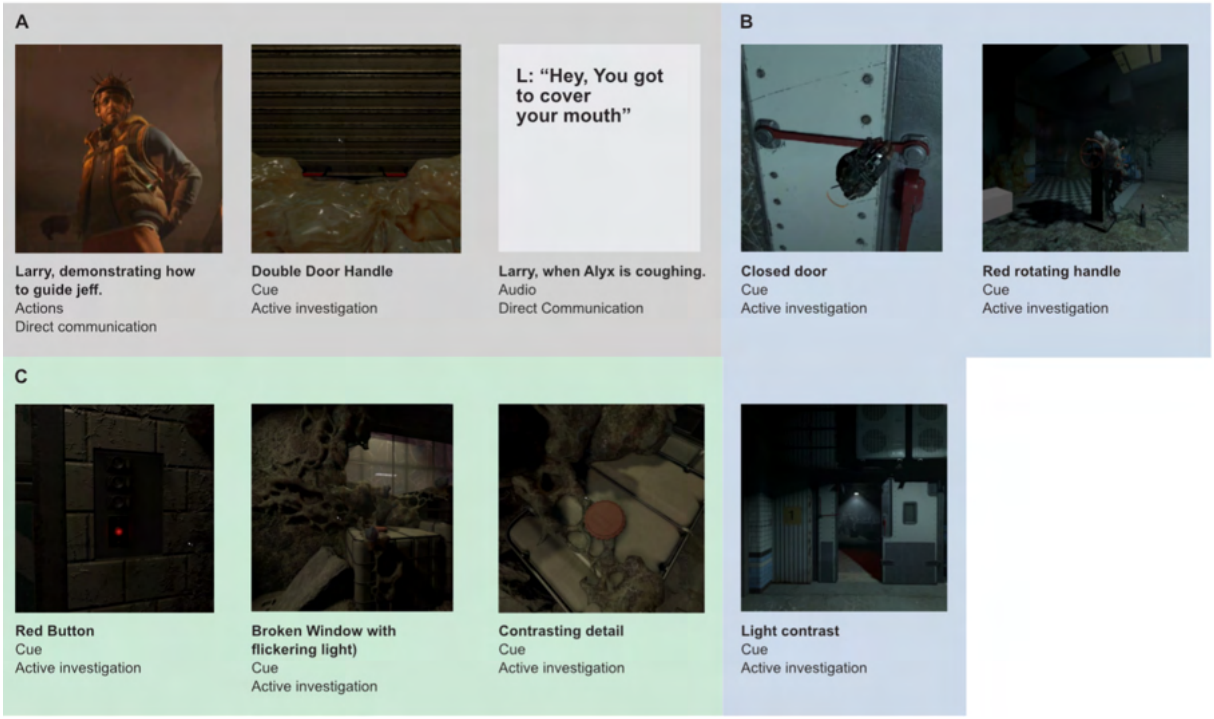
6.4 CHAPTER 7

Chapter 7 presents only one macro objective: pass through the distillery, but the phase itself is subdivided into parts in the scenario. Here we evaluate the first part of the chapter until the player activates an elevator that leads to the second part. The players must flee and use the environment to avoid an immortal enemy. Here the developers used the environment to guide users through three objectives:

1. Presents the enemy and how the sound mechanics work;
2. Teach the players how to lock the enemy;
3. Guide players to the elevator.

In the first moments of the level, the player is presented to another character (Larry), showing who the enemy is and the main mechanics. Those mechanics are heavily based on the environment and the objects that compose it. So we can consider that Larry is an element of action that will teach players how the world works and how to survive it. Furthermore, as we can see in Figure 24, it can be categorized as an element

Figure 23 – Environmental elements of chapter 2 classified by their type and category and divided on three macro objectives: A) Present the enemy and how the mechanics work; B) Teach the players how to lock the enemy; C) Guide players to the elevator.



Source: Author.

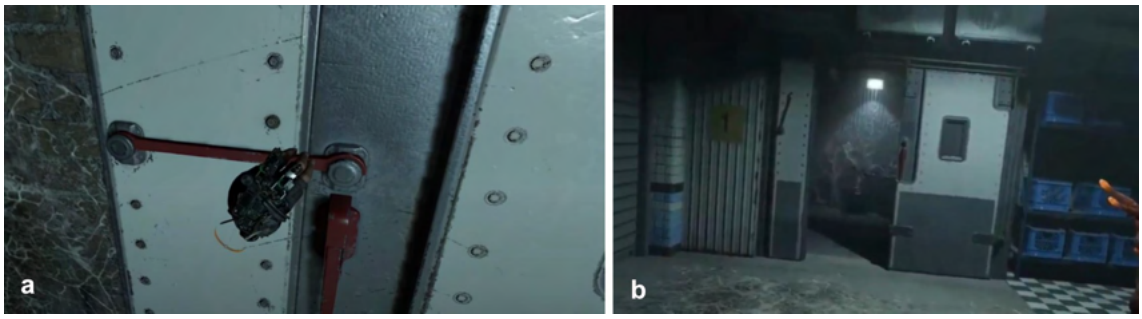
of direct communication, as he provides direct tips and guidelines on how to survive and put away the enemy. Those elements can be seen classified in Figure 23.a.

Developers presented a puzzle where the players needed to lock the enemy inside a room to open a door with a rotating lever. It occurs because the lever generates

Figure 24 – Larry presents the spore fungi to the player and the risk of being caught by coughing.

Source: Author.

Figure 25 – Presenting how functional items work and introducing them before they were essential a) the players are presented to a style of door lock; b) The player is indirectly invited to use the same kind of lock but now to close the door.



Source: Author.

noise that attracts the enemy. As shown in Figure 25, the developers presented a door that presents the same mechanics of other door that the players will need to use to complete one of the objectives in the future. After that, developers present a new mechanic through the environment and use the door as a Cue for future use. After that, light is used as a Cue to highlight the little room crucial for the puzzle to be solved on the second door. Those elements can be seen classified in Figure23.b.

During this part of the chapter, the developers applied some approaches to guide the users through the level, one of them is that they need to pass through a broken window (that can cause noise and attract the enemy). A window can be considered a Cue as it is possible to broke other windows to pass. Also, after the enemy is locked, the player can enter the hallway and activate the elevator with a highlighted button, also considered a Cue. Those elements can be seen classified in Figure23.c.

7 EXPERIMENT RESULTS

This chapter will describe the results regarding the participants and their profiles and the video analysis made for the experiment.

7.1 PARTICIPANTS

The participants (n=12) were gathered from Voxar Labs, a lab located on Centro de Informática (CIn) at Universidade Federal de Pernambuco, and focused on research in areas such as natural interaction, extended realities, and computer vision.

7.2 PRE-EXPERIENCE QUESTIONNAIRES

The first questionnaire was a demographic questionnaire, Subsequently, we applied a questionnaire based on GAIN - gameplay activity inventory (VAHLO; SMED; KOPONEN, 2018), questionnaire that was crucial to determine in which type the participants fit in, The condensed data of both forms can be seen on Table 5.

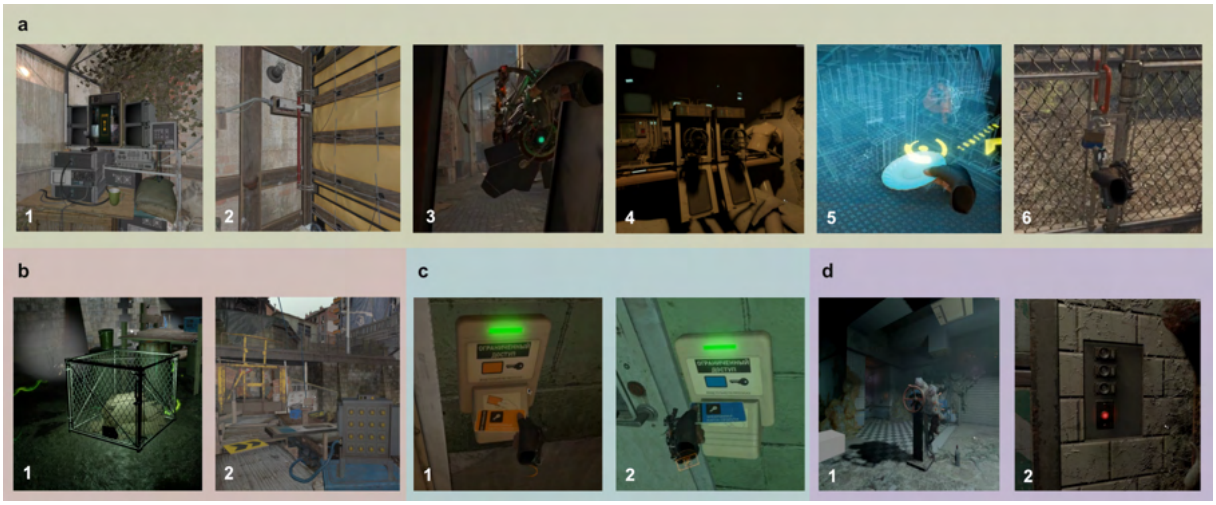
Table 5 – Table with all participants of this study. **Legend:** PG = Prescription Glasses; BP = Back Pain; Gt = Gastritis; Ph = Photosensitivity; AD= Attention Deficit Hyperactivity Disorder (ADHD)

Part.	VR Experience	Game Time	Age	Conditions	Player Type
P1	Rarely	3h-5h	24	PG	MERCENARY
P2	Rarely	5h-10h	25	PG	EXPLORER
P3	Rarely	5h-10h	28		MERCENARY
P4	Rarely	3h-5h	25		ADVENTURER
P5	Knowledgeable	3h-5h	24		ACROBAT
P6	One time	5h-10h	29	PG & BP	ADVENTURER
P7	Rarely	1h-3h	25		SUPERVISOR
P8	Rarely	1h-3h	34	Gt	ACROBAT
P9	Rarely	10h-20h	21	PG & Ph	COMPANION
P10	Rarely	5h-10h	29		EXPLORER
P11	Rarely	< 1	29	PG & AD	COMPANION
P12	Rarely	< 1	25	PG	SUPERVISOR

7.3 VIDEO ANALYSIS PREPARATION

The tests occurred without considerable problems; minor issues happened such as tracking bugs (issues with hand and head movement) and game bugs (collision issues and aim-related issues). We analyze the game sessions using an adaptation of Mondada (2006) video analysis method, the details of the adaptation are described in subsection 5.9.

Figure 26 – All the objectives mapped to be applied on the video analysis. a) The objectives on Test 1;b) The objectives on Test 2; c) The objectives on Test 3; d) The objectives on Test 4.



Source: Author.

To understand the dynamic of the players during the tests, we mapped objectives inside the environment that can help us evaluate players' efficiency and performance; those are tasks built into the game scenario by the original developers, and are crucial for the completion of the game section. They are:

- **Test 1:** 1) Press the button to answer the call; 2) Open the Sliding Door; 3) Put the headset on; 4) Put an object on the table; 5) Put the gloves on; 6) Destroy Padlock, they can be seen on 26.a.
- **Test 2:** 1) Open the cardboard cage (optional); 2) Insert the correct answer they can be seen on 26.b.
- **Test 3:** 1) Open the orange door; 2) Open the blue door they can be seen on 26.c.

- **Test 4:** 1) Rolling the lever; 2) Press the elevator button they can be seen on 26.d.

Those objectives helped us see where most players get stuck, or where they get confused. It was also a way to subdivide the timeline geographically, as those objectives are in static locations in the environment.

Table 6 – Players‘ aproximated time of exploration, idle, combat and confusion, and also their death count on each test.

Test 1							
Participant	Player Type	Exploration	Idle	Combat	Confusion	Death	Total Time
P1	Mercenary	05:40	10:10	-	01:00	-	27:40
P2	Explorer	05:20	08:20	-	00:40	1	25:40
P3	Mercenary	04:40	08:10	-	01:10	-	27:50
P4	Adventurer	02:50	10:10	-	00:20	-	27:10
P5	Acrobat	01:50	11:30	-	02:10	-	25:50
P6	Adventurer	15:00	28:10	-	00:30	-	58:52
P7	Supervisor	05:00	12:20	-	06:30	-	37:58
P8	Acrobat	03:10	16:40	-	01:00	-	35:20
P9	Companion	04:20	13:40	-	01:10	-	30:28
P10	Explorer	04:40	11:00	-	00:50	-	27:07
P11	Companion	03:00	20:10	-	00:00	1	37:25
P12	Supervisor	08:10	15:50	-	01:00	-	34:58

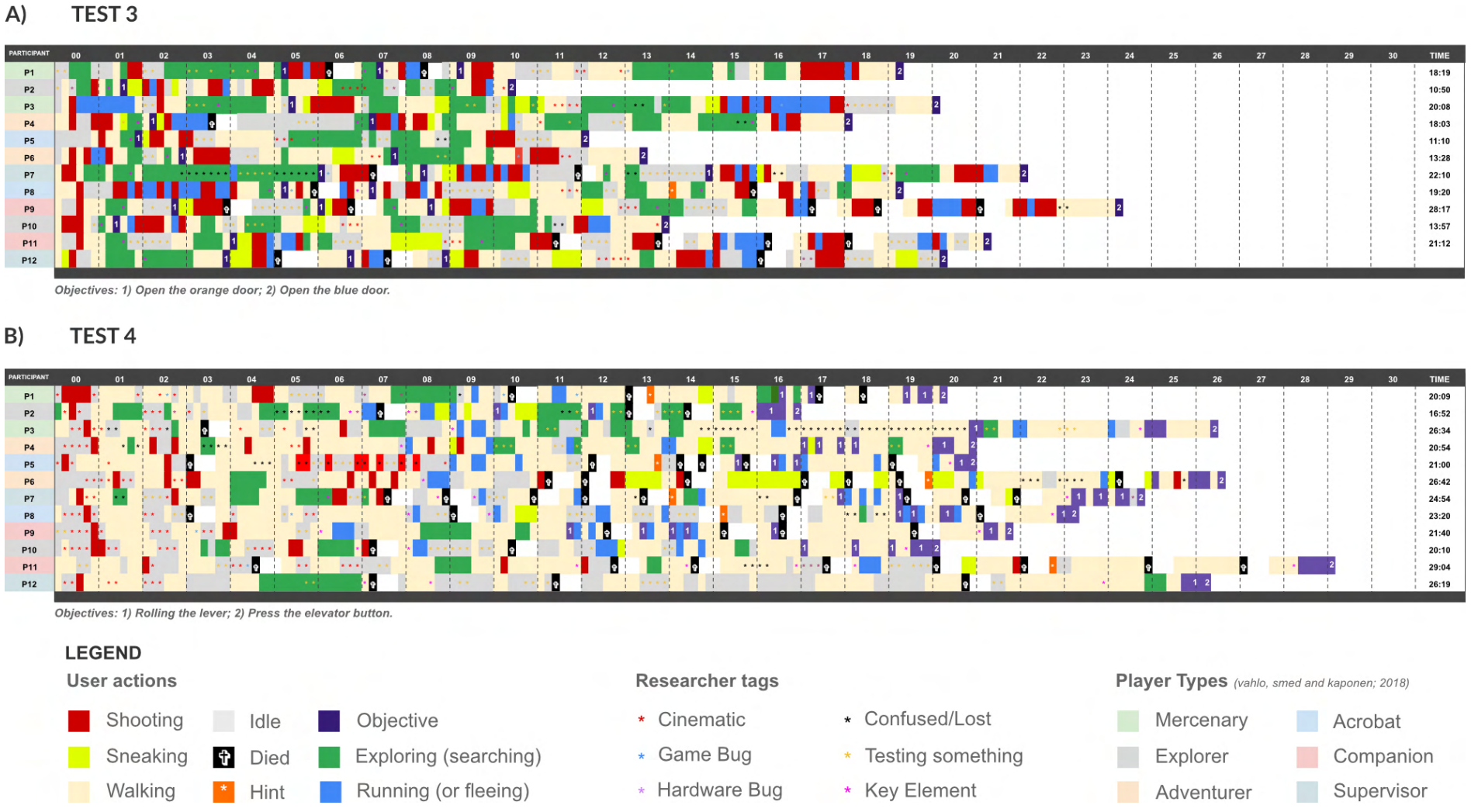
Test 2							
Participant	Player Type	Exploration	Idle	Combat	Confusion	Death	Total Time
P1	Mercenary	09:40	03:40	-	01:40	-	16:23
P2	Explorer	05:10	00:50	-	00:10	-	07:37
P3	Mercenary	05:20	00:20	-	01:10	-	09:00
P4	Adventurer	09:20	06:40	-	07:30	-	21:48
P5	Acrobat	02:10	04:30	-	00:00	-	09:30
P6	Adventurer	05:10	10:30	-	00:40	-	18:44
P7	Supervisor	01:00	03:50	-	00:50	-	08:00
P8	Acrobat	02:30	05:00	-	02:20	-	17:00
P9	Companion	04:10	01:00	-	00:00	-	08:39
P10	Explorer	03:30	02:00	-	00:10	-	07:43
P11	Companion	05:50	07:40	-	02:10	-	20:48
P12	Supervisor	07:40	06:00	-	02:50	-	18:45

Table 7 – Players‘ aproximated time of exploration, idle, combat and confusion, and also their death count on each test.

Test 3							
Participant	Player Type	Exploration	Idle	Combat	Confusion	Death	Total Time
P1	Mercenary	05:50	03:00	02:50	00:00	2	18:19
P2	Explorer	02:40	01:00	01:40	00:00	0	10:50
P3	Mercenary	06:00	02:20	02:10	00:20	0	20:08
P4	Adventurer	04:00	01:00	02:10	00:20	1	18:03
P5	Acrobat	03:20	02:30	01:30	00:20	0	11:10
P6	Adventurer	02:30	01:00	02:00	00:00	0	13:28
P7	Supervisor	06:30	01:50	03:20	02:50	1	22:10
P8	Acrobat	02:00	03:00	03:20	00:00	2	19:20
P9	Companion	02:30	04:10	04:00	00:20	5	28:17
P10	Explorer	03:50	02:00	01:40	00:20	0	13:57
P11	Companion	02:50	04:30	02:40	00:00	4	21:12
P12	Supervisor	02:10	03:50	02:30	00:00	3	20:15
Test 4							
Participant	Player Type	Exploration	Idle	Combat	Confusion	Death	Total Time
P1	Mercenary	02:00	02:50	01:10	00:10	4	20:09
P2	Explorer	04:50	01:40	00:10	01:40	3	16:52
P3	Mercenary	03:00	04:30	00:10	06:40	1	26:34
P4	Adventurer	02:10	01:40	01:10	01:00	0	20:54
P5	Acrobat	00:00	03:30	01:40	01:50	6	21:00
P6	Adventurer	00:50	04:00	02:00	01:20	7	26:42
P7	Supervisor	02:20	02:50	00:50	01:10	9	24:54
P8	Acrobat	00:10	06:20	00:10	00:40	4	23:20
P9	Companion	01:30	02:30	00:30	00:00	4	21:40
P10	Explorer	01:40	05:10	00:50	00:00	2	20:10
P11	Companion	01:10	06:00	00:40	00:40	8	29:04
P12	Supervisor	02:50	09:30	00:10	00:00	3	26:19

Source: Author.

Figure 27 – Results of the video analysis on Tests 1 and 2.



Source: Author.

Figure 28 – Results of the video analysis on Tests 3 and 4

7.4 VIDEO ANALYSIS RESULTS

On Figures 27 and 28 we present a timeline that was especially important to have a visual overview of all participants' experiences. On Tables 6 and 7 we present the approximated times to the most import tags. Having a visual way to compare between their sessions and point the moments where important events happened during their sessions. The timeline colors were also a way to visualize the player's behavior on different sections of the experience and how much time the players expect to do every action or task.

We present on Figures 31, 34, 32, 33 29, and 30 the overview of all player's game sessions, dividing the time (in seconds) for exploration, combat, idle, and confusion, and also presenting the number of players' in-game deaths. We do not include the actions Sneaking, Walking, Running and Hint and tags Cinematic, Game Bug, Hardware Bug, Testing something and Key elements because they are dynamic measures and only make sense in context. On the following sections we present the experiment results divided by the player types (VAHLO; SMED; KOPONEN, 2018).

7.4.1 Mercenary

On this type, the users are more focused on emotionally appealing experiences. In addition, participants P1 and P3 showed a high preference for exploration; P1 invested 27:10min of a total 81min of gameplay exploring, With a simmilar pace P3 invested 20:10min exploring of a total time of 83min. This was the expected behavior for users of this type, as described by Vahlo, Smed e Koponen (2018), mercenary players tend to enjoy some exploration, but we noticed that both users passed through important details too quickly, sometimes missing crucial information.

As we can see in Table 6, both users presented similar total time in Test 1. However, P3 explored and interacted for more time with the scenario and objects in the first moments than P1, interacting with elements as the "pet bug" showed in Figure 15; But advanced quickly on the following parts of the Test. Both players stopped to watch the cinematic moments in this Test. Showing that, they understand that in specific moments they need to explore in order to obtain crucial information about the story and the characters,in other moments, they tend to just pass through the environment seen it

Figure 29 – Overview of the video analysis of mercenary players considering all tests. *The action Idle includes moments where users were still or unaware of the environment; in many cases, they watched cutscenes or tested some game interaction.

Source: Author.

only as a path.

On Test 2, as shown in Figure 27.b, P1 and P3 spent much time exploring but got confused and started testing things without a clear objective; for P1, the hint "look at the input panel" was given at 13:50, which helped the participant understand the puzzle input and the answers. P3 noticed the panel and started testing random combinations until the hint "look at the cage" was given at 7:50. However, the player did not understand that it was a highlight on a specific answer; instead, he started to test combinations from the walls until the correct one happened.

As shown in Table 7 P1 and P3 have similar times on Test 3, but their behavior diverged on this one; P1 died two times on this Test and presented frustration for not understanding correctly how the guns work and needed a complementary explanation. P3, on the other hand, was much more cautious and *sneaky* but also had problems with gun controls during combat, which made the participant anxious and confused in specific moments.

On Test 4, the participants invested less time on exploration than what they did in other test; results can be seen on Table 7 P1 died four times in total, and received the hint "You can hide behind that wall" at 12:00min, and helped the participant pass through the initial encounter with the enemy, P1 understood the objective quickly but encountered complications to lock the enemy on the little room, and died two times trying. P3 only died one time in this test, but once again was much more cautious and slow-paced than P1 at the beginning; P3 presented a long moment of confusion during 14:40 to 20:50, no hint was given because the user already understood the objective ahead, but did not understand how to perform it, which lead to minutes of wandering and avoiding the enemy. After opening the final door, the participant seemed

very anxious and missed the red elevator button but found it after 40s when returning to the corridor again.

Besides having the same player type, P1 and P3 showed different behavior in combat but similar on exploration and general walking pace. P1 only appeared to be anxious on Test 3 stated that being deprived of control led him to feel powerless and afraid, P3 seemed afraid on Tests 3 and 4, and in those moments of high anxiety, the player seemed confused and lost for longer times than P1, as we can see on Figure 29. P3 tried to understand the guns and the scenario in advance, but on the combat moment also felt anxious because his weapon reload ability was not fast enough. A primary difference between the two users was the number of times each one "died" in-game; as said earlier, P3 was cautious and P1 more aggressive, considering the full experience P1 died six times and P3 one time as we can see on Figure 29. P3 also showed to be more sensitive to motion sickness and not much acquainted with horror games, and it may be the leading cause that, despite being an aggressive player, he tends to be more cautious towards enemies and seen to be interested in a smoother and more controlled experience than P1.

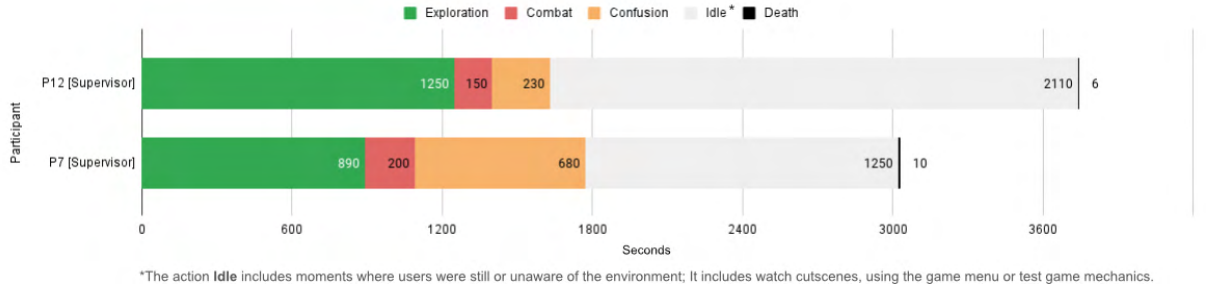
It was noted minor hardware malfunction, mainly regarding the tracking that failed on parts where the participant's hands were closer to the floor, occluded for the VIVE tracking stations. Additionally, some game malfunctions happened in Test4, mainly regarding the glass bottles that should have broken to attract the enemy.

7.4.2 Supervisor

Supervisor players are focused on management tasks and slow-paced games, like simulation, strategy games, and some action games. So it was expected that they were not heavy First-person Shooter players and not used to horror or thriller settings; characteristics presented on Half-Life: Alyx. As we can see on in Figure 27.a, The Participants, P7 and P12 have similar times in general, with less than five minutes of difference between them, except on Test 2, where P7 solves the puzzle with one of the general better times.

On Test 1, in the initial moments, both players felt lost and confused on what was the initial directive, and both needed a hint to find the first door, hint described on Table 4, achieving objective two after other players. P7 appears to be confused in various

Figure 30 – Overview of the video analysis of supervisor players considering all tests. *The action Idle includes moments where users were still or unaware of the environment; in many cases, they watched cutscenes or tested some game interaction.



Source: Author.

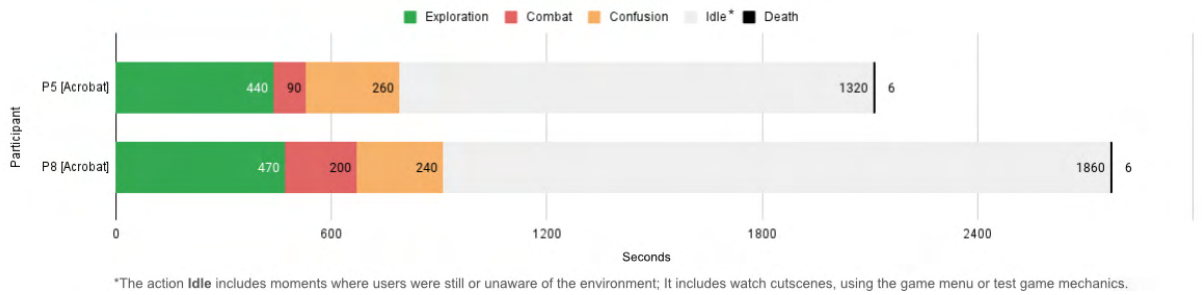
sections of this test, and the player had problems understanding the first objectives and the story going on. Besides not being a type of player inclined for that, P12 showed interest in exploration using 8min from the 34min of Test 1 on exploration and used that time to Test the interaction possibilities.

On Test 2, as we can see in Figure 27.b, P7 had one of the best conclusion times, around 8min, and did not perform objective 1, meaning that the player found the answer without the game guideline, using a visual logic that was applied to the construction of the evidence on the walls. On the other hand, P12 explored more the drawings, the scenario, and the assets during the gameplay; she found objective one early on the session, but needed two hints to understand the test resolution, they were "be at the right spot to see the answer" and "look at the panel," besides the player, already having discovered the panel and tested the buttons, did not connect it to the puzzle resolution.

On Test 3, as we can see in Figure 28.a, both players had problems with the enemies encounters, mainly with gun control and enemies management, both players had difficulties moving when enemies approached them, P7 felt motion sickness after one section of combat and needed a pause of the experience, P12 did not present any symptoms of motion sickness. However, it was heavily emotionally engaged in the experience, a characteristic that made it difficult for the participant to concentrate on combat and problem solving; it was also noted that P12 was among the sneakier players on this test, probably due to the anxiety promoted by the experience on these specific moments.

It was noted that on Test 4, both Supervisor users had difficulties dealing with the immortal enemy; P7 was the player that died the most during the game session (9 times). Results can be seen in Figure 28.b. The player seemed very anxious and did

Figure 31 – Overview of the video analysis of acrobat players considering all tests.



Source: Author.

not understand how exactly the enemy works, so the participant continues attracting the enemy continuously. In opposition to that, P12 was the player that stayed idling the most, a total of 9m30s from a session of 26m19s, where the player waited for the enemy to be in one specific position or just testing and trying to understand how he functions according to the participant's actions.

Both players appeared to be very anxious during the combat sessions, and it affected their judgment and strategies, on non-combat areas are where those players are prolific, as showed by the result of P7 on Test 2 seen on Table 6. Those players are not acquainted with action/horror experiences, so it is expected a lack of experience on this types of experience, nad their overall death count showed to be higher than the average as we can see on 30. It was observed that supervisor players were the ones that showed more engagement and anxiety during the tests, also corroborates with the VAS-A self-declared data on Tables 10 and 11. Another Supervisor player was excluded from the tests due to heavy motion sickness in approximately 4min of Test 1. Although we cannot confirm if it was caused by the experience or solely by the virtual environment setting, both factors could cause motion sickness. Nevertheless, this supervisor player was a user who previously had a non-interactive VR experience without any problems.

7.4.3 Acrobat

Acrobat players are focused on performance during gameplay; they tend to like coordination activities and sometimes sports games. Being VR a coordination activity in itself, it showed to be an essential factor in the acrobat participants' experience (P5 and P8).

Due to technical issues, the initial video part of P5 Test 1 was not recorded; the 3min mark is assumed by audio recordings done during the experiment. In those three minutes, P5 passes through Objectives 1 and 2. On Test 1, both players played in swift pacing; as a consequence of that, as we can also see in Figure 27.a, P5 results only show 2min of exploration from a 25min session and P8 3m30s from a 35m20s session. During the session, approximately after 15min P8 felt intense motion sickness and asked to interrupt the experience; this reaction may be caused by the fact that the user played at fast pace and was playing seated. When the session was resumed, the researcher proposed to change to stand mode and changed some settings on the game, such as just allowing walking by teleport, illumination reduction, and snap move for the sides.

As we can see in Table 6, P5 had the fastest time on Test 1; P5 is an knowledgeable user of VR, so that factor combined with the speed inherent by the game type showed as an essential aspect for this result.

On Test 2, both players maintained fast pacing during the session; that approach made it difficult for them to find the panel to insert the password on the entrance, showed in Figure 20; P5 found it after 7 minutes and P8 after 6min. P8 needed a hint to locate the correct password. The "be at the right spot to see the answer" the participant expressed some confusion after the hint but eventually understood the puzzle logic.

On Test 3, P5, an already experienced VR player, performed very well against the enemies, we can see on Figure 31 that P5 has lower combat time, meaning that he was more effective on combat tasks in general; before he experienced, the player took time to test and understand how the guns work (apart from the orientation already given by the researcher). On the other hand, P8 experienced many gun problems, which made the participant anxious and applied much cognitive load on the first combats.

Both players have difficulties regarding the path they should take after finding the blue card; the researcher noted that P5 did not see the blue door in the first room but came back there to look for something he had missing. On the other hand, P8 needed a hint to remember the objective because he was leaving the exploration area where the blue card is.

On Test 4, the players' pacing showed to be a problem when confronted with the enemy. Both players fell to the ground floor on the first parts of this map and died, as shown in Figure 28b. P5 tried to shoot the enemy many times until he noticed it was

Figure 32 – Overview of the video analysis of companion players considering all tests. *The action Idle includes moments where users were still or unaware of the environment; in many cases, they watched cutscenes or tested some game interaction.

Source: Author.

useless and more dangerous. Both players needed a hint to find the window to pass through the next room to continue the path to the objective. In general, this test needed a more analytic approach, but the nature of those players made it difficult for them to see that as the first option of gameplay style.

In general, it was observed that acrobat players go through the maps at fast pacing, in the majority of times not exploring elements and trying to interpret the pieces, on Figure 31 we can see that they had lower exploration times compared with the other players. It was noted that P5 did not pay much attention to the cutscenes; in general, he did not stop to listen to them. P5 and P8 showed a different behavior on Test 3 where the task is precisely to find an object, but in general, both players did not casually explore during the sessions. Furthermore, both players seemed to be very frustrated when they could not perform a specific (physical) task, such as reloading the guns or shooting in a specific way; according to P8, those situations caused a feeling of impotence during the session.

7.4.4 Companion

Companion players are the ones that do not enjoy aggression tasks and prioritize caretaking and cooperative experiences. It is not a group invested in the action and First-person shooter experiences. Hence, both players, P9 and P11, showed slow-paced gameplay during the experiences. However, as was also expected, their main challenge will be the combat situations, where they must deal with enemies and their lack of experience on shooters.

During Test 1, it was noted that both players had a slow pace and stopped a lot

to try things regarding interaction and controls, P11 expent 13m35s from a session of 37m25s, as We can see on Table 6 testing interaction and controls, full session is described in Figure 27.a, it seems that the participant did not feel very confident at the beginning of the experience. One interesting point was that both players always watched carefully to the cutscenes and waited for them to end before returning to walk or explore.

On Test 2, we have a discrepancy in time results for the two players, as can be seen 6. Where P9 has one of the best general times and solves the puzzle quickly; P11 had shown much confusion in understanding the problem to be solved and that the answer was in the wall. P11 needed two hints to solve the puzzle, the "look at the panel" and "be at the right spot to see the answer". The participant also spent much time trying random passwords. It may be associated with the fact that P9 was acquainted with puzzle games and mainly "Portal," a game that shares the same world with half-life, so it is a factor that may be useful to the player performance.

On Test 3, both players have difficulties dealing with the guns and the enemies simultaneously; it was noted that both of them are very anxious on the moments of combat, being P9 the player that died the most (5 times) during this test. Their main concern seemed to be how to reload the guns in the moments of the fight, the same problem encountered by supervisor players on section 7.4.2, it was difficult for both players to do the two things at once. P11 was one of the two players that ran away from the last encounter with enemies; the majority of the players engaged with them regardless of whether they were needed or not.

On Test 4, both players seemed calm during the encounters with the enemy, which was predictable and slow. However, P11 seemed confused with where to go and how to deal with the enemy, becoming very frustrated at some point in the session. P11 needed the hint "go through the window," which is a crucial finding to go to the next room, there both participants understood how to trap the enemy very fast.

It was clear that combat situations were complex to this type of player, mainly fast-paced action as happens on Test 3, we can see on Table 6 that they were the type of players that most died on this test, and also in the overview showed on 32. in general, the main difference between the players was in the understanding of the game dynamic and its pieces, P11 seemed confused in Test 2 and Test 4, where classic half-life characteristics appear, as its puzzles and embedded tutorials with actions or characters.

Figure 33 – Overview of the video analysis of explorer players considering all tests. *The action Idle includes moments where users were still or unaware of the environment; in many cases, they watched cutscenes or tested some game interaction.

Source: Author.

Hence, it became clear that the knowledge of other games of the series helped P9 surpass many challenges on the tests.

7.4.5 Explorer

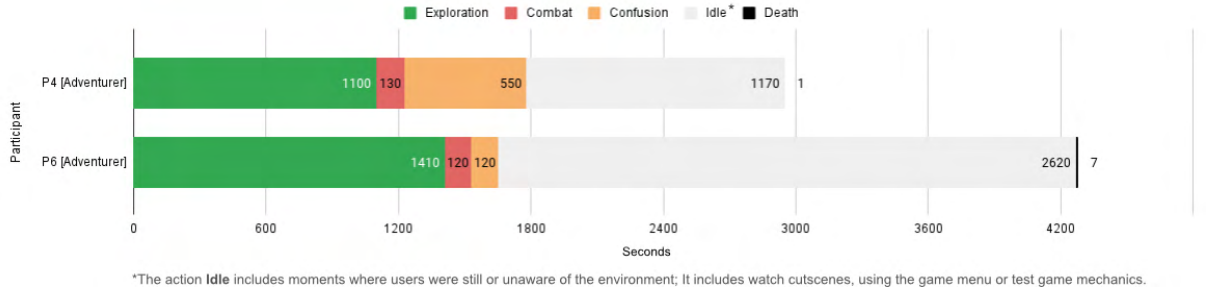
This type of player is focused on exploration tasks and is proficient in games with complex storylines. Both players, P2 and P10, have experience with other games of the franchise, as "Half-Life: Episode 2" and "Portal." Being so, this group seemed to be the target audience for the game.

On Test 1, both users seemed to be very comfortable with the scenario dynamic, where little or no information is given at first, and the information comes as the game progresses. P2 and P10 are not the players with more time invested in exploration, but they seem to be very assertive on the exploration tasks; they knew what to look for on those moments to progress on game introduction. Both players experience some confusion on specific moments, but not for too long.

On Test 2, the participants had similar times, as we can see in Table 6, both players are among the best times for this test without any hint from the researcher. P2 experienced three experience breaking hardware bugs described on subsection 7.4.7 where we needed to pause his session but did not disrupt the interpretation of the participant on the environment.

On Test 3, both players seemed to have fun on combat parts and did not have difficulties finding the cards needed to conclude the test; P10 did not notice the blue door on the first room, which is the final objective of this test. However, the player had the correct intuition to come back to the beginning and stated that was the right way

Figure 34 – Overview of the video analysis of adventurer players considering all tests. *The action Idle includes moments where users were still or unaware of the environment; in many cases, they watched cutscenes or tested some game interaction.



Source: Author.

because it had one additional enemy encounter on the way. The participant confirmed that using this specific strategy helped him build confidence in his taking. Explorer players are not heavily focused on combat scenarios; P2 was one of the two players that did not engage until the end of the last encounter with the enemies, noticing passing through them without effort.

On Test 4, both participants performed well on the wayfinding and understanding the objectives of the test, both had problems understanding the enemy, and there we saw a difference in behavior, P2 died four times and P10 only two, P2 had a more straightforward for testing (and losing) approach, performing tests directly with the enemy. P10 was more analytical than P2, he waited more and tested the enemy behavior safely at a distance, their sessions are described in Figure 28.b.

Both players seemed to be very comfortable in all scenarios, and had very alike overall experiences as we can see on Figure 33; they did not need any hint to find and conclude objectives; the experience from other games, including other *Valve* games, was crucial to understanding the level design and game dynamics. Furthermore, they were faster on all tests without needing any assistance.

7.4.6 Adventurer

Adventurers is the group that enjoys exploration a lot. However, they have a light taste for all the other task areas, which means a group with much variability regarding preferred styles and previous game experiences. However, few similarities were observed in the behavior of P4 and P6.

On Test 1, it was noted that P6 time was way above average; the player invested a

lot more time than the other players on exploration and testing, as we can see in Table 6.a, using 15min for exploration and 15min20s for testing (in some of this time the two aspects happened at the same time) from a total time of 58min52s. In addition, P6 was the one that explored the most the *Alyx refuge*, comment about the plan drawings and the objective being hacked or invaded *Pylon 7B*. P4 had a more straightforward approach on this phase, not watching all the cinematic carefully and not exploring a lot of the environment by himself.

On Test 2, both participants had difficulties solving the puzzle; both needed two hints to solve the puzzle, P4 needed the "look at the panel" and "you need to be in the right place to see the answer", and P6 needed "look at the cage" and "look at the panel." Both players spent some time trying random code combinations P4 invested around 6min to guess the code without game guidelines. P4 also experienced more confusion than P6. P6 invested 4min10s playing with the objects and testing interaction with guns.

In contrast, both players performed very well on Test 3; P4 had issues with the guns at first and took some time to understand and test them by himself. On the other hand, P6 felt very comfortable in this scenario, probably because he tested the pistol during Test 2 and Test 1. P6 did not demonstrate much anxiety during the fights. As a result, his final objective time was significantly faster than P4, as can be seen in Table 7.

On Test 4, results also diverged, P4 did not die in this scenario and remained calm during the encounters with the enemy, P6 seemed overwhelmed and showed to be very anxious during the encounters, and failed seven times during the encounters, P6 also needed the hint "go through the window" to proceed to the next room. On that test, P4 achieved his last objective faster with 20min54s against 26min42s, as seen in Table 7.

Despite having the same type, P4 and P6 had very different backgrounds and specific beneficial characteristics, as we can see on Figure 34, P6 had much more time in idle and had a slower pace compared to P4 as we can seen on Table 6 and 7. However, it was noted that both participants invested around the same time in exploring and combat as showed on Figure 34. In addition, both demonstrated intense curiosity about the possibilities the game provide and what they could do on the experience.

7.4.7 Summary and common problems

This section will describe common problems, behavior patterns, and general observations from the tests; some of them are linked by the user type, and some of them to the participant's background.

During exploration, some users like P1, P6, P10, and P11 tested specific interaction patterns. Although they got frustrated to know that some interactions are not possible in the game, actions like open books, use a calculator, or press buttons, some interactions like writing with a pen and turning the TVs off on Test 1, were well received.

As said earlier, when doing tests 3 and 4, we could see a direct relation to users personal background, users like P3, P6, P7, P9, and P12, felt overwhelmed by the experience in various moments, they all had in common the lack of experience and likeability from horror games, but being from different types they seem to get anxious in different situations, e.g., P3 felt much anxiety because he could not remember how to use the guns properly, users like P9, P7, and P12, could not handle to move and shoot at the same time. On the other hand, users like P2, P4, and P5, felt very confident around the enemies; this approach resulted in a much calmer game session and faster objective times.

We experienced some specific bugs caused by the HMD itself; on P2, P3, P4, and P5 sessions, we tried to use the Vive Pro's internal microphone, which disrupted the joystick tracking. Unfortunately, we could not explain or solve this bug, so an external audio microphone was set for the subsequent tests.

It is worth noting that participants of different types had different reactions when encountering some critical elements from the scenario; on Test 1, in Alyx's refuge, we were presented with a *pet bug*, the majority of participants did not interact or comment on that, but P11 and P9, companion type participants, interact with the pet shown in Figure 15, fed him and played with it for a time. P6, P10, and P12 found it strange or ugly; only P10 interacted with it directly. After the confrontation with Jeff, we observed another pattern, P12, P6, and P3, asked if the enemy could set himself free, and performed all subsequent tasks very anxiously and fast.

8 POST-EXPERIENCE QUESTIONNAIRES RESULTS

In this subsection, we present the results of the VAS SUS II questionnaires and highlight the data gathered from those answers.

8.1 VAS QUESTIONNAIRE

The Visual Analogue Scale (PALLAVICINI et al., 2018; AITKEN, 1969) is applied here as a tool for understanding the user's emotional state after every step of the experience and will be used complementary to the open-ended questions to form a better image of the player's thoughts during the experience. On this section, we present all the data collected:

We could notice on Table 8 that the average level of surprise and happiness was very high (above 9), Users like P6, P7, P9, P8, P10, and P12, felt very comfortable during the experience; for some, it was their first VR experience, it Being positive and safe for sure positively impacted the scores, as we can see none of the participants scored anxiety above five.

On Table 9, we can observe that P5 and P12 pointed their anxiety level as high (above 7); during the experience, both users stated that "they cannot solve the puzzle,"

Table 8 – VAS results from Test 1

Part.	VAS - A	VAS - HP	VAS - S
P1	1	8	7
P2	2	9	10
P3	1	7	7
P4	4	10	8
P5	4	8	7
P6	1	10	10
P7	1	10	9
P8	1	9	9
P9	1	9	10
P10	2	9	10
P11	3	8	9
P12	3	10	10
Avg	**2.09**	**8.92**	**8.83**

Table 9 – VAS results from Test 2

Part.	VAS - A	VAS - HP	VAS - S
P1	2	4	5
P2	3	8	9
P3	1	7	6
P4	1	8	6
P5	7	4	5
P6	1	6	6
P7	1	10	10
P8	1	8	7
P9	2	10	9
P10	1	9	8
P11	2	9	9
P12	8	7	8
Avg.	**2.5**	**7.5**	**7.33**

Table 10 – VAS results from Test 3

Part.	VAS - A	VAS - HP	VAS - S
P1	3	5	5
P2	8	7	8
P3	3	9	9
P4	10	9	8
P5	1	10	8
P6	1	10	10
P7	9	5	10
P8	1	10	9
P9	8	10	10
P10	6	9	7
P11	8	10	10
P12	10	9	9
Avg.	**5.67**	**8.58**	**8.58**

or they "are bad in puzzle-solving," in general pointing the problems to themselves, what generated much frustration.

As we can see in Table 10, there is a higher value on anxiety level when compared to Test 2; we can correlate that data to the combat situations present on this test. Besides that, P6 and P8, acrobat players, and P5, adventurer players, scored their anxiety as a minimum; the three of them are used to playing shooters and action games. As expected, P1 and P3, mercenary players, scored low anxiety on this test, probably for

Table 11 – VAS results from Test 4

Part.	VAS - A	VAS - HP	VAS - S
P1	5	5	5
P2	9	6	9
P3	3	9	9
P4	1	8	6
P5	3	8	7
P6	10	3	6
P7	9	6	10
P8	1	9	8
P9	10	10	10
P10	8	8	9
P11	10	10	10
P12	10	10	10
Avg.	**6,58**	**7,67**	**8,25**

the same reasons.

As we can see, even in the most anxious environment for them, players as P12, P9, P4 had fun and enjoyed the experience, and felt happy and surprised in a good way with the game. P1 and P7 were the only players that scored Lower than average on happiness; both of them stated specific reasons during the game session. P1 could not control the guns as he liked, so gunfight became a very frustrating task for him; after the experience, P7 said that he has "some level of arachnophobia" and that the enemies could be inducing some specific fear on him, the player needed to pause the experience during the test.

Finally, on Table 11 we had the highest averages on all tests, which could mean that it was the most emotionally intense of the four tests. P9 and P11, companion players and P12 that is a supervisor player, scored the maximum on all VAS tests, which was a surprise because they are not the types of players that enjoy such experiences, but managed to have fun and enjoy the experience during the specific test. P7 the other supervisor player, had a lower score on happiness in comparison, the player died many times and felt that his performance was not being good enough.

We had opposite scores between the adventurer-type players; P4 was one of the players with a minimum score on anxiety and one who did not die in-game during the test. P6, in opposition, had the maximum score and felt unhappy with the enemy

design and mechanics. Along with P4, the two acrobat players, P8 and P5, had lower scores on anxiety and enjoyed the dynamic to beat the enemy on the game sessions. In general, we can notice that anxiety levels do not necessarily mean a bad experience. Some players are vocal about how it made the experience more impressive and intense in VR.

8.2 SUS II QUESTIONNAIRE

The Slater-Usoh-Steed Questionnaire is a Likert-7 questionnaire applied to measure aspects of presence and engagement during the different stages presented to the participants. As we can see on Tables 12 and 13, there is no significant variability on average presence scores for the tests.

In a general way, we noticed that Q5 was a question which had the most significant number of minimum scores; we believe that the format of the question may be confused the users, maybe taking the direct association of real memories and game memories too literally, being a sci-fi game based on Eastern-Europe hardly it can be physically compared to a contemporary brazillian city, where all participants are based. Despite that, all test's averages stayed above 5, which we can consider a good score.

Table 12 – SUS II results from Test 1 and Test 2.

Test 1							
Part	Q1	Q2	Q3	Q4	Q5	Q6	SUS II Presence Score
P1	6	5	7	6	3	5	5.33
P2	7	6	6	6	4	6	5.83
P3	4	5	6	5	3	5	4.67
P4	6	6	5	6	7	5	5.83
P5	7	6	5	7	3	1	4.83
P6	6	6	6	7	1	7	5.50
P7	7	6	7	7	6	6	6.50
P8	6	6	5	6	6	7	6.00
P9	7	6	7	7	6	6	6.50
P10	6	6	6	2	7	7	5.67
P11	6	7	6	7	2	6	5.67
P12	6	6	5	6	2	6	5.17
						Avr.	**5.63**
Test 2							
P1	6	6	7	6	3	5	5.50
P2	5	5	7	5	2	5	4.83
P3	5	5	6	6	4	6	5.33
P4	4	2	3	2	2	3	2.67
P5	4	4	5	5	3	1	3.67
P6	4	4	4	6	2	4	4.00
P7	7	7	7	7	7	7	7.00
P8	6	6	5	7	4	6	5.67
P9	7	7	7	7	6	7	6.83
P10	6	5	6	6	6	6	5.83
P11	6	7	6	6	1	6	5.33
P12	6	3	5	6	4	5	4.83
						Avg.	**5.13**

Table 13 – SUS II results from Test 3 and Test 4.

Test 3							
Part.	Q1	Q2	Q3	Q4	Q5	Q6	SUS II Presence Score
P1	7	7	6	7	4	6	6.17
P2	7	7	6	7	2	7	6.00
P3	6	6	6	6	5	6	5.83
P4	5	5	5	5	5	6	5.17
P5	7	7	7	7	3	1	5.33
P6	7	7	1	7	1	7	5.00
P7	7	7	7	7	7	7	7.00
P8	6	6	5	6	5	6	5.67
P9	7	7	7	7	6	7	6.83
P10	7	7	7	7	6	7	6.83
P11	7	7	6	7	2	7	6.00
P12	7	7	5	4	5	6	5.67
						Avg.	**5.96**
Test 4							
P1	7	7	4	7	7	7	6.50
P2	7	7	6	7	1	6	5.67
P3	7	7	7	6	6	7	6.67
P4	4	2	3	2	2	3	2.67
P5	7	7	7	7	1	1	5.00
P6	7	5	1	7	1	6	4.50
P7	6	7	7	7	6	7	6.67
P8	6	6	5	6	5	6	5.67
P9	7	7	7	7	7	7	7.00
P10	7	7	6	6	7	7	6.67
P11	7	7	6	7	3	6	6.00
P12	7	7	6	1	5	7	5.50
						Avg.	**5.71**

8.3 THEMATIC ANALYSIS: OPEN-ENDED QUESTIONS

Here we will use a technique called Thematic Analysis (BRAUN; CLARKE, 2006) to present the main themes that the participants pointed out in the three open-ended questions we propose at the end of the questionnaire. The questions were: *1) What could be better on Half-Life: Alyx? 2) What should not exist on Half-Life: Alyx? 3) Was there some problem of any kind during the experience?* The count of occurrences is done independently of users, so one user could mention a specific topic on more than one question; the main discussed topics can be seen in the Table 14:

We divided the contents into three main categories: Suggestions; Issues, and Suggested to remove.

For the suggestions, we can highlight "Improve Walking" in which some users had different types of problems with the "continuous walking" mode of movement, the most common associated with motion sickness. Some of them asked to change settings with the researcher during the experience. We had five occurrences of users suggesting to "facilitate gun reload." It was an experience-breaking problem for some users. However, it is essential to notice that, in the standard game, there is a skill development with the guns. The test participants did not experience that, so it was expected that some problems related to combat interaction would appear on the highlights. We had five occurrences of "make interactive objects explicit," some users felt frustration for not finding important objects or knowing what is intractable or not; this one also relates to "improve object interaction" some objects, like books, notebooks, calculators, and others, did not present real-life affordances. Hence, users tried to use them as they imagined they should work and felt disappointed. Finally, we had three occurrences of "should be an open-world game" we noticed that some users felt that the fact that it is too linear, mainly on the selected parts for the tests, made the experience a little claustrophobic. Respectively, we had three and two occurrences for "better game hints" and "better initial approach." However, this one was also expected that some doubts could be answered in other parts of the game that were not played for the participants. The other suggestions had only one occurrence related to interaction and specific problems or ideas the users had during the game session.

The main issue on the occurrences was "motion sickness," which is a common issue for VR experiences. However, it has to be acknowledged that happened on these

Table 14 – Table containing the results of the Thematic Analysis(BRAUN; CLARKE, 2006), data obtained through open ended questions on the post-experience questionnaires.

Suggestions	**#**
Improve Walking	11
Facilitate gun reload	5
Make interactive Objects explicit	5
Improve Object Interaction (open things)	3
Should be open world	3
Better Game Hints	2
Better Initial Approach	2
Change dominant hand naturally	1
Could Have Hand Interaction	1
Improve Climb	1
Improve gun selection and health use	1
Improve hand-mouth	1
Improve Rotation	1
Should Have Melee	1

Issues	**#**
Motion Sickness	9
Could not reload fast	4
Could not continuos walk	3
Fatigue	2
Colider not working for enemy	1
Teleport not working	1
Tracking Problems	1
Trackpad Interaction Problems	1
Joystick Bug	1

tests, few of the motion sickness situations were game-breaking for the participants; only two participants asked for a break during the sessions, both of them due to motion sickness issues. An issue that also appeared on the suggestions is related to the reloading interaction; we had four occurrences of this problem during game sessions. Another issue that appeared on the responses and is also linked to responses is "could not continuos walk" some users could not use this mode of interaction because it caused motion sickness on them. We had two occurrences of fatigue, and both of them occurred on Test 3 with users that died a lot for the enemies in combat. The rest of the issues were specific bugs and problems during the sessions. Some of them were already discussed in Chapter 7.

In general, we could say that the main problems were caused by walking interactions and gun interactions, which can disturb the participant's experiences and cause motion sickness and fatigue, two basic VR problems.

9 DISCUSSION AND LESSONS LEARNED

On this section we will discuss the results from the experiments and propose guidelines for creating ES approaches that can enrich the level design, promote more engagement, and a better flow when navigating through the levels.

9.1 ACTIVE INVESTIGATION

Regarding the active investigation elements, some users argue that they are not explicit enough in some areas as on the introduction level (Test 1), where the user is presented to many objects, it was noted that on *Alyx refuge*, all users used the camera showed on Figure 15, but only P6 and P3 talked explicitly about *Pylon 7B*, that was the building being showed on the camera, both of them analyzed and interacted with the whiteboards also described on Figure 15. With that as a sample, a topic that was noted on the open-ended questions pointed at Table 14. On informal talks with the users after the experience was the fact that they felt overwhelmed by the information at the beginning, only three participants knew half-life's backstory (P2, P9, and P10), so it seemed that it was a critical factor on the construction of the context for new users, independently of player type.

We noticed on Test 2 that P4, P6, P11, and P12 did not notice the input panel at all, shown in Figure 20b, P5 and P8 (both Acrobat players) only noticed the panel after five minutes of game session. This resulted in frustration for those players, some like P8, P6, and P11, put the guilt in themselves, saying that it was straightforward, but they did not perform well. We can also attribute the performance of the Acrobat players to the speed at which both users walk and teleport in VR; it takes them some time to get calmer and look around. In conclusion, a simple positioning choice significantly impacted half of the players on Test 2; it is essential to say that not necessarily games intend to give all the information quickly. However, it is essential to point out that the main objective of the phase was not to find the panel when it became a problem for those users; it increased their cognitive load for the following tasks and also added frustration to the whole experience with the puzzle, as a symptom of cases like that *improve the visibility of interactive objects* also appears on Table 14 as a suggestion.

In a general way, P1, P6, and P12, players from different types, showed disappointment when he discovered the solution to one puzzle where they were stuck, they said that "expect much more of it," it also reinforces that when they missed a piece of crucial information prior to the fundamental objective, players tend to think that or it is more complex than it appears or they are an awful player.

On Test 3, the combat and investigation moments were sectorized, so we did not have any case where players did not find the cards that were essential for the tasks, but after the first combat section, P1, P7, and P8 forgot what the main objective of Test 3, (open the blue door showed on Figure 17b). Besides that, combat sections did not disrupt the exploration tasks because players could tell where they were safe and not.

The same did not occur on Test 4, where players demonstrated a higher level of anxiety, showed in Table 11, Players that are not used to horror and action experiences - Explorers (P2 and P10), Supervisors (P7 and P12) and Companions (P9 and P11) - were the ones that declared more significant anxiety scores on this test. Moreover, this was crucial to those players' experiences, except for P2 that presented the best time on this test, as shown in Table 7. Interestingly, besides the anxiety level is significantly higher, the level of happiness and surprise also grew, meaning that users felt happier that they concluded the section and were proud that they did it.

Despite being the players more prone to exploration, Explorer players (P2 and P10), were not the players with the longer exploration times; on Test 1, they had respectively 4min10s and 3min50s, which seems very low when compared with P6 (Adventurer player) that had 11m30s, but those players are focused and already know where to look at, so they were more assertive on exploration than other players, presenting lower confusion times.

Something interesting happened on Test 2, where P7 (Supervisor player) used a different strategy, noticed that developers put the answer drawing alone, not intersecting with other drawings, to solve the puzzle, and bypassed the game hints, and first objective the basket with floating cardboard activated by the red handle showed in Figure 17.a. Being on the top 3 times for this test, along with the Explorer players, times could be seen on Table 6. P11 (Companion player) also noticed and talked about this during the experience, but was already with all cues liberated.

One more time, is essential to highlight that P2, P9, and P10, have played previous Half-life games; it seems that those players had previous knowledge that applies to

Half-life:Alyx (VALVE, 2020), on the dynamics and puzzle style, they do not seem so lost as other players, meaning that, this historical base made a significant difference on their behavior and performance during the sessions.

9.1.1 Strategies

In this subsection, we will point out the identified ES strategies related to an active investigation, identified through the framework analysis and their effect on the participant performances.

9.1.1.1 Light Contrast

We identified clear strategies regarding active investigations on the parts we selected as tests, one of the most common was the *light contrast* as showed in Figure 21.b, where the developers marked a possible path or a point of interest to draw players attention. In that case, it worked well and showed the players the room as a critical part of the problem resolution. However, in the case of the broken window with flickering light, shown in Figure 21.c, half of the players could not find it or did not understand it as a way to go, it may be due to the lack of examples of this kind of interaction, as the users move to different parts of the game, they could not develop a slow learning curve, another aspect is that in non-VR games it is not common to be able to enter through closed windows or take every object on the environment, so it was expected that players could not imagine those as clear possibilities without having any previous experience as seeing it or doing it.

9.1.1.2 Glowing and Moving Objects

Another strategy was the glowing and moving objects, as a way to highlight essential elements on the scene, as the floating cardboard on Figure 17.c, but in that case, the majority of the players saw them initially as an interactive element, and some thought that it was, in fact, the puzzle, that in some way you could rearrange and get an answer from it, that was one of the aspects that caused frustration on users during Test 2.

On the glowing and moving objects of this puzzle, we had the issue that any of them were interactive, and it caused much confusion, leading players to think that they should interact with the lights and the "floating cardboard ." Therefore, it is a little misleading to put those elements together; the clearer understatement that what the players are doing is something like a "decryption" task could help them understand better; developers presented some elements of it and some players get it, but it was harder for the ones without previous half-life knowledge.

Finally, the flickering light window on Test 4, many users have a problem finding that element, and some users thought they should enter through the blue shielded door on the end of the hallway. It is clear that the idea there was to create a feeling that the user was trapped with the enemy. However, it would be more prosperous if it could have different options like proposed by some users, using one of the dead combined clothes to pass through the blue door, or even to trap the enemy differently, using the door that the player entered from - it would difficult some linear aspects of the development. However, it could make the experience richer and less painful.

9.1.1.3 Color Schemes

Apart from the symbolism presented in various game elements, the color patterns are an excellent strategy to show dependency or a relation between different elements, as we can see on the cards and doors on Test 3, that we can see on 21a and 21b, we saw during the very effective tests, and also applied with an excellent rhythm to not confuse the players.

The main problem observed regarding the investigation was due to the discoverability or interpretation of the elements and strategies applied. As an example of that, we had the puzzle of Test 2, the first problem being the discoverability of the panel, that many users did not see; P2 even stated that "it makes no sense being on that height, it was only put it like that too made more difficult to find and use", implying that the affordances are not correct on that panel. That task did not add to the overall puzzle resolution, so it upset some players.

In that case, it seems that a solution that can help mitigate lost users trying to find one specific element is to make more than one option for players to discover an object or objects that will lead them to solve the puzzle, have more than a straightforward

puzzle or have an interaction that "forces the player" to look at particular objects, as we saw, different kinds of players deal differently with those interactions, so it seems logical to develop different ways for them to discover in a way that makes sense for them.

9.1.2 Lessons Learned on Active Investigation

Based on the experiments, players of different types performance, and opinions on the list below, we will summarize guidelines on the production of strategies and elements for active investigation:

- In VR, in-game literature is not the best way to convey information; it is simply not easy enough to read long (diegetic) texts on VR;
- On the resolution of problems, it is essential that affordances work correctly; previous references and experiences are a significant part of problem resolution tasks;
- Contrasts of light, sound, or color are an excellent way to deliver cues;
- Patterns of light, sound, or color are an excellent way to set relationships between elements (those two presenting the same pattern);
- Near moving objects in VR are attractive, and players will mostly think they are interactive;
- Player's inexperience, interaction problems, or fatigue can heavily disrupt moments of investigation;
- Elements that serve as input devices for players as panels, padlocks, keyboards, must be easily discoverable, as they are the centerpieces to some micro-stories or puzzles, not finding them leave the players unaware of what problem they should solve;
- On moments of deep investigation, players must feel safe, but controlled tension can make the experience more interesting;

- When leaving cues to investigation is vital that they seem cohesive, that they do not look fake or planted (unless it is the objective);
- Actions are an excellent tool for portraying specific scenarios and practically narrating stories;
- Regarding evidence, elements are essential to corroborate themselves; information and objectives could be reinforced gradually;
- Allowing the players to do actions to discover facts themselves is a compelling approach to engage them on the storyline, but must be used carefully to avoid confusing them;
- Imagery can trigger memories of previous findings and help players connect pieces of micro-stories.

9.2 WORLD REINFORCEMENT

This section will discuss the world reinforcement elements and strategies used on Half-life:Alyx (VALVE, 2020) and how those approaches influenced the player's performance and understanding during the sessions.

The first aspect is geography; P6 was the player who commented more during the sessions about where the facts occured and identified environment elements as being of Russian culture, and the Cyrillic alphabet amplified that sensation. By the architecture and general environmental elements, it was clear that the game's events did not happen in the USA. For players who knew the Half-life series (P2, P9, and P10), it seemed clear since the beginning that it happened on City 17 (the same where Half-Life 2 events occur).

Those players seemed to be an advantage regarding the challenge to understand the context and the dynamics at the beginning of the game; none of them had problems understanding how the game tells the storytelling or presents environmental elements; once more, the previous experience helped the overall player experience.

On Test 1, we observed problems with affordances, like books that did not open or buttons that did not do anything on working equipment. However, some elements work; some players perceived them as inconsistent and strange behavior. Affordances

are essential to the believability of those experiences, and those independent elements of the environment add value to it and must be represented accordingly (MCMAHAN; LAI; PAL, 2016).

Mainly in the introduction, players are presented with the *Combine* Forces, on the environment they can see, their clothes, their voices, and their attitude towards the citizens. Then, practically, the developers constructed scenes that demonstrate the power relation between those actors and what the *Combine* forces mean to the people of the City 17.

9.2.1 Strategies

This subsection will discuss some strategies used on Half-life:Alyx (VALVE, 2020) regarding world reinforcement. The strategies analyzed play a crucial role in the data gathered from the user informally more then half of the users directly stated after Test 1 that they were very impressed with the world and the presentation of the city, those statements corroborate with better scores on VAS, showed on Table 8.

9.2.1.1 Evidence Overload

As said previously in subsection 4.3.1.1, evidence overload is a common way to present much information at the same time and leave the player to unpack it as helpful information. In the specific case of Test 2, this strategy is used to present information about the base story of the game, help the players solve the puzzle, and present alien elements as fungus and living organisms. This approach was successful; it was clear to all players that they should look to the mural to find answers.

9.2.1.2 Abandoned with past elements

During the four tests, players are presented with a city that presents elements in two languages, it not only reinforces the contrast of information, meaning that modern aspects, and more impactful on the player session were written in English, and content about older times of city 17 were presented in Russian. In addition, it reinforced the story and guided the players to more focused readings (as none of them could read

in Russian). We can see this strategy as a variation to the abandonment approach, described in subsubsection 4.3.1.2. In this case, the city was abandoned but "repopulated" or re-educated to a new kind of society on top of the older one.

9.2.1.3 Abandoned with overlayed elements

On Test 4, we can see another adaptation of abandonment, as described in subsubsection 4.3.1.2. Locally, the elements could reflect the use of space, as in Test 4. The players are inside a distillery, and it was also reinforced for the vodka bottles, which also serve an interaction purpose on the game sessions. However, the developers presented a completely human industrial environment with alien overlays, that is an approach that shows domination over a previous agent that was the owner of the place before; this strategy also appears on Test 1 and can be seen in Figure 11 but in that case the elements are from *Combine Forces*, their elements on top of human elements. This approach tells a lot in itself about the entire setting; the case presented on Test 1 seems more global, when the case of Test 4 seems more local, regarding the alien domination over human structures, this approach was well received by players that did not criticize the cohesion of the world or the events that occurred in it.

9.2.2 Lessons Learned on World Reinforcement

Based on these experiments, players of different types, performance and opinions on the list below, we will summarize guidelines on the production of strategies and elements for world reinforcement:

- Affordances must always be respected; they can be altered but not ignored; they are a way to instantly connect the user with references from the real-world and other experiences;
- Cohesion is crucial when we are presenting a world;
- When users understand the world around them by themselves, they felt empowered and excited.

- Signs were a successful way to transmit information universally, disregarding the player's culture or language;
- Different spaces are good to create a clear separation of what users must read and what they can if they want to know;
- World reinforcement is a passive characteristic for environments, so it is essential to build the strategies in an accessible way;
- Is critical that characters and the worlds they live make sense; it must be an essential task to unite these two aspects of the virtual experience.

9.3 DIRECT COMMUNICATION

VR being a medium where the free head movement is crucial to the fluid interaction, the developers cannot lock the camera on specific moments and perform classic cinematics. Instead, Half-life Alyx projects many of its direct communication elements on audio through Russel. This secondary character contextualizes many moments and is present throughout the game.

It was noted that both Acrobat players (P5 and P8), by nature, did not wait for the cinematic events to be over to continue walking, also not paying much attention to it; this fact is probably related to the high pace and excitement of the players during the experience. As a comparison on the video analysis of Test 1, test with more considerable cinematic time (audio and video), shown in Figure 27, we can see the difference between P5 (Acrobat) and P6 (Adventurer), P5 was performing other activity during 2min of cinematic from a total of 6min and 40min, P6 performed other activity during 1min during 8min30s of cinematic time [1].

The only video element that was presented during the tests was the Eli Vance video call on Test 1, P4(Adventurer), P7(Supervisor), P11 (Companion), and P12 (Supervisor) stated that they did not understand what the conversation was about. However, all understand that Eli is Alyx's father. During the initial moments of Test 1, P4(Adventurer), P7(Supervisor), P11 (Companion), and P12 (Supervisor) also declared that they did not understand what the primary objective of chapter one was, - A information con-

[1] Total time varies because cinematics can be cut short if ignored, or not even be triggered if it depends on specific exploration event.

tained at the video - analyzing their experiences I believe that, any of them has specific reasons that made them feel lost in the conversation; all of them are newcomers to VR, so it was noticeable that they felt a bit overwhelmed at the initial moments—discussing interaction modes, joystick mappings and game bugs with the researcher during the video call.

Another issue that happened, mainly in Test 3, was the users not hearing or not being able to pay attention to Russel's dialogue; P1, P4, P6, and P8 declared that they did not understand the dialogue between Russell and Alyx after the first enemy encounter, in the game sessions of P3 and P6 a game bug made the audio play during the fight, something that confused the players.

Actions and audio mainly present the relation of the citizens with the Combine Forces; in the first moments of Test 1, players can see the soldiers commanding citizens to go home, arrest people, and close the streets. These relations were well constructed, P6, P7, P10, and P11 presented adverse reactions when seeing how the soldiers dealt with people.

Another use of actions happened on Test 4, with the introduction of larry, which can be seen in Figure 23a; Larry introduces the players to Jeff, that will be the enemy on this test. P7, P8, P11, and P12 users thought that they needed to reach the part of the environment where larry was, literally following him, which caused some confusion on this part of the test - because it is not possible - but the tutorial on how to guide Jeff was very effective, only P7 did not understand the concept of throwing the bottles to guide the enemy, but quickly understood that the sound was the central dynamic of the enemy.

9.3.1 Strategies

In this subsection, we will point out the identified ES strategies related to a direct communication, identified through the framework analysis and their effect on the participant performances.

9.3.1.1 Practical Cinematics

As said in the last section, developers had to adapt their cinematics to a more accessible format, where the users can roam free; this was a good translation of a well-established format, and most classical form of direct communication, in the specific case of Half-life:Alyx (VALVE, 2020), many of these moments were conducted by Russel's dialogues guiding the player's vision through the environments. In general, it worked successfully on the experiment, with a few problems, but by the amount of information transmitted, it was understandable.

9.3.1.2 Universal Signage

Using symbols that mean the same thing in various languages and cultures, like stop signs, biohazard symbols, or arrows, the developers reduced the users' work and cognitive load that they will need to use to interpret more complex elements. In the case of the plaques of Test 2, it suffered from discoverability problems, but when the players saw it or got a hint for it, it was an easily understandable conduction.

9.3.1.3 Actions as Tutorials

For Test 4, the actions of Larry were essential for users to understand and be presented to the enemy satisfactorily and naturally, users also have space to pick bottles before practicing the throwing,

9.3.2 Lessons Learned on Direct Communication

- In VR, non-diegetic direct communication must not be applied. For example, it is not comfortable to read extensive menus on VR;
- Cinematic (videos or actions) must be treated with much care in VR. As a medium that cannot trap players' vision (as traditional games), it is hard to make sure they are paying attention to the correct elements, as developers intended;
- Direct communication should not spoil or create tension over the active investiga-

tion elements. Instead, both must work aligned to confirm players' discoveries;

- In VR, direct communication can disrupt the experience in crucial moments; it is essential to sectorize the moments where users will absorb information;
- Signage is an excellent way to create non-verbal static communication; it is also an excellent way to guide users, but it must be a reason for those elements to exist; they must not hurt the cohesion of the environment;
- Actions and Videos are an excellent combination to reveal something about a character or crucial information that will help the players to construct a general meaning for the story that is being presented;
- It is possible to create elements that guide users' vision naturally, e.g., a spark in the dark, a character is walking faster than other characters. This can perform practical cinematics with actions naturally and immerse players in an interactive situation with the characters;
- Tutorials disguised as actions or videos were generally well received by players;
- Direct communication is helpful in complex information messages, but it must be limited not to bore the players;
- Other characters can be interactive agents for when players actively need direct assistance.

9.4 LIMITATIONS

During the construction of the presented work, we confronted various setbacks, mainly due to the COVID-19 pandemic (2019 to 2022); as a work that required in-person experiences, that factor was determinant on aspects such as:

- **Number of participants:** The original number was a minimum of 24 participants but was shrunk to 12 due to restrictions of the university and the lab that hosted the research.
- **Variability the Participants:** The research could not be open to the whole university, as another restriction imposed by the Centre that accommodates the lab

(Centro de Informatica). The Institution only allowed people with professional or educational credentials to enter the buildings, making it impossible to enter with external participants; This restriction remained until late 2021.

- **Scalability:** Besides the logistical limitations, in some cases, the experiments became longer than what was expected, so it was decided to host at max two experiments per day, as some of the initial experiments were 3 hours long (complete experience with breaks, questionnaires, and interviews).

The aspects above had, as a consequence, some limitations on the information that we gathered in the study. Manly regarding the number of 2 participants per group (totaling 12 participants), this limitation affects us regarding the generalization of the findings; in some groups, we saw similar behavior (as Explorers, Acrobats, and Companions), but in others (Mercenaries and Adventurers) their strategies were different, so becomes complicated for the research to determine when the type of player associates some behavior and when is associated to background personal experience of the players.

10 CONCLUSION AND FUTURE WORK

The purpose of this study is to highlight that ES has shown promising results in the field and has been discussed for years as a strategic approach to building environments and portraying long stories. When combined with the benefits of VR, it can amplify the VR experiences on a deep level, making them more vivid and engaging. The know-how on ES is mainly obtained through previous experiences from authors from the field. In this work, we focused on obtaining knowledge through an experiment, users feedback and performance during game sessions. To achieve that, we developed the ESC Framework, also incorporating all the knowledge obtained from previous authors on the field. The team analyzed players of different types to understand the effect of those approaches on them . What was apparent in the results is that it is essential to build a structure that guides players through complex stories, mainly in VR, where many distractions can occur. Users are encouraged to touch and take the environment elements into their hands; those experiences rely a lot on what the users are facing and understanding of those virtual spaces.

As the main objective, we focused on understanding the impact of ES on VR players, making the users' good experience the main goal was the best way to present curated information regarding what is crucial for the approaches to work or not on many situations. A literature review was constructed to point out the main definitions, techniques, and methods regarding the scope of this study; all this data was the base for the construction of the framework and the experiments. It was a crucial phase for us to understand the field.

Based on those, we proposed the ESC Framework as a classification tool for ES elements, which also help to identify and understand strategies on existing experiences. The framework is a way to organize this dataset of assets analytically, thinking about their purpose and objective on the scene. The framework can also be used as a design space for new experiences; we propose that the same structure can be used reversely to sketch strategies, elements, and environments quickly, helping researchers, designers, and developers construct virtual worlds based on narrative. The framework helped us shape the experiments, focusing on specific parts of the selected game, the parts that would lead us to the most impactful moments, to obtain the crucial reactions and

feedback from the participants; The classification of the game environments was vital information to know what to expect from the users during the game sessions and to be aware of what elements were found and what was not. It also opens to discussion on what to do regarding the discoverability of those elements on scene.

The results brought by the framework aligned with the data gathered from the experiments on the analysis brought various insights and highlights of how to construct those environments. Those can help designers and developers to build experiences in a strategical way, always with the most engaging, efficient and pleasant experience possible in mind.

Regarding the findings, the framework gives us information about the elements of those scenes and how they are grouped along with the strategies and objectives of those environments. The ESC Framework was a crucial tool on this process. Being Half-life: Alyx (VALVE, 2020) a commercial game with a complete experience and many hours of possible gameplay, the framework was beneficial for us to understand how to divide and organize the elements and identify strategies that the users would use on the experiments.

On the experiment results, we presented that not necessarily anxiety-inducing experiences are necessarily bad experiences. As we can see in Table 11, even when some users present the maximum anxiety level, they can still have fun and enjoy the experience of overcoming those challenges; this style of experience design is also discussed in Chapter 3. Results also showed that the different types of players had different results and behaved differently according to their play style or preferences. It also reinforces the discussion on Chapter 3 that it is not possible to design a solution that accesses every user, but it is essential to make the experience available and customizable for different players. Even in a narrative way, some users felt obliged by the game to do a specific task or action when they were trying to solve the problem in a way that the game does not allow, it generated frustration and removes the player a bit from the immersive state. In general, the ideal situation seemed to be present different ways to solve problems and expect that users find the ones that will be more coherent with their type of resolution.

In Chapter 9, we inserted three sets of lessons that we learned during the application and analysis of the experiments, some of them were directly related to VR, some to action games (as is Half-Life: Alyx (VALVE, 2020)), others are general to ES. Those

lessons are a way to concentrate our findings straightforwardly, considering the literature, framework development, and players feedback that are the fundamental parts of this work.

As future works, we can point out that the method could be simplified in order to facilitate the tests, or even research objectives could be more focused on a specific type of player (the ones defined by Vahlo, Smed e Koponen (2018) or experience (e.g., Horror games, shooting games or sports games) Doing so, researchers will have a lower test time with the participants. Moreover, the findings can be more specific to an area.

The research team encountered a set of difficulties that forced us to make the application of the experiments locally, among them: the lack of known users with VR equipment at home, the lack of players with the specific game, and the impossibility of controlling the game data (as saves) in different accounts and computers. One of the possibilities that can solve part of this problem is instead of using a direct part Half-Life: Alyx (VALVE, 2020) campaign, is to make a mod that uses the exact parts of the original experience that is needed, this is a possibility because all the maps are provided on the map editor by the developers of the game. Moreover, this possibility would allow researchers to invite people from the game community to perform the experiment accompanied by a researcher remotely. However, this alternative showed to be costly and create a vast number of new difficulties, but it could be used on different objectives.

Another future work is to make this experiment more scalable; regarding the number of participants, the solutions could also be the ones described above or even new aspects added to the experiment. It would undoubtedly reinforce some of our findings and bring more to the discussion.

In this work, a lot was discussed about the practical way to tell the stories and how to embed them inside the environments. However, the discussions regarding ES are not over, many subjects can be explored and analysed through the scientific lens regarding the application and consequences of those approaches. The focus on the construction of story-based experiences should always be to deliver those stories in the best way possible, The idea that we can help developers and designers achieve the objective by sharing knowledge and tools that they could use to improve and amplify their experiences is one of the key motivations for this project.

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