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Atmospheres of Immersion

Designing and Experiencing in Architecture and Virtual Reality

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Guilherme Nunes de Vasconcelos

Atmospheres of Immersion
Designing and Experiencing in Architecture and Virtual Reality

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ATMOSPHERES OF IMMERSION: DESIGNING AND EXPERIENCING IN ARCHITECTURE AND VIRTUAL REALITY

GUILHERME NUNES DE VASCONCELOS

Tese submetida à Comissão Examinadora designada pelo Colegiado do Programa de Pós-Graduação em Arquitetura e Urbanismo da Escola de Arquitetura da UFMG como requisito para obtenção do grau de Doutor em Arquitetura e Urbanismo, área de concentração: Teoria, produção e experiência do espaço.

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RESUMO

Essa pesquisa investiga a produção e a experiência da imersão em arquitetura e realidade virtual (VR), com o objetivo de desvelar os efeitos cognitivos da VR e compreender por quais motivos essa tecnologia ainda é subutilizada pelos arquitetos para projetar. Esse estudo se aproxima da cognição pela perspectiva enativista, assumindo que a cognição não se restringe apenas ao cérebro de um sujeito, mas se estende por todo o organismo, incluindo o acoplamento sensório-motor do organismo com o ambiente. A imersão é abordada a partir do ponto de vista da fenomenologia, priorizando, sempre que possível, as experiências em primeira mão do autor. Alguns dos aspectos teóricos que emergiram durante a pesquisa foram investigados por meio da prática, seja por meio de experiências imersivas de terceiros, seja pela produção de dois 'estudos práticos' desenvolvidos para a tese. Os conceitos de tecnologia e imersão foram estudados para avaliar a pertinência do termo 'tecnologias imersivas' e para fundamentar teoricamente a possibilidade de uma 'arte da imersão'. A experiência de imersão em arquitetura e VR é analisada, chegando ao conceito de atmosfera como um possível território comum às experiências. A noção de representação, por sua vez, guia a discussão sobre a produção da arquitetura. A relação entre corpo e representação arquitetônica também é investigada, desvelando como a eficiência tornou-se cada vez mais um padrão, implicando a redução dos aspectos subjetivos e o desengajamento do corpo durante o projetar. O estudo mostra que os softwares disponíveis para o desenvolvimento de experiências imersivas em VR são ou muito complexos, demandando o desenvolvimento de habilidades que não são usualmente parte do domínio dos arquitetos, ou muito limitados, restringindo a experimentação. A análise da percepção da imersão e da atmosfera revelou aspectos subjetivos relacionados à instrumentalização da imaginação dos arquitetos, dificultando a percepção de usos alternativos para a VR. Por fim, argumenta-se que o potencial mais significativo da VR para os arquitetos relaciona-se às atmosferas improváveis que essa tecnologia pode trazer à presença, permitindo que os arquitetos experimentem e sejam afetados por espacialidades que não são apenas uma reprodução digital da aparência e/ou do comportamento de um ambiente físico.

Palavras-chave: imersão, realidade virtual, projeto arquitetônico, atmosfera, cognição, experiência

ABSTRACT

This research investigates the production and experience of immersion in architecture and virtual reality (VR), aiming to disclose VR's cognitive effects and to understand why architects still underuse it for designing. Assuming that cognition is not restricted to a subject's brain, this study adopts an enactivist perspective on cognition, implying that it extends through the entire organism, including its sensorimotor coupling with the environment. Immersion is approached from a phenomenological standpoint, prioritizing, whenever possible, the author's first-hand experiences. Some theoretical aspects that emerged were investigated through practice, whether experiencing third-party immersive experiences or producing the two 'practice studies' developed for this thesis. The concepts of technology and immersion were studied to evaluate the pertinence of the term 'immersive technologies' and to ground theoretically the possibility of an 'art of immersion'. Immersion in architecture and VR is analysed, arriving at the concept of atmosphere as a possible common ground between experiences. The notion of representation, in its turn, guides the discussion on the production of architecture. The relationship between body and architectural representation is also investigated, disclosing how efficiency became increasingly the standard, which implied the reduction of subjective aspects and the disengagement of the body in designing. The findings show that the software available for developing VR immersive experiences are either too complex, demanding the development of skills that are not usually part of the architects' domain, or too limited, restricting experimentation. The analysis of the perception of immersion and atmosphere disclosed some subjective aspects related to the instrumentalizing of architects' imagination, which hinders the perception of alternative uses of VR. Finally, it is argued that the most significant potential of VR for architects is related to the unlikely atmospheres it can bring to presence, allowing architects to experience and be affected by spatialities that are not only a digital reproduction of the look and/or behaviour of a physical environment.

Keywords: immersion, virtual reality, architectural design, atmosphere, cognition, experience

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0. On a personal level

My interest in immersion begins as a child. My parents, very talented with manual skills, soon realized that I did not inherit such skills and chose to initiate me early on in the world of video games and computers. As a result, I have some ability with digital things, and if I have any manual talent, it is limited to the digits.

Therefore, I dedicated a good part of my life to devices that involve the gesture of pressing with fingers, such as controllers, keyboards, and musical instruments. Among these, I found an analogue apparatus that stands out: a 1950's Tele-Visex stereoscope that was a gift from my grandmother to my father (FIG. 1). The Tele-Visex was the Brazilian version of the famous View-Master from the 1930s. It consists of a Bakelite device with a small lever on the right side, and a slot on the top, where to be used, a pressed card reel should be inserted. Each reel has 14 images, and the stereoscopic effect happens when opposed images align with the device viewers. Thus, each reel has seven positions that are changed by pushing the lever. The reel spins with each movement, revealing a pair of images and its corresponding title, which is printed on the reel and visible only without wearing the device.

Seven movements correspond to a revolution, and a story or theme is presented. The reels I inherited from my father were related to children's stories (e.g., *The Three Little Pigs, Snow White,* *Mother Goose*) or generic topics (e.g., *The Maoris from New Zealand, Trained Chimpanzees*). This device introduced me to the potency of stereoscopic immersion, a stronger and more convincing type of immersion than the experiences I had with video games or movies. However, as a good part of our childhood interests and objects, Tele-Visex was soon forgotten in some drawer.

Many years later, a quick visit to the office of my friend's father sedimented a desire that I did not even know I had. It was a small and ordinary office, but the smell of old paper, the light, the drawings on the desk, and some low volume music in the background, composed an intellectual atmosphere that was enough to seduce me into architecture. I was presented, once more, to the potency of immersion and its effects.

The encounter that led to this thesis came even later, already as an architecture lecturer. In 2016, someone invited me to test the new virtual reality (VR) equipment that arrived at our school. I was so affected by the experience that I went to the school on the weekend, and I do not know how many hours I spent downloading and playing every game and software available for VR.

Since then, I have become increasingly interested in the phenomenon of immersion in its various manifestations, which led me back to my father's Tele-Visex. By looking through this device, it is possible to foresee several questions investigated here, such as the possibility of feeling somewhere else, the relation between movement and perception, and the experience of unlikely atmospheres: questions that resonate strongly with architecture.

These three immersive experiences help contextualize from where I am approaching the discussions of this thesis. I try to gaze in the intertwining of body and technologies, architecture and VR, seeking to disclose the intricacies of producing and experiencing immersive experiences and their effects on a subject.

1. Introduction

The departing point of this thesis is based on an intuition that VR could play a key role in architectural design practices. The real estate agents and some architecture offices already envisioned the seductive, convincing, and communicative potential of presenting their products in VR. By using VR, the challenging task of explaining plans and sections to people who do not know the codes necessary to understand this type of drawings satisfactorily can be substituted – or supported – by the experience of the 'space' itself.

To imagine a space from its bi-dimensional representation is not a simple cognitive process. First, one has to understand what is represented in terms of codes and scales and then imagine him/herself in a specific position concerning that space. The drawings' scaled dimensions should be related to his/her body position accordingly to have an accurate idea of the space. Nonetheless, the materials, furniture, reflections, light, etc., should also be part of that mental imagery. It can be said that the creation of precise mental images is a difficult task, even for experienced architects.

As architects started to migrate from drawing boards to computers during the 1990s, it became less expensive to produce three-dimensional models and perspectives, which certainly helped the study and communication of the conceived spatialities. Nowadays, architects' most advanced software can extract, from the same model, the respective drawings and perspectives. However, perspectives are produced from a photographic standpoint, and even the parameters used when setting up these images are based on photography, such as selecting the camera's lenses, aperture, 'film' sensibility to light, etc. In this sense, the digital perspectives' limits are similar to those of photography: limited to screen/paper size, lack of depth, and what is portrayed is a predetermined and static view.

In cognitive terms, perceiving a space through photography is certainly more accessible than through technical drawings. However, as I intend to argue throughout this work, cognition is not restricted to the brain: it is embodied, that is, "cognition depends on the kinds of experience that come from having a body with various sensorimotor capacities" (Varela, 1992, p. 329).

In this sense, perception is constituted, at least partially, of sensorimotor knowledge, of knowing "the way sensory stimulation varies as a function of movement that is the basis of our ability to have world-presenting sensory experience" (Noë, 2004, p. 117). If we look at the conventional design process as practised by architects, it can be said that it seems to take the body and its movements into account in a limited way.

On the other hand, the experience of VR incorporates, at least in part, some of the body movements. For example, the current off-the-shelf hardware offer 'six degrees of freedom' (or 6DoF) in terms of movements, which means that VR devices can track translation movements (e.g., forward/back, up/down, and left/right) and rotation movement (e.g., pitch, yaw, and roll). Usually, the body parts detected are the head and the hands, but more parts can be included through other peripherals, if necessary (Lang, 2013).

As I described earlier, VR's relevance for architecture was already stated, although in what I consider as a very limited way. Therefore, to understand the limits of using VR in architecture, this investigation aims to study how architects produce and experience architecture from a cognitive standpoint.

1.1. Why study the cognitive aspects involved in producing and experiencing architecture and VR?

Among the several theories for cognition, three stand out, cognitivism, connectionism and enactivism. In an uncomplicated way, it can be said that cognitivism is based on the hypothesis that cognition is related to the manipulation of symbols, having the computer as a model. Thus, cognition aims to represent the world or features of the world in a certain way, or in short, for cognitivists, cognition is mental representation. On the other hand, connectionism tries to explain cognition using as model artificial neural networks that reproduce, in a simplified way, the brain elements, such as neurons, synapses, etc. For connectionists, information is stored in the connection strength between digital neurons. In this sense, mental processing depends on activating specific units with a particular strength, making the process dynamic and independent of symbolic processing, as argued by cognitivists (Buckner & Garson, 2019).

Varela et al. (1993) proposed the concept of *enaction* as an alternative from the traditional accounts of cognition. The enactivist theory argues that organisms have agency over their experience, emphasizing that the "experienced world is portrayed and determined by mutual interactions between the physiology of the organism, its sensorimotor circuit, and the environment" (R. A. Wilson & Foglia, 2017, para. 15).

Enactivist theory, sometimes called ‘embodied cognition’, is based on the idea that cognition depends on a physical body. Therefore, it is interested in understanding not only how “physicality opens up the experience of the self, the world and the others, but rather aims to specify the *mechanisms* that explain just how cognition is grounded in, and deeply constrained by, the bodily nature of cognitive agency” (R. A. Wilson & Foglia, 2017, para. 28). This premise has its roots in phenomenology and was developed mainly by Merleau-Ponty (1961, 1945/2012), Clark (1997, 2017), Varela et al. (1993), Shapiro (2011), and Noë (2004, 2012). Several pieces of evidence point to body participation in cognitive processes. For instance, when talking, we usually gesture, which facilitates communication and our thought processing. Another example regards the use of the body for remembering: when phone numbers needed to be memorized, it was not unusual to mimic the pattern of movements used to dial the number to remember it. Additionally, some of the spatial concepts we use are directly related to the body position, such as ‘up’, ‘down’, ‘front’, and ‘back’ (R. A. Wilson & Foglia, 2017).

In a first view, architecture and VR seem to present little in common: the former has to do with our everyday life, housing our bodies and activities, as the latter lacks materiality, and its existence is constrained to a specific time and space when someone is immersed in it. Since its popularization in the early-1990s, VR has been used in architecture mainly for visualization. VR experiences became increasingly similar to the physical world, and this ‘realistic’ aspect of VR seduced the architects to the extent that it seems to be a barrier to advancing its uses for other purposes.

Whoever experiences wearing a VR head-mounted display (HMD) understands why it is so easy to be seduced by what is presented: it deceives you into feeling that you are present ‘there’. Furthermore, depending on the experience, even subtle movements of the head and hands are captured, enabling the exploration of the digital space similarly to how it is done in the physical space.

However, even if there are similarities (and there are several), VR and architecture experiences cannot be considered equivalent. Studying their differences can inform us about the limits of each technology and experience, which can open up possibilities for other uses of VR. Both experiences can be divided into two stages, the experience of production and the experience of experiencing.

In this study, the production of architecture is restricted to the design phase that antecedes the building itself. In this phase, the architect conceives the spaces and represents them through technical drawings, which compose the documentation that contractors will use to erect the building. The production of VR is related to the moment when the elements needed for the experience are modelled, programmed, and assembled.

However, to consider production and experience as two different moments, an apparent division is created in a process that is not perceived as such. Usually, one of the leading causes that determine the end of both architecture and VR production is the deadline, a time limit rather than the limits of the process of production itself. In this sense, the distinction between production-experiencing is arbitrary since one can always question when and where the production ends and experience starts. Or rather, is there no experience of what is produced during production?

In architecture, the iteration cycle between producing-experiencing tends to be more dilated than in VR, mainly due to the organizational complexities involved in any space's physical construction. The construction's materiality requires a time of its own, which, however optimized, resists the immediacy that characterizes the digital.

Nevertheless, the cognitive aspects of producing and experiencing seem to be dialogically related. In other words, the experience of producing can inform the 'experience of experiencing' and vice-versa.

Since 2012, VR equipment, such as HMDs and tracking systems, has improved technologically and has become more affordable. In addition, the gaming industry's growth influenced the development of easy-to-use and free game engines used to create VR applications, making the programming of VR experiences easier than the 1990s scenario. In its current development stage, in 2020, it is possible to experiment and modify the development of immersive experiences 'from inside', using VR equipment, almost in real-time. The possibility of being present and having agency over space and other elements of an immersive experience as they are created is recent and can transform how VR applications are developed.

On the other hand, architects have been producing spaces in practically the same way for some decades. Since the 1990s, the Computer-Aided Design (CAD) software became architects' primary tool, substituting, to a large extent, their traditional instruments, such as drawing boards, rulers, pencils, etc. The CAD tools, especially the software that operates as a digital drawing board (e.g., AutoCAD), require a cognitive engagement far from trivial from its users. Therefore, there are several levels of abstraction that should be considered in the operation of this software.

The gains brought by digital tools for productivity and precision are hard to deny, which justifies their massive adoption. Additionally, digital drawings can be altered, revised, or reformulated more cost-effectively. However, digital tools also bring some losses, especially regarding the body's engagement with what is produced. The movements involved in operating traditional tools were related, in a certain sense, to what was being drawn. In this sense, the body engages differently in handmade drawings depending on the shape and size of what is being drawn, which does not happen in digital drawing.

The subsequent generation of software used by architects based on parametrization, such as the Building Information Modeling (BIM) and generative design software (e.g., Grasshopper), added even more abstraction to the design process. In their latest versions, the leading BIM software embedded VR visualization natively. Before integrating this feature, the visualization in VR demanded the use of other software, the conversion of files into other formats, and even some programming to make the model navigable in VR. Therefore, this step seems like a critical move toward seamless integration of VR in the architectural design process. Currently, the interactions in VR with the building models are still limited mainly to visualization, design compatibilization, and minor modifications. However, in the following versions, these limitations tend to be overcome.

Nevertheless, even though BIM software automates a significant part of technical drawings, enabling and ensuring the consistency of the architectural documentation, it does not seem that BIM software is the most appropriate for the early stages of design, where spatial perception, creativity, and sensibility have a significant role in the experimentation that characterizes this phase.

If we consider the development of architectural and VR software as a vector, it is possible to say that they are pointing in different directions. It seems that the vector of architectural software is pointing in the direction of the optimization of the design process that is each time more controlled, abstract, and disembodied.

On the other hand, the development of VR immersive experiences seems to point in the direction of becoming less abstract, for example, by easing the programming of interactive elements through visual scripting (e.g., Bolt 2, Blueprints), by adding ready-made solutions for implementing support for VR output, and even enabling the design of VR experiences while in VR[1]. Furthermore, after adding and setting up VR in the engines, to get 'in' and 'out' does not take long and literally depends, potentially, on clicking a single button. In this sense, the possibilities for experimenting with space from 'within' facilitated by the current development stage of VR technology can favour a better understanding of the cognitive aspects involved in the perception and design of spatialities.

The architectural design process was and still is extensively discussed by scholars worldwide. One of the seminal works in this field, developed by Schön (1983), considered design as a conversation with situations' materials. The architect shapes the situation from her/his initial appreciation based on her/his perception. Then, the situation 'talks back' to the architect, which responds to the backtalk, setting up the conversation. If the architect is perceptive enough, the situation can be reflective, as her/his reflection-in-action can iteratively construct the problem and action strategies.

In other terms, the reflective conversation is about seeing, moving, and seeing again. The architect needs to draw something, observe what was drawn, reflect on it, and restart the cycle by drawing again. By being simultaneously observer and observed, the architect can discover the unintended consequences of his/her moves through a critical attitude towards what is being created (Schön, 1992).

Nevertheless, a "designer's knowing in action involves sensory, bodily knowing. The designer designs not only with the mind but with the body and senses" (Schön, 1992, p. 5). Tschimmel (2011) argues in the same direction, considering perceptual reflection, which involves the body senses, as an essential skill and procedure in designing: "What the designer perceives with all his senses while he is reflecting on a design task has a profound impact on how a situation is interpreted, how analogies to other knowledge domains are made, and how design solutions are developed" (Tschimmel, 2011, p. 4).

The medium used by the architect can be considered as part of the situations' material where the conversation takes part, as argued by Schön (1983). In terms of cognition, "simple external props

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[1] See the video for more information: "VR Editor: Building VR in VR with UE4". https://bit.ly/3pjJs70. Accessed 12 Nov. 2020.

enable us to think better and hence to create more complex props and practices, which in turn 'turbocharge' our thought a little more, which leads to the development of even better props" (Clark, 1997, p. 62). If this holds, an architect who uses VR to design rather than bidimensional digital interfaces or pen and paper will think differently. Thus, ideally, a medium should introduce new ways of acting and perceiving.

In this sense, by considering the body as an inseparable part of cognition (embodied cognition), it can be assumed that the different ways of bodily engaging with a medium in the design process produce changes in designing. Therefore, the investigation of the processes of production and experience of architecture and VR can reveal how the architects' cognition can be affected depending on how they produce or experiment.

1.2. Aims

This thesis aims to discuss from a phenomenological perspective the immersive experiences in architecture and VR, relating the production and experience of immersion in both mediums, seeking to disclose the effects on cognition that VR can offer and understand the current limits for the effective incorporation of VR into architects' design processes.

1.3. Objectives

a) To understand how the concepts of technology and immersion are related in the context of immersive technologies through a bibliographic and documental survey from diversified sources;

b) To discuss the modes of engagement of a subject with immersive experiences, studying the possibilities for interaction between subjects and technologies for immersion;

c) To investigate the similarities and differences between the immersive experiences of architecture and VR and how these experiences affect the subject's cognition;

d) To analyze the experience of production in architecture relating the development of representation technologies (from technical drawing to BIM software) and architect's body engagement during production;

e) To develop, present and discuss two immersive experiences (practice studies) in VR to understand through practice the technical aspects, limitations, and workflow involved in the experience of production in VR;

1.4. Methodology

Qualitative research intends to deal with the essence and ambience of things, considering the concepts, definitions, characteristics, meanings, symbols, metaphors, and descriptions of things (Berg & Lune, 2017). Furthermore, qualitative research has the "capacity to take in rich and holistic qualities of real-life circumstances", as well as the "flexibility in design and procedures allowing adjustments in process", and "sensitivity to meanings and processes of artifacts and people's activities" (Groat & Wang, 2013, p. 257).

The qualitative research strategy adopted in this thesis is based on, but not restricted to, phenomenological inquiry. Merleau-Ponty (1945/2012) defines phenomenology as

> the study of essences; and according to it, all problems amount to finding definitions of essences: the essence of perception, or the essence of consciousness, for example. But phenomenology is also a philosophy which puts essences back into existence, and does not expect to arrive at an understanding of man and the world from any starting point other than that of 'facticity'. . . . *phenomenology can be practiced and identified as a manner or style of thinking.* (Merleau-Ponty, 1945/2012, pp. vii–ix)

According to Groat and Wang (2013), phenomenology is the most established and well known qualitative research strategy adopted in architectural research. The phenomenological studies aim to investigate the meaning of the lived experiences of a phenomenon for several individuals to ideally reduce individual experiences to a description of its universal essence (Creswell, 2007). It is important to note that this description is limited by the researcher's perception of what s/he considers essential. The phenomenon's essence is also an interpretation of the phenomenon since it is almost impossible to separate the researcher from how the research is done. However, these descriptions should not be taken as the endpoint of the investigation. Instead, they should be the foundation for discovering the "underlying commonalities that mark the essential core of the phenomenon" (Seamon, 2000, p. 159).

Among the assumptions that underlie phenomenology, 'radical empiricism' seems to stand out. This way of studying arises from the researcher's experience, with his/her firsthand contact with the phenomenon. However, as Seamon (2000) argues, it should be called *radical* to differentiate itself from the empiricism used by positivists, who consider data from an objectivist perspective as something that exists and could be quantified. In this sense, the understanding of a phenomenon should arise "directly from the researcher's personal sensibility and awareness rather than from the usual second-hand constructions of positivist science – e.g., *a priori* theory and concepts, hypotheses, predetermined methodological procedures, statistical measures of correlation, and the like" (Seamon, 2000, p. 163).

In this sense, phenomenological inquiry seems to be an adequate method to investigate immersive experiences in architecture and VR. However, some theoretical questions regarding this phenomenon were handled from a more traditional perspective through literature review and critical thinking. This procedure is by no means incompatible with a phenomenological inquiry. Though, since phenomenology is an interpretive process, it is essential to recognize and specify the philosophical assumptions that reveal, to a certain extent, the 'where' and 'how' the phenomenon is being observed (Creswell, 2007).

Thus, before discussing immersive experiences, I found it necessary to investigate theoretically some of the concepts related to experience. Nevertheless, that part of the investigation is not detached from the phenomenological inquiry since I have often resorted to examples of immersive experiences that many readers of this work may have lived.

In a first moment, the documental and bibliographic review aimed at critically studying authors who have discussed, in the context of immersive technologies or 'technologies of immersion': a) the notion of technology and how it is related to human development; b) how our cognition is related to technology; c) the experience of immersion; d) the notion of presence in its multiple contexts; and e) the cognitive aspects of immersive experiences. This part of the research (presented in Chapter 2) was critical to refining our theoretical understanding of the so-called 'immersive technologies' and pointing to some limits and inconsistencies in using these terms. Furthermore, this discussion contributed to 'setting the tone' for approaching the study of immersive experiences from an embodied perspective.

In the following, the investigation aimed to discuss the distinct modes of engagement of a subject with immersive experiences, considering the notion of embodied cognition and the theory of *affordances* (Gibson, 1979/2015). The discussion presents some exemplars of immersive experiences to illustrate some of the arguments used. Whenever possible, I tried to prioritize the examples I experienced, opting for somewhat canonical examples only when I could not find one that is analogous and available to experimenting.

In parallel, aiming to investigate through practice the technical aspects, difficulties, challenges, procedures, and other details regarding the creation of immersive experiences in VR, I have developed two immersive experiences. These experiences do not aim to be experiments in a classical sense since there is no intention to assess any variable or to evaluate any hypothesis through them. They intend to operate in a poetic, intuitive rather than rational logic. They do not intend to solve any problem or to attend to any specifications.

Therefore, from now on, these experiences will be referred to as *practice studies* in reference to the musical *études*. In music, a study is a composition that explores "a particular technical problem in an aesthetically satisfying manner" (Britannica, n.d.). Therefore, the nomenclature practice study seems adequate to our purpose since it aims to deal through practice with a technical problem (the development of VR immersive experiences) without neglecting the aesthetic character of the experience itself (the effects of immersion).

Both practice studies were inspired by moments of my personal history. I tried to extract from these remarkable personal events a verb that can, to a certain extent, summarize and guide the studies production. The verbs are an orientation rather than a restriction, pointing a direction for exploration. In addition, for each practice study, I have produced a text to contextualize the experience. The idea of conceiving the studies from themes related to my personal history may seem, at first glance, a narcissistic decision. However, this decision was an attempt to avoid using VR in the way architects already use it today, that is, as a means to present a conventionally designed architectural space. By choosing to work in this way, I had more freedom to develop the studies without being overly restricted by rules or conventions of architectural and constructive reasoning.

Due to this thesis format and the still existing limitations in accessing VR equipment, I chose to present the practice studies through conventional videos. While watching these experiences through bidimensional display is far from ideal, the videos intend to offer a glimpse into the imagined possibilities for VR's use beyond the reproduction or simulation of physical environments. The spatialities and events that compose the practice studies were designed from the idea of creating atmospheres – a concept explored in-depth in Chapter 4. In this sense, there was no functional or normative concern in the studies development, which gave me the freedom to explore spaces, events, and sensations unlikely to be experienced outside VR.

. The studies were made using the game engine Unity, extensively used to produce video games, and were conceived, modelled, and programmed exclusively by me. Game engines are complicated and complex software, and there is a "discrepancy between the way the software is intended to operate and the way architects may use it" (Pérez-Gómez, 2016a, p. 214).

On the one hand, the studies production showed the software inadequacy for creating experiences intuitively and sensitively. On the other hand, the practical studies disclosed some of the common aspects between architectural and VR experiences. In this sense, the observations from the production and experience of the practical studies were fundamental for further discussions on experiencing and producing immersive experiences in architecture and VR, especially in Chapters 4 and 5.

In summary, at times, the investigation assumes a hermeneutical-phenomenological approach, studying and interpreting any "material, object, or tangible expression imbued in some way with human meaning" regarding immersive experiences. At other times it takes place as first-person phenomenological research where "firsthand experience of the phenomenon [serves] as a basis for examining specific characteristics and qualities" (Seamon, 2000, pp. 165–167).

1.5. Thesis overview

This thesis is organized into six chapters, including this introduction. Its second chapter, *Technology and Immersion*, presents a discussion on the themes of technology and immersion to understand how these two terms relate in the context of immersive technologies. The first section offers a comprehensive discussion on technology, its etymology, how technology and memory relate, the cognitive aspects of memory and technology, and technology's social and environmental aspects. In the second part, the discussion on immersion is presented. The main definitions of immersion are offered, and the concept of presence is studied in its distinct manifestations. The third section then proposes to re-examine the term 'technology of immersion', extensively used in the literature, in the light of previous discussions.

Chapter 3, *The subject within immersive experiences*, discusses the modes of engaging a subject with immersive experiences. The interaction between a subject's body and the immersive experience design is considered in terms of *affordances* (Gibson, 1979/2015). Several examples of physical and digital immersive experiences are presented to illustrate the discussion. The analysis of the immersive experiences reveals the relevance of a subject's movement for perception and points to the importance of studying the production and experiencing architecture and VR to our investigation.

After the third chapter, the two practice studies are presented. The studies *To Cut* and *To Overflow* are, essentially, VR immersive experiences. However, due to the limitations of this thesis' format and the likely unavailability of VR equipment, I had to find an alternative way to present them. There are presented the transcription of the narration heard through the experience, a collage image, and a YouTube link to a first-person video of each immersive experience for each practice study.

Chapter 4, *The atmosphere of immersion: experiencing architecture and VR*, proposes identifying and discussing the similarities and differences between the immersive experiences of VR and architecture. The chapter is organized into three sections. The first one is dedicated to VR. It starts by discussing its emergence as a concept from works that possibly served as inspiration for VR's further developments. Several 20th-century devices that were important for VR development are analyzed. In addition, the possibility of feeling immersed in VR is discussed from a cognitive standpoint. Lastly, the most recent advancements in VR hardware are also examined. The second section discusses architecture, presenting some of its founding myths. An in-depth discussion of immersion and atmosphere is presented from the perspective of production and experience. The relation between immersion and cognition is also investigated. The chapter concludes with a discussion regarding VR and atmospheres in the context of architectural design, presenting the potential and the difficulties involved in producing VR immersive experiences.

Chapter 5, *Representation and the production of architecture: techniques and the movement between enhancement and enchantment*, discusses the development of architectural representation techniques from the 16th century to the present day. There is analyzed how architecture became a formal profession and how it relates to the systematization of the geometric representation of space. Then, from the investigation of distinct representation processes, from technical drawing to BIM software, the changes in architect's engagement with designing are presented and discussed. The notion of efficiency, which permeates the design process, is also analyzed. Lastly, the use of VR for designing is discussed regarding the concepts of enhancement and enchantment.

In chapter 6, *Conclusion,* the concluding arguments regarding methodology, atmosphere as a paradigm for architectural design, and immersion are offered. Finally, the perceived limits for imagining other uses for VR in architecture and some suggestions for further research are presented.

2. An introduction to technology and immersion

This chapter discusses how technology and immersion are related in the context of the so-called immersive technologies or technologies of immersion, terms that are generally applied to digital technologies such as head-mounted displays (HMDs), controllers, etc. The terms technology and immersion are analyzed separately to understand if they are adequate in the context of this research.

The discussion of technology begins with the attempt to understand the term beyond its association with anything digital. This first moment of discussion seeks to understand how technology was present since the early days of humankind in the development of the first lithic tools and how technologies can be seen as having some agency over us, imposing, to a certain extent, the reorganization of our lives, spaces, schedule, etc. Afterwards, a discussion about technology and memory is proposed to understand, as some authors suggest, if technology can be considered an externalization of human memory. The social and political aspects involved in the development and adoption of technologies are also discussed. Lastly, the relationship between technology and environments is analyzed.

Our study of immersion begins by relating it to the Catholic rite of baptism, an experience that is common in the Western world. Then, some of the existing definitions for immersion are presented and analyzed to understand if immersion is a property of some particular technology, or if it is something subjective, or something that happens 'in-between'.

An analysis of immersion as a phenomenon that does not necessarily relate to technology is also offered. In this context, presence is discussed considering its multidimensionality as a concept that can either involve or not technologies. Telepresence or presence mediated by technology is also considered, particularly to what concerns its relationship with immersion. Therefore, the embodied experience of presence is discussed from an enactivist perspective, which considers perception an experience that does not separate body and mind.

The last section discusses both terms together – 'technologies of immersion'. In the scope of this work, I suggest and justify that a better term should be 'technologies for immersion'. Lastly, the possibilities for investigating the use of these technologies from the perspective of an 'art of immersion' are presented, where form, content, and context should be considered.

2.1. Technology and the human: extension and exteriorization

As I write this thesis on a computer that enables me to access many contents through the Internet – texts, videos, music, etc. – my Google Assistant reminds me that I have to check the food in my oven. A few minutes later, I receive a video call on my smartphone as the smart lamp in my office changes its colour, adapting to the afternoon's sunlight. As this scenario illustrates, it is undoubtedly commonplace to affirm that we are surrounded by technology. However, while it seems obvious to recognize computers, smartphones, and other electronic gadgets as technologies, at a first look, it seems harder to admit that we were surrounded by technology long before the existence of any electronic device. A quick look around reveals that our existence depends on all sorts of technologies since the objects around us and the spaces we inhabit are products of some technological processes. In this sense, it seems necessary to study how technology has been defined and how we relate to it.

Heidegger (1977), in his famous work *The question concerning technology* from 1954, questions the essence of technology in an attempt to prepare us for what he calls a 'free relationship with technology'. The notion of essence is related to "*what* the thing is" (Heidegger, 1977, p. 4). The question about the 'essence of technology' "cannot be answered by defining our concept of technology but rather by describing our practices" (Dreyfus & Spinosa, 2003, p. 340). Nonetheless, Heidegger (1977) argues that there are two possible definitions for technology: an instrumental definition, where technology is a means to an end, and an anthropological definition, where technology is a human activity. According to (1977) Heidegger, the two definitions are encompassed by the instrumental definition since any technology is "a man-made means to an end established by man" (Heidegger, 1977, p. 5).

In addition, Heidegger (1977) analyzed the causes (or aspects) of "what is responsible for the creations of technology. These aspects all belong together, contributing to a process of molding something, bringing it forth" (Dahlstrom, 2018, p. 47). This bringing-forth is related to the Greek notion of *poiésis*, which has to do with "the practical activity of human production" (Feenberg, 2006, p. 6). Heidegger (1977) argues that this bringing-forth is the movement of taking something out of concealment, to bring it forth into unconcealment: "Technology is a mode of revealing. Technology comes to presence [*West*] in the realm where revealing and unconcealment take place, where *alétheia*, truth, happens" (Heidegger, 1977, p. 13).

Alétheia is translated as 'unconcealedness', something that is

> brought to presence within some opening that itself has a structure. Beings or entities thus *appear* only against, from, and within a background or opening, a framework. But the opening or clearing within which they take the shapes they assume, is itself structured. Overall this structure has as an invariant feature, a concealing-revealing ratio. Thus one may say that it always has some selectivity factor as an essential feature. Understood in this way, it becomes clear that beings as such are never simply *given:* they appear or come to presence in some definite way that is dependent upon the total field of revealing in which they are situated. (Ihde, 2010, pp. 30–31)

This notion of technology as a revealing mode can be related to the concept of 'medium as extension' discussed by McLuhan (1964/1994). The author approaches the theme of technology having as a central point the body and its senses. According to McLuhan (1964/1994), it is possible to consider that "all media are extensions of some human faculty – psychic or physical" (McLuhan & Fiore, 1967/2001, p. 26). Clothing, for example, figures as an extension of our skin, a microphone as an extension of voice, and a lever as an extension of arms. However, the idea of extensions goes beyond searching for a correlation between a technology and what it extends. As the author explains, these extensions have a profound impact on us. They "work us over completely. They are so pervasive in their personal, political, economic, aesthetic, psychological, moral, ethical, and social consequences that they leave no part of us untouched, unaffected, unaltered" (McLuhan & Fiore, 1967/2001, p. 26).

In a certain sense, the extensions promoted by technologies transform our very perception of the world. The notion of the 'world as perceived' is discussed by Merleau-Ponty (1945/2012) and can be roughly defined as what a subject perceives of reality. Perception presents itself as a "re-creation or re-constitution of the world at every moment" (Merleau-Ponty, 1945/2012, p. 240). The embodied experience of the world, which will be discussed further, is at the centre of Merleau-Ponty's theory on the world's perception. It is a continuous process that involves a subject interacting with the world through her/his body. Through this interaction, s/he creates and attributes meaning to her/his experiences with the world. In the author's words: "The senses and one's own body generally present the mystery of a collective entity, which without abandoning its thisness and its individuality, puts forth beyond itself meanings capable of providing a framework for a whole series of thoughts and experiences"(Merleau-Ponty, 1945/2012, p. 146).

Thus, it is noteworthy that the extensions proposed by McLuhan (1964/1994) are aspects that are not present in the medium itself but that emerges from its interaction with a subject that perceives its effects on her/himself and its surroundings. One of McLuhan's most quoted passages – "the medium is the message" – is related to these effects of technologies on us (McLuhan, 1964/1994, p. 7)[2]. The 'message' is precisely the changes a medium introduces into human life in scale, pace, or pattern. McLuhan (1964/1994) considers that a medium's content has incidental effects and is ineffective in shaping our associations and actions.

This point becomes clear when we analyze how the introduction of TVs in residences in the mid-1900s transformed everyday life. In terms of physical organization, the presence of a TV in a room forces a change in the furniture's layout to enable its visual access. Some adaptations in the families' routine were also needed to make them available to watch TV since programs are broadcasted at specific times. Furthermore, the infrastructure needed to enable a TV show to be accessed by anyone anywhere involves a massive number of professionals, spaces of production, other technologies (e.g., antennas, cameras, cables, controlling stations), and many other facilities, each one imposing its rhythm and organization to work (FIG. 2).

It is possible to say that the effects of the introduction of TVs into homes reveals or brings to presence a framework, or "a particular form of the human taking up a relation to a world through some existential intentionality" (Ihde, 2010, p. 33). The perception of technology as an extension, as proposed by McLuhan (1964/1994), is related to Heidegger's notion of revealing since it helps to disclose how technology can reorganize our reality – from the physical settings to our very perception of the world.

Nevertheless, McLuhan (1964/1994) points out that any extension promoted by technology is followed by a certain numbness or blocking in our perception. This side-effect relates to the body's new ratios and equilibriums demanded by the technology. The author argues that the body reacts by 'self-amputating' a part of itself and/or its senses, causing the 'numbness'. The TV, in this case, extends the sense of touch since it "involves maximal interplay of all the senses", having as a consequence the amputation, to some degree, of our critical sense (McLuhan, 1964/1994, p. 333).

McLuhan (1964/1994) suggests that humanity is continuously modifying and being modified by its technology. In the same direction, Flusser (2017) argues that the best way to investigate how the population of a particular epoch lived, thought, felt, etc. is to study what they fabricated, equating the history of humankind to the history of fabrication. The process of fabrication

[2] Some naïve interpretations of this passage consider 'medium' as mass-media communication and 'message' as the content transmitted by the medium.

involves four transformations: to seize something from nature, to convert it into something manufactured, give it applicability, and to use it (Flusser, 2017).

Figure 2 – Families everyday life: how TV reorganized the home space and time. Image by the author.

The process of fabricating an artefact involves a specific type of knowledge and skill for each transformation step: for instance, a shoemaker knows how to select the best leather for her/his shoes but probably does not know how to produce a quality leather as the skiver does. Both knowledge and skill are developed through an iterative process of making, experimenting, and remaking. It can be said that these transformation processes build not only the artefact but the builder itself: “a shoemaker does not only make leather shoes but also, by means of his activity, makes himself a shoemaker” (Flusser, 2017, p. 34).

Nonetheless, there are several underlying cognitive processes ongoing throughout the production of a shoe that can be extended to other cases and help us to introduce some aspects to our discussion. Even in trivial everyday activities, there are a significant number of cognitive operations taking place, and the analysis of these operations can assist in a broader comprehension of our cognitive apparatus. In this sense, it seems reasonable to consider how the shoemaker can guide her/his actions when producing the shoe.

The situation faced by the shoemaker is constantly changing as a result of her/his activity. Thus, it could be said that the shoemaker perceives the situation, leading to an action that changes her/his perception of the situation, which leads to another action, and so on. A Cartesian dualistic approach to this situation will likely consider that the shoemaker perceives the situation with her/his mind and acts with her/his body, supposing that mind and body are two separate entities. However, this study adopts a different standpoint, based on the notion of *embodied cognition*, that understands body and mind as inseparable entities. (Clark, 1997, 2008; Merleau-Ponty, 1968, 1945/2012; Noë, 2004, 2012; Shapiro, 2004, 2011; Varela et al., 1993). Embodied cognition implies that "the reference point for understanding perception is no longer a pregiven, perceiver-independent world but rather the sensorimotor structure of the perceiver (the way in which the nervous system links sensory and motor surfaces)" (Varela et al., 1993, p. 173). We will return to this point further on.

In this sense, the knowledge of the shoemaker and knowledge, in general, is something that "emerges through the primary agent's bodily engagement with the environment, rather than being simply determined by and dependent upon either pre-existent situations or personal construals" (R. A. Wilson & Foglia, 2017, para. 18).

The question of knowledge and skill is at the very roots of the word technology, which means, first, a discourse or an explanation – a *logos* – about techniques – *tekhné.* Stiegler (1998) considers that *tekhné* designates all the skill domains, which is problematic since all human activities are related to some skills. However, each technique has a certain specialization since each one demands a specific set of skills. Technology is defined as

> the discourse describing and explaining the evolution of specialized procedures and techniques, arts and trades – either the discourse of certain types of procedures and techniques, or that of the totality of techniques inasmuch as they form a system: technology is in this case the discourse of the evolution of that system. (Stiegler, 1998, p. 94)

Flusser (1983) reminds us that nature tends to a progressive loss of information in a process known in thermodynamics as entropy. In this field, entropy refers to the energy exchanges within a system that tends to stabilize. In other words, a system that tends to produce more probable situations each time. According to Flusser (1983), we are probably the only species that deliberately act in opposition to this loss of information by "creating improbable situations, and by storing them to prevent them to be forgotten" (Flusser, 1983, p. 1).

From this perspective, it seems possible to affirm that humans are storing information in making a technical object, as the shoe in our last example. Stiegler (1998), following Leroi-Gourhan (1993), considers that technical objects are attempts to exteriorize memory. That becomes somehow evident when we make a note about something we cannot forget. Nevertheless, is it possible to affirm the same when analyzing other not-so-obvious objects? Is it even possible to affirm that the note, or the words that compose it, are a form of memory?

One of the first technical objects invented by humans more than 500.000 years ago (Gibbons, 2009), the stone knife, seems to be an efficient way to store information about 'how to cut'. The fabrication of the blade presupposes not only that its fabricant knew about the plasticity of the material, how to work it, and that a thin surface is more efficient to cut, but it also presupposes a gesture, a 'know-how' to use it. Another evidence that the information stored in the stone knife relates to its deformation through use, which progressively erases the information embedded in the object, disabling it (Flusser, 1988).

Stiegler (2006) considers that human memory is originally "exteriorized, and that means that it is technical from the start" (Stiegler, 2006, para. 2). However, although it can be said that the lithic tools store some kind of memory, they were not produced with this intention. According to the author, the first *mnemotechniques*, or supports technically made for storing memories, appeared just in the late paleolithic period (ca. 10.000 B.C.E), to support ritual narratives in the form of mythograms and tattoos in the body of sorcerers (Stiegler, 2010). Writing, invented in the early days of Mesopotamian civilizations (ca. 3.500 B.C.E), marks the gradual transition from mythological to rational thinking (Leroi-Gourhan, 1993). This happened at the same time as the development of agriculture and sedentarism:

> The process set in motion by settled agriculture contributed . . . to putting the individual more and more firmly in control over the material world. . . As soon as writing became exclusively a means of phonetic recording of speech, language was placed on the same level as technics, and the technical efficacy of language today is proportional to the extent to which it has rid itself of the halo of associated images characteristic of archaic forms of writing. . . For classical as well as modern thinking, the alphabet is more than just a means

> of committing to memory the progressive acquisitions of the human mind; it is a tool whereby a mental symbol can be noted in both word and gesture in a single process. (Leroi-Gourhan, 1993, pp. 211–212)

The exteriorization of memory through techniques is seen by Stiegler (1998) as a structure of inheritance and transmission that is external to us and non-biological, meaning that it is not genetic but can be acquired. The author distinguishes three types of memories from which the human develops: the genetic memory, the epigenetic memory –the memory of the central nervous system, and the *epiphylogenetic* or the technological memory (Stiegler, 1998; Vaccari & Barnet, 2009). The latter "designates a new relation between the human organism and its environment. Technics and the human are constitutive of each other" (Vaccari & Barnet, 2009, p. 14).

The possibility of exteriorizing memory has several implications discussed by the author, especially in his trilogy *Technics and Time*. In the second volume, *Disorientation*, published in 1996, the author discusses the 'industrialization of memory'. As the author argues, memory "is objectified when it is technically synthesized" (Stiegler, 1996/2008, p. 97), that is, when it can be inscribed as something 'external' to a subject by means of technique. Therefore, from the moment memory is objectified, it can be exchanged, and in this sense, it becomes commercial capital. According to Stiegler (1996/2008), this gives rise to the process of industrialization of memory, which

> exists insofar as it becomes "information" in the limited sense employed in information theory, as merchandise whose value is correlated with its time and space of diffusion. It can thus be "re-opened", making all previous forms of memory, all of the already-there, into "raw material", such that general knowledge itself becomes information. Since information is "inseparable from its organization", mastery of the latter is mastery of information itself, informational organization determining the conditions of information access and selection. (Stiegler, 1996/2008, p. 107)

The industrialization of memory imposes new conditions for memorization, determining, to some extent, what should be selected to be memorized, retained or forgotten, effaced. The notion of 'what happens' becomes subordinate to being 'covered', revealing the preceding process of selection done by the technical-industrial apparatus of memory with the primary objective of producing surplus value. In this sense,

> the media are not satisfied with "co-producing" events but, more and more frequently, actually integrally produce them, in a veritable inversion by which the media recount daily

> life so forcefully that their "life story" seems not only to anticipate but ineluctably to precede – to determine – life itself. (Stiegler, 1996/2008, p. 116)

The industrial complex of memory and its effects is only possible through exteriorization of memory, as Stiegler (1996/2008) argues. However, it seems necessary to discuss some other aspects relating to the notion of exteriorization. First, to consider that something could be externalized implies that this something was previously internal. That is, it presupposes that this 'external something' exists independently of an observer. Second, the notion of memory itself needs to be better understood to grasp how and if it can be externalized and accessed.

The externalization of memory is discussed in Leroi-Gourhan's work *Gesture and Speech,* published in 1964. Apparently, the question of interiorization-exteriorization was not a problem for the author. However, Stiegler identified this problem and tried to resolve it through the notion of 'technical consciousness':

> If there is no consciousness in the sense of "creative consciousness", nor then in the sense of what is ordinarily called consciousness, if there can only be a technical consciousness that is nevertheless not the simple automatic or programmatic-genetic behavior of a fabricating animal, then there must be anticipation. "Technical consciousness" means anticipation without creative consciousness. Anticipation means the realization of a possibility that is not determined by a biological program. Now, at the same time, the movement of "exteriorization", if it seems to presuppose this anticipation, appears here to be of a strictly zoological origin, to the point of still being determined by the neurophysiological characteristics of the individual. (Stiegler, 1998, p. 151)

Stiegler (1998) admits that exteriorization induces to think on a preceding interiorization. Notwithstanding, this author suggests that both interiority and exteriority are created in a single movement, where there is no precedence of one over the other, nor one is the origin of the other:

> "Interiority" would be only the expectation, the call, or the promise of exteriorization – the tendency to exteriorization. Now, expectation means projection and future – anticipation. The whole problem, which thus becomes the distendedness of the past, the present, and the future, is caught in a circle in which the tool appears at one and the same time *qua* the result of anticipation, exteriorization, and *qua* the condition of all anticipation, anticipation appearing itself *qua* the interiorization of the originary fact of exteriorization. (Stiegler, 1998, p. 153)

That constitutes the "paradox of exteriorization" (Stiegler, 1998, p. 175), where humans and tools invent each other, which poses us another question: is it possible to consider any technology as an extension of ourselves (as argues by McLuhan) if what is extended and the extension constitute one another? To deal with this matter, we must first investigate another question we have previously placed concerning memory.

2.1.1. The mechanisms of memory: storage, recalling, and/or acting out?

The Merriam-Webster (2020) dictionary defines memory as "the power or process of reproducing or recalling what has been learned and retained especially through associative mechanisms" or "the store of things learned and retained from an organism's activity or experience as evidenced by modification of structure or behaviour or by recall and recognition" (Merriam-Webster, 2020). Thus, both definitions share the understanding that memory relates to storing information – by 'associative mechanisms', 'modification of a structure'–and the process of accessing what was stored – through 'recalling' or 'recognition'.

The work of the neuroscientist Eric Kandel can be considered as one of the most relevant works on the memory of recent times. Kandel (2005) was interested in understanding an animal's behaviour's ability to be modified by what it learns, which leads him to question what changes in the brain when something is learned and how this information is retained.

During his research, Kandel (2005) discovered that even in animals with a very simplified nervous system, there are distinct memory storage processes, one for short-term memories, which last minutes, and one for long-term memories, that can last for days or months. In one of his experiments, the tail of the mollusc *Aplysia californica* (the species used throughout the study) was sensitized using a certain number of electrical shocks, and then another part of the mollusc's body was stimulated and observed. These observations enabled him to discover that the passage of one type of memory to another required spaced repetitions: a single shock gave rise to short-term memory and four or five spaced shocks gave rise to long-term memory. Furthermore, Kandel (2005) found that the long-term memory mechanism was physiologically distinct, requiring the synthesis of new proteins. Moreover, the cellular and molecular mechanisms for storing short- and long-term memories were conserved in mammals.

However, his research was limited to studying implicit memory, considered the simplest case of memory storage, defined as "memory for perceptual and motor skills and is expressed through performance, without conscious recall of past episodes" (Kandel, 2005, p. 356). The explicit memory, related to the conscious recall of moments, people, places, and objects, is still a process that demands further research. Although the scientific knowledge of explicit memory remains limited, there is a certain agreement that it involves specific anatomical structures, such as the medial temporal lobe and the hippocampus in humans. The mechanisms and specificities related to how information is transformed as it is stored and recovered from the hippocampus remain to be discovered (Kandel, 2005). This structure is also related to spatial tasks, and the information is stored in the hippocampus as a "cellular representation of extrapersonal space – a cognitive map of space" (Kandel, 2005, p. 360).

This view of explicit memory as representations of information produced by and in the brain cannot be considered a consensus (Brouillet, 2020; Dijkstra & Zwaan, 2014; Varela et al., 1993). 'Memories-as-representations' is still an ordinary approach associated with *cognitivism*, a 'branch' of the field of cognitive science that has the digital computer as a guiding metaphor for its theories.

As Varela et al. (1993) explain,

> cognitivism consists in the hypothesis that cognition – human cognition included – is the manipulation of symbols after the fashion of digital computers. In other words, cognition is *mental representation:* the mind is thought to operate by manipulating symbols that represents features of the world or represent the world as being a certain way. (Varela et al., 1993, p. 8)

Since the 1990s, alternative theories, such as *enactivism*, have gained ground in questioning the cognitivist approach. According to the enactive theory, "the ultimate aim of cognitive processes is not to recover representations or to construct new representations of a pre-existent world, but rather to create the world in which people act" (Brouillet, 2020, p. 1). For the enactivists, cognition emerges from the interaction between an organism and its environment. The former does not just passively receive information from the environment but constructs its perception of the world by interacting with it within the boundaries of what it can perceive (Brouillet, 2020; Varela et al., 1993; Ward et al., 2017).

In this sense, memory cannot be understood in terms of storing and recovering representations of a pre-existent world. To consider that

> our memories may be enacted is to say that they are the product of the actions we take to account for them in a given situation. In other words, this means accepting that our memories are no longer considered as the recovery, *sensu stricto*, of an event that happened in the past, but rather as the product of a cognitive elaboration constructed here and now. (Brouillet, 2020, p. 1)

Thus, memories are not static since they are under continuous revision from past and present experiences, implying that there is no 'library of memories' from where one can recover information. Nonetheless, memory can be considered as the memory of our actions, or more specifically, "the traces of what has been enacted by our actions" (Brouillet, 2020, p. 2).

Notwithstanding, non-representational cognition is contested even by some researchers who agree significantly with enactivist theories (Clark, 1997; Clark & Toribio, 1994; Steiner, 2019). For instance, problems that "involves reasoning about absent, non-existent, or counterfactual states or affairs" can be considered as "representation-hungry" problems (Clark & Toribio, 1994, p. 419). To think of something inexistent, such as a unicorn or a building that is still being designed, for example, requires the use of some 'inner' resource to happen and, according to Clark and Toribio (1994) and Clark (1997), this resource is "some kind of internal representation" (Clark & Toribio, 1994, p. 419). As Steiner (2019) explains, the need for representation does not invalidate the enactivist theory of cognition. Instead, it points out that occasionally representation is needed: "some basic or minor cognitive tasks do not require representationalist explanations, but other, more complex and evolved tasks surely require them" (Steiner, 2019, p. 154).

2.1.2. The cognitive aspects of memory and technology

Now that distinct mechanisms and theories of memory have been presented, it is possible to look again into technology, this time considering the enactivist perspective. First, we will return to the definition proposed by Stiegler (1998) of technology as an exteriorization of memory.

Throughout his work, Stiegler does not disclose which cognitive theory he subscribes to. Nonetheless, his definition of technology and the 'paradox of interiorization' rely on the Cartesian dualistic division of mind-body and internal-external, which is problematic since it supposes two instances that exist independently and separately. Furthermore, considering that there is a continuity in the process of exteriorization of memory from its first appearance in the Lower-Paleolithic age to the present day, the author seems to include too much under a single process (Reveley & Peters, 2016).

The production of a lithic tool from this dualistic perspective considers that the artefact is the materialization of an intention that existed in the mind of the toolmaker, i.e., an internal representation that preceded even the agent's external movements that produced the artefact. Therefore, the tool does not take part in the agent's cognitive realm *per se*, functioning just as an *index* of a mental process. In this sense, the tool becomes just an "epiphenomenal cognitive residue left in the archaeological record by the operational sequence of the knapping gesture" (Malafouris, 2013, p. 162). If we consider that memories are the result of the interaction between an organism and its environment that are stored not as representations but as traces of our actions, it is not possible to regard a lithic tool as an exteriorization of memory, as suggested by Leroi-Gourhan (1993) and Stiegler (1998).

Therefore, a pre-existent lithic tool "does not function as a memory storehouse that records the sequence of tool-making procedures, which then insinuates itself into the hominin mind in the form of a plan" (Reveley & Peters, 2016, p. 1456). Additionally, the knapping process cannot be considered as the simple execution of an intention but as a process that reveals the agent's intention itself:

> intentionality is not a property that stops at the boundary of the biological organism. The best angles for flake removal are neither identified or imagined in the knapper's head before the act. The topography of the knapping activity and the accurate aiming of a powerful blow are neither pre-planned nor recollected; they are embodied, and therefore they must be *discovered* in action. (Malafouris, 2013, p. 174)

However, returning to the example of the note on a paper, does it count as an exteriorization process? A sceptical approach can hold that things and technologies do not have memories themselves, but they aid our cognition by helping us remember. From this perspective, the note figures as an 'external amplifier' that diminishes our cognitive load. However, as Malafouris (2013) explains us, this approach does not consider something fundamental:

> the constitutive intertwining of cognition with material culture. . . [that is,] Human thinking is, first and above all, thinking *through*, *with*, and *about* things, bodies, and others. . . Thinking is not something that happens "inside" brains, bodies, or things; rather, it emerges from contextualized processes that take place "between" brains, bodies, and things. (Malafouris, 2013, pp. 77–78)

To explain his point, the author presents us his analysis of the Mycenaean clay tables, artefacts used for administrative purposes around the 15^{th} century B.C.E. Malafouris (2013) explains that these clay tables cannot be regarded as a disembodied abstract code but as a situated technology that instantiates a new way to remember and forget: "The Mycenaean simply reads what the Linear B tablet remembers. In fact, being able to read, that person no longer needs to remember" (Malafouris, 2013, p. 79). Therefore, the inscriptions on the clay table enabled Mycenaeans to substitute the laborious mental process of recalling for an easier one, reading, a process of perception.

Thus, information, "once inscribed on the clay tablet, transcends the biological limitations of the individual person and becomes available 'out there' for other people to use, comment on, transform, or incorporate it" (Malafouris, 2013, p. 82). Following McLuhan, the author proposes that the clay table imposes a new pace and establishes a new "ecology of memory" (Malafouris, 2013, p. 82) that is not reducible to its constitutive elements, biological or artificial.

Lastly, is it still possible to agree with McLuhan's suggestion that all technologies are extensions of our bodies? From what we have presented so far, this argument seems acceptable within some conditions. Technologies not only can extend our physical and/or mental abilities, but they can also modify our perception by introducing new or distinct rhythms and scales to our bodies. That is, a hammer that extends a hand, or a prosthetic leg that re-extends an amputated member, can amplify or even open new possibilities for the body. However, it is possible to affirm that extension is an event that lasts as long as someone uses the technology. Thus, it is not possible to say that a hammer is an extension *per se*; it becomes an extension when used; that is, the extension and the extended constitute one another through use.

2.1.3. The social aspects of technology: the SCOT theory and its limits

The invention and use of a technology can transform us and the environment we live in. In short, the "tool guides the grip, the grip shapes the hand, the hand makes the tool, and engaging with the tool shapes the mind" (Malafouris, 2013, p. 174).

Until this point, the discussion followed McLuhan's (1964/1994; 1967/2001) suggestion to a certain extent, focusing mainly on the effects of technology. One of the main critiques of this approach was posed by Williams (1974/2004), who recommended that technology study should also consider its causes to escape superficiality.

To analyze just the effects of technology can give the impression that new technologies are "discovered, by an essentially internal process of research and development, which then sets the conditions for social change and progress" (R. Williams, 1974/2004, p. 5). This approach, called 'technological determinism', implies that technological development is not affected by external influences, and the economic and social impacts of technology shape society (Bijker, 2006).

As Bijker (2006) points out, technological determinism is politically debilitating since it excludes social participation and regulation, leaving it to politics, which should anticipate the effects of technology and prepare society for it. As an alternative, Pinch and Bijker (1984) propose the social construction of technology theory (SCOT), arguing that the process of development of technology "does not follow its own momentum, nor a rational goal-directed problem-solving path, but is instead shaped by social factors" (Bijker, 2006, p. 6). Therefore, society starts to figure as an agent with a role in determining, to some extent, which technology or variant should thrive.

The development of technology is then considered multi-directional, where the variants of a particular technology are pondered by the forces and socially relevant groups that choose the 'surviving' variant (Pinch & Bijker, 1984). In this sense, technology is seen as constructed and interpreted culturally, which means not only that "there is flexibility in how people think, or interpret artefacts, but also that there is flexibility in how artefacts are *designed*" (Pinch & Bijker, 1984, p. 421).

However, the SCOT theory proposed by Pinch and Bijker (1984) also has its fragilities. Some authors argue that SCOT's approach is narrow and does not consider relevant questions regarding technology and human experience (Russell, 1986; Winner, 1993). The concept of 'relevant social groups' was considered especially problematic due to its imprecision in determining the historical location of these groups and how they relate to the analyzed technology. Furthermore, it leaves important questions open: who determines which social group should be considered relevant? Those without a voice and/or those who do not form a group but are affected by a technology will be considered relevant?

The absence of a "solid, systematic standpoint or core of moral concerns from which to criticize or oppose any particular patterns of technical development" (Winner, 1993, p. 374) points to an attempt to remain politically neutral. In this sense, Pinch and Bijker (1984) seem not to consider it relevant to assume a critical position regarding the politics of a technological development process, which debilitates the analysis. Politics is determining for technological change in a context

> of state funding and direction of R&D; the dominance of military objectives; state ownership of infrastructure and other production facilities; state purchasing and investment; state regulation of many activities; state mediation between management and

> workforce; political and legal battles between developers of major projects and objectors; and so on. (Russell, 1986, p. 340)

Winner (1993) argues that the SCOT theory does not consider the possible social effects of technology. The author considers insufficient an explanation of why some technologies thrive as others disappear, which ignores the consequences it may have for human communities, their everyday lives, and the distribution of power in society. Curiously, the emergence of SCOT theory was motivated by the discomfort with McLuhan's (1964/1994) approach, which focused mainly on technologies' social and individual effects, which suggests that one can complement the other.

2.1.4. The environmental aspects of technologies

In 1950 the German architect Mies van der Rohe affirmed that technology "is far more than a method, it is a world in itself. . . .Wherever technology reaches its real fulfilment, it transcends into architecture" (van der Rohe, 1971, p. 154). Although it may seem biased for an architect to make this claim, his statement found some reverberations outside the architectural field.

McLuhan (1964), for example, stated that his phrase 'the medium is the message' could be better explained by considering a new medium as environmental:

> New media, new technologies, new extensions of human powers, tend to be environmental. Tools, script, as much as wheel, or photograph, or Telstar [communication satellites], create a new environment, a new matrix for the existing technologies. . . Technologies, as they tend to create total environmental change, could plausibly be regarded as archetypal. . . To sum this up, it can be enunciated as a principle that all new media or technologies, whatever, create new environments, psychic and social, that assume as their natural content the earlier technologies. (McLuhan, 1964, pp. 239–242)

Although expressed in diverse ways, both authors argue in the same direction, and in a certain sense, one complements the other, pointing to a specific agency of technology to transform our surroundings. However, since the discussion of architecture will occur in Chapters 4 and 5, this section focuses on the notion of environment.

From an enactivist perspective, the "world is inseparable from the subject, but from a subject which is nothing but a project of the world, and the subject is inseparable from the world, but from a world which the subject itself projects" (Merleau-Ponty, 1945/2012, pp. 499–500). This point is discussed at a biological level by Maturana (1970/1980) by observing organisms and their environments.

Maturana (1970/1980) considers living systems as units of interactions that exist in an ambience where they interact – the niche. Organism and niche are mutually dependent, and one cannot be defined without the other. For an observer, the niche is a part of the environment defined by "the classes of interactions into which an organism can enter" (Maturana, 1970/1980, p. 3). However, from the standpoint of the organism, the niche corresponds to the whole environment.

Since humans can be considered complex organisms, the same applies to us. Nevertheless, our complex nervous system enables us to expand our domain of interactions, including those between the nervous system and its internal states. In this sense,

> An organism with a nervous system capable of interacting with its own states is capable of *descriptions* and of being an observer if its states arise from learned orienting interactions in a consensual domain: it can *describe* its describing. . . Through *describing* itself in a recursive manner, such an organism becomes a self-observing system that generates the domain of self-consciousness as a domain of self-observation. (Maturana, 1970/1980, pp. 18–19)

The emergence of the observer implies considering that humans are living in a "continuously changing domain of *descriptions*" that are generated through our "recursive interactions within that domain", that is, "man changes and lives in a changing frame of reference in a world continuously created and transformed by him" (Maturana, 1970/1980, p. 26). As a self-observing system, humans can describe themselves concerning the environment either and simultaneously as an actor (the one who acts) and the one on whom one (environment) acts. That becomes evident through the concept of 'Anthropocene', proposed by Crutzen and Stoermer (2000).

According to the authors, the impacts of human activities on the global environment – earth and atmosphere – are still growing, and thus humankind needs to be considered a central role in geology and ecology. The term Anthropocene was proposed to designate the current geological epoch, which started in the late-18th century. This period coincides with the Industrial Revolution, which made the effects of human activity even more noticeable globally (Crutzen & Stoermer, 2000). The authors argue that it can be interpreted as a call for a new description of the environment that considers the consequences of human activity on preserving humankind by preserving the environment.

In this sense, the concept of Anthropocene is possible only from an observer's perspective, which can establish a distinction between man and environment, and at the same time, recognizes man's dependence on an environment that holds certain qualities. Notwithstanding, the coincidence of the Anthropocene's beginning with the period of the Industrial Revolution is related to the role technology assumed in this period. Without the invention of the technologies that characterized this period, namely steam engines and cotton machinery, there would likely be no Industrial Revolution nor the social and economic consequences it entailed.

As Flusser (2017) explains to us, the Industrial Revolution substituted the tool for the machine, which he defines as "tools designed and fabricated through scientific theories, and that is exactly why they are more effective, faster and more expensive" (Flusser, 2017, p. 35). It also inverted the relation of humans and tools, transforming humans' existence.

For example, a needle that broke in a tailor's workshop is substituted by another. That is, the tool is variable, and the human is constant. Likewise, in industry, the man who gets sick or old is substituted by a healthier or younger man: the machine is constant and the man variable. In this sense, the machine has agency over the man that moves and acts in the machine's function; man becomes a 'functionary' (Flusser, 2002a).

Moreover, the rhythms of production and consumption were also changed by machines. In general, each machine was created to perform a single or a limited set of tasks in producing a commodity. In the example of needle production, there was a machine to cut the wire and another to sharpen it, which led to the worker's specialization. If in the tailor's workshop the worker knew not only the whole process but also knew how to make the needle from beginning to end, in industry s/he is specialized in just a part of the process. In this sense,

> the object which labour produces – labour's product – confronts it as *something alien,* as a *power independent* of the producer. The product of labour is labour which has been embodied in an object, which has become material: it is the *objectification* of labour. Labour's realization is its objectification. . . . The *alienation* of the worker in his product means not only that his labour becomes an object, an *external* existence, but that it exists *outside him*, independently, as something alien to him, and that it becomes a power on its own confronting him. (Marx, 1844/1977, pp. 68–69)

This excerpt helps us to understand an essential feature of the Anthropocene, which is the proliferation of technology that constituted the technosphere, or

> the set of large-scale networked technologies that underlie and make possible rapid extraction from the Earth of large quantities of free energy and subsequent power generation, long-distance, nearly instantaneous communication, rapid long-distance

> energy and mass transport, the existence and operation of modern governmental and other bureaucracies, high-intensity industrial and manufacturing operations including regional, continental and global distribution of food and other goods, and a myriad additional 'artificial' or 'non-natural' processes. (Haff, 2014, pp. 1–2)

In a certain sense, the technosphere can be seen as a global phenomenon that actualizes the notion of the environment itself, leading us to question what composes the 'natural' environment for our society? Latour (1990, 2009) suggests that naturalization and socialization cannot be thought of separately or as opposites, and the notion of society should also include non-human actants, that is, technology.

However, the notion of Anthropocene occludes some aspects of its own cause. As Moore (2016) argues, the standard narrative of Anthropocene's argument says that

> the origins of the modern world are to be found in England, right around the dawn of the nineteenth century. The motive behind this epochal shift? Coal and steam. The driving force behind coal and steam? Not class. Not capital. Not imperialism. Not even culture. But . . . you guessed it, the *Anthropos:* humanity as an undifferentiated whole. (Moore, 2016, p. 81)

The notion of Anthropocene does not challenge "the naturalized inequalities, alienation, and violence inscribed in modernity's strategic relations of power and production" and suggests, albeit surreptitiously, that responsibilities should be distributed equally among humanity (Moore, 2016, p. 82). In addition, the Anthropocene attempts to be a milestone for this 'new era' but does not reasonably explain the reasons that led to it. Humanity has been consuming far more natural resources and producing far more waste since Industrial Revolution, but why? Because we can? To answer these questions, it seems reasonable to ask: are we living in the Anthropocene or "are we living in the *Capitalocene* – the 'age of capital' – the historical era shaped by the endless accumulation of capital?" (Moore, 2017, p. 3).

It can be said that the Capitalocene is based upon the creation of Cheap Nature, understood "as work/energy and biophysical utility produced with minimal labor-power, and directly implicated in commodity production exchange" (Moore, 2016, p. 99). As the author explains,

> This Cheapening is twofold. One is a price moment: to reduce the costs of working for capital, directly and indirectly. Another is ethico-political: to cheapen in the English language sense of the word, to treat as unworthy of dignity and respect. These moments of Cheapening work together, rendering the work of many humans – but also of animals,

> soils, forests, and all manner of extra-human nature – invisible or nearly so. (Moore, 2017, p. 7)

In a certain sense, the notion of Capitalocene reveals what is undisclosed by the Anthropocene, that there is a driving force called capitalism that accelerated the process of exploiting natural resources irresponsibly in the name of profit. Humanity, in capitalism, is far from homogeneous, and a big part of it is excluded from its alleged 'benefits'. Nevertheless, the notions of Capitalocene and Anthropocene seem to be much more complementary than contradictory. Furthermore, our interactions with technologies are still creating new technologies that populate and interfere with our environment.

If we consider humankind as an organism – with all the restrictions and distortions that such homogenization produces – it is possible to say that humans expand their environment by creating objects from what is extracted from it, which changes the relationship between humankind and the environment. In this sense, an object is not contained by its edges and limits but is connected to a "swarm of entities that seem to have been there all along but were not visible before and that appear in retrospect necessary for its sustenance" (Latour, 2010, p. 2).

Some authors (Callon, 1986; Latour, 2010) propose that the world's things should be regarded as a network. That should not be confused with things that look like a net or a network in the sense of a 'computer network'. Instead, it should be taken as a mode of inquiry in which something exists through a "complex ecology of tributaries, allies, accomplices, and helpers" (Latour, 2010, p. 5). The entities that compose the network are indissociable from it, which gave rise to the concept of actor-network (Callon, 1986; Latour, 2010). Many associated and heterogeneous elements shape the technical objects, and, for this reason, it is impossible to describe these elements without describing the actor-network itself (Callon, 1986). Some of the main characteristics of the actor theory network are, 1) the non-hierarchy between entities, i.e., humans and non-humans have the same importance; 2) the reversibility of characterization of elements, that is, any element can be seized either as an actor or network - "an actor is nothing but a network, except that a network is nothing but actors"(Latour, 2010, p. 5); 3) the subversion of spatial concepts of far/close, i.e., where spatially distant entities can figure out as 'close' elements in certain descriptions of an actor-network (Latour, 2017).

The catastrophe that happened in 2002 with the *Columbia* shuttle can help to illustrate the concept of actor-network. Beyond the object that was launched into the sky and exploded, there was NASA, a high-specialized and complex organization, signalling that the

> action of flying a technical object has been redistributed throughout a highly composite network where bureaucratic routines are just as important as equations and material resistance. Yes, it is a strange space that of a shuttle that is just as much *in* the sky as *inside* NASA, but that's precisely the space – hard to describe and even harder to draw – that has been made visible by the deployment of networks in my sense of the word. (Latour, 2010, p. 2).

Therefore, even if a technology is supposed to be invisible – such as the wireless technologies, GPS, and others – the network points to its materiality: the need for infrastructure, satellites, power companies, etc. In this sense, McLuhan's (1964) argument that technologies tend to create a new environment becomes more evident.

Since there are several social and environmental ills as consequences of the technosphere, Winner (1993) suggests that developing a technology should be followed by an inquiry about how our technology-centred world can be reconstructed. According to the author, we should redirect "our technological systems and projects in ways inspired by democratic and ecological principles" (Winner, 1993, p. 376).

The new ecology established by the technosphere interferes directly in the environment through all phases, from production to consumption and disposal, as the recent plastic rain phenomenon demonstrates (Simon, 2020).

If technology can be regarded as a quasi-autonomous process with its dynamics, as Haff (2014) suggested, it becomes somehow indistinct from what we call 'natural'. For instance, genetic technologies (e.g., DNA editing, cloning, genetic therapies, etc.) point to a certain permeability between technology and biology notions or even to a dialogical relation between certain aspects of one and the other.

2.2. Understanding the experience of immersion

In the western world, especially in the so-called Christian countries (such as Brazil), the notion of immersion is associated to some degree with the ritual of water baptism. This rite consists of immerging or spilling water over a candidate's head (affusion) to mark her/his initiation into the Christian life, freeing her/him from the influence of the 'Evil One' and allowing her/his entrance into the realm of God (Libreria Editrice Vaticana, 2005). Some theologists question which way of baptizing, by immersion or affusion, is the correct one. However, the Greek word from where 'baptize' comes from means to dip, immerge, or plunge (Marshall, 2002). Therefore, for our investigation, the theological aspects are not relevant, and our focus should remain on the act of immersion itself.

First, we should consider that we are immersed in some type of medium from gestation to death. Thus, our body is an immersed body *par excellence.* In a certain sense, it is possible to consider birth as a process that summarizes, to some extent, our embodied experience. Human existence can be seen as the repetition of emerging movements from one medium (e.g., a mother's placenta) and immerging into another (e.g., the atmosphere).

Anyone who has experienced a dive in a pool can perceive that the medium change entails a change in perception. When underwater, we perceive sounds differently, our voice sounds strange, our vision becomes blurry, and we need to re-learn how to move since our body becomes lightweight and walking is no longer possible. In a certain sense, the change of medium enables us to experience our bodies distinctly. However, as the rite of the baptism and the birth process symbolize, immersion is as crucial as emersion. In the former, the candidate becomes a member of the church just when s/he comes out of the water, 'renewed' and with a 'purified body', and the child that lived for several months inside the mother's womb has her/his life counted from the moment s/he emerges from mother's womb.

However, as we intend to investigate, full-body immersion seems to be just one type of possibility to experience immersion. Janet Murray coined an important definition for immersion in her book *Hamlet on the Holodeck*, from 1997:

> A stirring narrative in any medium can be experienced as a virtual reality[3] because our brains are programmed to tune into stories with an intensity that can obliterate the world around us. . . The age-old desire to live out a fantasy aroused by a fictional world has been intensified by a participatory, immersive medium that promises to satisfy it more completely than has ever before been possible. . . The experience of being transported to an elaborately simulated place is pleasurable in itself, regardless of the fantasy content. We refer to this experience as immersion. *Immersion* is a metaphorical term derived from the physical experience of being submerged in water. We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming

[3] Virtual Reality will be discussed in Chapter 4.

> pool: the sensation of being surrounded by a completely other reality, as different as water is from air, that takes over all of our attention, our whole perceptual apparatus. (Murray, 2016, pp. 98–99)

Therefore, according to Murray (2016), immersion can be experienced through any medium as long as it presents an inspiring narrative that can mobilize our perceptual system. However, it seems that the experience of immersion changes with the medium.

Some authors (Slater, 1999, 2003; Slater & Wilbur, 1997) argue that immersion is related to digital technologies as a property of these mediums, "and describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" (Slater & Wilbur, 1997, p. 3).

This clashes with Murray's definition for at least three reasons: 1) by considering immersion related to what a technology can deliver in terms of experience; 2) the restriction of immersive experiences to digital technologies, which dismisses, for example, the sensation of being immersed in analogue mediums, such as books, movies, games, or other activities; 3) by dismissing the role of narrative in immersive experiences.

In complement, Slater (1999, 2003) argues that immersion is composed mainly of objective mensurable aspects, and for this reason, it is possible to compare and classify the immersive systems according to their characteristics. Immersion is then "system immersion", that is, an ensemble of software, hardware, and "the characteristics of a virtual environment, how it responds to people's actions, and very importantly, their own self-representation within the environment" (Slater, 1999, p. 3). Slater and Wilbur (1997) distinguish immersion and presence, being the latter a human reaction to immersion, a state of consciousness. This division between immersion as something related to the object and presence to the subject reveals a particular conception of reality associated with some type of objectivism, where an object's qualities are independent of a subject to qualify them.

Slate and Wilbur's immersion definition can offer some practical advantages, such as classifying and comparing multiple immersive technologies. However, it seems acceptable only if we assume that it simplifies the phenomenon of immersion. Although the discussion of immersive technologies will take part in the following chapters, it is necessary to consider that the design of any immersive technology should depart from understanding how perception works to deceive a subject into perceiving her/himself as immersed. In this sense, Slater and Wilbur (1997) seem to fail to perceive that there is no immersion without someone being immersed. Even the argued 'mensurable aspects' can only be assessed by an observer that constructs its objectivity (Merleau-Ponty, 1945/2012), which can be defined as the "subject's delusion that observing can be done without him" (von Foerster apud Glasersfeld, 1996, p. 2).

Ryan (2015) discusses immersion from the perspective of the involvement of subjects with narratives. According to her, it is possible to be immersed in narratives in three forms: spatial immersion, temporal immersion, and emotional immersion. In narratives, spatial immersion is related to the response to the elements that compose the setting and depends "more on the coincidental resonance of the text with the reader's personal memories than on generalizable textual properties" (Ryan, 2015, p. 86). Temporal immersion relates to the process of disclosing story elements to the reader as the narrative time passes, interleaving the events that constitute the story and the dynamics of revealing the events to the reader. The latter, emotional immersion, relates to the response to characters (Ryan, 2015).

In addition, Ryan (2018) argues that there is a category of immersion that distinguishes from narrative immersion and its three 'varieties'. Ludic immersion, she argues, "presupposes an interactive environment and is independent of any kind of concrete world and narrative content; it is experienced by chess and bridge players as intensely as by players of computer games" (Ryan, 2018, p. 99).

Similarly, McMahan (2003) considers that immersion can either capture the player in two levels, the diegetic level, related to the history of the fictional world and its characters, and the non-diegetic level, which relates to the player's affection for the game and her/his strategy involved in playing. In digital games, immersion can be achieved by fulfilling three conditions: "(1) the user's expectations of the game or environment must match the environment's conventions fairly closely; (2) the user's actions must have a non-trivial impact on the environment; and (3) the conventions of the world must be consistent" (McMahan, 2003, pp. 68–69)[4].

Lukka (2014) investigated immersion in the context of live-action role-playing (LARP), a form of playing role-playing games (RPG) where participants impersonate their characters by dressing,

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[4] A more in-depth discussion about immersion in digital games can be found in Ermi and Mäyrä (2005), Thon (2008), Jennett et al. (2008), and Calleja (2011).

moving, speaking with an accent, and behaving accordingly. Based on a classification established by Ermi and Mäyrä (2005), the author classifies the LARP's immersive experience as *imaginative* immersion, where one becomes "absorbed with the stories and the world, or begins to feel for or identify with a game character" (Ermi & Mäyrä, 2005, p. 101). Furthermore, according to Lukka (2014), immersion can be both a state, when it is related to the subjective experience of being another person in a diegetic reality, or as a process, when it refers to an "automatic unconscious reaction to and interaction with the environment mediated by personality trait resulting in immersive state" (Lukka, 2014, p. 88).

Ermi and Mäyrä (2005) consider two other types of immersion in digital games: challenge-based immersion, which relates to motor and/or mental skills, such as logical thinking or problem-solving, and sensory immersion, which is related to the audiovisual element of the game. However, as the authors explain, the gameplay experience is "an interaction between a particular kind of game and a particular kind of game player" (Ermi & Mäyrä, 2005, p. 100).

In this sense, immersion is something that emerges from gameplay and is not something intrinsic to the game. That becomes somehow clear as the same game can be immersive in different ways for different players. For instance, an RPG videogame (e.g., *Skyrim*, *The Witcher*, *Red Dead Redemption*, etc.) can offer a rich diegetic universe with profound and complex histories that can enable players to immerse themselves in it for hundreds of hours. On the other hand, some players are interested in just finishing the game in the fastest way. This type of gameplay is called *speedrun* and can be regarded as a challenge-based immersive experience. Speedrunners can spend more hours playing than a traditional player, trying to discover the fastest way to beat all the puzzles and reach the endgame[5].

Some fundamental differences between immersion in digital and analogue gaming should be addressed. In a digital game, the player will interact with a preprogrammed environment and characters independently of the game genre. Even in multiplayer games, the possible interactions among players are limited by the programming. Furthermore, there are also hardware limitations for interaction, such as the available controllers, screen resolution, processing power, etc. In most digital games, the body participates in a somewhat reduced way, through the senses of vision and

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[5] To understand more about the speedrunning culture in gaming, see: https://bit.ly/3pkt2LD. Accessed 12 Nov. 2020.

hearing, sometimes by speaking, and through the hands. Furthermore, even the hands' interaction is mainly limited to fingertips, which presses buttons and move levers. The most common exception comes from computer games that use the mouse as a controller, especially in first-person shooter games, where the arm and wrist movement is necessary to drag the mouse around bi-dimensionally.

The condition for immersion in LARPs is related to the commitment of players to their characters and narrative. Players have an 'agreement'[6] to assume their character for the game session's duration, behaving according to a shared common expectation. Furthermore, since LARP is an in-person interpretative game, costumes and props play an essential role in immersion. However, no matter how much effort players put into producing physical elements for characters and scenarios, Lukka (2014) points out that players continually ignore elements that could break the immersion.

In this sense, LARP players enact the storyworld, creating the conditions for immersion. For this reason, immersion in LARP games is fragile, existing as long as the players are committed to producing the storyworld through their actions and interactions.

It seems reasonable to question how players decide to continue acting and to stay immersed in LARPs. The plurality of immersive experiences, which can take many forms, "arises from some form of psychological motivation to engage with certain stimuli" (Bowman, 2018, p. 380). Immersion is sometimes compared, mistaken, or even equated to the experience of *flow* (Douglas & Hargadon, 2000; Ermi & Mäyrä, 2005; Michailidis et al., 2018). Physic entropy, which can be defined as one of the leading forces that affect consciousness, is related to the disorganization or disorder of the psychic system that deters us from carrying out our intentions. It is generally associated with distraction, but can also be experienced as anxiety, fear, panic, pain, etc. (Csikszentmihalyi, 2007). The state of flow can be defined as the opposite of physic entropy, a state of optimal experience, "when the information that keeps coming into awareness is congruent with goals, psychic energy flows effortlessly. There is no need to worry, no reason to question one's adequacy" (Csikszentmihalyi, 2007, p. 39)

[6] According to Balzer (2011), the agreement between players is based on at least three set of rules: rules of irrelevance, that sets what should be irrelevant in the game and should be ignored; constitutive rules, that redefines certain objects in the storyworld context (e.g. a foam ball can be regarded as a fireball); and regulative rules, that are the actual rules of the game.

In interactive narratives, such as hypertext fiction or digital gaming, immersion and engagement can offer readers/players the opportunity to experience the flow state (Douglas & Hargadon, 2000). Brown and Cairns (2004) propose a scale of involvement to measure immersion in video games. The scale begins with engagement, relating to the investment of attention, time, and efforts a player has to overcome the barrier of accessing the game, which is related to her/his personal preferences. Once engaged, the player can become further involved with gaming, reaching the level of 'engrossment'. This level is related to game construction when game features are combined "in such a way that gamers' emotions are directly affected by the game" (E. Brown & Cairns, 2004, p. 1299). The authors add that, at this point, some gamers alter some characteristics of their physical environment to favour involvement with gaming, for instance, by turning lights off and volume up. In a certain sense, these actions towards the physical environment demonstrate the player's willingness to overcome or replace the visual and sound stimuli of her/his physical environment with those coming from the digital environment. The third level proposed by Brown and Cairns (2004) is total immersion, which is equated to presence, a notion that will be discussed further on. The barriers to total immersion are empathy and atmosphere. The former is related to the attachment a player feels for a character and a situation. Atmosphere,

> is created from the same elements as game construction. The graphics, plot and sounds combine to create this feature. What makes atmosphere distinct from game construction is relevance. . . . The reason this is important is because of the use of attention. If gamers need to attend to sound, as well as sight more effort is needed to be placed into the game. The more attention and effort invested, the more immersed a gamer can feel. (E. Brown & Cairns, 2004, p. 1299)

It is possible to say that LARP players seem to experience something similar to total immersion, as Brown and Cairns (2004) described. Nonetheless, as our understanding of immersion progresses, the similarities of the phenomena of immersion and flow become evident. Michailidis et al. (2018) affirm that "immersion and flow do not appear as conceptually distinct, and their proposed differences are not compelling enough to set immersion apart as a different mental state", suggesting that the terms could be used interchangeably (Michailidis et al., 2018, p. 5).

As Balzer (2011) points out, to achieve immersion in LARP, players should distinguish the storyworld from 'reality' on four different levels: 1) the temporal level, when they should be able to identify the beginning and end of the LARP event; 2) the spatial level, where players should distinguish between the gaming and non-gaming areas ; 3) the topical level, meaning that players ought to consider only storyworld subjects and objects as relevant; and 4) the social level, when players need to distinguish between their actual person and their role as an in-game character.

Therefore, when relating to gaming either digitally or physically, the state of immersion seems to demand something from the subject, a certain willingness or pre-disposition to feel immersed, which remains to be explained. From this, it must be considered that some enjoyment can be obtained from the immersive experience, or the voluntary engagement with the situation would not happen. If we equate immersion and flow, one possible explanation refers to the autotelic character of the flow experience, as described by Csikszentmihalyi (2007). The word comes from Greek *auto*, meaning self, and *telos*, meaning goal, about a "self-contained activity, one that is done not with the expectation of some future benefit, but simply because the doing itself is the reward" (Csikszentmihalyi, 2007, p. 67). The author explains that a major part of our experiences combines autotelic and *exotelic* motivations about those aspects external to the activity itself, such as making money, achieving prestige, etc.

An additional explanation for the motivation to immersion can be regarded from the concept of volition. As Keller (2008) explains, motivation has two levels, being the first 'will', "which refers to a person's desires, wants, or purposes together with a belief about whether it is within one's power to satisfy the desire, or achieve the goal" (Keller, 2008, p. 84). The second level is related to the act of using the will – 'volition' – "which refers to a process for converting intentions into actions" (Keller, 2008, p. 84).

As we mentioned earlier, there is no immersion without someone to be immersed. It seems necessary to complement this statement since, at least in gaming environments, the immersed subject (the player) needs to decide to act towards immersion. A possible rephrasing then could be: there is no immersion without someone enacting it.

The desire to be immersed (will), which is converted into an act (volition), can have distinct motivations. One of these, which I would like to return due to its relevance to the discussion of immersion in games, is narrative. The narrative is a fundamental aspect of immersion in fictional worlds, "an engagement of the imagination in the construction and contemplation of a storyworld which relies on purely mental activity" (Ryan, 2015, p. 246). Compared to imaginative immersion, narrative immersion considers players' active role in constructing the storyworld: players create the storyworld as they get absorbed by its stories (Ermi & Mäyrä, 2005; Lukka, 2014). Therefore, "fantasy worlds (whether online or off) are always as good as the imaginations holding them together" (Wertheim, 2000, p. 235).

In this sense, it is possible to affirm that there is a tie between imagination and narrative. Therefore, perception seems to be supplemented by an imagination that responds accordingly to an unfolding narrative. The existence of this tie enables not only LARP players to see a person painted in green as an 'orc', but also allows, for example, that Dom Quixote sees a giant where there is a windmill. Imagination, thus, plays an essential role in immersive experiences, as argued by Ryan (2015). The author considers that immersion can be regarded as "the response to a text, whatever its medium, that is able to conjure the presence of a world to the imagination" (Ryan, 2015, p. 137).

During the late-1980 and 1990s, the MUDs – multiuser domain or multiuser dungeon – became popular among RPG players. The MUDs were one of the first experiences of persistent multiplayer real-time games, which were text-based and inspired by the medieval fantasy RPG *Dungeons & Dragons.* The main difference between a MUD and a novel is that "while the reader of a novel encounters a world fully formed by the writer, MUDers are actively involved in an ongoing process of world-making" (Wertheim, 2000, p. 234). The digital domain of MUD

> provides a place where people around the globe can *collectively* create imaginative "other" worlds and experiences. Within these worlds you can not only express your own alter egos, you can participate in group fantasy that has the richness of texture generate by many imaginations working together. (Wertheim, 2000, p. 237)

As we can see, the narrative is a critical component of some types of immersion. The narrative does not pertain to the medium, but it emerges from the subject's interaction with the medium, be it a book, a MUD, or a character. Therefore, imagination, or "the faculty to make and decipher images" (Flusser, n.d., p. 1), depends on a particular type of engagement with the medium to produce the images that illustrate the text. In this case, is it possible to say that imagination creates the stimulus for the perception of immersion?

Kosslyn et al. (2001)[7] consider creating mental imagery as a process within the brain, without any stimuli coming from the senses. In turn, perception occurs "when information is registered

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[7] In this paper the authors present a review of several studies regarding mental imagery using neuroimaging techniques and Transcranial Magnetic Stimulation. This technique is "used to induce a transient

directly from the senses" (Kosslyn et al., 2001, p. 635). The authors explain that, in many cases, the mental processes involved in creating mental imagery are like those involved in perceiving the situation depicted in imagination. Furthermore, the motor system can also be engaged by mental imagery, which can help to explain the reasons why 'mental practice' can improve performance by exercising some brain areas, building "associations among processes implemented in different areas, which in turn facilitate complex performance" (Kosslyn et al., 2001, p. 639).

These findings corroborate with the Principle of Undifferentiated Encoding, which claims that "the response of a nerve cell does not encode the physical nature of the agents that caused its response. Encoded is only 'how much' at this point of my body, but not 'what'" (Von Foerster, 1973, p. 4). Our nervous system is structured anatomically and physiologically as a closed network of interacting neuronal elements, and "any change of relations of activity in it leads to further changes in relations of activity in it" (Maturana, 2008, p. 109). In this sense, what interacts with the environment is not the nervous system but its sensors and effectors, intersecting with some nerve cells. From these considerations emerge one of our experience's main characteristics (and limits), that is, our inability to distinguish between 'perception' and 'illusion' (Maturana, 2008).

Thus, from the nervous system standpoint, it does not matter if a stimulus is captured by the sense organs or produced internally by imagination. The distinction is only possible to be made by an observer that sees the 'inside' and the 'outside' of an organism (Maturana, 2008). Therefore, if one has sufficient knowledge about how our sense organs capture the stimuli from the environment, it is possible to deceive the nervous system into perceiving something as 'real' even if the source of the stimuli are just two skilfully produced dissimilar images, as the virtual reality systems provide.

Therefore, the design of immersive experiences becomes possible by knowing how perception works, opening up the possibility for an 'art of immersion' as Sloterdijk (2006/2011) puts it. The author argues that this *immersionkunst* – 'art of immersion' or 'immersive art' – can be seen as a phenomenon potentially able to replace whole environments, as a method that "unframes images and vistas, dissolving the boundaries with their environment" (Sloterdijk, 2006/2011, p. 105).

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interruption of normal activity in a relatively restricted area of the brain. It is based on the generation of a strong magnetic field near the area of interest, which, if changed rapidly enough, will induce an electric field sufficient to stimulate neurons" (Kosslyn et al., 2001, p. 635).

As we discussed in this section, immersion is related to the perception of a subject. However, an aspect of immersion shows up consistently in the discussions on immersion: the notion of presence.

2.3. Presence: a concept that permeates various experiences

The study of immersion is permeated by other concepts that help to explain immersive experiences. Between these concepts, presence is mentioned continuously either as the subjective part of the immersive experience (Slater, 1999, 2003; Slater & Wilbur, 1997) or as something that overlaps or intertwines with the concept of immersion. The term's use goes back to 1951, but it was a variation, telepresence, coined in the 1980s, that established presence as an organized and structured research field. As early as 1992, the MIT Press launched the journal *Presence: Teleoperators and Virtual Environments*[8] , and in 2002 the *International Society for Presence Research* (ISPR) was founded.

The definition of telepresence that somehow established the field was provided by the cognitive scientist Marvin Minsky (1980):

> Each motion of your arm, hand, and fingers is reproduced at another place by mobile, mechanical hands. Light, dexterous, and strong, these hands have their own sensors through which you see and feel what is happening. . . To convey the idea of these remote control tools, scientists often use the words 'teleoperator' or 'telefactor'. I prefer to call this 'telepresence'. . . *Telepresence* emphasizes the importance of high-quality sensory feedback and suggests future instruments that will feel and work so much like our own hands that we won't notice any significant difference. . . The biggest challenge to developing telepresence is achieving that sense of "being there." Can telepresence be a true substitute for the real thing? Will we be able to couple our artificial devices naturally and comfortably to work together with the sensory mechanisms of human organisms? (Minsky, 1980, paras. 1–18)

Therefore, unlike immersion that can occur without technology mediation, according to Minsky's definition, telepresence is dependent on some kind of technology. As Biocca (2015) teaches us, in telepresence, the prefix '*tele*' is rooted in the idea of transporting someone's senses to a different place (e.g., tele-vision, tele-phone).

[8] See the journal webpage "PRESENCE: Virtual and Augmented Reality". https://bit.ly/3eUv54j. Accessed 12 Nov. 2020.

Steuer (1992) proposes a distinction between presence and telepresence. According to him, presence is related to one's perception of the environment as "mediated by both automatic and controlled mental processes", or "the sense of being in an environment", and telepresence is defined "as the experience of presence in an environment by means of a communication medium", that is, it is related to "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment" (Steuer, 1992, pp. 4–5).

This definition points out that our experiences are always mediated, in presence by our biological constitution (Lombard & Jones, 2015), and in telepresence by adding a technological 'layer' of mediation. However, from the nervous system's standpoint, there is no difference between both, and only an observer can distinguish between presence and telepresence. As von Foerster (1973) teaches us, in the world

> there is no light and no color, there are only electro-magnetic waves; 'out there' there is no sound and no music, there are only periodic variations of the air pressure; 'out there' there is no heat and no cold, there are only moving molecules with more or less mean kinetic energy, and so on. (Von Foerster, 1973, p. 4)

Nevertheless, our everyday experience shows us that presence is not something given and seems to be associated with attention. It is not hard to 'get lost' by scrolling infinitely through Facebook, Instagram, or being captured by the smartphone's flickering screen warning that another WhatsApp message arrived. In the following, presence will be discussed as a phenomenon related to perception and, therefore, to cognition.

As we are dealing with the notion of embodied cognition, it makes no sense to treat presence as a mental phenomenon since, from this perspective, mind and body are not dissociated. Thus, presence will be discussed as a phenomenon related to the cognitive processes of an embodied subject.

2.3.1. Presence as awareness in meditative practices

The association of attention and presence appears, for example, in the meditative practices that became popular in the Western world since the late-1970s. The most known meditation technique, mindfulness, adapted from the teachings preached in the Theravada Buddhism canon, *Satipatthana Sutta* (The Discourse on the Establishing of Mindfulness). In its original form, mindfulness was a religious practice aimed at purification, disciplining, and overcoming bad sensations and feelings through purposefully focusing on the body, feelings, and mental qualities (dhammatalks.org, n.d.).

The mindfulness practised in the West was stripped out of any religious context. One of the prominent techniques advocates is Jon Kabat-Zinn, from the University of Massachusetts Medical School. He was responsible for making mindfulness mainstream through his stress reduction program and his writings. For the author,

> *Mindfulness* is synonymous with awareness. My operational definition of mindfulness is 'the awareness that arises from paying attention on purpose, in the present moment, and non-judgmentally'. . . And mindfulness can be cultivated, developed, and refined, carefully and systematically, as a practice, as a way of being through *mindfulness meditation*. (Kabat-Zinn, 2018, pp. 30–31)

To explain what he means by presence, Kabat-Zinn (2015) refers to the classroom, or more specifically, to the attendance list used by teachers worldwide. When a child responds 'present' to the teachers' call, no one doubts that the child is in the classroom. However, in many cases, only the child's physical body is in the classroom. The child can be 'wandering' through other places and times, fantasizing about something, somewhere far from the classroom. As the author explains:

> To be present is far from trivial. It may be the hardest work in the world. And forget about the "may be". It is the hardest work in the world – at least to sustain presence. And the most important. When you do fall into presence – healthy children live in the landscape of presence much of the time – you know it instantly, feel at home instantly. And being home, you can let loose, let go, rest in your being, rest in awareness, in presence itself, in your own good company. (Kabat-Zinn, 2015, p. 949)

It is interesting to note how Kabat-Zinn (2015) definition of presence holds similarities with the notion of immersion, as the total immersion described by Brown and Cairns (2004), and the notion of flow (Csikszentmihalyi, 2007). Nonetheless, although meditation and flow can share common attributes, such as the loss of sense of time and space, there are distinctions between them (Peifer, 2012).

Sheldon et al. (2015) compared mindfulness, defined as reflective awareness and flow, as a process related to absorption and control in terms of compatibility of experiences. According to the authors, both states share some common characteristics at first, but they can be regarded as antagonists if looked deeper. As they conclude: "boosting a person's ability to remain mindful during an activity might actually undermine their ability to get absorbed in that activity" (Sheldon et al., 2015, p. 281). However, as the authors admit, other researchers argue on the contrary direction, suggesting that meditation can increase flow ability in athletes (Aherne et al., 2011; Kaufman et al., 2009).

Nonetheless, what seems to be clear is that both mindfulness and flow are related to presence in a certain sense. During mindfulness, presence seems to reveal itself from the subject's awareness of her/his own thought processes, an immersive experience directed 'inwards'. In flow states, the subject is, in a certain sense, intertwined with an activity s/he performs with a minimum of self-referentiality, present (or total immersed) in the activity being performed.

The discussion of presence proposed here should be comprehensive enough to encompass these apparently antagonistic experiences and others closer to the focus of this work, such as telepresence or the presence mediated by technology.

2.3.2. Discussing ISPR's definition of (tele)presence

As we could see, presence is a state that demands conscious efforts to be achieved, or as some meditators prefer, presence needs to be cultivated. In the early-2000s, the electronic mailing list *presence-l listserv* gathered scholars interested in the theme of presence that discussed and elaborated a definition for the term that the ISPR adopted. In its first paragraph, we read that,

> Presence (a shortened version of the term "telepresence") is a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. Except in the most extreme cases, the individual can indicate correctly that s/he is using the technology, but at *some level* and to *some degree*, her/his perceptions overlook that knowledge and objects, events, entities, and environments are perceived as if the technology was not involved in the experience. Experience is defined as a person's observation of and/or interaction with objects, entities, and/or events in her/his environment; perception, the result of perceiving, is defined as a meaningful interpretation of experience (International Society for Presence Research, 2000, para. 1).

It is noteworthy that, according to this definition, the possibility of presence is based on a mismatch between what the senses perceive and what the subject decides to experience. As it is stated, the subject cannot perceive the technology involved in the experience in some extreme cases, meaning that the subject is often aware of it. The possibility of deciding to be immersed will be discussed in further chapters. ISPR's definition is limited regarding experiences involving other types of mediation, such as the state of presence of meditation, unless it considers that biological mediation is also a technological mediation, which does not seem to be the case. In this sense, it is essential to recognize that this definition is comprehensive enough just to encompass the experiences mediated by technologies.

Telepresence is then a phenomenon that "involves continuous (real-time) responses of the human sensory, cognitive, and affective processing systems to objects and entities in a person's environment" (Lombard & Ditton, 1997, pp. 14–15). Following this definition, the highest degree of telepresence is the complete failure to identify the role of technology in the experience. In this case, telepresence will be equal to presence, explaining why ISPR opted for using 'presence' instead of 'telepresence'. In this sense,

> presence requires researchers to compare human perceptions and responses in the context of technology with human perceptions and responses in contexts that do not involve technology (often referred to as "face-to-face" or "interpersonal" contexts or, somewhat confusingly, "nonmediated" or "real" contexts). (International Society for Presence Research, 2000, para. 2)

ISPR's statement proposes five dimensions for the concept of presence that involve perceiving physical environments, social interactions, or both. The dimensions/types of presence are spatial presence, sensory presence, social realism, engagement, and social presence. However, as some authors point out, there is no consensus in the definition of presence, and not seldom each researcher creates her/his terms to deal with the same context, pointing at the same time to the relevance and a certain fragility of this type of classification (K. M. Lee, 2004; Lombard & Jones, 2015).

2.3.2.1. The five dimensions of presence according to ISPR

The first dimension proposed by ISPR is spatial presence, which has to do with the feeling of being somewhere else. It can be said that it corresponds to how the term is most used, as in *tele*presence (Heeter, 1992; Minsky, 1980; Steuer, 1992). From the user's perspective, it is related to the feeling of 'transportation' to a different place from where the body physically is. Spatial presence has to do with perceiving an opaque interface as a transparent one, "that erases itself, so that the user is no longer aware of confronting a medium, but instead stands in an immediate relationship to the contents of that medium" (Bolter & Grusin, 1999, pp. 23–24).

As examples of this type of presence, we can cite the movies *The Lawnmower Man* (1992), *Matrix* (1999), and the episode *Striking Vipers* (2019) from *Black Mirror* series. In the first, the interface is responsible for translating the character's body movements to his digital avatar, and in the other two, the characters' nervous systems were connected directly to the digital realm. In all cases, the characters were not aware (consciously or not) of the interface during the experience and acted as 'being there' (FIG. 3).

Figure 3 –. Left: Still from *The Lawnmower Man* (1992), Center: Still from *Matrix* (1999), Right: Still from *Striking Vipers* (Black Mirror's episode - 2019) The notion of 'spatial presence' as depicted in some movies: the characters act as 'being there'. Collage by the author.

The second dimension, sensory presence, is defined in ISPR's statement as what occurs

> when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that s/he is in a physical location and environment in which the sensory characteristics correspond to those of the physical world. (International Society for Presence Research, 2000, para. 11)

Sensory presence has some overlapping with spatial presence, but its difference has to do with corresponding to the user's expectations about how objects, events, and/or people s/he may encounter during the experience may behave. It is more related to the feeling of 'it is here', as Lombardi and Ditton (1997) put it.

Social realism, the third dimension as defined by ISPR, relates to perceiving the social characteristics of the experience as they do or could exist in the physical world, fulfilling, to some extent, the user's expectation about how social interactions should happen. One example of social realism is the game *Death Stranding* (2019). It takes place in the post-apocalyptic United States, and the characters were interpreted by well-known actors, such as Norman Reedus and Léa Seydoux. Their faces, bodies, and voices were captured and used to animate their photorealistic digital versions, conferring the game dialogues and interactions with a rare sense of realism (FIG. 4).

Figure 4 – Social realism: The digital models of Norman Reedus and Léa Seydoux interacting in the game Death Stranding. Still from the game *Death Stranding* (2019). LAVDN. https://bit.ly/3lrWWv3. Accessed 12 Nov. 2020.

The fourth type of presence is defined as engagement. It occurs when the user's perception is directed away from the objects, events, and/or people from the physical world and to the direction of those created by technology. It is sometimes regarded as 'presence as immersion' (Lombard & Ditton, 1997), or 'perceptual presence', about "the degree to which a virtual environment submerges the perceptual system of the user" (Biocca & Delaney, 1995, p. 57). As an example of this type of presence, we can look at a user immersed in VR who can freely walk for some time. Her/his attention gets directed to the 'digital' world, and after a while, s/he will probably be unable to tell where her/his body is facing physically.

The last type of presence, as described by ISPR, is social presence. It is related to failing to perceive "the role of technology that makes it appear that s/he is communicating with one or more other people or entities" (International Society for Presence Research, 2000, para. 17). This dimension is subdivided into other three aspects: a) social actor within the medium, when a one-way communication, between human and technology, seems to be two-way communication with another entity; b) co-presence, that is related to two-way communication with other people as if they are sharing the same physical location when they are at distinct locations; and c) medium as a social actor, where the user fails to acknowledge that s/he is having a communication with the medium itself, and not with another human being. The difference between 'a' and 'c' is that in the first, the user fails to perceive that is no feedback between the user and the other entity, e.g., when a TV host asks something to the viewer that feels like s/he is interacting with the host.

As we stated earlier, other authors propose distinct classifications for presence. In the early-1990s, Heeter (1992) worked on her three dimensions of presence: personal, social, and environmental. One of the most comprehensive studies in this same sense was developed a few years later by Lombard and Ditton (1997), where they presented an extensive literature review and proposed six conceptualizations for presence. Biocca (1997) also identified three dimensions of presence: physical, social, and self-presence. In the early-2000, Lee (2004) proposed another influential classification based on 'domains of virtual experience' that uses Biocca's work as a basis but trying to resolve some inconsistencies identified in the field as a whole.

Some of the features that capture our attention in ISPR's presence definition are an excessive overlapping between the so-called dimensions and the notion of failure of perception as a constitutive factor of the experience of presence. To some extent, the excessive overlapping is addressed by ISPR's definition itself when it is said that dimensions are "in many cases nonorthogonal or overlapping" (International Society for Presence Research, 2000, para. 8). Thus, it seems more relevant to briefly discuss the notion of failure of perception.

As ISPR defines, perception is "the result of perceiving. . . a meaningful interpretation of experience" (International Society for Presence Research, 2000, para. 1). The failure of perception, or misperception, is exemplified in regards to the physical world by "the hearing of voices by schizophrenics; perceptions during dreams and daydreams, and less clearly, perceptions during role-playing games and perceptions that result from the use of various drugs" (International Society for Presence Research, 2000, para. 25).

This issue is somehow problematic since it associates the 'normality' of perception with a limited range of wake states, excluding those linked to mental conditions, such as schizophrenia. It is not surprising that these limited states are those linked to the individual who can be used as a labour force, the productive individual. From this perspective, dreaming, schizophrenia, or playing, for example, can be considered as deviations from this normality, possible only for those who misperceive.

On the other hand, considering some experience as arising from misperception can be said only from an observer who is not present. When the subject is present, there is no room for misperception since recognizing any 'flaw' in perception means ending the experience of presence, even if momentarily. Of course, we can misperceive things around us, but what is missed can only be perceived if a new perception occurs. We will return to this topic in Chapter 4 when we discuss the cognitive possibility of VR. Nonetheless, facing the limits of ISPR's definition and its relevance to the study field, it seems important to understand other themes' approaches.

2.3.3. The experience of presence as availability and presence in thought: a difference of degree

So far, we have discussed presence in a technological and non-technological sense. We presented some of the possible definitions for the term and its use in distinct contexts. For meditators, presence involves being aware of the mind-body processes, which is a state of mind that is hard to achieve and even harder to sustain. For researchers interested in telepresence, the term is a multidimensional concept with many forms. Telepresence aims to vanish in transparency, dribbling the clumsiness of the technologies involved in the mediation of the experience.

However, we discussed presence based on what we perceive, from the stimuli that come to our sensors from either physical or digital sources. In this section, we wish to discuss the other aspects of the experience of presence that do not necessarily involve what is in the 'foreground' of the perceptive field, but to those aspects that are partially or fully occluded from us, but that constitutes our experience of presence.

In this sense, we can return to some childhood experiences related to these aspects of presence. For example, it is not rare to find someone who, as a child, feared the 'closet monster' – an entity that was hidden inside the wardrobe – or by ghosts that haunted entire houses. These, and many other experiences, share that they were terrifyingly present, although they were not really present. Or were they?

As Noë (2012) reminds us, our visual perception, for instance, includes not only what is visible but what is hidden or occluded from us. For example, if we look at our smartphones, we perceive their presence as a whole, even though there are parts hidden from our view. We do not need to think, judge, or infer that the smartphone is there: we have a "visual sense of its presence" (Noë, 2012, p. 16). The author calls this phenomenon of an object present only to consciousness as the problem of 'presence *in* absence'.

A complementary example presented by Noë (2012) regards the perception of a room full of people, colour, and details. It is impossible to see everything in detail simultaneously since our focus area is restricted to our view's central part. Everything looks somewhat blurred in the periphery of our field of view, yet we have the perceptual sense of these entities' presence. In this sense, these features of the world

> fall within the scope of your perceptual awareness despite the fact that they are, in a straightforward way, out of view, or concealed, or hidden, or absent. They are present in experience – they are *there* – despite the fact that they are absent in the sense of *out of view*. They are present precisely *as* absent. (Noë, 2012, p. 18)

Nöe (2012) argues that the visible is something that is available from a particular place. Thus, in the example above, the sense of presence does not come from a representation constructed in mind (as some cognitivists may argue), but it shows what is available from that specific place. In this sense, when I focus on an area of my field of view that was previously blurred, that part becomes available to perception.

This notion of availability is related, to some degree, to what Merleau-Ponty (1945/2012) defines as space. For the author, space "is not the setting (real or logical) in which things are arranged, but the means whereby the position of things becomes possible" (Merleau-Ponty, 1945/2012, p. 284). Space can then be understood as the universal power which enables things to be connected. However, this connection exists only "through the medium of a subject who traces out and sustains them" (Merleau-Ponty, 1945/2012, p. 284). This subject is then immersed in space, in a world "all around me, not in front of me" (Merleau-Ponty, 1961, p. 178). A subject that can be seen as the origin of perception and spatiality, the centre from where all directions and distances depart (Merleau-Ponty, 2004; Vetö, 2008).

In this sense, parts of my field of view that were obscured are brought to presence by my body's movements within the space. That can help to explain why the smartphone in the example above could be felt as present. We have a practical understanding that the 'invisible' part of the smartphone can be accessed through the head and body's simple movements. Thus,

> perceptual consciousness is a special style of access to the world. But access is not something bare, brute or found. The ground of access is our possession of knowledge, understanding, and skills. Without understanding, there is no access and so no perception. (Noë, 2012, p. 20)

Therefore, our sensorimotor understanding is what can bring the world into focus: "to perceive something, you must understand it, and to understand it you must, in a way, already know it, you must have already made its acquaintance" (Noë, 2012, p. 20). However, considering that we need to develop an embodied understanding to perceive has as a consequence the impossibility of perceiving novelty. As the author explains, "there are no novel experiences. The conditions of novelty are, in effect, the conditions of invisibility. To experience something, you must comprehend it by the familiarizing work of the understanding" (Noë, 2012, p. 20).

Noë's claim offers a way to explain the common myth of the 'invisible ships'. It is said that when the European colonizers were arriving at their destinations' coasts, the natives ignored the massive presence of the ships. The myth seems to originate from the voyage made in 1770 by the *Endeavour*, a 32-meter-long ship under the command of Captain James Cook. The onboard botanist, Joseph Banks, registered in his journal their arrival at the Botany Bay in Australia:

> These people [the natives] seemed to be totally engaged in what they were about: the ship passed within a quarter of a mile of them and yet they scarce lifted their eyes from their employment; I was almost inclined to think that attentive to their business and deafened by the noise of the surf they neither saw nor heard her go past them. . . Not one was once observed to stop and look towards the ship; they pursued their way in all appearance entirely unmoved by the neighbourhood of so remarkable an object as a ship must necessarily be to people who have never seen one. (Banks, 1768)

According to Banks (1768), the natives seem to perceive the ships just when they were somehow close to the coast when they started to protect themselves by throwing rocks, shouting, and menacing with lances. Thus, it is possible to suppose that when the ships moved from the distant and blurry periphery of the field of view to occupy a place in its focused centre, the natives could relate to these objects. They probably moved their bodies to understand better what they were seeing until realizing that something was approaching the coast, in this case, something perceived as threatening.

As Noë (2012) explains, an object or quality is perceptually present when two conditions are satisfied:

> (1) Movement dependence: Movements of the body manifestly control the character of the relation to the object or quality.
>
> (2) Object dependence: Movements or other changes in the object manifestly control the character of the relation to the object or quality. (Noë, 2012, p. 22)

However, perceptual presence does not explain the childhood fears mentioned at the beginning of this section. The presence experienced by children seems to be from another type since the entities were not perceptually available for them. Noë (2012) considers this other type of presence, where an object is present to mind without being perceived by the senses, as *thought* present, i.e., a presence that is possible through other skills of access, such as linguistic, conceptual, and descriptive skills. The author considers that the difference between thought presence and perceptual presence is a difference of degree, not type. Thus, in comparison with ISPR's definition of presence, what they call 'misperception' is, for Nöe (2012), a different degree of presence.

In this sense, I can, intentionally or not, bring objects into thought presence, as the child does with its monsters and ghosts. Nevertheless, I cannot bring into presence nonexistent objects. I can only bring into presence something that has some level of resonance to what I know (or believe) that exists. Childhood's monsters and ghosts are familiar in a closer sense to what Freud (2019) called *unheimlich.* The term's analysis escapes from our objectives here, but it seems sufficient to our discussion to say that *unheimlich* is related to what is uncanny, strangely familiar, and unsettling.

If it is correct that perceptual and thought presence are similar in type and different in degree, it is possible to suppose that the effects of each type of presence should also be similar. Some evidence points in this direction. For example, the technique of mental practice (or mental imagery), which can be defined as the rehearsal of a mentally performed task, has been used in different contexts with positive results. Several mental practice techniques are used with athletes of all levels to improve fine and gross motor skills, skill learning or refinement, or even motivational improvements (Rogers, 2006).

The mental practice has also been used in the medical context. Trained surgeons reported using mental imagery frequently before the operation to prepare for surgery (Edwards et al., 2004). According to Sanders et al. (2008), mental imagery has been used successfully in medical education, presenting better results in live surgery performance than conventional study through textbooks.

An explanation for the similarity of effects between thought and perceptual presence can be derived from the brain's study when dreaming. In this state, a subject can experience worlds that resemble, to a significant extent, the wakeful world with richness of colour, shapes, movements, people, events, conversations, etc. There are several differences between dreaming and waking consciousness as well, such as "reduced attention and voluntary control, lack in self-awareness, altered reflective thought, occasional hyperemotionality, and impaired memory" (Nir & Tononi, 2010, p. 92). Nonetheless, the similarities between these states are significant. The Rapid Eye

Movement (REM) sleeping phase, usually associated with dreaming, is considered "a modified attentive state in which attention is turned away from the sensory input, toward memories" (Llinás & Paré, 1991, p. 525). These authors consider that "wakefulness is nothing other than a dreamlike state modulated by the constraints produced by specific sensory inputs" (Llinás & Paré, 1991, p. 525). As Maturana (2008) explains, the nervous system operates similarly during wakefulness or dreaming, as a closed network that functions without any reference to what is 'external' to it.

In summary, presence is something that is achieved. Even in the most technologically advanced virtual reality systems, where there are significant efforts in representing a world in all its dimensions of realism, it needs to be perceptually available to be felt as present by a subject. The same seems true to thought presence when one needs to sustain thought about a person or object to make it present to the mind. Thus, as Noë (2012) puts it, the experience of presence can be considered as something fragile that demands our engagement to occur.

2.4. All together now: technologies of immersion?

As we discussed earlier in this chapter, any technology analysis is not a straightforward task. The development and use of any technology are part of an ever-changing system in which cultural, social, economic, and political aspects interact and influence each other. Therefore, the emergence of a technology is preceded by circumstances that, at first sight, apparently do not relate to the technology itself.

Then we discussed how the adoption of a technology could transform us entirely. By considering technologies as extensions of our human faculties, we argued that technologies could be seen as elements that exist regarding our bodies, and their use can alter the pace, scale, and/or the patterns of our activities. Furthermore, we saw that technologies tend to be environmental. They tend to be incorporated into our environment, becoming part of the 'niche' where we interact and transform our surroundings, sometimes in harmful ways.

Afterwards, we discussed immersion as something related to the experience of a subject absorbed in an activity that is not necessarily related to technology. In this sense, it was possible to understand that there are several types of immersion and that an immersive activity for a subject is not necessarily immersive for another. We also discussed imagination's role in immersive experiences, especially in mediums that do not present any given images, such as in LARPs, books, and MUD games. Finally, we envisioned the possibility of designing experiences aiming to provoke the sensation of immersion in a subject.

At that point, we introduced the concept of presence to the discussion, a notion that surrounds, intersects, overlaps, and extrapolates immersion to a certain sense. Therefore, it was possible to understand how conscious efforts can achieve presence, as in the meditative practices, where presence relates to cultivating awareness. Additionally, we discussed how our biological constitution always mediates our perception of the world. Then we analyzed telepresence, or the possibility of achieving the sense of presence through technology mediation, the second layer of mediation to our perception. The dissection of telepresence in its multiple dimensions revealed how the achievement of presence is complex and demands multiple aspects. Lastly, it was possible to understand how the experience of presence can be seen as a possibility of re-centralizing the body as the point from where perception occurs, that is, from where space, people, events, and objects are presented to our perception. In this sense, we saw how our experience is composed of visible and invisible parts of that world and how we need to develop a sensorimotor understanding to perceive something as present.

From these discussions, we can begin to analyze the immersive technologies themselves. The terms – immersive technologies or technologies of immersion – are widely used by scholars and laypeople about a restricted group of digital devices: the HMDs, controllers, gloves, vests, or other devices used to present some digital content.

However, from the perspective of this work, these terms – immersive technologies – do not seem adequate. As has been discussed, immersion is a quality of experience. It is a characteristic of something that occurs in certain circumstances and presupposes a subject who experiences it and feels immersed. Thus, to characterize a group of technologies as immersive seems to point to the possibility of an experience happening without a subject to experience it, which is impossible.

Throughout the discussion, we built an understanding of technology that is not restricted to the digital realm, as well as it was possible to perceive that immersion can take place in many other forms than those presented by the so-called 'immersive technologies'. In a way, almost all technologies can pose, depending on how and who is using them, as 'immersive technologies'. This makes the term, to a certain sense, useless. However, it is possible to say that some technologies were designed to provoke the sensation of immersion in a subject. For example, when digital technologies are involved in an immersive experience, the perception of immersion can emerge in the subject only when s/he is wearing the technology. Thus, in this case, the technologies can be considered a medium from where the stimuli are conveyed to a subject's sensors, whose nervous system changes the relations between neuronal elements, giving rise to specific sensations and behaviours. The behaviour "that the observer sees as he or she beholds the organism as a totality in a medium arises in the encounter of the organism with the medium in a manner in which both the organism and the medium participate" (Maturana, 2008, p. 111).

In this sense, I propose to refer to the technologies that can be coupled with a subject, serving as a medium for stimuli, and designed to make her/him perceive her/himself as immersed, as technologies *for* immersion. Thus, technologies for immersion are based on the development and refinement of knowledge on how perception works and how to induce someone into perceiving something in a certain way.

Therefore, it does not make sense to restrict the technologies for immersion just to digital technologies, as the denominations 'immersive technologies/technologies of immersion' tend to suggest. On the contrary, we agree with Grau (2003) when he affirms that "the idea of installing an observer in a hermetically closed-off image space of illusion did not make its first appearance with the technical invention of computer-aided realities", but it is part of the core of "the relationship of humans to images" (Grau, 2003, pp. 4–5) – an idea that goes back to the classical world.

Furthermore, to our understanding, the definition of technologies for immersion should be understood and aligned with Sloterdijk's (2006/2011) suggestion of considering the existence of an *immersionkunst*. As presented earlier, *immersionkunst* could be translated either as 'immersive art' or 'art of immersion'. The former seems problematic in the same manner as 'immersive technologies' since all art can be perceived as immersive, not only in the moment of fruition but also when it is being produced. Moreover, immersive art seems to qualify something already done, sounding like a static label that does not refer to 'how' something is produced but to the product itself. Thus, in the context of this work, it seems more interesting to consider the latter translation, the art of immersion, since it points to the possibility of inscribing the knowledge about the perception of immersion into a process that is a constant and dynamic 'work-in-progress'. An *immersionkunst* can be regarded as an investigation through the practice of the many aspects involved in the experience of immersion.

In the context of this work, the study of the technologies for immersion will be approached as a part of this art of immersion. Thus, it should not be restricted to the 'hard' components of the experience: the form or the physical supports and elements that make it possible for the subject to have agency over the experience. Instead, it should also include the 'soft' aspects or the content of the experience itself since they are indissociable.

However, as we have already discussed, the development and adoption of a particular technology are dialogically related to the political, economic, social, and cultural context where it takes place. It seems possible to distinguish between at least two contexts of immersive experiences, that of production and that which refers to the context of experiencing itself. Nevertheless, the two contexts can be regarded simply as the context of experiencing since even the perception of a particular 'context of production' is based on the subject's experience in a specific place and time. Thus, our analysis will be guided, as much as possible, by what experience can disclose, or to use Heidegger's term, what it can 'bring forth'. Our approach can be considered phenomenological since it prioritizes experience to approach the knowledge of something. As Park et al. (2000) reminds us,

> The phenomenological concept of disclosure presents an ambiguity between what pre-exists to be revealed by the device and what is introduced as new: the device simply discloses, and in certain contexts it may be appropriate to declare the disclosure is of something pre-existing or that it presents a new concept. (Park et al., 2000, p. 6)

The other side of disclosing is concealing. As any magic trick demonstrates, a magician makes a coin disappear in front of our eyes just by revealing and concealing it at the right moment using the right gestures. Heidegger (1951/1971) illustrates the movement of disclosing-concealing as follows:

> The bridge swings over the stream with case and power. It does not just connect banks that are already there. The banks emerge as banks only as the bridge crosses the stream. The bridge designedly causes them to lie across from each other. One side is set off against the other by the bridge. . . With the banks, the bridge brings to the stream the one and the other expanse of the landscape lying behind them. It brings stream and bank and land into each other's neighborhood. (Heidegger, 1951/1971, p. 6)

In this sense, as Coyne et al. (2002) explain, the bridge reveals something

> that already exists: the banks, the river, the flow. It may also conceal something that was hitherto present: the distance between the banks, certain views from down the river, the force of the water, the danger of the crossing (Coyne et al., 2002, p. 270).

Therefore, the introduction of the bridge in the landscape revealed and concealed what already existed but also introduced something new, for instance, new ways of crossing the river, new views of the river, new possibilities for the exchange of goods, etc.

The movements of concealing-disclosing seem fundamental to the very functioning of the technologies for immersion. This relation becomes evident in the very gesture of wearing a VR HMD or entering an architectural space: something needs to be concealed from our perception to allow the revealing of other things.

From all we have discussed throughout this chapter, disclosing is an interesting perspective to analyze the entanglement between technologies for immersion, the art of immersion, and an immersed subject. Our investigation of immersive experiences should also consider the intertwining of subject and 'object' or the content of the experience. The immersed subject is the one who crosses and is crossed by the immersive experience and who, in this process, also affects and is affected by it.

To suppose the inseparableness between experience/experienced, or immersion/immersed can be seen as a kind of unwanted contamination of the analysis, a kind of boundary to our investigation proposal. Furthermore, I contend that it is exactly that, a boundary for an analysis that does not intend to be totalizing or aims at the phenomenon's exhaustion.

Thus, in our investigation, the subject's experience is a kind of Ariadne's thread to which we can turn when we proceed with our analysis. From this standpoint, it is possible to approach the production of immersive experiences as the experience of producing immersive experiences, which involves the spaces, procedures, gestures, software, and other aspects of production. The same can be applied to the experience of fruition, or the experience of experiencing, and all that it involves.

In our next chapter, we will look at some immersive experiences from this standpoint to understand what is possible to perceive through experiencing them in terms of disclosure and concealment.

3. The subject within immersive experiences

In this chapter, a discussion on the modes of engagement of a subject with immersive experiences will be presented. By modes of engagement, we refer to how subjects and technologies for immersion can interact. The possibilities of interaction between subject and technology are defined by the subject's body and the very design of the technology itself. In this sense, we will approach the analysis from the standpoint of *affordances* (Gibson, 1979/2015). In this sense, the examples presented further are essential as they illustrate the discussion. Thus, the examples were selected not only by their relevance as immersive experiences but also by what they can help in our attempt to disclose several aspects related to the perception of immersion.

Humans have remained practically the same for a few thousand years in terms of biological and physical constitution. However, even though our bodies are similar to those of our ancestors, our engagement with the world around us has been significantly transformed. From the standpoint of embodied cognition, as we mentioned before, there is no separation between mind and body because cognition is indissociable from a body. Nonetheless, the body is "the vehicle of being in the world" and "I am conscious of my body *via* the world, that it is the unperceived term in the centre of the world towards which all objects turn their face" (Merleau-Ponty, 1945/2012, p. 94).

Our body, Merleau-Ponty (1968) explains, is

> a being of two leaves, from one side a thing among things and otherwise what sees them and touch them; we say, because it is evident, that it unites these two properties within itself, and its double belongingness to the order of the "object" and to the order of the "subject" reveals to us quite unexpected relations between the two orders. (Merleau-Ponty, 1968, p. 137)

The body is one and the other simultaneously. Even when something is said of a body, as if it has an objective existence, it is said by an embodied subject. In this sense, even when we bring immersive experiences to the foreground, against the background of other types of experience, we also bring forth an immersed body that is engaged in experiencing.

The transformations in our body engagement with the world become evident, for instance, by looking at the cinema experience at the end of the 19th century. As Buck-Morss (1992) remembers us, in the early days of cinema, the image of a close-up of a head that suddenly smiled was sometimes perceived with horror by the audience as a giant severed smiling head. Another famous anecdote regards the movie *L'Arrivée d'un train en gare la Ciotat* produced by the Lumière brothers in 1895[9]. The myth says that the audience sometimes panicked and moved 'away' from the screen, fearing the incoming train. It is possible that both reactions would be seen today as unexpected, which points to the possibility of a specific adaptation of the subject to the medium, in this case, the cinema.

Another evidence of this medium adaptation was probably experienced by many when re-watching a movie that was considered remarkable for its computer graphics. A second view of the movie some years later can reveal dated and obsolete effects. If the movie is stills the same, it is possible to suppose that something in the observer changed.

Since our interaction with technologies for immersion did not start with digital technologies, it is supposable that our engagement with immersive experiences has also been transformed to some exchange. It does not mean that an independent and disembodied knowledge on engagement is simply inherited in a Lamarckist way. The ubiquitous presence of digital technologies positions us in a very different place from those of our parents or grandparents. For example, today, it could be said that the relationship between a child and digital technologies precedes its birth through medical imagery or social-media profiles presenting pregnancy from start to end. That is, the digital presence of a child precedes its existence as a subject. If it were possible to bring a baby from the 19th century into the present day, and offer her/him devices with all sorts of screen sizes and resolutions, when this baby is returned to her/his time, s/he would probably not be frightened by the incoming train in the movie, or other interactions with moving images on the screen. In this sense, being exposed to the possibilities of immersion through technology probably affects our engagement and the effects of these experiences. The child learns through interacting with the devices that the image is contained and could not physically harm them.

For a similar reason, the immersive effects of the experience of environments such as the *Sacro Monti di Varallo*, which we will see further, can be considered less impressive today than they were a few centuries ago. The *Sacro Monti* was a 'proto-installation' that mixed site-specific paintings and sculptures to depict relevant passages of Biblical narrative. It was not made just to be seen but to be walked through, around, and touched. In comparison with what is possible today in terms of images and interactions, it is hard to believe that the experience of the *Sacro Monti* was

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[9] This anecdote is questioned by Loiperdinger and Elzer (2004). The authors argue that there is no evidence that the panic of the audience really happened.

immersive. In part, this is because we now have technologies for immersion that are more effective in capturing and reacting to our body's interactions and movements, which helps to maximize the immersive effects of a given experience.

Since we consider architecture a technology for immersion, it seems necessary to look at it from the same perspective, which means to recognize that we are affected by spatialities that, for the most part, do not react to our interaction or even to the movements of our body. The 19th-century subject that was frightened by the train on screen would probably have little difficulty dealing with the architecture of our time. There were several significant improvements in construction technology since the 19th-century: the buildings have become taller, to some extent more efficient and with formally innovative volumes. Some buildings have become interactive by integrating other technologies, such as sensors of presence, temperature, humidity, etc., and gadgets like automated curtains and wi-fi lamps. However, most of the effects of immersive architectural experiences seem to come from the unveiling of the ambiences by a subject in movement that is affected by the environment as s/he moves. The movement here must be understood comprehensively, involving the movements through space from a subject that crosses a room and those more subtle, such as the eyes and head movements. In this sense, is it possible to consider that this immersed subject is engaged in interacting with architecture? Or does s/he need to touch, push, and knock to be considered as interacting?

If we consider that a subject can be affected by the perception of spatiality, then we have to consider that there is some kind of interaction going on. In this case, the interaction seems to be related to the possibilities of engagement offered by the spatiality and how that engagement resonates with the subject's embodied cognition. As I move my body through spaces, I am affected by what seems to emanate from the space, its *atmosphere*, a theme discussed in further chapters.

Therefore, we can affirm that there are differences in the modes of engagement available to a subject regarding the technologies for immersion. That is, certain technologies afford certain modes of engagement or of interacting with them.

The notion of what something affords was developed by Gibson (1979/2015) as the *theory of affordances*. According to the author, "the *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes,* either for good or ill. . . . It implies the complementarity of the animal and the environment" (Gibson, 1979/2015, p. 119). The affordance of something has to be measured relative to the animal, which means that an affordance is always an affordance concerning some entity. As the author explains

> An important fact about the affordances of the environment is that they are in a sense objective, real, and physical, unlike values and meanings, which are often supposed to be subjective, phenomenal, and mental. But, actually, an affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer. (Gibson, 1979/2015, p. 121)

It is possible to consider that each technology for immersion is perceived as having its affordance regarding the modes of engaging with that technology. Anything in our environment can have multiple affordances, such as a bottle, which affords to grab, drinking, and looking through it, but it also affords being thrown at someone or recycled into something else. What is evident is that the affordance of a particular element of the environment has to do with how a subject perceives the element regarding his/her own body, tracking possibilities for acting.

The notion of affordances points in the same direction as our earlier discussion on the enactivist theory of perception and action, as pointed by Clark (1997), Noë (2004), and Varela et al. (1991/2016)[10]. Noë (2004) proposes a reformulation of affordances in the context of enactivism. For the author, to perceive is

> to perceive structure in sensorimotor contingencies. To see that something is flat is precisely to see it as giving rise to certain possibilities of sensorimotor contingency. To feel a surface as flat is precisely to perceive it as impeding or shaping one's possibilities of movement. . . . When we perceive, we perceive in an idiom of possibilities for movement. . . . To perceive is (among other things) to learn how the environment structures one's possibilities for movement and so it is, thereby, to experience possibilities of movement and action afforded by the environment. Gibson's theory, and this is plausible, is that we don't see the flatness and then interpret it as suitable for climbing upon. To see it as flat is to see it as making available possibilities for movement. To see it as flat is to see it, directly, as affording certain possibilities. (Noë, 2004, p. 105)

3.1. The affordances of immersive experiences

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[10] There are differences and incompatibilities between Gibson's theory of perception and what the other authors argue. The disagreement between authors refer, in great part, to the notion of environment invariants described by Gibson (1979/2015). Varela et al. (1991/2016) discuss these differences in pp.203-205.

The concept of 'sensorimotor contingency' was developed by O'Regan and Noë (2001) to explain aspects of vision and visual consciousness. Sensorimotor contingency refers to the "*structure of rules* governing the sensory changes produced by various motor actions" (O'Regan & Noë, 2001, p. 941). Each sense has its own set of rules. For instance, in vision, the movement of the eyes shifts the sensory stimulation of the retina, which produces distortion in the perceived image. However, the same eye movements do not interfere with hearing, but head movements do.

However, there is another dependency that needs to be addressed that is the movement of the object. As Noë (2004) explains,

> our sensory relation to the world varies along two dimensions. The relation is *movement*-dependent when the slightest movements of the body modulate sensory stimulation. But when you see an object, your relation to it is also *object*-dependent; that is, movements *of the object* produce sensory change. (Noë, 2004, p. 64)

In this sense, the analysis of the relationship between movement and perception gains even more relevance. The movements that should be considered refer to the experience itself, the movements afforded by the technologies for immersion when the subject is immersed in them. Thus, the other affordances that do not refer to the immersive experiences but to the 'object' itself are not part of the analysis. For example, a stereoscope affords being thrown, like any object of its size, but throwing the stereoscope is not part of the movements afforded by the immersive experience offered by this device.

Thus, the examples presented below are based on the modes of engagement that their experiencing afford. These were selected to understand the various possibilities of interaction that immersion technologies can offer. In this sense, we will start with examples involving more subtle movements, which may seem to the observer even as non-movements, to those that afford an engagement of the body as a whole.

3.2. The subject's subtle movements

Our analysis starts with an experience that is not even visual. The Virtual Barber Shop is an experience that became popular during the 2000s but was produced in 1996 by the company QSound Labs. The experience consists of a 5-minute demo of a 'virtual haircut' recorded binaurally, making its experience adequate through stereo headphones.

It starts with the barber assistant, Manuel, calling the barber, Luigi, to cut the listener's hair. Before starting the haircut, Luigi demonstrates the experience's binaurality by moving from right to left when talking to the user, explaining how the recording was made. Luigi picks up scissors and gets very close to the right 'ear' and starts 'cutting' from right to left, passing through the back and top of the head, then he repeats the movements using a hair clipper. During the experience, Luigi moves in the space, approaching and distancing from the listener while Manuel plays the guitar on the room's left side.

The sound was captured using two microphones located at each side of a dummy's head, and the playback was divided in the same way. The sound captured by the left or right microphone gets played through the correspondent speaker of the headphones. This simple technique hides the complexities involved in the sense of hearing. As Møller (1992) explains, to ensure that the sounds are captured correctly, the dummy head has to be a copy of an

> average human head, including nose, orbits, pinnae and ear canals, and sometimes the head is even attached to a torso copy. Also, the acoustical impedance of the ear drum is sometimes simulated. By accurately copying a human head it is ensured that sound waves reaching the head, undergo the same transmission on their way to the ear canals, as if they were reaching a real listener. (Møller, 1992, p. 172)

Even with such specialized equipment, due to each person's anatomical singularities, problems of localization of sound sources can still occur, especially from sounds coming from the front or back of the head, which are sometimes perceived as inverted. Nevertheless, the binaural recording technique "gives a very realistic impression of being present during the recording, and people are often surprised with the authenticity" (Møller, 1992, p. 173). The experience can be so convincing that some people, including myself, report feeling the hair really being cut, or even the vibration of the hair clipper through the scalp, indicating that the binaural audio can deceive the brain into perceiving sensations related not only to hear but to other senses too.

The experience does not afford the movements of the subject. Since the headphones are coupled to the subject's ears, even head movements, which typically affect hearing, do not interfere with the experience. Our sensory dependency relates not only to our movement but also to the movements of the objects regarding ourselves (Noë, 2004). In this case, the immersed subject was spatially fixed in the moment of recording, coinciding with the microphone positioning. In a sense, it is precisely this 'immobility' that allows the subject to distinguish clearly the elements that make up this immersive experience.

The *Virtual Barber Shop* shows how immersive experiences can be created by sound without using any visual cues. Its illusion is related to presenting two dissimilar sounds that allow the subject to perceive through hearing spatial and positional effects. This strategy was inherited or at least based on the principle that structures another technology for immersion, the stereoscope.

Stereoscopes are, in fact, a category of apparatuses. Charles Wheatstone invented the first stereoscope in 1838. It was part of an experiment to demonstrate stereopsis, a phenomenon described by the author in the *Contributions to the Physiology of Vision* (1838). Wheatstone (1838) observed that each eye saw the object differently when placed near an observer. However, from these dissimilar images, the brain could produce one single image. Therefore, Wheatstone (1838) questioned:

> It being thus established that the mind perceives an object of three dimensions by means of the two dissimilar pictures projected by it on the two retina, the following question occurs: What would be the visual effect of simultaneously presenting to each eye, instead of the object itself, its projection on a plane surface as it appears to that eye? (Wheatstone, 1838, p. 373)

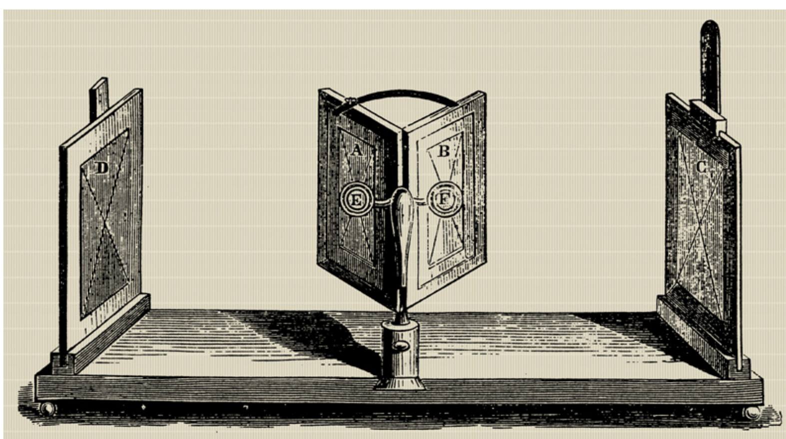

Figure 5 – The stereoscope was initially used to demonstrate stereopsis, or how the brain can form a single three-dimensional image from two dissimilar bi-dimensional images. Wheatstone, Charles. "Wheatstone mirror stereoscope". Wikipedia. https://bit.ly/35mijJy. Accessed 04 Feb. 2020.

The Wheatstone's stereoscope (FIG. 5) consisted of two plane mirrors placed orthogonally in which two different images of the same subject are reflected in each mirror. The clumsy design of the Wheatstone's stereoscope was briefly substituted by more portable and elegant solutions that eliminated the mirrors, like the one designed by David Brewster in 1839 and the one designed by

Oliver Wendell Holmes in 1861. According to Crary (1998b), the stereoscopes were "the most significant form of visual imagery in the nineteenth century, with the exception of photographs [...] it defined a major mode of experiencing photographically produced images" (Crary, 1998b, pp. 116–117).

The stereoscopes were particularly distinct from photography and painting by the sense of depth and presence it enabled (Crary, 1998a). On the other hand, the experience of stereoscopic images was exclusively individual. The Brewster's stereoscope (FIG. 6), for instance, concealed the images inside the stereoscope, being accessed only by coupling the apparatus with one's eyes, which made the experience even more intimate than other models.

Figure 6 - Holmes stereoscope (left), Brewster stereoscope (right) and some cards with stereoscopic images. The latter provides a more intimate experience. Albers, Dieter. "Stereoscope viewer, on display at Schulhistorische Sammlung". 2009. Wikimedia. : https://bit.ly/3posnJe. Accessed 05 Feb. 2020.

In comparison with the Virtual Barber Shop, the object, in this case, is static. However, it affords some movements from the perspective of the user. The stereoscopic images need to be inserted correctly, with the correct orientation, to allow immersion. As in the previous example, the device must somehow be 'wear' correctly, which points out a 'pre-immersive' moment that is also part of the immersive experience. Crary (1998a) argues that these movements are part of an "inexhaustible routine of moving from one card to the next and producing the same effect, repeatedly, mechanically", which points not only to the relationship of consumption that seems to take place, as well as its velocity (Crary, 1998a, p. 132).

The experience of the stereoscope itself is related to the visual exploration of the stereoscopic image. During the experiencing, the movements allowed are mainly related to the eye, which are inherent to visual perception. The eye moves two to three times per second in what is called saccadic movements, revealing a certain instability in the functioning of vision despite our perception of visual stability. This point is extensively discussed by Noë (2004), and for our discussion, it suffices to say that the affordance of eye movement by stereoscopes is not only necessary for our perception, but it reveals the differences between how we experience a scene and how photography depicts it. This difference points, once more, to the enactivist notion that our perception of the world does not rely on the internal representation of that world, in the sense that we do not construct a mental image of the world that orients us.

As Noë (2004) explains, "You perceive the scene not all at once, in a flash. . . . We gain content by looking around just as we gain tactile content by moving our hands. You enact your perceptual content, through the activity of skilful looking" (Noë, 2004, p. 73). As discussed in further chapters, only a tiny part of our eyes (the fovea) has maximum visual acuity, which requires us to keep our eyes in constant motion depending on where we need to focus. The process of photography distinguishes itself from the vision in many points, including this. Standard cameras, and especially those available at the mid of the 19th century, when stereoscopes were invented, need certain immobility to have acuity in the production of images. The photography used in stereoscopes, or even the drawings used, is practically uniform in visual acuity.

The device affords the visual exploration when using a stereoscope in part due to this uniformity, which allows the immersant to focus her/his gaze in different parts of the representation, gaining knowledge of it as the eyes scan the images. The coupling between observer and stereoscope fixes the observer in a static point that coincides with that of the photographic camera. However, there are differences in the perception of photography and stereoscopic photography that will be discussed further below.

Our following example also departs from the notion of a fixed observer. However, it is not a photography presented through a device, but a room with its walls and ceiling painted in a particular way. The *Salla delle Prospettive* was commissioned by the Sienese banker Agostino Chigi, the richest man of Rome, to 'stage' his elevated social position (Rowland, 1984). Baldassare Peruzzi between 1516-1518 painted the work. It consists of a room adorned with a fresco painted

> in exact perspective, of a hall with columns, which surrounded visitors to the room. . . . Between the pillars of the colonnaded portico, the observer 'sees' a view of Rome's buildings nestling in a realistic portrayal of the Roman Campagna. . . . Here, the illusion of depth, which is created by the use of mathematical perspective is not contradicted or undermined by any elements of decoration in the Villa Farnesina, and this produces the feeling of an irresistible relationship with the painted landscape: immersion. (Grau, 2003, p. 38)

As in any perspective, there is a fixed spatial place from where the painting is organized to make the illusion work. Therefore, the artist needs to perpetuate a glance from where all the mathematical proportions, line inclinations, and textures were constructed. Therefore, the *Sala delle Prospettive* has its maximum illusionary potential associated with a specific fixed point in the space, a point through which one can repeat what the artist intended to reveal 'through his own eye'[11].

Peruzzi's work relied on the combination of architectural and pictorial elements to produce the illusion. The actual doors were adorned with painted frames, and an arrangement of painted columns supported the apparently heavy ceiling. In the back of the room, facing those who enter it, is the most prominent part of the *Sala*: the Doric columns in the foreground, a balustrade, and Rome's landscape.

[11] In Latin, *perspectiva* means 'seeing through'.

Figure 7 - A small displacement of the observer starts to deform the perspective. “Sala delle Prospettive”. Wikimedia Commons. https://bit.ly/3pmcByu. Accessed on 02 Feb. 2020.

In the figure above (FIG. 7), it is possible to see that as an observer distance from the ‘optimal point’, the illusion starts to break up: the floor appears to be leaning towards the top, the disposition of columns loses its sense, etc. This ‘optimal point’ fixes a monocular eye in space, from where the perspective is built.

In this case, some of the subject’s body movements, such as walking through the room, lessen the immersive effects of space. The *Sala* affords more movements than those needed for the immersive experience. There is an essential distinction between this example and the two preceding ones in how the observer is positioned regarding the representation. As Grau (2003) reminds us

> In spaces of illusion, the moving observer receives an illusionary impression of space by focusing on objects that move toward or away from him. The depth of a painted space, however, is experienced, or presumed only in imagination. (Grau, 2003, p. 16)

The *Sala* as a space of illusion has to afford the physical presence of the observer, who is free to experience it from various positions. As mentioned, the depth effects are perceived fully just when the observer's position coincides with the ‘optimal point’. Nevertheless, it could be said that part of the immersive experience is related to seeing the perspective effects falling apart by moving around the room. It is interesting to note that the absence of demarcation of the original point-of-view in the physical space in some way contributes to the immersive experience. This absent point of view establishes the scenic relationship between the spectator and the object.

In comparison with the previous example, Crary (1998a) argues that the stereoscope as "a means of representation was inherently *obscene*. . . . [because] it shattered the *scenic* relationship between viewer and object" (Crary, 1998a, p. 127). As the author argues:

> The stereoscopic spectator sees neither the identity of a copy nor the coherence guaranteed by the frame of a window. Rather, what appears is the technical reconstitution of an already reproduced world fragmented into *two* nonidentical models, models that precede any experience of their subsequent perception as unified or tangible. It is a radical repositioning of the observer's relation to visual representation. . . . The stereoscope signals an eradication of "the point of view" around which, for several centuries, meanings had been assigned reciprocally to an observer and the object of his or her vision. There is no longer the possibility of perspective under such a technique of beholding. The relation of observer to image is no longer to an object quantified in relation to a position in space, but rather to two dissimilar images whose position simulates the anatomical structure of the observer's body. (Crary, 1998a, p. 128)

The author refers to the stereoscopes, but I contend that the binaural experience of the Visual Barber Shop is somehow similar since it produces the notion of depth through the presentation of two dissimilar sounds, one for each ear.

As we argued above, there are differences in the perception of planar and monoscopic images, such as photography, painting, and stereoscopic images. The main difference concerns the effects they produce on an observer. When an observer faces a painting, such as the one in the *Sala*, or photography, the same image stimulates both eyes, although we know that the stimuli are slightly different for each eye. The perception of stereoscopy depends on the stimuli dissimilarity. Each eye or ear receives only one dissimilar image or sound. That is, stimuli are isolated by design, as a headphone or the Wheatstone stereoscope demonstrates. Therefore, experience effects are produced by the observer itself since it is s/he that produces the transformation of two images or sounds into an experience that is perceived as a unity.

3.3. The movements within reach

From these examples, we can move to those that afford subtle movements and specific movements of a body. The examples below are related to a specific range of the movements that a subject can perform through the immersive experience, from the bodily scale to a room's scale. Unlike the previous examples, the body movements here interfere in the immersive experience and are, in fact, necessary for better enjoyment.

In this sense, the peepshow boxes can figure as one device that allows movements at a bodily scale. These rectangular boxes made of wooden panels were trendy in the Netherlands during the 17th century. According to Brown et al. (1987), only six of those boxes survived despite their popularity. One of the most famous and conserved boxes is at the National Gallery in London (U.K.). It simulated the interior of a Dutch house and was painted by Samuel Van Hoogstraten (1627-1678). This peepshow box consists of a "five-sided box painted on the inside to show a domestic interior: the sixth side is open to admit light, which was probably filtered through specially treated paper" (C. Brown et al., 1987, p. 63).

As the other peepshow boxes, Van Hoogstraten's *Peepshow with Views of the Interior of a Dutch* House (FIG. 8 & 9) works following the same principle: the scene was painted on the inside faces of the box and was constructed to be seen from a peephole in one of the box sides. However, this peephole box, in particular, offers the possibility of seeing its interior from two different peepholes, one at each side of the box, which implies a greater complexity in the construction of the perspectives and makes it unique in terms of viewing experience (Spencer, 2008). The viewer can see a "convincing illusion of receding space with apparently free-standing figures and furniture […] although there are no actual models standing in the box" (C. Brown et al., 1987, p. 68).

The voyeuristic aspect of the peepshow boxes could not be despised since there is a certain erotic appeal in the act of peeping into others' houses, their personal and intimate spaces. Van Hoogstraten was probably aware of this aspect in his work and made an explicit reference to the viewer's presence through two figures, a dog that gazes back to the viewer and a woman that a man observes through some glass panels as she reads (Spencer, 2008). In this sense, the painter offers the viewer both opportunities: to peek without being noticed and of being surprised by another gaze.

In terms of movements, it is interesting to note how these devices play with the position of the observer's body. The size and height of the peephole demand that the observer intends to peek and position her/himself for it. Furthermore, to see through the peepholes, the observer needs to move around the box. The coupling with the object, however, is made through just one eye per observer. As we mentioned above, this Van Hoogstraten's peepshow box affords more than one observer, adding a social aspect to the experience.

Figure 8 - The voyeuristic aspect of looking into someone's house. Van Hoogstraten, Samuel. "Peepshow with Views of the Interior of a Dutch House". The National Gallery – UK: https://bit.ly/3pmOv6J. Accessed 12 Nov. 2020.

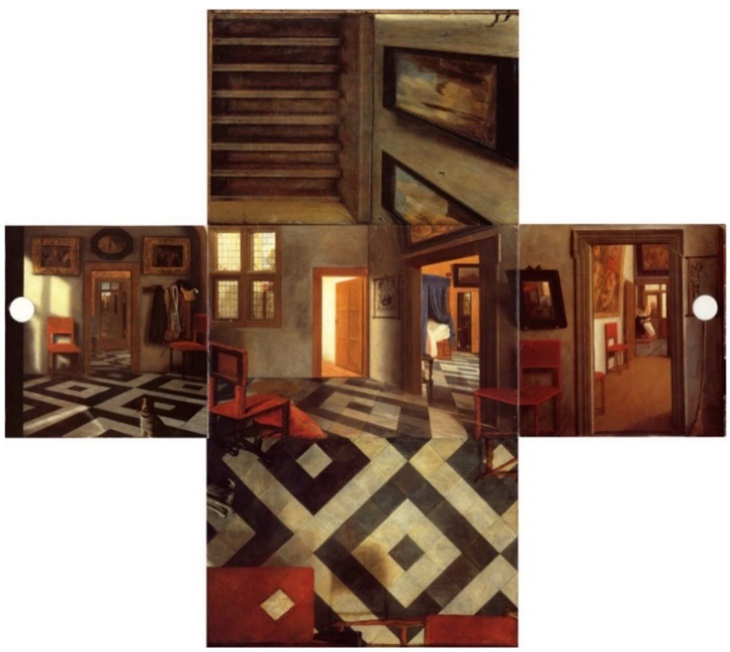

Figure 9 - The four planes that compose the Van Hoogstraten's peepshow box. Small, Michael. "Visible World". The National Gallery – UK: https://bit.ly/3kpM1Rk. Accessed 12 Nov. 2020.

Once an observer peeks inside the box for the first time, s/he gains a particular knowledge from the represented space. From this knowledge, the observer can orient her/himself, since moving to the left in the physical space to peek from the left side of the box corresponds to seeing the representation 'as if' standing on the left of the represented space. Although it is necessary to decouple from the box to move around it, there is a coherence between body movement and point of view. It could be said that the scaled representation of the space also scales the body movements needed to access it, in the sense that one single step that enables changing from peephole to peephole corresponds to a change of several meters regarding the point of view.

Another evidence of the 'call-to-play' of this peepshow is the presence of an anamorphic painting on the box lid. The painting (FIG. 10) of a Venus and an infant Cupid in bed

> appears distorted when viewed conventionally, but assumes the correct proportions when viewed obliquely from a fixed point or peephole. It is based on the principle of negative perspective, since the positions of painted image and perceived image are reversed with respect to conventional perspective painting (C. Brown et al., 1987, p. 67).

Figure 10 – An anamorphic painting on the external side of Van Hoogstraten's peepshow box. On the left, the image is viewed from above. On the right, the point-of-view from where the drawing was planned to be seen. Nakamura, Jun. "Seeing Outside the Box: Reexamining the Top of Samuel van Hoogstraten's London Perspective Box". Journal of Historians of Netherlandish Art. https://bit.ly/3bW7ujy . Accessed on 27 May 2021. Collage by the author.

The following example affords movements of a different order. The installation The Forty Part Motet (A reworking of "Spem in Alium" by Thomas Tallis 1573) (2001) was produced by the Canadian artist Janet Cardiff. This work is currently being exhibited at the contemporary art centre INHOTIM[12], in Brumadinho, Brazil. Cardiff recorded the Salisburg Cathedral Choir performing the piece *Spem in Alium* by the British Renaissance composer Thomas Tallis. The recording has 14 minutes of duration, 11 minutes of music, and 3 minutes of intermission. The

[12] INHOTIM website: https://bit.ly/2GUML37. Accessed 12 Nov. 2020.

recording is played through 40 loudspeakers mounted on stands, arranged in an oval setting facing the centre.

A motet is a form of early polyphonic music that persisted for more than five centuries (ca. 1220-1750): "it generally consists of an unaccompanied choral composition based on a Latin sacred text" (Apel, 1969, p. 541). Polyphony is "music that combines several simultaneous voice-parts of individual design, in contrast to monophonic music, which consists of a single melody, or homophonic music, which combines several voice-parts of similar, rhythmically identical design" (Apel, 1969, p. 687). Usually, in musical presentations that involve a choir, it is positioned in front of the audience. Therefore, the music reaches the listeners' ears mostly from this frontal position and ambient reverberations. The presentation spaces are usually designed to offer an ideally uniform sound experience since the audience is generally not allowed to change places during the performance, remaining static throughout the experience.

Spem in Alium was composed of eight choirs of five voices. Each loudspeaker in Cardiff's work corresponds to a voice that was recorded individually. As it generally occurs in polyphonic melodies, the choirs participate in the song in distinct manners. Sometimes all voices sing simultaneously, and, at other times, only one or two choirs participate, which confers this specific piece a dynamic that is considered unprecedented by the time it was composed (Cole, 2008). The potency of Cardiff's work resides in stressing the presence and movements of each voice that makes up the choirs:

> While listening to a concert you are normally seated in front of the choir, in traditional audience position. With this piece I want the audience to be able to experience a piece of music from the viewpoint of the singers. Every performer hears a unique mix of the piece of music. Enabling the audience to move throughout the space allows them to be intimately connected with the voices. It also reveals the piece of music as a changing construct. As well I am interested in how sound may physically construct a space in a sculptural way and how a viewer may choose a path through this physical yet virtual space. (Cardiff, 2006)

The reduced materiality of Cardiff's work (FIG. 11) contrasts with the presence of sound that fills the space (and the ears) from single or multiple sides simultaneously. The loudspeakers are positioned at head's height, increasing the sensation of the presence of the choirs. It is not uncommon to see visitors sitting with their eyes closed throughout the piece or wandering around, listening to voices individually. Cardiff's aural immersive experience creates a spatiality that extrapolates the music itself and continues through the intermission: the cough, haw, murmurs, and other small noises made by the choir singers merge with the noises of the visitors and the ambient, giving an aspect of continuity to work and deceiving the visitors even more.

Figure 11 - The movement of voices and the movement of the listener co-compose the experience. Motta, Pedro. "Forty-Part Motet by Janet Cardiff". 2001. https://bit.ly/3eSt34x. Accessed 12 Nov. 2020.

In a certain sense, the experience of Cardiff's work can be defined as a composition of movements. There are sounds of voices moving from speaker to speaker, crossing the room, and the melodic movement of voices in the song. All these movements intersect with the immersants' movements within the room.

From these two examples, it is possible to perceive that subject's movement is an essential part of immersive experiences and that it could participate in the very design of the technologies for immersion. It is interesting to note that the subject's movements disclose progressively the possibilities offered to her/him. There is no sign on the peepshow box saying, 'look here', nor any advice on Cardiff's work indicating that one should move around the room. Thus, it is possible to suppose that there are not only the 'skilful looking' as argued by Noë (2004) but also other types of skilful movements, which are less related with the quality of the movements and more with its effects, in what they produce in terms of sensorimotor knowledge to the subject. In the cases where the immersive experiences afford a wide range of movements, it is possible to say that they enrich the experiences. If someone approaches the peepshow box from just one side or listen to *Forty Part Motet* from a static seated position, in terms of aesthetical possibilities, the immersive experience gets diminished. In other words, the experience is still immersive but not to its full potential.

3.4. The subject on displacement

Displacement is a term that may assume several meanings depending on the context. For example, in fluid mechanics, displacement is related to the volume of fluid pushed out by an object when immersed in it. In geometry, displacement is the difference between the initial and final position of a body in motion. In psychoanalysis, displacement is related to an emotional shift from one object or person to another, and in linguistics, it is associated with the unique ability of men to communicate things that are remote in time and/or in space (Freud, 1933; Hockett, 1960).

There are certainly other significative uses of the term in other fields, but it is possible to envision a shared aspect that permeates the various meanings from what was presented. This 'common ground' is related to the word's etymology, which means removing something from its position and putting it in a different place (Online Etymology Dictionary, 2020). Thus, displacement is related to movement, but it points not just to it but also to a certain sense to a trajectory marked by an origin and destination.

In this work context, displacement also points to a particular scale of the immersive experience, where the subject should be able to move from one place to the other, not just a part of its body but as a whole. The subject on displacement can move by, within, and through the space of the immersive experience.

However, where is the 'origin' from where this subject displaces? Is it related to the context (in a broad sense) from where s/he accesses the experience? Is it the physical place where s/he is located? The answer seems to depend on where the focus is placed. Since our focus is on the subject's experience, I suggest that the answer from this perspective is unveiled only *a posteriori*, that is, the 'origin' of the displacement 'emerges' with the experience when the 'destination' is reached. In this sense, there are no equal displacements provoked by the same immersive experience since each subject 'is moved' by it in a particular way. Therefore, it can be said that the movement implied in displacement can also be regarded as a movement of the subject, not only the apparent movement of his/her body.

The already mentioned *Sacro Monti di Varallo* is an interesting example of this double possibility of displacement. It is composed of a set of edifices comprising a basilica and 45 chapels which gather frescoes in which about 4,000 figures are depicted, and 400 full-scale statues are displayed, representing the life of Christ and Mary, bringing together architecture, painting, and sculptures in the same place.

The *Sacri Monti* was a Catholic enterprise commissioned by Fra Bernardino Caimi to Pope Innocent VIII, representing the *luoghi della passione*, where Christ suffered in Jerusalem. The exemplar of *Varallo* is just one of the many *Sacri Monti* that were built. The idea was to offer the pilgrims the experiences of Christ's life, from Annunciation to the Last Supper, as if in Jerusalem from the Bible. According to Grau (2003), the *Sacro Monte di Varallo* alone received thousands of visitors per day. Visitors considered the fidelity of images, scale, distances between buildings identical to their counterparts in the Holy Land.

Figure 12 – An interior view of a chapel at the Sacro Monte di Varallo. Mattana. "Chapel 15 – The Healing of the Lame – Polychrome clay statues and frescoes". 2013. Wikimedia. https://bit.ly/2UoQFUU. Accessed 12 Nov. 2020.

Gaudenzio Ferrari, one of the leading artists working at the Sacro Monte di Varallo between 1490-1528, used a representation technique mixed frescoes with life-sized terracotta sculptures wearing real clothes and having natural hair and glass eyes (FIG. 12). This technique, which was lately named *faux-terrain*, consists of arranging three-dimensional objects as if they appear to "grow out of the picture's surface or stand free in the area between the observer and the image", creating the illusion of "adding a third dimension to a flat representation"(Grau, 2003, p. 44).

The idea behind the production of the *Sacri Monti* was to integrate the observer in the events portrayed. As Nova (1995) affirms, the visitor of *Varallo* was an actor-participant and not just a spectator. The pilgrims' involvement was stimulated by the exhortations that encouraged them to participate in the experience of suffering by weeping, beating themselves, and touching the sculptures (Nova, 1995).

The visitor's path through *Varallo* started in the church, where the friars instructed about the correct frame of mind to approach the journey and that the places were just a reproduction of the Holy Land. The friars directed the tour through the chapels, offering speeches to narrate the events, adding an extra layer of drama to the experience. According to Nova (1995), it is probable that the pilgrims were encouraged to interact with the sculptures, holding the baby Christ in their arms or even kissing his feet. Furthermore, the attention to detail in the scenes' production goes to the point that the fruits in the Last Supper were changed according to the season.

Nova (1995) advises us that the *mise-en-scéne* of the *Sacro Monte di Varallo* was so effective in deceiving pilgrims' eyes that the friars needed to continually remind the audiences that the places being visited were replicas. To avoid 'holy-places peregrinations' to *Varallo*, many of the represented elements, such as the Sepulchre and the tomb of the Virgin, received inscriptions where one could read that these elements were copies "similar in every detail" to their originals (Nova, 1995, p. 120)[13].

The investment of time and energy in the design and construction of the *Varallo* was enormous. As Nova (1995) reminds us, even the topography and the Jerusalem environment were accurately reproduced. The replicas of sacred places presented at the *Varallo,* produced from real places, compose and contrast, simultaneously, with the invented artworks – sculptures and paintings – that do not hold a 'real' counterpart. The political intentions behind the production of these works become evident in the character sculptures in the scenes, where the sacred figures were invariably represented as European, with fair skin, thin noses, and straight hair, while the executioners and others were depicted with darker skin and sometimes even with monstrous faces (FIG. 13).

[13] An extensive analysis of immersive spaces along history is found on the cited book, Grau, O. (2003). Virtual art: From illusion to immersion. Cambridge, Mass: MIT Press.

Figure 13 – Ethnic differences in the representation of Jesus and the tormentors are visible in skin color and faces. Mattana. "Chapel 36 – The Road to Calvary – Polychrome clay statues and frescoes (17c)". 2007. Wikimedia. https://bit.ly/3eRytwN. Accessed 12 Nov. 2020.

The investment of so much effort in creating the *Sacri Monti* to allow pilgrims to visit scenes and places they could only imagine can be seen as evidence of the recognition of the ecstatic potential of the experience by the Catholic Church. Moreover, the *Sacri Monti's* experience aroused the curiosity of distinct social classes, being visited by popular and aristocrats (Nova, 1995).

The conception of the *Sacri Monti* was based on a very ingenious strategy of mixing the replica of existing elements, such as topography, buildings, and sacred places, with the invention of scenes created from the reading of the Bible. This strategy may have been used to confer a status of truth to the experience, making copy and invention a coextensive whole to the eyes of an inadvertent pilgrim.

The *Sacro Monte di Varallo* received many visitors simultaneously, and due to the size and realism of the sculptures, it is possible to imagine how disorienting the experience could be. The combination of the subject movements, with the movement of other pilgrims, the immobility of the sculptures, the religious narrative, and the presence of 'real' elements (fruits, hair, clothes) certainly created an atmosphere of exceptionality to the experience, which contributed to the feeling of being present somewhere else, as described by Nova (1995).

It is noteworthy that the Sacro Monte tradition managed to cross the ocean and reach Brazil. The *Santuário do Bom Jesus de Matozinhos*, located in Congonhas (Minas Gerais), is considered one of the last and most significant exemplars of this tradition (FIG. 14).

Figure 14 – The church and the prophets at Santuário do Bom Jesus de Matozinhos. 2021. Photo by the author.

According to the memorial presented for the subscription of the *Santuário* as a UNESCO heritage site:

> Concerning the spatial organization, it is also the only one [Sacro Monte] in which the architectural and sculptural ensembles are mutually balanced and have equivalent value; which is not surprising, since its main author, Aleijadinho, was at the same time a remarkable engraver, sculptor, and architect.
>
> For the first time, the extraordinary ensemble is, undoubtedly, the magnificent integration of prophets statues with the architectural support made up of the churchyard and its staircase with terraces and imposing retaining walls. The vertical blocks and whimsical contours constituted by the statues seem to sprout from the parapets, opposing the dominant horizontal line with rhythmic modulations endowed with a powerful force of expression. (MEC, 1984, pp. 38–39)[14]

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[14] Original: "Em relação à organização espacial, é também o único no qual os conjuntos arquitetônico e escultural equilibram-se mutuamente por terem valor equivalente; o que nada tem de surpreendente, pois seu principal autor, o Aleijadinho, foi ao mesmo tempo, gravador, escultor e arquiteto notável. A impressão mais forte que se apodera do visitante, ao olhar pela primeira vez o extraordinário conjunto é, sem dúvida, a magnífica integração das estátuas dos profetas ao suporte arquitetônico composto pelo adro da igreja e

The *Santuário* is located on a hill (*monte*, in Portuguese) in the upper part of the Congonhas city. The pilgrims access the *Santuário* from the lower part of the terrain. There are six chapels distributed along the way to the church, at the top of the hill.

Each chapel presents a scene of Christ's passion, with sculptures and paintings made by Aleijadinho. The chapels are small and modest in terms of finishing, and most of the year, they remain locked, being accessible to vision only through the door's grilles. In addition, the chapels receive light only through the grilles and small openings in the walls, which makes them darker than the external environment.

This contrast between interior-exterior makes it impossible to see the interior of the chapels from a distance, forcing pilgrims to approach them. In this movement of getting closer, the scene is progressively unveiled with the characters emerging from darkness until they are fully seen (FIG. 15)

Figure 15 - Approaching one of the Santuário's chapel: contrast and changing atmospheres through movement. 2021. Photos and collages by the author.

Compared with *Varallo,* the *Santuário* chapels have fewer sculptures and less detailed paintings, but they are no less impressive. Some sculptures stand out, either for their expressiveness or for the way they interact to create the ambience of the scene, as the yellow-eyed Christ, whose gaze seems to pass through the spectator, or the frozen soldier using the hammer (FIG. 16)

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sua escadaria com terraços e imponentes muros de arrimo. Os blocos verticais e contornos caprichosos constituídos pelas estátuas parecem, de fato, brotar dos parapeitos, opondo à linha horizontal dominante modulações rítmicas dotadas de poderosa força de expressão".

Figure 16 -Two remarkable sculptures: the yellow-eyed Christ and the 'frozen' soldier. 2021. Photos and collage by the author.

The highlight of the Sanctuary experience is the arrival at the church. The distance between the last chapel and the stairs that give access to the church is considerable, and the movement within that space is essential for the experience. Aleijadinho managed to create an immersive experience by combining a few elements and the pilgrims' movements.

The 12 Prophets sculptures are positioned so that they seem to form several distinct groups depending on the distance and from where one looks (FIG. 17). These effects are even more potent on days of celebration when the place is full of people, and the prophets seem to merge with visitors (FIG. 18).

Another example that forces visitants movements in specific directions is the wetGRID, an installation produced by a team led by the architect Lars Spuybroek from the office N.O.X. The installation was designed to house the art exhibition *Vision Machine*, which happened during 1999-2000 in the *Musée des Beaux-Arts* (Nantes, France). The exhibition presented works from diverse artists such as Jackson Pollock, Yves Tanguy, Max Ernst, Paul Klee, photographs from Etienne-Jules Marey, some drawings made under the influence of mescaline by Henri Michaux and works of many architects and contemporary artists.

The installation was described as follows:

> Our installation is designed for the large atrium space of the museum, where daylight enters from above through a skylight. The interventions consist of a large undulating floor and two cotton-covered irregular volumes expressly conceived as an extension to the exhibition and meant to involve people's movements into ways of seeing. (Spuybroek, 1999)

Figure 17 – Movement and perception: the different groups of prophets. 2021. Photos and collage by the author.

Figure 18 – Prophets and pilgrims merging. Marcel Gautherot. 1947 circa. https://bit.ly/3rKvyMP . Accessed 27 Jul. 2021.

The proposal designed by Spuybroek was based on an attempt to subvert the Cartesian axis that conventionally guides the production of architecture, that is, the vertical (walls) and horizontal (floor) axis. As the author suggests, the museums and exhibitions are usually composed of a horizontal plane, where the architect designed the possible movements of a visitor, and a vertical plane, where the pictures are usually hanged. From this point of view, it is possible to argue that “the part that sees is separated from the part that walks. You either walk or see. Perception and action are completely separated” (L. Spuybroek, personal communication, 2000, p. 2).

Although the author presents an explanation where perception figures as something passive, which is not supported by the enactivist perspective, this does not diminish the power of the work as a whole. The wetGRID (FIG. 19) offers a path through the exhibited works that privileges not only the vision, as in a conventional exhibition, but the whole body. The visitor needs to swerve, lean forward or backward, tilt the head up or down to experience the exhibition. To some extent, this strategy is linked to some of the presented works produced under the effects of psychotropic drugs.

Figure 19 - View of the wetGRID. A waving cotton membrane that involves the space of the exhibition. Daniel Davis. “wetGRID NOX architects”. 2011. https://bit.ly/2UhJ8Yh. Accessed 12 Nov. 2020.

Furthermore, the cocoon-like form of the pavilion and its location, installed at the atrium of the 18th-century *Museé,* positively contributed to the experience's unexpectedness. Specific parts of the exhibition's narrowness force certain proximity between visitors’ bodies, which is also uncommon for this type of space, where neutrality, impersonality, and lack of personal contact are expected (FIG. 20). On the contrary, some of wetGRID’s spaces pose a particular type of negotiation between visitors, involving distancing, togetherness, contemplation time: a negotiation about recognizing and dealing with presence.

The notion of displacing through space is also quite present in Le Corbusier's work. Charles-Edouard Jeanneret-Gris, or Le Corbusier, was undoubtedly one of the most prominent and influential modern architects of the 20th century. His production – books, buildings, and theoretical projects – still influence architects worldwide. Among his many contributions to architecture theory, one concept seems especially relevant in the context of this work, the *promenade architecturale*.

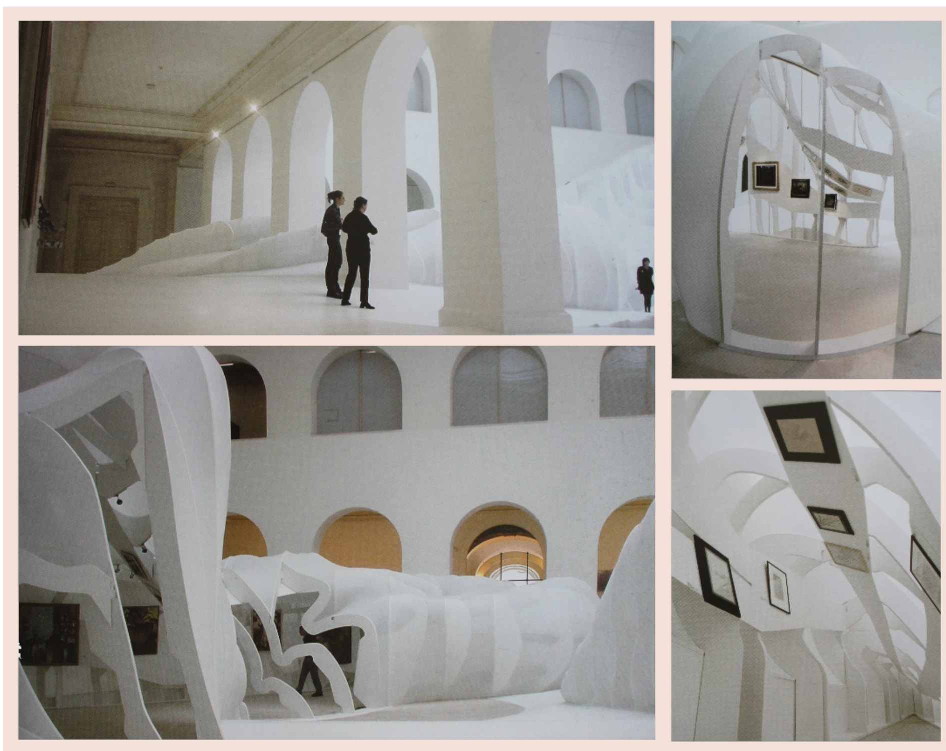

Figure 20 - Internal view of the wetGRID. Oz, Cristina. "NOX/ Lars Spuybroek". 2013. https://bit.ly/38AEIUA. Accessed 12 Nov. 2020.

The origin of the concept was explained by Le Corbusier and Jeanneret (1947) in the description of his most famous building *Villa Savoye* in Poissy, France:

> Arab architecture gives us a valuable lesson. It is appreciated *by walking*, with the foot; it is by walking, by moving that we see the development of the orders of architecture. It is a principle contrary to Baroque architecture, which is conceived on paper, around a theoretical fixed point. I prefer the teaching of Arab architecture. In this house, it is a real

> *promenade architecture*, offering constantly varying aspects, sometimes unexpected, sometimes stunning.[15] (Le Corbusier & Jeanneret, 1947, p. 24)

In this sense, the *promenade architecturale* recognizes the potency of considering the association of perception and movement for architecture, not only for conceiving architecture but for exploring it, that is, for the experience of architecture as a whole. In a certain sense, Le Corbusier (1947) proposes to include the moving subject in the design from the beginning. That differs from a conventional way of designing exclusively through orthographic drawings, which places the designer 'outside' the building[16].

A building closer to my experience and that can illustrate the notion of the *promenade* is the *Museu de Arte da Pampulha* (FIG. 21), designed by Oscar Niemeyer in the early-1940s as part of the Pampulha's architectural and landscape complex in Belo Horizonte. It was commissioned by the city mayor at that time, Juscelino Kubitschek, and it was designed initially to be a Casino, a function it held for just three years, 1943 to 1946, when gambling was banned in Brazil. It became a museum in 1957 and received its current name in 1996 (Mendonça, 2013).

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[15] Original in French: *"L'architecture arabe nous donne un enseignement précieux. Elle s'apprécie à la marche, avec le pied; c'est en marchant, en se déplaçant que l'on voit se développer les ordonnances de l'architecture. C'est un principe contraire à l'architecture baroque qui est conçue sur le papier, autour d'un point fixe théorique. Je préfère l'enseignement de l'architecture arabe. Dans cette maison-ci, il s'agit d'une veritable promenade achitecturale, offrant des aspects constamment varies, inattendus parfois étonnats."*

[16] This point will be discussed in depth in Chapter 5.

Figure 21 – Museu de Arte da Pampulha. Laboratório de Fotodocumentação Sylvio de Vasconcellos (Escola de Arquitetura/UFMG). Accessed 27 Jul. 2021.

The building was initially accessed only via cars, through a *porte-cochère*, placing the visitor at the main door, ready to enter the building. The main hall is a space to see and be seen. The ramps connecting it to the mezzanine and the bronze mirrors covering a double-height wall serve as circulation routes and catwalks. In addition, these ramps in the main hall significantly compose the atmosphere of this environment, configuring 'corners', directing looks and flows, and giving the notion of *promenade* a unique relevance. In this sense, the *promenade* provided a meaningful exploration of the spaces and presented visitors to the building and visitors to each other (FIG. 22).

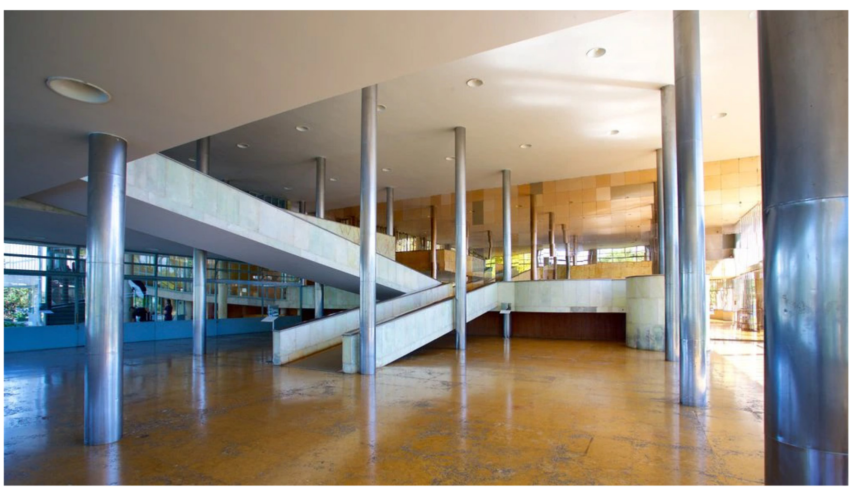

Figure 22 – Museu de Arte da Pampulha, Main Hall: ramps, mirror and movement. Tourism Media. https://bit.ly/2VayXIC. Access 27 Jul. 2021.

The rounded-shaped ballroom is accessed from the inside, via ramps, and outside via a staircase, connecting it to the bar. The walking path to the ballroom reveals the lake (*Lagoa da Pampulha*) and its silent presence that makes up the atmosphere of the place.

The circulation routes in the *Museu* are not marginal to experience but are essential since they present both external and internal spaces along the route. Walking around the *Museu* is an experience in itself, revealing several more-or-less hidden 'corners', which were probably used by couples looking for a more reserved place. In this same sense, the paths around the building and the possibility of exiting and entering through accesses other than the main one provided an opportunity to escape from unwanted or prohibited encounters (FIG. 23).

The notion of subjects in movement is fundamental to architecture's experience. However, designing from this perspective of a moving subject and what s/he can perceive is a complex exercise. It is not easy to navigate spaces using just imagination, as we sometimes stressed during this thesis. The movements offered by the *Museu* are multiple and varied, as well as the atmospheres revealed from these movements. In some way, the subject gives her/himself up to the immersive effects of architecture through these movements. Metaphorically, it can be said that one moves the other: architecture is moved by the subject's walk, which is moved by the effects of architecture itself, which displaces her/him even more.

Figure 23 – The many corners and the Museu: circulation routes and the staircase to the round-shaped ballroom. Tourism Media. https://bit.ly/2Vcrxoc. Access 27 Jul. 2021.

The following two examples are, deliberately, the only ones that use technologies that are instantly recognized as immersive technologies. As part of our research involves demonstrating how the phenomenon of immersion is part, to some extent, of our relationship with the various spaces and devices around us, we chose to talk about VR experiences last. In addition, we have a particular interest in these examples due to the way the immersant's movements are taken into account.

The first one can be considered *hors-concours* in terms of digitally immersive experiences. *Osmose* (1995) was conceived by the Canadian artist Charlotte Davies, who started her career as a painter in the late-1970s. During the 1980s, Davies got interested in experimenting with 3D digital spaces, becoming one of the founding directors of the company Softimage in 1987. The company was responsible for the unique effect of famous movies, such as *Jurassic Park* and *The Matrix*, and was considered one of the world leaders in developing 3d animation software (McRobert, 2007). Davies left Softimage in 1997 to pursue her artistic research full-time, founding the company Immersence[17] in that same year.

The second example is *The Chalkroom* (2017) by the artist Laurie Anderson and Hsin-Chien Huang. Anderson is one of the most renowned and awarded multimedia artists, working as a visual artist, composer, poet, photographer, filmmaker, vocalist, instrumentalist, and electronics whiz (Anderson, 2020).

The first ideas that became *Osmose* were sent for budget approval in September of 1993 by the artist. She envisioned creating an "immersive interactive, visual/aural experience of 'nature space'" (McRobert, 2007, p. 14). Davies (1997) describes the work as:

> Osmose invites the spectator to an initiation into a poetic universe. The "immersant" (a neologism created by the author) has to wear a stereoscopic viewing helmet with incorporated spatialized sound, and a jacket fitted with sensors which will detect the movements of the body and breathing. The sonic environment interacts with the visitor's spatial positioning, their movements and the speed of them. Both its limpid aesthetic and its floating mode of navigation mean that Osmose strongly evokes the submarine world - which Char Davies has explored for several years. Thus, vertical movements are governed by deep breaths, in for up, out for down. The horizontal movements react to the movements of the body: leaning forward, backward, left, right. With a 360° view, the visitor can traverse twelve symbolic territories which are intermingled or follow each other: the clearing, the forest, the tree, the leaf, the cloud, the lake, the earth, the underground world, the abyss, the code, the text and "Lifeworld". (Davies, 1997)

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[17] IMMERSENCE Website. https://bit.ly/35qUrUq. Acessed 12 Nov. 2020.

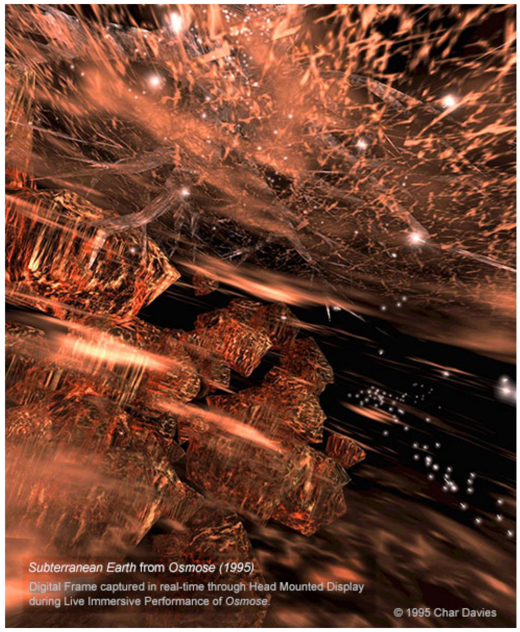

Figure 24 – Davies, Char. "Subterranean Earth from Osmose (1995) - Digital Frame captured in real-time through Head Mounted Display during Live Immersive Performance of Osmose". 1995. Immersence. https://bit.ly/38CDvMI. Accessed 12 Nov 2020.

Osmose's immersive experience (FIG. 24) was designed to be personal and individual; however, the physical space where the immersion took place offered a different experience. The part of the installation that was opened to a broader audience included a large-scale stereoscopic video and audio projection of "imagery and sound transmitted in real-time from the point-of-view of the individual in immersion", as well as a translucent screen where the audience could witness the silhouette and body movements of the *immersant* (*Immersence*, 1995).

The author expected to cause a "feel of loosening the boundaries between self and the world" (Davies & Harrison, 1996), but the sensations and emotions exceeded her expectations. Many immersants described a feeling of being disembodied and embodied simultaneously. Others reported the experience as emotional and euphoric, and some felt "an intense sense of loss when the immersive session is ending, and even cry afterwards" (Davies & Harrison, 1996).

According to some authors (Davies & Harrison, 1996; Dyson, 2009), the immersive experience in *Osmose* involved an alteration of the mind/body state, and it suspended the capacity of rational thought and conversation in some people temporarily. As Grau (2003) observes, the "suggestive presence *in* a totality of images gives rise to a mental – in *Osmose,* meditative – absorption. The psychological power of this new art of illusion becomes apparent in this work as in no other of the genre" (Grau, 2003, p. 199).

Nevertheless, apart from the buzz *Osmose* caused, some critics were concerned with the absence of interaction between immersant and the digital environment. Coyne (1999) affirms that the work

> provides freedom of movement through a "virtual space", but a space in which there is nothing to do except contemplate, look, listen, and "float around". Based on the notion of relaxation through contemplation, for all its quality as an artwork, it is difficult to see how this work presents as a spatial environment beyond its immediate fascination, because there is nothing to do. (Coyne, 1999, p. 159)

These critics are pertinent, considering that digital environments' possibilities are vaster than just navigating and contemplating. However, "*Osmose* is about being-in-the-world in its most profound sense, i.e., our subjective experience as sentient, embodied, incarnate, living being embedded in enveloping flowing space" (Davies, 2002, p. 111).

The last example of this series, *The Chalkroom*, was presented at the Massachusetts Museum of Contemporary Art (MASS MoCA) and other VR work by Anderson, named *Aloft* (2017). However, we choose *The Chalkroom* due to its complexity and interaction with the exhibition space. Additionally, *The Chalkroom* received the award "Best VR Experience" at the 74th Venice International Film Festival (*Biennale Cinema 2017 | Official Awards of the 74th Venice Film Festival*, 2017).

The Chalkroom's experience begins with the immersant entering a room (FIG. 25) in which the walls, ceiling, and floors are covered with glowing words and gestural drawings. This space was mapped and digitally modelled to make the transition to VR more fluid. Then, when the immersant wears the HMD, s/he seems himself located in a familiar place (Markonish, 2017). As Anderson affirms, "my interest in VR really is when you can map a real space and have fun like seeing the difference between the virtual one and the real space" (Bech Dyg, 2017).

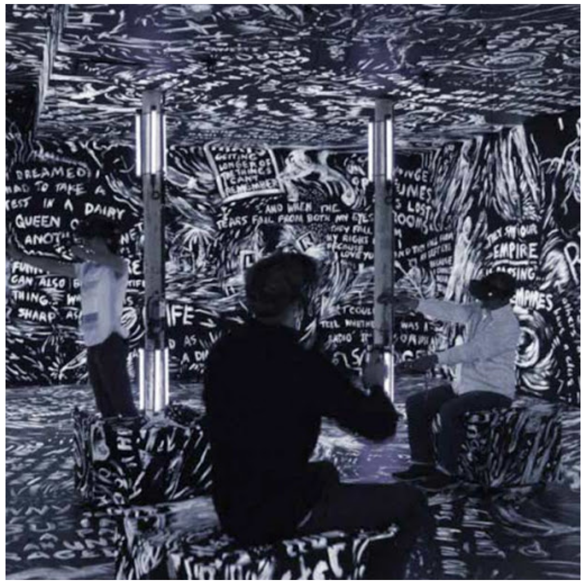

Figure 25 – A still from The Chalkroom: the continuity between exhibition and digital space. Anderson, Laurie. "The Chalkroom". 2017. Laurie Anderson. https://bit.ly/2GTPRo2. Accessed 12 Nov. 2020.

The experience in *The Chalkroom* can be described as:

> You sit at a station, put on the VR headgear, and hold two joysticks. As you stretch your arms forward, you gently "glide" through a labyrinth, guided only by a faint light. You "move" through pitch-dark rooms with white images and scribbles all over, as in the actual gallery, until you "stop" at a specific spot. Anderson's soft voice informs you that you have reached the center of The Chalkroom, and that you can now begin your journey. Several tabs appear on your screen, indicating different domains within The Chalkroom that you can visit, each of which offers fragments of different stories by the artist, accompanied by a soft music. In each scenario, you find yourself "gliding" around monumental black walls, dense with glowing texts and images. While at times you find the walls connected to a floor and a ceiling, they mostly appear as immense monoliths mysteriously suspended in ominous, bottomless voids. The abysses are likely to make you uncomfortable, scared even. The absence of a ceiling in the labyrinth is occasionally compensated by a glimpse of a nocturnal sky with drifting clouds, only to change back into a deep void. You can choose to "stop" to read texts or look at images, all the while "hovering" right above a floor, below a ceiling, or before one of those giant walls, where you can "maneuver" up and down to inspect its content. However, due to the overwhelming presence of texts visible only in a dim light, you can have no more than a glimpse of any section. It is all but impossible to memorize and recall any of the writings. One of the tabs even encourages you to "write" on the walls; but as you gesture to write with the joystick in your right hand, swarms of white letters rapidly fly away from the surface. You can write nothing. Finally, as in Aloft, you hear the artist calmly announcing the end of the session. (Sanyal, 2019)

In an interview for the *Louisiana Channel* in 2017, Anderson comments that in the first moment, she was resistant to VR due to its flatness, brightness, and very oriented to gaming structure and that she needed to invent a language that is atmospheric, dark, and dusty, in order to work in the medium. She affirms that most experiences in VR are "kind of task oriented – you sort of get that, you do that, you shoot that, whatever – it will be a really interesting thing to make it more kind of visually dazzling without having to, you know, do stuff in there"(Bech Dyg, 2017).

It is interesting to note that almost 20 years after Coyne's critique of *Osmose*, the artwork produced for VR stills focused on contemplation and exploration rather than interacting with digital objects. However, the main difference between *Osmose* and *The Chalkroom* (FIG. 26) is related to another point of Coyne's critique: the 'nothing to do' in the former was substituted by narrative and eventual interactions in the latter. In *The Chalkroom,* the immersant is free to fly through eight rooms covered with giant chalkboards, as Anderson's voice guides the experience (Huang, 2018).

Even with the disadvantages of age, almost 25 years later, *Osmose* is still relevant in VR discussion since some of the strategies used by Davies hold their pertinence despite the obvious technological advances. One of these strategies is the use of immersant's breathing movements to navigate vertically and the body's leaning to navigate horizontally. Compared with *The Chalkroom*, where the immersant stays sat during the experience and uses only off-the-shelf hand controllers to navigate, *Osmose* presents to the immersant the possibility of exploring the digital environments through movements of the body that are either automatic (breathing) or unusual (leaning). By affording to breathe and lean as ways to move through the experience, the immersant can become conscious of these subtle and often automatic movements of the body. In a certain sense, through *Osmose*, we can recognize that our body is a moving body, despite our awareness of it. It incorporates and functions to more bodily aspects than just eyes, ears, and hands, as in *The Chalkroom*.

Figure 26 - One of the eight rooms in The Chalkroom. Huan, Hsin-Chien. "La Camera Insabbiata VR Exhibition". 2017. Hsin-Chien Huang + Storynest. https://bit.ly/3luAQrS. Accessed 12 Nov. 2020.

Apparently, in creating *The Chalkroom*, Anderson considered the commercially available equipment (HMD and controllers) as enough to develop her experience, focused mainly on creating the digital content, namely, the narrative text, three-dimensional models, interaction, etc. As McLuhan (1964/1994) points us, "the 'content' of any medium is always another medium" (McLuhan, 1964/1994, p. 8). In this sense, Davies goes further with *Osmose*, considering her medium, not just the digital content, but also the hardware, as the vest she produced to capture the immersant's breathing movements.

What seems like the thread that connects the examples about displacement is not the only movement *per se*. There is an 'approaching' to the movement that is somehow present throughout the examples where displacing experience is not just a consequence of the designed spaces but a starting point for designing. For instance, when we look at the arrangement of the figures in *Varallo* or the *Santuário*, or the disposition of artworks in wetGRID, it is possible to understand how the body is related to these spaces in particular ways. There is intentionality from the designers to direct the visitors' movement's behaviour to some extent. When a sculpture is placed in the pilgrim's way, the designer was, in fact, designing a movement of deviation from that sculpture.

In VR experiences, the displacement as a departing point is even more evident. Despite the differences, both experiences depend on the subject's displacement. *Osmose* is more ingenious in incorporating movements into the experience through gadgets that work from breathing and body tilt, but *The Chalkroom* also incorporates displacement as an essential part of the experience. In *Osmose*, the constant body movements are reflected in the experience, in the sense that inhalation and exhalation imply floating up or down. In *The Chalkroom* the immersant is somehow more static since s/he stretches her/his arms in a direction to move. In these immersive experiences, as in many VR experiences, the subject is constrained to some extent to the physical boundaries of the space, which impedes him/her to displace as s/he pleases. The way found by the artists to offer greater mobility to immersants results in the perception of another type of movement, where the subject moves more than s/he is moving physically. To some extent, the digital world must move towards the subject so that s/he can perceive her/himself in movement.

3.5. Observing the immersed subject: modes of engagement and perception

The examples presented here does not intend to be a 'panorama of immersive experiences'. Instead, they are illustrations for the discussion regarding the notion of immersion. The chapter started by presenting briefly the theory of affordances by Gibson (1979/2015), which was in tune with our perspective of perception and cognition. Then, the examples were presented according to which types of movements were afforded.

Therefore, the presentation starts with those experiences in which mainly subtle movements, or the absence of movements, were considered. These examples made it possible to understand further sensorimotor contingency (O'Regan & Noë, 2001). In some cases, the absence of body movements was compensated by the movement of the 'object' itself, as was the case in Virtual Barber Shop. In other cases, the object remains still, and the subject could move her/his eyes over the object.

Then, the experiences where broader movements were also afforded were analyzed. It was possible to perceive how the devices' design favoured, or even determined to some extent, the movements of a subject and the consequent effects of those movements in perception. The peepshow boxes established a pivot from where the subject could move around, and the Forty Part Motet vanished with the notion of this 'external pivot', giving back to the body the notion of 'pivot of the world' as argued by Merleau-Ponty (1945/2012).

The last part of examples was analyzed from the notion of displacement and how this was a constitutive aspect for designing the experiences. It was possible to understand how the notion of a subject in movement can figure as a starting point for conceiving immersive experiences, either digital or not.

Nonetheless, the notion of modes of engagement, used as a reference to what is afforded in terms of interaction within the immersive experiences, reveals or restates the personal characteristic of immersive experiences. In general, throughout the analysis of the examples of immersive experiences presented above, it was possible to disclose several aspects of our perception.

From an enactivist perspective, perceiving is a way to explore how things appear. To perceive something is "a way of encountering how things are, but it is a way of encountering how things are by making contact with how they appear to be" (Noë, 2004, p. 164). It is through skilful exploration of the world that we perceive and learn about the world. The world affords our perceptual activity, and it mediates our active exploration through its appearance. In other words, it is by exploring the world's appearances that it is possible to discover how things are.

It is in this sense that immersive experiences make us question our way of perceiving them. By experiencing immersion in the *Sala,* in the *Santuário*, in the *Museu*, or through the peepshow boxes, one can perceive not only the environment depicted in these works. These experiences disclose that perception is a process that occurs concerning the perceiver. Through the movements involved in these experiences, it is possible to perceive how visual experiences depend on the observer's vantage point and even how fragile perspectival effects are. If we turn our attention to the examples that were less based on visual stimuli, such as the Virtual Barbershop or the Forty Part Motet, one can perceive the potency of sound to create spatialities and the role of binaurality in our perception of space and movements.

The examples that made use of VR – Osmose and The Chalkroom – disclosed how a subject could learn new patterns of sensorimotor skills to explore other types of spatialities. Movements inherent to human bodies but not part of their habitual repertoire for displacement, such as breathing, leaning, or stretching the arms, were assimilated as soon as the connection between physical and digital body movement was perceived. These experiences reaffirm certain plasticity and extendedness of perceptive processes that were early discussed by Stratton (1897), Merleau-Ponty (1945/2012), McLuhan (1964/1994), Clark and Chalmers (1998), and Rowlands (2010).

In the architectonic examples, namely, the wetGRID, the *Santuário*, and the *Museu,* the notion of skilful exploration through movements get even more evident. Nonetheless, the discrepancy between the designer's advantage point and the immersant is also stressed, meaning that a designer’s intention can lead to experiences that are different from that intention. Furthermore, as in the other examples, the effects of spatialities on a subject also become evident through the presented examples.

However, the presented analysis can be questioned since some examples were not experienced in first-person by me. I have experienced the Virtual Barbershop, the stereoscope, the Forty Part Motet, the *Santuário*, and the *Museu*. Nonetheless, it is possible to argue that the material used to analyze the examples (e.g., videos, pictures, plans, texts, reports) were sufficient for our intentions here. They are not substitutes to in-person experiences, but they offer us a grasp of what those experiences appear to be. In regards to pictures, Noë (2004) teaches us that

> Pictures construct partial environments. They actually contain perspectival properties such as apparent shapes and sizes, but they contain them *not* as projections from actual things, but as static elements. Pictures depict because they correspond to a reality of which, as perceivers, we have a sensorimotor grasp. Pictures are a very simple (in some senses of simple) kind of *virtual* space. What a picture and the depicted scene have in common is that they prompt us to draw on a common class of sensorimotor skills. (Noë, 2004, p. 178)

To consider immersive experiences and what they disclose on perception is relevant for this discussion, especially regarding the possibility of an art of immersion. Until here, the discussion on immersive experiences was made comprehensively, comprising technologies for immersion that go from the object's scale to architecture. From now on, the discussion will restrict itself to the immersive experiences in VR and architecture. However, it does not seem that presenting more examples of experiences in VR and architecture is the most appropriate path to continue our investigation.

Regarding the analysis of pictures, Noë (2004) emphasizes that most writings about the importance of art for perception focus on analyzing paintings and pictures as *objects of perception*. Noë (2004) suggests that other perspectives can offer a further understanding of perception:

> It is not pictures *as* objects of perception, that can teach us about perceiving; rather, it is *making pictures* – that is, the skillful construction of pictures – that can illuminate experience, or rather the making or *enacting* of experience. Picture making, like experience itself is an activity. it is at once an activity of careful *looking to* the world, and an activity of reflection on *what you see* and *what you have to do to see*. (Noë, 2004, pp. 178–179)

It seems more interesting to look into the experiences of production of architecture and VR, which will be made in the following chapters. There are properties of the immersive experiences that can only be disclosed by analyzing the production of those experiences. Nonetheless, other aspects of cognition related in special to VR experience also need our attention. For instance, it seems necessary from a cognitive standpoint to understand how one can perceive her/himself as 'being there', as it is felt in VR experiences, while still knowing that s/he 'stills here'?

In addition, the study of the production of immersive experiences is directly related to the study of its appearance in a double sense. It is a study about how these experiences are perceived by a subject and a study of its appearance in the sense of its emergence. In other words, the investigation of the production of immersive experiences presents an opportunity to disclose the path taken by those who conceive the experiences, including the procedures and tools used.

A. Practice Study One – To Cut

The first practice study takes place in a room where the finishings of the walls, ceiling, and floor change as the user touches some of the 'digital tongues' spread around. The text below is played as the experience unfolds (FIG. 27).

Video: https://youtu.be/IJxDL3ejyZw

***

The act of cutting is something intrinsic to humans. The first tools we ever built were tools for cutting. For this reason, I believe, to cut is something deeply embedded in us, on our psyche. Since birth, we are marked by cuts. To be born is to emerge either from an organ that resembles a cut or from a literal cut on the mother's womb. As soon as a baby is born, he or she needs to be separated from his or her mom by cutting the umbilical cord.

I was told that I suffered another cut when I was a baby: my grandfather, who was a physician, saw that I had a lisp caused by tongue-tie — the frenulum of my tongue would hinder me from speaking correctly. He did what whatever loving grandfather should have done: he took me from my mother's arms, went to the kitchen, and asked my grandmother to hold me as he grabbed scissors and cut my frenulum. No anaesthesia, no ice. A plain and simple cut. I am sincerely thankful for them for intervening (and my mom for letting them do that). Sometimes I think that he might have cut too much since I am constantly overspeaking. Nonetheless, this was an enabling cut, one that enabled speech.

Another experience of cut happened when I was a child of 8-10 years. I was naked and jumping with my brother in my parents' bed and my dad, who is a mechanical engineer, saw that one side of my scrotum was lower than the other, which could indicate an intestinal hernia. He was right, and I needed surgery to correct that. My biggest fear at that time was that I secretly believed that I was a robot and the surgery would reveal this secret. I do not know where this belief came from, but I was pretty sure that to let others know about this was not a good idea. The surgery day came, I was operated on, and when I woke up, I felt that everyone around knew that I was a robot, and they were pretending they did not know it. That was also an enabling cut, one that somehow increased my symmetry. However, it was also a revealing cut: something needed to be cut to be seen through, to look into.

If we analyze the act of cutting, we can see that it is essentially a spatial operation. As a gesture, to cut something intentionally is something that can mobilize us deeply: hands, wrists, and arms need to be coordinated with eyes. Add to this the fact that our bodies are not naturally adapted to cut. We usually need an instrument to perform the cutting. So, the gesture begins with the instrument being held and positioned at point A and, with the right pressure and velocity, moved to point B. The cut is something that exposes by separating what was a unity. It changes what is in contact with what. Also, the cut usually has as some of its effects the production of an impossibility. The impossibility of re-joining 'as-it-was' what was separated by the cut. The rejoining comes with a 'residue', or an effect of the cut, the scar.

In the digital realm, cutting has other characteristics. But first, is it really possible to digitally cut? Well, is not virtual reality a cut? When I wear my headset, I'm not present anymore in the physical world. I become digitally born to this limited reality. But how can someone be born without any materiality? Obviously, I'm deceived into thinking I'm digitally born. By whom? By numbers, essentially, zeros and ones. Looking back, I feel that I wasn't completely wrong in believing that I was a robot: here, I exist in a way that is closer to it. But now, let's go back again to the tongue episode. As you can see, the tongues are here to be touched. Or better, I'm here to be touched by tongues. Digital tongues. Tongues as interfaces. The word language itself comes from the Latin 'lingua'. To punish humanity for their pride, God gave man many languages, many 'linguae´. Today I know that when my grandfather cut my tongue he was freeing me from this divine punishment: by being able to speak, I'm freed from this God.

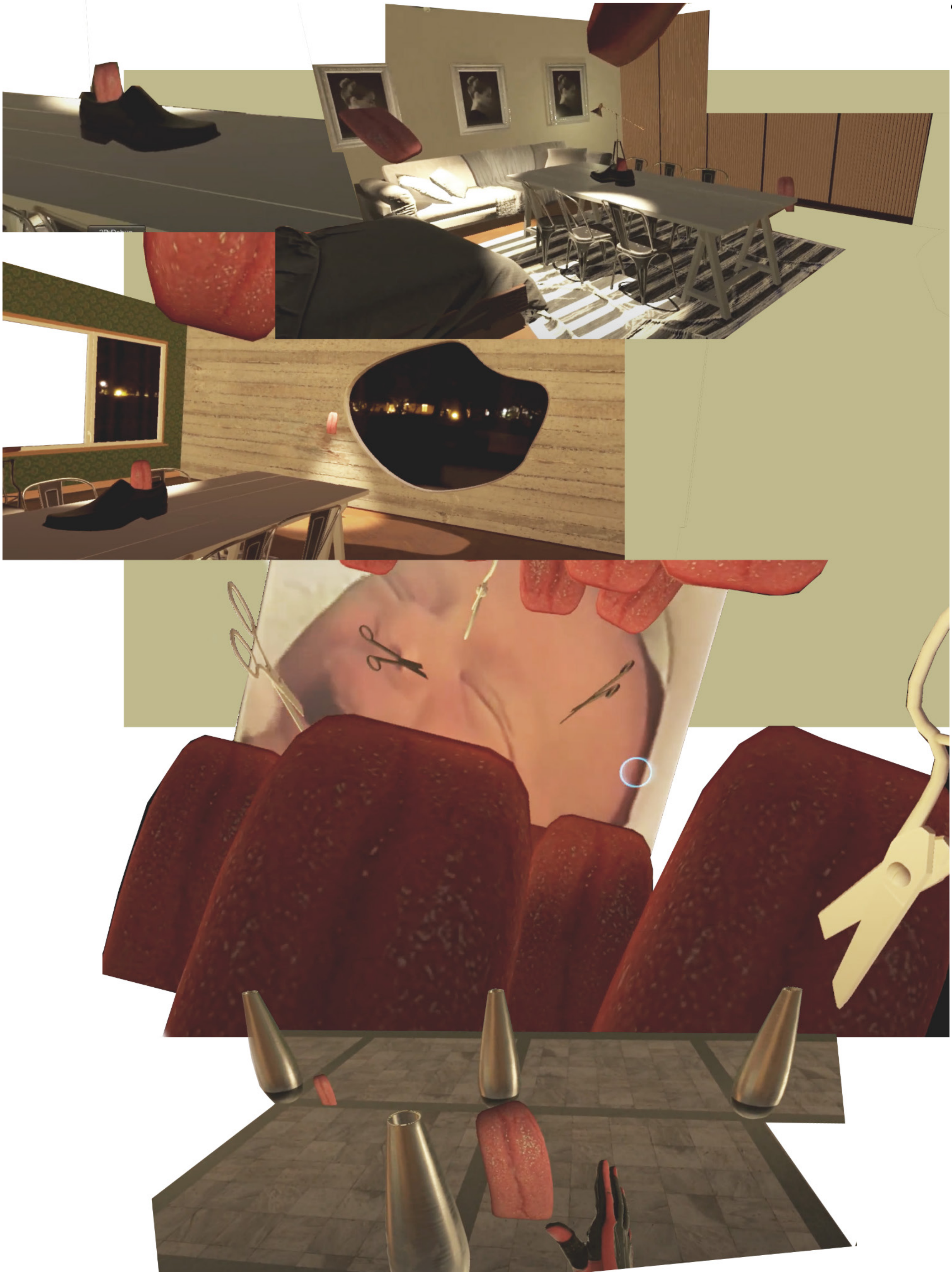

Figure 27 - A collage of screenscaps from the first practice study (To Cut). Collage by the author.

B. Practice Study Two – To Overflow

The second practice study starts in a confined space where one can move just a few steps. Some translucent green cubes fall from the ceiling, filling the space. The boundaries dissolve to reveal a bigger and darker room, with only four spotlights over four bigger rotating cubes in the rooms' corners. The green cubes start to float around, shedding light on other surfaces of the room. Suddenly, the room is flooded by a blinding white light. When it fades, one is floating in a white 'no-space' along with the green cubes. Then, the ambient fades to black, and the cubes become the only and pale light sources. The text below is narrated through the experience (FIG. 28).

Video: https://youtu.be/crCiWB8Umto

***

> There are several ways to observe overflow. When you place a glass inside a bowl of water, with the mouth facing upwards, and slowly move the glass into the water, you can feel the tension building up. It increases until the point where it gets dissolved by the water that fills the glass. You see – overflow has something to do with limits, with an inside and an outside, with the exchange of something, and with equilibrium. At the body level, I contend that it is possible to experience overflow in at least two moments: the crying and the orgasm. Yes, they have distinct natures, but aren't they similar events? In one case and in the other, there is a point of no return, where it gets impossible to hold, and you have to let it take you from a state of tension to another state, where something of yours is put into circulation in the world, and you get – at least for a short moment – dissolved, when words are no longer enough, and you just experience it, an ecstatic overflow.
>
> If we change the scale of our observations to something broader, where we are no longer confined as far as our body reaches, other possibilities of overflow appear. When you are in a room, for example, you may experience an overflow of time by the lack of stimuli, by boredom. You listen to the 'tic' of a clock and you look forward to the next 'tac'. You look around and perceive that there is not much to see. Or to do. You can only give yourself to that space and that moment. And you get so bored that you start to see or listen differently, the subtleties of sounds are better perceived and even space seems to gain more rigid contours. But where are the other possibilities of

overflow? Well, we can find a way to dissolve everything. At least it might look they're dissolving.

I have a recurrent dream that I'm in a vast no-space, similar to this where you are now. I don't have any references of scale except for my body, but you don't have a body here. Just these cubes that are following you around, floating up or down. This state of nothingness enchants me. In my dream I could simultaneously see myself from first and third person and this displacement, this lack of location is good to be experienced, at least for a while. Our last stop on overflowing is in a certain way an experience of voidness, an attempt to look into the abyss, but it does not feel scary. It is just emptiness. Well, at the end everything returns to the body and what it can perceive. So, there's no experience of overflow without a body, without tricking the body. And here we can experience an overflow of nothingness. The Heart Sutra teach us that:

"Therefore, given emptiness, there is no form, no sensation, no perception, no formation, no consciousness; no eyes, no ears, no nose, no tongue, no body, no mind; no sight, no sound, no smell, no taste, no touch, no object of mind; no realm of sight... no realm of mind consciousness. There is neither ignorance nor extinction of ignorance... neither old age and death, nor extinction of old age and death; no suffering, no cause, no cessation, no path; no knowledge and no attainment."

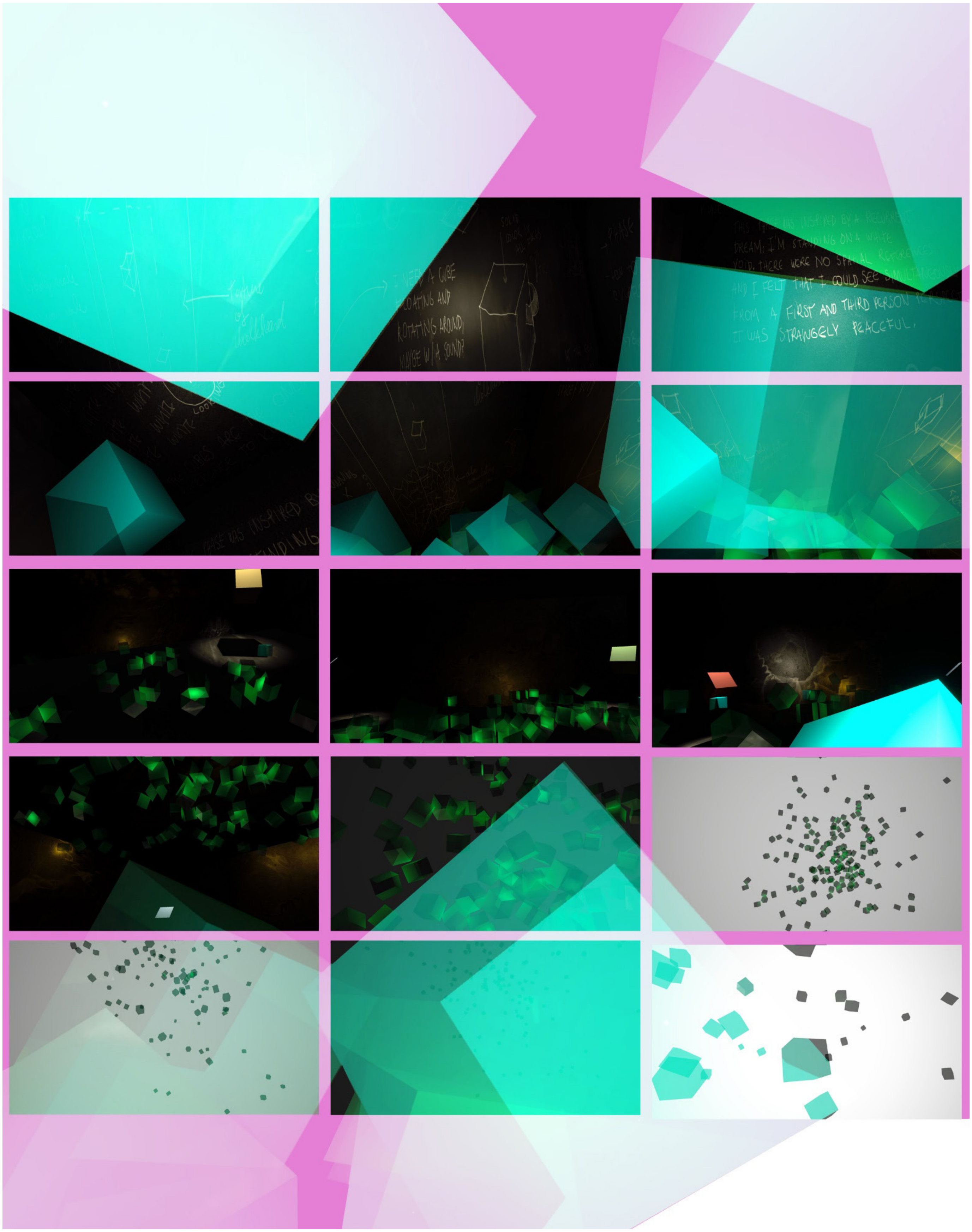

Figure 28 - A collage of screencaps from the second practice study (To Overflow)

4. The atmosphere of immersion: experiencing architecture and VR

This chapter aims to investigate the similarities and differences between the immersive experiences of VR and architecture. Comparing these experiences can reveal their singularities, which can help us understand how each experience affects the subject cognitively and which perspectives are opened to use VR in architectural practices better.

This chapter is divided into three moments. The first one is dedicated to the study of VR, and it starts by discussing one of VR's possible origins. There will be presented some works in literature, cinema, and others, to understand how the concept of VR could emerge. Some of the most relevant devices that somehow paved the way for VR during the 20th century will also be presented and discussed. Then, the cognitive possibility of VR will be introduced, discussing the cognitive processes involved in the immersive experience of VR in an attempt to understand how we can perceive that we are 'there', even though knowing that we are 'here'. In the following, the most recent advancements in VR hardware will be approached to understand how the body is being captured by these devices and the possible consequences of capturing this type of data.

The second moment is dedicated to the discussion of architecture. It starts with presenting the idea of the primitive hut, the central part of one of the founding myths of architecture. It will be discussed how the presence of architecture was associated with a change in the behaviour of primitive humans. The notion of houses as waiting stations from where humans could observe the plantations' growth will also be discussed. The relation between language development and houses is also explored to understand how the latter allowed humans to make distinctions and perform activities requiring concentration.

The last moment of the chapter is dedicated to discussing immersion and the notion of atmosphere as proposed by Böhme (2016) and others. The atmosphere can be regarded as something that happens *in between* a subject and space, in the sense that it is related to the 'feeling' one can perceive as emanating from a specific space. I argue that immersion experience is essentially related to the atmosphere in the sense that it is the atmosphere that changes when one experiences immersion through VR or architecture. The notion of atmosphere will be discussed from the perspective of experience and production to understand how it is possible to create spatialities from the orchestration of effects. In addition, environment and cognition will also be investigated to figure out how the first is part of the latter and how can we use spaces to help in our tasks. Thus, there will be presented arguments on the possibility of intelligent use of spaces relating to those uses where space plays an essential role in diminishing the cognitive demands for performing specific tasks.

The concluding part of the chapter is dedicated to the discussion relating VR and atmospheres in the context of architectural design. We suggest that an intelligent use of VR should relate to its use to support imagination, enabling architects to experience and produce more adequate atmospheres. The current difficulties in producing VR immersive experiences will also be presented to nuance the discussion, especially those related to the universe of programming unfamiliar to architects in general.

4.1. The 'origins' of VR

The physicist Wolfgang Rindler defines the horizon as "a frontier between things observable and things unobservable" (Rindler, 2002, p. 134). In this sense, it is possible to consider that the horizon exists only concerning an observer and changes according to the observer's position, concealing and disclosing as the observer moves. The search for a single origin of something appears to me as walking towards a horizon that seems to be ever-distancing but invariably stays at the same distance from my body. However, the colours, contours, and textures of the horizon change as I walk, affecting me accordingly. The same can be said regarding the origins of VR, either as a term or as a technology. As one investigates devices or works from the past that could mark VR origin, they point to other possible origins in an even deeper past.

Nonetheless, this does not invalidate the search, quite the contrary. As we move to the past, we can understand where the ideas that shaped our current VR experience may have come from. Furthermore, studying these somehow 'original' works makes it possible to imagine how VR experiences were imagined in the past. In this sense, we can evaluate if it is worth taking back some of the ideas that were not implemented or were discarded due to contingencies that do not currently exist.

This theoretical walk towards the horizon can be regarded as a spatio-temporal walk that advances forwards while looking backwards in time. If we push this metaphor further, considering that the horizon in question is similar to the terrestrial one, it can be said that at some point, we will arrive at the same starting point from which we began our journey. However, it seems that the horizon we are talking about is distinct from the terrestrial one. The field of cosmology works with a concept of horizon that seems adequate to our metaphor. The event horizon can be defined as follows:

> for a given fundamental observer A, is a (hyper-) surface in space-time which divides all events into two non-empty classes: those that have been, are, or will be observable by A, and those that are forever outside A's possible powers of observation (Rindler, 2002, p. 134).

It seems that when we talk about searching for an origin, we are referring to this class of events that are 'forever outside', impossible to be observed. Thus, no matter how one walks towards the horizon, it remains an insurmountable frontier. Nonetheless, it is possible to suppose that the observable events' class expands as we move towards the horizon. In this sense, it is possible to return to the walking's departure point, but not as a repetition or a function of a circular path. Instead, this return can be regarded as an option to return to it again, from a different and expanded perspective.

Thus, the proposal is not to establish an origin for VR outside my possibilities as an observer. Instead, the proposal is to investigate some of the works and ideas that gave origin to the contemporary notion of VR to expand the understanding of the very contemporary notion of VR. As this journey towards the past would take me infinitely more and more to the past, I opted to restrict this investigation to the examples that are closer in time to the VR phenomenon.

In this sense, one of the first works in the 20th century that announced the possibilities for immersion was the short story *Pygmalion's Spectacles*, written by the sci-fi author Stanley G. Weinbaum in 1935. The story describes Dan Burke's encounter with an eccentric professor, Albert Ludwig, who invented a special type of glasses that presents a multisensorial movie with image, sound, smells, and touch. By wearing glasses filled with a special liquid, the protagonist perceives himself at another place, at *Paracosma* – the Land-beyond-the-world – where he interacts with two characters, Galatea and Leucon. The reality in Paracosma seems quite different. The uncanny land has its sun, tiny and red, an unearthly flora, emitting music and iridescent colours.

The organization of Paracosma is also curious. Just four people are living there, but only two of them are present. There seems to be a lack of interest of Galatea and Leucon about the other two people. Throughout the story, there seems to be a sense of a destiny that cannot be changed. Some laws restrict the world's possibilities; they are "the unalterable laws of the world, the laws of Nature. Violation is always unhappiness" (Weinbaum, 2006, p. 11). In Paracosma, the events are predetermined and "nothing is unforeseen" (Weinbaum, 2006, p. 7). The time and the existence of the characters seem to begin to exist from the moment the glasses are worn.

If we analyze the epoch when the book was written, it is possible to suppose some of the author's inspirations for writing it. One of the possible influences, the stereoscope, was invented a hundred years before, becoming incredibly popular during the 19th century. Even so, its popularity declined by the end of that century, in part due to its supposedly link with pornography and other "indecent" matters (Colligan, 2008; Crary, 1998). However, in some sense, the stereoscope eradicated the observer's notion as a 'point-of-view'. As Crary (1998b) remembers us, "The relation of the observer to image is no longer to an object quantified in relation to a position in space, but rather to two dissimilar images whose position simulates the anatomical structure of the observer's body" (Crary, 1998b, p. 128).

The first two decades of the 20th century were also of great importance for cinema. The debates about its relevance as a medium and its social and aesthetical consequences took place in newspapers and literary journals, interesting a wider audience than just the *connoisseurs.* From 1985 to 1909, the cinema did not attract the mainstream critics' attention and was perceived as a technological curiosity. Until 1920, cinema was considered a danger to literature, a menace that could extinguish books (Kaes & Levin, 1987). Furthermore, until 1926, the film industry made a significant effort to develop a system that could play synchronously sound and image[18]. The *Vitaphone* debut, an invention that solved the image and sound problem with enough quality, happened in August 1926 (Beck, 2011).

In this sense, the epoch when *Pygmalion's Spectacles* was written was very rich in technological development linked to the presentation of images and sounds. Nonetheless, Weinbaum (2006) pushed the boundaries further ahead of what was possible at that time, including the protagonist as part of the experience, perceiving himself as interacting physically with the characters, outpacing the cinema viewer's role.

To what concerns VR, it can be said that *Pygmalion's Spectacles* envisioned the potentialities of the technology and some of its limits. Weinbaum (2006) pointed to the possibilities and consequences that the experience of immersion in environments that could be potentially more interesting than

[18] A comprehensive history of the efforts to incorporate sound in cinemas was provided by Jay Beck in "The Evolution of Sound in Cinema" (Beck, 2011).

our physical reality can entail. At the experience's end, the protagonist was in love with Galatea and was disappointed with himself for falling in love with a 'vision'.

When Professor Ludwig explained how the illusion of immersion was obtained, he also disclosed a few limits in common with VR:

> The trees were club-mosses enlarged by a lens […]. All was trick photography, but stereoscopic, as I told you – three dimensional. The fruits were rubber, the house is a summer building on our campus – Northern University. And the voice was mine; you didn't speak at all, except your name at the first, and I left a blank for that. I played your part, you see; I went around with the photographic apparatus strapped on my head, to keep the viewpoint always that of the observer. (Weinbaum, 2006, p. 14)

As in VR, the experience is to a considerable extent prescribed by the programming. In *Pygmalion's Spectacles,* the objects and props were built from the physical world elements that appeared different when observed through the glass. In VR, the elements that appear to the observer are made from the same building blocks: zeros and ones. In this sense, since all VR elements share the same digital essence, they can be transformed in size, appearance, colour, texture, etc., without effort.

The interactions with characters were also predetermined by the script and direction of Professor Ludwig, the inventor. Despite the professor's explanations about the interactions being imagined by the protagonist, what he is describing can be considered the roots for the interactions digital games present today.

In many modern digital games, including those where the player assumes the first-person point of view, the possibilities of interactions with either other players, non-playable characters (NPCs), and the environment are also limited by programming. In comparison with *Pygmalion's Spectacles,* the gaming environments can present more complex types of interactions among entities, leading to, for example, games with endings that change according to players' decisions. Nonetheless, it can be said that in both experiences, the player and *Pygmalion's* protagonist were limited by script, either the movie script produced by Professor Ludwig or by the programming scripts written by game developers.

In VR, it is no different: all the elements need some programming level, even those not interactable. This does not mean that each element in VR needs to be programmed from scratch, since the game engines already provide a series of preprogrammed parameters for each element, such as size, position and rotation in the digital space (which is essentially Cartesian, with three spatial axes), material, weight, etc. However, the modes of interaction, or how the user can interact with elements, need to be defined through programming.

For example, if *Pygmalion's Spectacles* was reproduced in VR, a scene where the protagonist touches the hand of Galatea will need several definitions. In a simplified way, the developer should associate the hand of the digital avatar with the position and rotation of the user's physical hand, equating the movements in physical and digital space. The developer would also need to establish that the polygons that form Galatea's hand are 'rigid' and should 'collide' with the user's hand. Additionally, to simulate the touching, the developer could add some haptic feedback to the 'collision', such as vibrations in the user's controller.

This brief comparison allows us to imagine how long was the path to arrive at VR as we have today. Another essential step in this direction was designed by the filmmaker Morton Heilig. From 1957 to 1962, he developed the Sensorama Simulator, an "entirely new kind of communication device that creates for its user the illusion of being physically present in a different environment" (Heilig, n.d., p. 1). It consisted of a booth-sized device that integrates visual projection, binaural audio, vibration, and a system that can project a breeze with predefined odours. These components work synchronously to provide similar stimuli for the user's senses as if s/he was present in the simulated situation.

Heilig (n.d.) envisioned that his invention could be used for education, training, entertainment, public relations, psychological research, and therapy, which are essentially the main VR applications. In a certain sense, the Sensorama was the invention that could materialize, at least partially, what Weinbaum has proposed in his tale. A statement on the use of Sensorama was given almost 30 years after its invention by VR enthusiast Howard Rheingold:

> For thirty seconds, in southern California, the first week of March, 1990, I was transported to the driver's seat of a motorcycle in Brooklyn in the 1950s. I heard the engine start. I felt a growing vibration through the handlebar, and the 3D photo that filled much of my field of view came alive, animating into a yellowed, scratchy, but still effective 3D motion picture. I was on my way through the streets of a city that hasn't looked like this for a generation. (Rheingold, 1991, p. 50)

However, Sensorama also pointed several bottlenecks for the development of multisensorial immersive experiences. Instead of Weinbaum's elegant glasses filled with a special liquid capable of provoking all kinds of sensations in those who wore it, Sensorama was an ingenious *assemblage* of various mechanical and electrical components. A system of components should work perfectly and synchronously with the other systems to provide a flawless immersive experience for each sense (FIG. 29).

Figure 29 – A person using the Sensorama Simulator. Morton Heilig. "Sensorama". 1962. Retrieved from https://bit.ly/3rKg9wa. Accessed on 20 Jan. 2021.

Heilig's strategies to stimulate the senses are still present in the latest VR systems, such as stereoscopic images, binaural sounds, and vibrations. The sense of smell was addressed in Sensorama by using vessels containing the odours used in the experience, which were projected at specific times into the user's hood (FIG. 30).

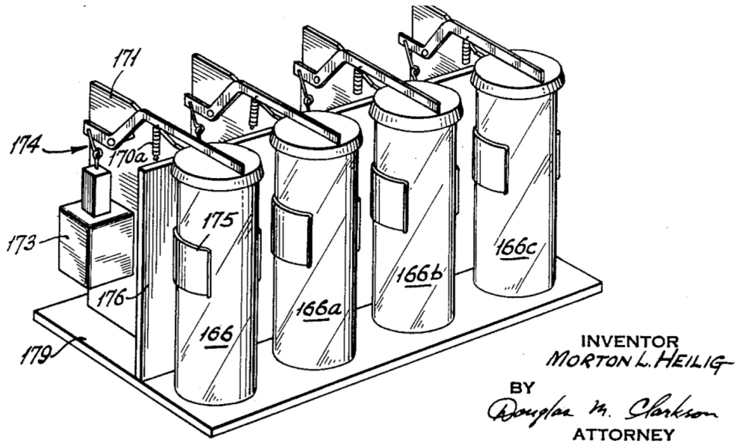

Figure 30 - Scheme of the vessels containing the odors used in Sensorama. Morton Heilig. 1962. "*SENSORAMA SIMULATOR* (US Patent Office Patent No. 3.050.870)". Accessed in 20 Jan 2021.

However, the stimulation of the olfactory sense in VR remains a complex question. Even today, the most advanced VR systems rely exclusively on vision, hearing, and touch. Several reasons for this involve hardware and psychophysical issues, as Barfield and Danas (1996) and Bouchard and Baus (2017) presented. Nonetheless, what Heilig was able to accomplish with Sensorama was impressive in many ways. Additionally, he pointed out how the body would be represented in VR, a body divided into parts that are stimulated separately but in a synchronized way.

In 1965, Sutherland published an essential short essay about the possibilities that a kinesthetic display could open. The *Ultimate Display*, as he calls it, was envisioned as a device that could address as many senses as possible, sensing our body muscles' positions and perceiving where we are looking at and adapting accordingly. The Ultimate Display was imagined as a "room within which the computer can control the existence of matter", but also as means to explore "concepts which never before had any visual representation" (Sutherland, 1965, pp. 1–2). In part, what Sutherland imagined was similar to what was described in *Pygmalion's Spectacles* and was realized – at least partially – in Sensorama. However, I consider that the fundamental advancement proposed by Sutherland was the notion of interaction mediated by a computer. In the Ultimate Display, the computer is the central piece of the experience, receiving information from the user, processing it, and producing the correspondent stimuli to be perceived.

Three years later, in 1968, Sutherland and his student Bob Sproull developed a three-dimensional display (FIG. 31), having as the fundamental idea to "present the user with a perspective image which changes as he [the user] moves" (Sutherland, 1968, p. 757). The epoch's technological limitations restricted the images shown in the HMD to wireframed cubes and other simple geometric figures that were presented overlapped to the 'real' world. Additionally, the system was so massive that it had to be hanged from the ceiling, which led to its name, *Sword of Damocles,* about a Sicilian anecdote[19]. Nonetheless, it was the first time that the user could interfere with what is being presented by using his/her own body's movements.

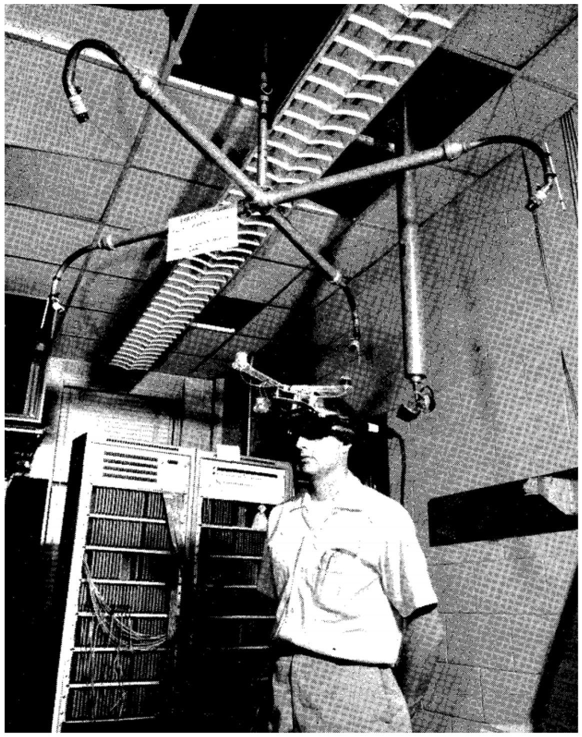

Figure 31 - The Sword of Damocles in use: the equipment was so massive that it had to be hung from the ceiling. Ivan Sutherland. 1968. "A head-mounted three-dimensional display".

Sword of Damocles was not Sutherland's first realization with computers and graphics. In 1962, Sutherland presented the *Sketchpad* as part of his doctoral thesis, which was considered the "most important computer program ever written" (Rheingold, 1991).

> The Sketchpad system makes it possible for a man and a computer to converse rapidly through the medium of line drawings [...] by eliminating typed statements (except for legends) in favor of line drawings, opens up, a new area of man-machine communication. (Sutherland, 1963/2003, p. 17).

The system consisted of a lightpen used to draw on a display screen, a keyboard, and the Sketchpad program. It allowed that "anyone could see for themselves that computers could be used for

[19] A short footage of the Sword of Damocles being used: https://bit.ly/2K2QKMk. Accessed 12 Nov. 2020.

something else besides data processing. And in the case of Sketchpad, seeing was truly believing" (Rheingold, 1991, p. 90). Unknowingly, Sutherland gave a decisive step both in human-computer interaction and in the development of CAD applications.

J. C. R Licklider's work probably inspired Sutherland, a key figure in the development of computer science and a colleague of Claude Shannon, the inventor of information theory and Sutherland's PhD supervisor (Rheingold, 1991). In 1960, Licklider published the text *Man-Computer Symbiosis,* where he argued that, at that time, computers were designed

> to solve preformulated problems or to process data according to predetermined procedures [...] However, many problems that can be though through in advance are very difficult to think through in advance [...] One of the main aims of man-computer symbiosis is to bring the computing machine effectively into the formulative parts of technical problems. (Licklider, 1960, p. 10)

The equipment for input and output were the least advanced department of data processing, according to Licklider (1960). In the text, the author suggested that researchers should develop equipment to facilitate interaction with computers, both in terms of display and controls. He even suggests that something should be created with the same ease of use and flexibility as a pen and paper, or a blackboard, which Sutherland took further.

However, the computers at that time were limited in number, availability and processing power. In this sense, other technological advances would lead to VR creation as we know it would have to wait until computers became popular, which happened only in the 1980s, with personal computers.

Rheingold (1991) presents several actors working to develop immersive technologies from the 1960s to the 1980s. Due to the limited focus of this work, we will focus on the actors that resonate with our goal of accessing a certain origin of VR related to how we perceive this technology today.

In this sense, it is important to take up another influential text by Licklider and Taylor (1968), *The Computer as a Communication Device*. When computers were being used primarily for data processing, the authors already pointed out the possibilities they could open to human communication. The authors predicted the creation of *online interactive communities*, which share not a common location but common interests. At some points, however, there was an excess of optimism and a certain naivety when they say, for example, that

> life will be happier for the on-line individuals because the people with whom one interacts more strongly will be selected more by commonality of interest than by accidents of proximity […] Unemployment would disappear from the face of the earth forever, for consider the magnitude of the task of adapting network's software to all the new generations of computer, coming closer and closer upon the heels of their predecessors until the entire population of the world is caught up in an infinite crescendo of on-line interactive debugging. (Licklider & Taylor, 1968, p. 40)

Then, in the 1980s, Jaron Lanier's work, a decisive actor in VR history, starts to catch the attention of a wider audience. At that time, his interest was in developing ways to enable "people to exchange simulations – images and sounds and dynamic models – just as we exchange spoken and written words" (Rheingold, 1991, p. 158), what he called *post-symbolic communication*. In 1984, Lanier worked at his company, VPL Research Inc., on a visual programming language to make computer programming accessible to a more significant number of people. The notion of post-symbolic communication can be regarded as the transcription below:

> When you make a program and send it to somebody else, […] especially if that program is an interactive simulation, it is as if you are making a new world, a fusion of the symbolic and natural realms. Instead of communicating symbols like letters, numbers, pictures, or musical notes, you are creating miniature universes that have their own internal states and mysteries to be discovered. (Rheingold, 1991, p. 159)

At that time, Lanier was still referring to communication through bidimensional displays. Nonetheless, he and his partner at VPL Research, Thomas Zimmerman, experimented with using the body and, more specifically, the hand as an input to manipulate the visual programming language elements. Zimmerman developed a digital glove, the DataGlove, that captured a user's hand movements as a means to interact with music synthesizers, and Lanier saw its possibilities for interacting with computers in a broad sense. As soon as 1987, VPL developed a full-body version of the DataGlove, the DataSuit, and their HMD, the Eyephone, becoming the first company to offer off-the-shelf VR equipment for a wider audience.

It is important to note that, since the early ideas laid in *Pygmalion's Spectacles*, there seems to be a desire, or an intention, which underlies the presented examples, that has to do with allowing a body to experience alternative environments or realities. Over time it was possible to capture inputs from the body, first from the fingers with the keyboards, then from the head movements with the HMD, and finally from the whole body with the DataSuit. As we look at these systems today, they seem rudimentary, yet what they have achieved and opened in terms of possibilities has not yet been fully explored.

4.2. The cognitive possibility of virtual reality

As we discussed in earlier chapters, in our daily experience, we can experience different moments of immersion. Immersion can be experienced by coupling with technologies for immersion and engaging in activities that capture our attention and/or imagination. However, it can be said that VR established a new mode of engagement of the subject with an immersive experience. However, first, it seems reasonable to question: how can we experience immersion in VR? That is, how can we experience the sensation of 'being there' while still 'being here'?

In VR, the stimuli to the senses are produced through a series of computations. As Copeland (1996) affirms, "to compute is to execute an algorithm, [… that is] a finite list of machine executable instructions such that anyone or anything that correctly follows the instructions in the specified order is certain to achieve the result in question" (Copeland, 1996, pp. 335–337). Therefore, to simulate the stimuli, it is necessary first to compute it, which implies understanding it mathematically.

However, here we have a point that is fundamental to our discussion on the cognitive possibilities of VR. To understand something mathematically, one needs to construct a model of that something, a representation that can be compared with how the thing is perceived. In this sense, the model of something cannot be a copy but just a resemblance of how something is perceived when available to perception.

This can be more easily understood, for example, when dealing with three-dimensional digital models, which can have a counterpart in the physical world. A digital apple shown in a computer display can appear to the eyes like a physical apple in terms of texture, colour, reflectivity, etc., but all those characteristics aim to correspond to the information available to our perception to construct the model. Therefore, if the digital model is made to be viewed only externally, there is no need to include the apple's internal parts, such as its seeds or pulp.

However, the physical apple experience exceeds its visual appearance: I know I can, for example, grab the apple, feel its texture and temperature with my hand, smell it, listen to the sound it produces when I rub my hand on it. That is, I can produce an understanding of the apple with my whole body. This type of understanding, the sensorimotor knowledge, already presented in previous chapters, can be defined as

> what regulates and makes sense of the perceptual information received by an active perceiver, and allows her to predict that which would arrive were she to engage in particular activities, enabling her to experience objects as spatially extended and located, and having as properties with which she can make contact. (Roberts, 2010, p. 104)

The physical apple is perceived as present as it is available to my body, and, in some sense, it responds to my interaction. On the other hand, it can be said that the digital apple is also present, but in a more limited way, since it is available just to some of my senses. Thus, it seems reasonable to contend that one of VR development aims is to fill this gap between the differences in availability between physical and digital objects. In other words, the aims are related to increasing the degree of presence of a digital object in VR.

In part, the difference in the levels of presence between an apple on a computer display and an HMD is related to the interaction between what is being presented and my body. The apple on a computer display does not react to my movements in the same way as a physical apple. It could be said that the computer display is not aware of my body, so I perceive the apple as less present. In a way, the strategy to increase the feeling of presence adopted by VR developers is related to the body's inclusion in the experience. However, this body that offers itself to the presence of digital objects does so part-by-part.

In VR, each stimulus is the result of a calculation. Therefore, each sense needs a separate model. However, some senses, such as smell, touch and taste, seem more resistant to modelling[20]. The current commercial VR systems can provide high-definition images and sounds. Concerning haptic feedback, it is still quite limited compared to physical touch. However, to get around this limitation, the developers have improved the system for detecting hand and finger movements, as I will present further.

[20] The SCHI Lab (UCL/Sussex University) (http://multi-sensory.info) has developed several experiments to stimulate smell, touching, and tasting. Another interesting work on digital taste and smell is: Ranasinghe, N., Karunanayaka, K., Cheok, A., Fernando, O., Nii, H., & Gopalakrishnakone, P. (2011). Digital Taste and Smell Communication. *Proceedings of the 6th International ICST Conference on Body Area Networks*. 6th International ICST Conference on Body Area Networks, Beijing, People's Republic of China. https://doi.org/10/ghvp7k

In a way, separating the body into its parts is a condition for enabling its digital presence. Still, these parts are not rejoined digitally but physically. The 'rejoining' becomes evident when you are about to 'enter' into VR: first, couple your eyes with the HMD, then your ears with the headphones. That is, to see and hear in VR, I need to offer my physical eyes and ears to coupling. Usually, in VR, hand-controllers are the last devices to be worn. Thus, there is a moment when one can already see the digital space and even the digital hands, which can be lying beyond what is perceived as the body's usual limits. In this sense, the coupling moment can be perceived with greater intensity: one must coordinate his physical hands, which are, until then, digitally invisible, to reach the digital hands and then hold the controllers. This means that one needs to offer a gesture with her/his physical hands to acquire its digital version, to make them visible.

The digital body, although constituted by separated parts, is perceived almost instantly as a unity. Even if the model that represents my hand, for instance, does not correspond to a human hand, I can still sense that model that takes the place of my hand as my hand[21]. The physical body seems able to take possession of these digital body parts to create, with some ease, a synthesis of this coupled body.

However,

> It is not the epistemological subject who brings about the synthesis, but the body, when it escapes from dispersion, pulls itself together and tends by all means in its power towards one single goal of its activity, and when one single intention is formed in through the phenomenon of synergy. (Merleau-Ponty, 1945/2012, p. 270)

Nevertheless, we already knew beforehand that we could experience VR with our bodies. However, as Jarvilehto (1999) reminds us, "perception is a process involving the whole organism-environment system", and it is not a linear process, but, "rather, a circle involving both the sensory and motor organs as well as the events in the environment" (Jarvilehto, 1999, p. 97).

In complement, Merleau-Ponty (1945/2012) states that

> The sensor and the sensible do not stand in relation to each other as two mutually external terms, and sensation is not an invasion of the sensor by the sensible. It is my gaze which subtends colour, and the movement of my hand which subtends the object's form, or rather my gaze pairs off with colour, and my hand with hardness and softness, and in this transaction between the subject of sensation and the sensible it cannot be held that one

[21] I had the experience to 'initiate' several persons into VR, and invariably, one of the first movements that they perform when immersed is bringing the digital hands close to the eyes and inspecting them.

> acts while the other suffers the action, or that one confers significance on the other. (Merleau-Ponty, 1945/2012, p. 248)

As we discussed in earlier chapters, our nervous system cannot distinguish the nature of a stimulus. Due to its closedness, it can only react according to the stimulus intensity. Besides, it is the organism that "interacts with the medium through its sensors and effectors, not through the nervous system" (Maturana, 2008, p. 109). In this sense, the nervous system changes the internal relations of activities between its elements without any input and output relation with the medium.

Furthermore,

> Due to the structural intersection of the neuronal elements of the nervous system with the sensory and effector elements of the organisms, the sensors and effectors participate in the structural dynamics of both the organism and the nervous system and the organism stay operationally independent. (Maturana, 2008, p. 110)

Thus, the organism and nervous system modulate each other continuously. It can be said that this generation of "internal dynamics that gives origin to internal and external sensory and effector correlations in the organism" (Maturana, 2008, p. 110) enables it to stay alive. The main consequence of this strict closedness of the nervous system is that it

> does not operate with representations of the medium, nor does it operate with symbols of the features of the medium, and it does not use in its operation dimensions proper to the description of the medium by an observer [...] It follows from this that the distinctions between inside and outside, and between virtual and non-virtual realities that an observer may make do not apply to the operation of the nervous system. (Maturana, 2008, pp. 111–112)

In this sense, only an observer can distinguish between 'virtual' and 'non-virtual'. The nervous system cannot distinguish between perception and illusion, and it is precisely this supposed inability that makes VR experience possible. However, an observer's very existence that can be simultaneously observer and observed seems like a point of relevance to our discussion. That is, how can we experience VR as 'real' even knowing that it is, in fact, an illusion?

Maturana (1988) explains to us that our operation as observers consists of making distinctions in language. As observers, we can reflect upon our experience, but "any explanation or description of what we do is secondary to our experience of finding ourselves in the doing of what we do" (Maturana, 1988, p. 2).

If we return to the protagonist's immersive experience in *Pygmalion's Spectacles*, we can see that, despite his knowledge about the illusory nature of the experience, he was able to fall in love with Galatea. Even knowing the impossibility of a romance with Galatea, the protagonist does not cease to be affected by the experience after emersion. Furthermore, some of the immersive experience effects persisted even after a detailed explanation given by Prof. Ludwig on the mechanisms that enabled the experience.

In this case, to offer *a posteriori* explanation of the experience was not enough to eliminate its effects. It can be said that explaining an experience to a subject can change its perception of the immersive experience to some extent, but what happens if the explanation is offered *a priori*? For example, let us suppose that a person never experienced VR and, before immersing her/himself, this person reads an extensive explanation about the processes that take place: the tracking of her/his head and hands, the stereoscopy, etc. Does this explanation change the 'feeling' of the experience? Is s/he still able to experience immersion and to be affected by it?

The answer is yes to both questions. The explanation can change the experience, but in a limited way since it is not enough to impede the immersive experience. However, although it seems obvious, a phenomenon can only be explained after observing that phenomenon[22]. In this sense, an explanation is

> always an intended reproduction or reformulation of a system or phenomenon, addressed by one observer to another, who must accept it or reject it by admitting or denying that it is a model of the system or phenomenon to be explained. (Maturana, 1978, p. 2)

We can better understand why language affects our perception of a phenomenon in a limited way if we go back once more to the nervous system's organisation. Since the nervous system is a closed network of interacting neurons, its organization does not feature the possibility of inputs and outputs. Although "it can be perturbed through the interactions of its components, for it, in its operation as a system, there are only states or changes of states of relative neuronal activity, regardless of what the observer may say about their origin" (Maturana, 1978, p. 8).

However, the possibility of observing an organism's behaviour and its subsequent description are at the roots of the possibility of VR. Therefore, for instance, it is because the observer can observe

[22] There can be some exceptions to this affirmation. Some phenomena, such as those described by the theoretical fields of astronomy or physics, can be explained by theoretical and / or mathematical models before having the conditions to observe the phenomena.

the phenomenon of human vision and propose an explanation to its mechanism – in this case, the *stereopsis* – that it can produce a model that can (ideally) generate a phenomenon that coincides with the one observed, in this case, the *stereoscopy*. Then,

> the observer uses the proposed model to compute a state or a process that he or she proposes as a predicted phenomenon to be observed in the modeled system. Finally, in the fourth operation he or she attempts to observe the predicted phenomenon as a case in the modeled system. If the observer succeeds in making this second observation, he or she then maintains that *the model* has been validated and that the system under study is in that respect isomorphic to it and operates accordingly. (Maturana, 1978, p. 1)

However, observer, "who can make distinctions and specify that which he or she distinguishes as a unity, as an entity different from himself or herself that can be used for manipulations or descriptions in interactions with other observers" (Maturana, 1978, p. 3), and observed, are part of the same organism. Thus, it can be said that there are two domains: the domain of the internal states (nervous system) and the domain of interactions (where the observer describes her/his interactions). However, for the observer contained in the organism, these two domains seem to intersect and manifest as a single domain, or the domain of experience (Maturana, 1978)[23].

The domain of experience can be equated to what we can experience with our embodied cognition. In this sense, our body can be taken as the ground zero for our experiences. It is the point from which the descriptions of our interactions can be made, the body as the invariable and persistent place from where the observer observes. On the other hand, our body can also be taken as the 'ruler' from where we evaluate and validate the models we create, that is, the body as an 'object' that can be observed. Thus, as Merleau-Ponty (1968) teaches us, the body is structured as a *chiasma*, or the intertwining of sensible and sentient, and is this "essential link between sentience and sensibility, which first opens the body to the world" (Toadvine, 2012, p. 340).

So, it can be said that our ability as observers to distinguish ourselves from this structural chiasma allows us to experience immersion in VR. Therefore, it is only possible to experience immersion if we can distinguish it from non-immersion. However, the operation of distinction occurs in language, in the domain of interactions, which is 'invisible' to the domain of internal states.

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[23] Maturana (1978) suggests that these two domains does not intersect with each other, but this becomes obvious just a for a super-observer, that is, for an observer that can observe itself observing.

Merleau-Ponty (1945/2012) uses the example of two hands of the same subject touching each other to explain a concept that can be useful for our discussion. The author says:

> when I touch my right hand with my left, my right hand, as an object, has the strange property of being able to feel too. We have just seen that the two hands are never simultaneously in the relationship of touched and touching to each other. When I press my two hands together, it is not a matter of two sensations felt together as one perceives two objects placed side by side, but an ambiguous set-up in which both hands can alternate the roles of 'touching' and being 'touched' (Merleau-Ponty, 1945/2012, p. 106).

This alternation between roles was later called reversibility by the author. Thus, the possibility of reversibility enables us to choose among the distinctions we can make despite its coincidence or simultaneity, in this case, between touching and touched. Through reversibility, I can operate my perception into bringing to the surface that that was available to my perception and that somehow, I decided to perceive.

If we look once more at the phenomenon of immersion in VR, we can see that it is an experience that is analogue to that of the hands touching and touched. When in VR, I am in a state where I can perceive myself as immersed and non-immersed since I can distinguish that the experience is an illusion. For example, when I am immersed and think that I might be too close to a wall, I choose to reach out my arm to see if I am safe. This movement of my body is not driven by the stimuli that came from the HMD or the controllers. I chose at that moment not to be immersed, guaranteeing my safety. When the necessary positional adjustments are made, I can offer myself to be immersed once again.

Therefore, the illusion needed to experience immersion in VR can be taken as just a moment in reversibility, where I choose to distinguish myself from the next moment of non-immersion. The reversibility or the change of roles in either situation is possible, according to Dillon (1983), because "after all, they are roles played by a unitary sensor, my own body" (Dillon, 1983, p. 369). From what we discussed, we can say then that our body is a unity that interfaces our nervous system and the world, holding the potency to reunite what language can distinguish.

Therefore, we can see that immersion in VR is a phenomenon that captures us at different cognitive levels, an experience of intertwining that occurs at the level of sensations, language, and the body. The possibility of experiencing VR is, in short, due to our ability to distinguish what is and what is not VR and to choose through our body what distinction to experience.

4.3. The state of the art of VR devices

If we consider, as Heim (2017) suggests, that there were two other waves of interest in VR, one in the 1980s and another in the 2000s, we are, since 2015, living the 'third wave of VR'. In other words, it is the third time that VR is promised to be the next big thing. However, according to the author, this third wave presents some differences from the earlier two:

> Where before virtual reality had been the mainly area of experimentation and speculation, now commercial products were getting into the hands of consumers. Where previously VR had been the domain of imagineers […] there were now thousands of consumers wearing VR headsets […] Virtual reality had become an actual product that promised future upgrades in hardware performance and in software scope. (Heim, 2017, p. 261)

The decisive step that catalyzed this third wave was taken in 2012. At that year, a young VR-enthusiast was planning a crowdfunding campaign to release his prototype of a new HMD. Before launching it, Palmer Luckey was already being courted by tech investors that gave him a few hundred thousand dollars to help in marketing. The crowdfunding raised more than ten times the original goal in thirty days, and the *Oculus Rift* prototype DK-1 was officially launched. In 2014, less than a year since the first units of DK-1 reached the campaign supporters, Facebook bought the company by more than 2 billion dollars (Ewalt, 2018).

Before the DK-1,

> VR headsets were big and heavy, packed with customs screens and complicated optics. They had small fields of view, so wearing one felt like looking at the world through a porthole. The images they displayed had poor contrast and low resolution. And the picture was laggy – turn your head and it took a moment for the system to react, creating a disparity between motion and vision that inevitably led to nausea. […] Oculus Rift contained a 1280-by-800-pixel screen, split in two in order to show each eye a different 640-by-800-pixel image. […] Before Rift, the best consumer-level headset on the market had 45-degree horizontal field of view, about half the range of human vision. […] But the Rift's view was stunning 90 degrees and 110 degrees vertical. It filled the user's entire field of view, cutting them off from the real world and immersing them in the virtual. (Ewalt, 2018, pp. 66–67)

It is possible to understand the importance of Luckey's innovations for VR when we look back at VR reports in the 1990s. Several authors point to the limitations and problems of low-FOV and low-resolution as a limitation for a greater sense of immersion or presence (Aukstakalnis & Blatner, 1992; Biocca, 1992; Earnshaw et al., 1993; Psotka & Davison, 1993). Lin et al. (2002) found a correlation between the size of FOV and the sense of presence. According to these authors, the sense of presence increases as the FOV gets bigger, varying significantly between a FOV of 60-140 degrees, and reaching a certain plateau between 140-180 degrees.

After the DK-1, the FOV of the HMDs presented some variations. The most recent HMDs' FOV varies between 100 degrees (10 degrees less than DK-1) and 130 degrees (30 degrees more than DK-1)[24]. This variation suggests that probably a 100-degree FOV is sufficient to provide a satisfactory experience. However, the human standard visual field varies between 107-109 degrees per eye, 214-218 degrees combined (Strasburger, 2020). Since HMDs can present half of the FOV we can perceive, how do we still feel immersed?

One possible explanation is related to 'useful FOV', that is,

> the area around the fixation point from which information is being briefly stored and read out during a visual task. When there is too much information, the useful field contracts to prevent over-loading of the visual system, just as the pupil constricts with too much light. The useful field of view is therefore varying in width from moment to moment according to the amount of information on the display. The useful field of view cannot exceed the normal physiological limits set by the ordinary visual acuity tests. (Mackworth, 1965, p. 68)

Evidence of the elasticity of useful FOV's size was provided by Williams (1982) when studying how demanding visual cognitive tasks relate to FOV size. The author found that the useful FOV changes "according to processing demands. Reasonably difficult visual-cognitive tasks will result in a generalized shrinkage of this useful field size" (L. J. Williams, 1982, p. 692). Another study shows that even trivial tasks such as conversation can impair our useful FOV (Atchley & Dressel, 2004).

In a certain sense, the notion of useful FOV is present in some of the most recent VR developments. As the VR displays developed, the image resolution of these screens increased significantly. For instance, the *Oculus Quest 2*, a standalone device[25], has a maximal resolution of 1832x1920 pixels per eye, which offers a combined resolution of 3664x3840 pixels.

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[24] Oculus Quest 2, launched in 2020, has 100 degrees of FOV and Valve Index, released in 2019 has 130 degrees. (The 360 Guy, 2020)

[25] Until 2019, the HMDs needed a connection to high-performance computers to work. With the launching of Oculus Quest come to light the category of standalone VR devices, which work without being connected to a computer.

In a VR experience, each digital element results from a series of calculations to determine its appearance and position on the screen. Since VR needs two different images to work stereoscopically, this calculation work needs to be done twice. Furthermore, all this work should be done in real-time, considering the observer's position and direction for the experience to be effective. As the resolution increases, more processing power is demanded, making the whole process quite computationally costly.

However, as Williams (1982) demonstrated, our vision's acuity varies according to the activities we perform. Besides, our visual acuity is also non-uniform in terms of physiology. Our retinas are composed of two photoreceptors, cones and rods. These photoreceptors are positioned in different eye parts, and there are approximately 5 million cones and 100 million rods per eye. The cones are primarily responsible for perceiving "colors, brightness, fine details, and sudden changes" (Hsu et al., 2017, p. 55). They are located in the highest concentration in the retina's fovea region, which presents the greatest visual acuity. The rod photoreceptors are very sensitive to light but do not present much acuity. They are responsible for initiating vision when low illumination is available. Additionally, there are no rods in the fovea region (Wandell, 1995).

The VR developers, aware of this characteristic of our vision system, proposed a rendering technique that presents an image that is a superimposition of high- and low-resolution images. The high-resolution image occupies an area that corresponds to what the fovea region can perceive, and the low-resolution occupies the periphery of that region, occupying the entire FOV. This eye-tracking strategy was adopted in the mid-1980s (Levoy & Whitaker, 1990) but recently became available for commercial VR HMDs with the *HTC Vive Pro Eye*. This device has a built-in eye tracker that consists of nine infrared lights and an infrared camera per eye. The lights illuminate the eyes that are captured by the cameras, and from this information, a vector can be calculated, representing the gaze direction (Sipatchin et al., 2021). By knowing where the gaze is located, the computer can process the *foveated rendering*[26], which "delivers higher video quality with lower computing power by allocating more computer resources on more crucial video regions" (Hsu et al., 2017, p. 55).

[26] A detailed explanation of the technique is available in this video: https://youtu.be/hKSlewfW_5Q

Some of the possibilities opened by eye-tracking in VR are, for instance, the investigation of viewing behaviours and spatial navigation (Clay et al., 2019), researches involving low vision impairments (Sipatchin et al., 2021), and studying shopping behaviours (Meißner et al., 2019).

Combining eye-tracking and foveated rendering seems to be a step towards a more accurate body capture by VR devices. As we are used to, an image with a uniform resolution seems adequate when it is impossible to track where the observer is looking. This type of image becomes obsolete and inadequate when the observer's gaze is incorporated into image generation.

Analogously, hand and fingers tracking also improved. The controllers used either in Oculus or HTC Vive HMDs (the two leading manufacturers) are similar in terms of functionality. Both controllers allow 6DoF of movements with millimetric precision. However, the finger interactions enabled by these devices were limited to the thumb, which could slide across a tracking surface and press buttons, the index finger, which could pull a trigger and the other three fingers that could press buttons. In this sense, natural hand movements like squeezing, pointing to a place, pinching, picking an object, etc., were usually not performed using the same gestures as with the physical hand.

Developers proposed some workarounds to this issue at the software level. It is the case of the *VirtualGrasp*, developed by the Swedish company *Gleechi*[27]. Through the use of "predictive & adaptive machine learning algorithms that analyze the physical properties of a virtual object", the developers were able to "decipher the most appropriate and realistic grip formation for the hand model and snap to that position" (GLEECHI AB, 2018).

I had the opportunity to test Gleechi's solution in 2018, and it was an exciting experience. I was wearing an Oculus Rift HMD with standard controllers and was led by developers through digital training related to maintenance procedures in a paper pulp industry. In the first moments of the experience, it was curious to see that when my digital hand approached an object, it would automatically adapt to find the best gripping position according to the algorithm. The mismatch between my physical hand's fixed position holding the controller and the movements of the digital hand may have been the cause of strangeness. However, after a few moments, my awareness was

[27] https://www.gleechi.com/virtualgrasp

directed towards the digital hands, as if they were somehow incorporated into my way of 'naturally' interacting with the world[28].

Valve developed another relevant solution for hand-tracking in 2018. The *Valve Index Controller*[29] has 6DoF and can track finger positions and motions individually and grip pressure (FIG. 32). The solution created by Valve is a combination of hardware and software. Algorithms evaluate the information gathered by the 87 sensors per hand to interact more naturally with the digital environment (VALVE INDEX, 2019). These controllers are a relevant innovation since they are an off-the-shelf solution provided by a relevant player in the game industry. Furthermore, Valve's solution still maintains the standard VR controllers' good attributes such as the buttons, tracking for the thumb, and trigger. In this sense, these controls seem to be much more versatile than glove-type tracking solutions.

Figure 32 – The Valve Index Controller: 87 sensors to detect movements of the hand, fingers, and pressure. Valve. 2019. Retrieved from https://bit.ly/3j3qXBk. Accessed in 27 Jul. 2021.

In mid-2020, Oculus provided an image-based hand and finger tracking solution for the Oculus Quest. It works

> by using the inside-out cameras on Oculus Quest 2 and Quest. Your headset will detect the position and orientation of your hands and the configuration of your fingers. Once

[28] At that point I remember that it was almost possible to 'feel' in the physical hand the sensations of the digital hand without any haptic feedback. It was an experience that has some common points with Merleau-Ponty's description of the blind man's cane: "The blind man's stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch and providing a parallel to sight" (Merleau-Ponty, 1945/2012, p. 165).

[29] https://www.valvesoftware.com/en/index/controllers

> detected, computer vision algorithms are used to track the movement and orientation of your hands. (OCULUS, 2019)

This solution is still being used only for navigation and a few specific apps since it has some limitations. For instance, the user needs to have her/his hands within his/her field of vision to track them precisely. If the hands leave the FOV, which is quite common in our everyday experience, tracking stops working, which does not seem adequate and can break the feeling of immersion.

4.4. Possibilities and consequences of capturing the body

The recent advances in VR technologies seem to be related to the refinement of the coupling mechanisms between the body, devices, and digital environment. In a certain way, the body parts captured by these new VR devices are still the same captured by 'old' ones, heads and hands. However, these parts now appear in more 'detail', such as the direction of the gaze and the position and movement of fingers.

In VR, the physical body is captured separately, and each part of the body is represented digitally as a set of information. For example, the head is represented as a digital element that has a position and a rotation in an abstract three-dimensional space divided into three planes, X, Y, and Z. The movement of any body part is essentially an operation of difference between its position and rotation in a moment t and its new position and rotation in a subsequent moment $t+1$.

This logic helps us perceive how close the question of time is to the very notion of computing. Evidence of this proximity appears, for example, when someone says that a computer is fast or slow, qualities that relate to speed and so to time. Furthermore, microprocessors' performance – one of the components responsible for calculations – is assessed by multiplying the frequency of the processor's core times the *Instructions Per Cycle* it can handle, two aspects related to time (*CPU Frequency*, 2018).

On the other hand, time can also be represented digitally, and, for this reason, it could be 'captured' as any other data. Thus, it is possible to 'record' an immersive experience not only in terms of space (e.g., position, rotation, gaze direction etc.) but also time. That is, it is possible to know how long and when a particular action was taken.

However, we neither perceive our bodies as a juxtaposition of parts nor time as a sequence of events. As discussed earlier, even with these differences between how computers capture our body or measures time, we can still experience immersion. In this sense, what I can perceive in VR as a correspondence between my physical body movements and its digital counterpart is just an appearance, a resemblance. Furthermore, it can be said that it is an outdated resemblance since there is a time (albeit small) between the physical movement and the computational time needed to represent it digitally.

Thus, there is a difference between the time captured by computers and the time perceived by subjects[30]. The time digitally represented on computers is objective, a data inscribed in the computer's memory that is, in a way, constant. Thus, the time on a computer, and more precisely in immersive digital experiences, is data that will always present itself in the same way with the same attributes when accessed. Therefore, it can be said that the digital representation of time is somewhat absolute because they do not affect each other[31].

The same is not valid for how we perceive time. As Merleau-Ponty (1945/2012) explains, time is "not a real process, not an actual succession that I am content to record. It arises from *my* relation to things" (Merleau-Ponty, 1945/2012, p. 478). In this sense, the perception of time as a sequence of events does not seem pertinent since there are "no events without someone to whom they happen and whose finite perspective is the basis of their individuality. Time presupposes a view of time. It is, therefore, not like a river, not a flowing substance" (Merleau-Ponty, 1945/2012, p. 477).

In a certain sense, "what is past or future for me is present in the world. It is often said that, within things themselves, the future is not yet, the past is no longer, while the present, strictly speaking, is infinitesimal, so that time collapses" (Merleau-Ponty, 1945/2012, p. 478). As we discussed in Chapter 2, we do not store memory as representations in our brain. Unlike computers, we do not 'recover' a static memory from our storage. Our memories are re-enacted according to our present situation. Thus, it can be said that the perception of time for a subject is relative. In addition to the

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[30] The understanding of perceived time is far from a pacified topic: it was, is and will probably be an issue in constant dispute by philosophers, neurologists, cognitive scientists, psychologists, etc. In this work, in the same way as I did previously, I opted for the explanation given by phenomenologists, especially by Merleau-Ponty.

[31] This does not mean that digital time cannot be manipulated: it can. However, even the manipulation of time, or the manipulation of any other captured data does not affect other captures.

common sense that says that present is a consequence of the past, it could be said that the way we perceive and re-enact the past is also a consequence of the present. Furthermore,

> each present reasserts the presence of the whole past which it supplants, and anticipates that of all that is to come, and that by definition, the present is not shut up within itself, but transcends itself towards a future and a past (Merleau-Ponty, 1945/2012, pp. 488–489).

An example that can illustrate the difference between digital time and perceived time is presented in the short movie *Player Two* (2016) by John Wikstrom[32]. The story is based on a YouTube comment by the user *00WARTHERAPY00* that narrated his personal experience of racing with his deceased father through a video-game console. More than ten years after his father's death, the narrator found his old video game and played a racing game that he used to play with his father. To his surprise, the videogame had automatically saved one of his father's races in memory. This saved game allowed him to re-enact the act of playing 'with his father', or more precisely, to play with the digital data corresponding to the exact spatial position and movements in time of one of the races performed by his father. Thus, despite the father's physical absence, the narrator could perceive him as present through the data captured by the videogame. However, even though the digital data remains unchanged, the subject has changed, and the possibility of playing again with his father in the present transformed and gave a new meaning to his experience.

Moreover, this capture of time by digital devices is not new, as the above example demonstrates. It can be said that videos and even photos are, in a certain sense, a way of inscribing and marking time in technical objects that are ideally stable. These inscriptions make the 'time', or the memory of the events that happened at that time, available in an analogous way as the Mycenaean's clay table discussed in Chapter 2.

Since smartphones became ubiquitous, we became somehow used to allowing data from our bodies to be captured. For instance, Google knows not only what you searched for on a specific date but where you were when you searched for something. With services like Google Photos, we are reminded daily about photos that were taken years before. For instance, through Google Timeline (FIG. 33), I can 'remember' that I drove from home to school on February 26th of 2018, stayed there for six hours and had lunch in a specific restaurant.

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[32] https://vimeo.com/162531355

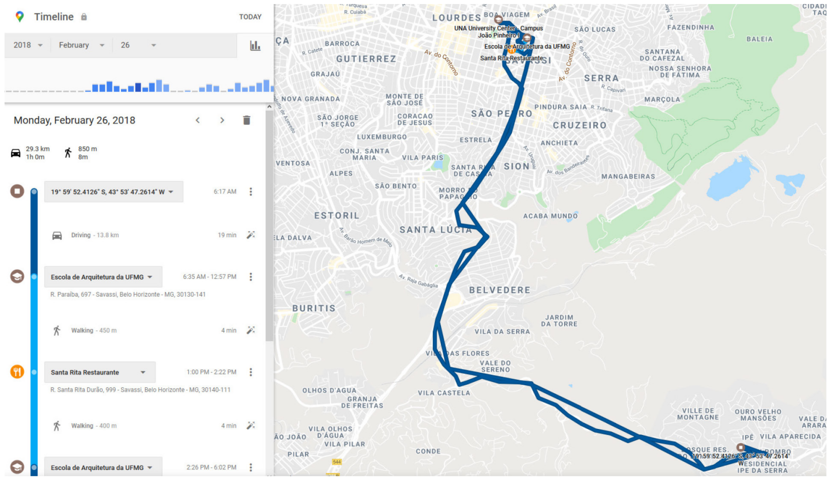

Figure 33 - My personal Google Timeline on 26/02/2018. Image by the author.

If we look again at VR devices' new tracking possibilities – head, gaze direction, hands, and fingers – we can start to imagine some of the possible consequences of having all these data captured. If experienced by many people, the same immersive experience can gather significant data to lead to insights about the experience itself.

For example, in training situations, the tracking data can allow instructors to perceive if trainees are looking into the right places when performing risky tasks, check if instruments are held correctly, and even assess the average performance level of participants. Research with reduced mobility people can also be done using these data, allowing the development of interface, space, and product solutions that could be, ideally, better for this audience. In this sense, rather than listing all possibilities opened by new VR tracking devices, it suffices to say that each immersive experience can develop a particular way of using the devices and data.

On the one hand, the user can feel more 'powerful' because s/he has a more accurate digital correspondence of her/his body, allowing her/him to perform actions in better ways. On the other hand, not all possibilities for capturing the body are advantageous for the user. Therefore, it seems crucial to ask who owns all this data from users’ experience. Moreover, what can this data disclose about the user individually and as a collective?

All these data points inevitably to the possibility of control and surveillance. Zuboff (2015) argues that the so-called ‘big data’, or the treatment, analysis, and extraction of insights from an extensive set of data, is a component of a new logic of accumulation called *surveillance capitalism*.

> ‘Big data’ are constituted by capturing small data from individuals’ computer-mediated actions and utterances in their pursuit of effective life. Nothing is too trivial or ephemeral for this harvesting: Facebook ‘likes’, Google searches, emails, texts, photos, songs, and videos, location, communication patterns, networks, purchases, movements, every click, misspelled word, page view, and more. Such data are acquired, datafied, abstracted, aggregated, analyzed, packaged, sold, further analyzed and sold again (Zuboff, 2015, p. 79).

To what concerns VR, it is important to consider that one of the main drivers of innovation in the field today is Facebook, which owns Oculus. It is not too late to remember that, in early-2018, Facebook gave unrestricted and unauthorized access to the personal information of more than 87 million users to the data firm Cambridge Analytica. This data was integrated with other gathered data, such as browsers cookies, online purchases, voting results, and others to build a database of more than 230 million US adults, which gave them the ability to micro-target users individually with messages and advertisements more likely to influence their behaviour (Isaak & Hanna, 2018). As *The Guardian* newspaper revealed, this data was used to build “a system that could profile individual US voters, in order to target them with personalized political advertisements” (Cadwalladr & Graham-Harrison, 2018, para. 2).

Since October 2020, Oculus users have been required to log in to Facebook to continue using their HMDs (Robertson, 2020). Then, the company could incorporate individually to the Facebook personal profile of each Oculus user another set of data from VR use. According to the Supplemental Oculus Data Policy, the company can collect information about a) user’s physical features, b) content created by the user (e.g., avatar picture, 3d objects, and audio), c) interactions, d) environmental, dimensions, and movement data, e) information from third parties, and f) technical system information (OCULUS, 2020).

In this sense,

> Now ‘reality’ is subjugated to commodification and monetization and reborn as ‘behavior’. Data about the behaviors of bodies, minds, and things take their place in a universal real-time dynamic index of smart objects within an infinite global domain of wired things. This new phenomenon produces the possibility of modifying the behaviors of persons and things for profit and control. In the logic of surveillance capitalism there are no individuals, only the world-spanning organism and all the tiniest elements within it. (Zuboff, 2015, p. 85)

A commercial VR system in 2018 was able to track 18 types of movements of the head and hands in a frequency of 90 times per second. Thus, a 20-minute VR experience generates “2 million unique recordings of body language" (Bailenson, 2018, p. E1). As the author argues, this nonverbal data tracked from VR experiences can improve prediction algorithms already used by Facebook, Google, and other big-tech companies. For instance, by using behavioural data captured in VR, researchers found correlations between head movements and emotions (Li et al., 2017), predicted the performance of participants in a VR task by tracking facial movements (Jabon et al., 2011), and investigated the interaction of pedestrians and fully autonomous vehicles at a crosswalk (Deb et al., 2018).

As Bailenson (2018) points out, the behavioural data captured in VR can be used as input for training algorithms that can analyze, categorize, and pair body language and behavioural outcomes. In this sense, immersive experiences in VR can inform systems that interfere with the physical world, which goes against the common sense that perceives VR as separated from reality.

I suggest that we take another look into how our body is captured in VR. For the application to know where my gaze is pointing when I am immersed in VR, one programming solution uses the function *Raycast*. This function casts an invisible ray from the origin (the eye) in the direction gathered by eye-tracking. However, to allow gaze tracking, the objects in the scene needs to be sensitive to the ray, which does not happen by default. In a certain sense, it can be said that it is only when the object perceives that it was seen that the gaze is tracked.

The same happens when tracking hands, for instance. The digital hand needs to 'know' that it is associated with the controllers' data to track and display the correct movements. Even object interactions happen in the same way: it needs to be programmed as something that can be picked up to be grabbable by the user.

Therefore, we can perceive that any element in VR is potentially a sensor that can store data that goes far beyond just its geometry, colour, texture, etc. Even invisible elements, which escape the user's perception, can perceive aspects of the user's interaction with the digital environment. However, although it is possible to perceive each digital object as an element that seems to exist, apart from the other elements, all digital objects are connected by definition. While they can have different programming, the digital elements are constituted in the same way, through codes compiled in an application. In this sense, it is possible to say that what perceives and tracks the user is not the object element but the environment as a whole.

In the movie *Slavoj Žižek: The reality of the virtual* (2004), the Slovenian philosopher states that he considers VR a miserable idea: "It simply means; let us reproduce in an artificial digital medium our experience of reality" (Wright, 2004). Therefore, he suggests an inversion, instead of 'virtual reality', to consider 'the reality of the virtual', that is, the "reality – by this I mean efficacity, effectiveness, real effects – produced, generated by something, which does not yet fully exist; which is not yet fully actual" (Wright, 2004).

This 'reality of the virtual' seems to become more tangible as it captures more and more data about our bodies, interactions, etc. The question is not about just capturing data itself but who captures it and what they do with it.

The subject that offers her/his body to be captured does so, in general, as a means to just experience immersion itself. It is unlikely that people would object to providing their data for causes that would help other people or create behavioural models that would bring some collective benefit. Likewise, it is difficult to deny that the new forms of interaction brought about by the new tracking devices are exciting and thought-provoking. In that sense, what seems to be left to us is to become aware of the issue and how it can affect us beyond VR experiences.

In a certain sense, this situation has some similarities with the sci-fi movie *They Live*, produced in 1988 by John Carpenter. The protagonist Nada (nothing) finds a sunglass in a box he retrieves from a recently destroyed church. When he wears the sunglass, he can see 'behind' the presented images. At a certain moment, Nada looks at a billboard where it is possible to see an advertisement for what appears to be a VR system, where a 'transparent computing system' is announced. When he puts on his glasses, he simply sees the word OBEY (FIG. 34).

Would such a solution for VR make us more comfortable with our data being captured? What could a feature like this reveal about the immersive experiences we access? Would we find out that we are 'spied' on in other ways? Would these discoveries transform our relationship with VR, and would we mobilize to change it, or would we accept this as the price to pay for the experiences?

Figure 34 - Two frames of the movie *They Live.* The first one is what the protagonist sees without the sunglass. The second one, in black and white, is what he sees when wearing the sunglass. John Carpenter. 1988. Collage by the author.

4.5. Some founding myths of architecture: the hut and the house

In the first chapter of this work, we discussed the possibility of an *immersionkunst*, an 'art of immersion', as suggested by Sloterdijk (2006/2011). According to the author, architecture is "the original form in which the immersion of humans in artificial environments has been developed into a culturally controlled process" (Sloterdijk, 2006/2011, p. 105).

The search for this original space from where architecture unfolded produced a few myths regarding architecture's origin. One of the best known and accepted myths was the primitive hut, present since the first known treatise on architecture, Vitruvius' *Ten Books on Architecture*, dating from I BCE. Vitruvius (1914) argued that the discovery of fire caused men to group together and agree on the first words that gave birth to language. Then, those primitive men started to construct shelters. Some men made "them of green boughs, others dug caves on mountain sides, and some, in imitation of the nests of swallows and the way they built, made places of refuge out of mud and twigs" (Vitruvius, 1914, p. 54). The primitives were able to learn from each other's experiences, which improved their construction standards. Vitruvius (1914) then pointed to the differences between the primitive huts according to the places and materials available where they were erected. In this sense, the author seems more interested in the general idea of a primitive hut rather than in a singular physical manifestation.

An updated version of this myth was offered in 1753 by Marc-Antoine Laugier in his *Essay on Architecture.* Laugier (1977) argues that by imitating nature, men could discover the principles that guide architecture. This myth tells the story of a primitive man that "without any aid or guidance other than his natural instincts" (Laugier, 1977, p. 11), needed a place to rest. This man moved from the grass to the forest and then to a cave, seeking shelter from these natural environments' discomforts. Then,

> He wants to make himself a dwelling that protects but does not bury him. Some fallen branches in the forest are the right material for his purpose; he chooses four of the strongest, raises them upright, and arranges them in a square; across their top he lays four other branches; on these he hoists from two sides yet another row of branches which; inclining towards each other, meet at their highest point. He then covers this kind of roof with leaves so closely packed that neither sun nor rain can penetrate. Thus, man is housed. (Laugier, 1977, pp. 11–12)

In this version of the myth, the primitive hut appears from a single man's efforts, devoid of any social interaction and learning, a man who fears no other man and could very well be Adam himself in the Christian paradise. Furthermore, this version of the myth presupposes, unlike Vitruvius, a singular physical manifestation of architecture from where "all the splendors of architecture ever conceived have been modeled" (Laugier, 1977, p. 12). A model from where one could distinguish between the essential building parts, those who are the cause of beauty, and those added by caprice, which are the cause of the fault.

Rykwert (1999) presents an extensive account of the primitive hut in architectural theory, extending from Vitruvius to Le Corbusier and Frank Lloyd Wright. The author explains that the primitive hut constituted a reference point for many architectural theorists to speculate on construction's essence. As the author concludes

> Whether it is a rite, a myth or an architectural speculation, the primitive hut has always appeared as a paradigm of the building, as a standard by which other buildings had to be judged in some way, since they arose from such weak beginnings. These cabins have always been set in an idealized past. (Rykwert, 1999, p. 237)[33]

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[33] Original: "Se trate de un rito, de un mito o de una especulación arquitectónica, la cabaña primitiva ha aparecido siempre como paradigma del edificio, como patrón por el que de algún modo había que juzgar a

Nevertheless, in any version, the primitive hut myth describes a space that is much more a shelter than a house. The use of 'primitive' to qualify the hut seems to have more to do with a notion of 'original' than with a derogatory meaning of the term[34] (Cairns, 2006). However, using this same word to qualify a man as primitive seems to establish a distance between this man and us. It is hard to agree that we would feel 'housed' in a hut comparable to that of the myth, without a bathroom, electricity, and Wi-Fi.

In this sense, Sloterdijk (2016) proposes an alternative, a myth for the 'primitive house' that "contains the prehistoric hut and subsumes it, to the extent of taking over its functions: harboring sleep, protecting from weather and vermin, providing a sphere of withdrawal for sexual matters and a comfort sphere for states of sluggish digestion" (Sloterdijk, 2016, p. 477). For the author, the house can be considered as the "basic version of immersion technology" (Sloterdijk, 2006/2011, p. 105), an artificial environment where humans immerse themselves.

Sloterdijk (2016) remarks that, with the proper abstraction, the primitive house can be seen as a machine to "harbor boredom", or "an inhabited clock", where the farmers could wait for the harvest cycle while digesting, sleeping and procreating, protected from weather and natural dangers (Sloterdijk, 2016, p. 477). Thus, the necessity of building artificial environments where humans can sojourn can be seen as a part of a structural change in the *modus vivendi*, which involves ceasing to be nomadic and starting to cultivate the land.

An interesting aspect of the primitive house proposed by Sloterdijk (2006, 2016) is its association to both a project and a mode of production. In a certain sense, the primitive house emerged from the temporal imposition of farming. Therefore, to suit the rhythms imposed by nature to plant, plough, harvest, and stock, men needed a place to wait: a dwelling. Leroi-Gourhan (2002) points out that the first permanently occupied houses coincide with the first rhythmical representations' appearance.

In this sense, a little as suggested by Vitruvius (1914), language played an essential role in developing houses. Leroi-Gourhan (2002) suggests that the language is the main instrument that enabled the symbolic inscription of spatio-temporal phenomena, which correspond to "a real

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los otros edificios, pues de tan endebles comienzos surgieron. Estas cabañas se han situado siempre en un pasado idealizado."

[34] For an in-depth discussion on the use of the term primitive in architecture, see: Odgers, J. (2006). *Primitive: Original Matters in Architecture* (1st ed.). Routledge.

appropriation of time and space made through symbols, to domestication in the strictest sense of the term, since they lead to the creation, in and from the house, of a controllable space and time"[35] (Leroi-Gourhan, 2002, p. 124). This symbolic domestication

> is translated in the passage from the natural rhythmicity of the seasons, days, walking distances, to a rhythmicity regularly conditioned by the network of symbols, calendars, schedules, metrics, symbols that transform humanized time and space into the stage where man commands the entire movement of nature.[36] (Leroi-Gourhan, 2002, p. 124)

Therefore, the primitive house, as suggested by Sloterdijk (2016), can also be seen as a point of observation from where it is possible to measure the time and establish a primitive calendar, which is "a cycle marked by the return of a particular species of prey, the maturity of a particular plant, or plowing"[37] (Leroi-Gourhan, 2002, p. 127). As the author teaches us:

> The organization of inhabited space is not only a technical convenience, but also constitutes, in the same way as language, the symbolic expression of a globally human behavior. In all known human groups, *habitat* corresponds to a triple need: the need to create a technically effective medium, the need to ensure a framework for the social system, and the need to order, from a point, the surrounding universe.[38] (Leroi-Gourhan, 2002, p. 131)

The anthropologist Peter J. Wilson presents a distinct account of the appearance of dwellings. According to the author, humans started to live in relatively permanent houses in a time that precedes the domestication of plants and other animals (P. J. Wilson, 1988). Domestication is a term related to the *domus*, the house¸ and means 'to tame', or literally, to 'dwell in a house' (*Domesticate | Origin and Meaning of Domesticate by Online Etymology Dictionary*, 2021). Thus, humans needed a house to tame themselves and to shelter plants and animals.

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[35] Original: "[…] uma verdadeira apropriação do tempo e do espaço feita através de símbolos, a uma domesticação no sentido mais estrito do termo, visto que conduzem à criação, na casa e a partir desta, de um espaço e de um tempo controláveis".

[36] Original: "traduz-se na passagem da ritmicidade natural das estações do ano, dos dias, das distâncias de marcha, para uma ritmicidade regularmente condicionadas pela rede de símbolos, calendários, horários, métricos, símbolos que transformam o tempo e o espaço humanizados no palco em que o homem comanda todo o movimento da natureza."

[37] Original: "um ciclo que é marcado pelo retorno de uma dada espécie de caça, pela maturidade de uma determinada planta ou pela lavoura".

[38] Original: "A organização do espaço habitado não é só uma comodidade de técnica, pois também constitui, a mesmo título que a linguagem, a expressão simbólica de um comportamento globalmente humano. Em todos os grupos humanos conhecidos, o *habitat* corresponde a uma tripla necessidade: a de criar um meio tecnicamente eficaz, a de assegurar um enquadramento ao sistema social, e a de ordenar, a partir de um ponto, o universo circundante."

According to Wilson (1988), neither language nor tools could significantly change the landscape and the living environment, although they certainly changed human conduct. It was the process of domestication or the "adoption of architecture for shelter and settlement as the more or less permanent living condition of the species" that consisted in the first cultural move that "physically altered the landscape" (P. J. Wilson, 1988, p. 9). As a consequence of domestication, it could be said that it enhanced humans' well-being and survival, but it is also a physical barrier between humans and between humans and the 'natural environment', which created new problems and demands. Domestication "sets in motion the process of community living and creates the conditions for political life, the public life and the private life" (P. J. Wilson, 1988, p. 9).

In a certain sense, this reinforces the view of houses as a technology for immersion since it enables humans to reorganize themselves spatially and socially by emerging from the 'natural environment'. However, it is essential to note that it is not the house's presence that reorganizes the space and the social, which would confer the house an objective existence and meaning, detached from the human himself. Instead, the humans' relationship between themselves, the house, and the environment seem to promote this reorganization. Thus, through language and the movements of immersion and emersion from 'natural' and 'artificial', humans were able to understand their very possibilities of reorganization.

4.6. Dwelling-as-filter: separating the usual from the unusual

Sloterdijk (2016) argues that after humans had become accustomed to the cycles of planting and harvesting observed and controlled from the sojourn in the house, our dwelling entered a second stage that includes the signs that announce a future event that was getting closer. Thus, in a certain sense, human houses were always "receiving stations for messages from extraordinary" (Sloterdijk, 2016, p. 482).

The house can 'harbour boredom' partly because it allows humans to surround themselves with triviality, which enabled the distinction of what is non-trivial. On the other hand, triviality implies a lack of stimuli, one of the burdens of housed life. Sloterdijk (2016) proposes that houses can be taken as receivers that sort "incoming things into significant and insignificant ones, thus preventing the mental implosion that occurs when everything or nothing is informative" (Sloterdijk, 2016, p. 484). Furthermore, the house can figure as a habitus machine, an "agency for finding usable repetitions" (Sloterdijk, 2016, p. 486).

Similarly, Wilson (1988) claims that the adoption of architecture as the living environment enhanced the "opportunities for concentration by erecting physical barriers against intrusion and interruption; reduced the chances of distraction; and hindered the free-flow capacity of people to pay attention to one another as an undifferentiated feature of the routine of everyday life" (P. J. Wilson, 1988, p. 176).

In the text *Exile and Creativity*, Flusser (2002b) describes the change of surroundings experienced by an expelled as the removal of the blanket of habit – a *dis-covery* – which makes everything sharp and noisy: "In habit, only change is perceived; in exile, everything is perceived as if in the process of change" (Flusser, 2002b, p. 106). Thus, whoever

> lives in a home finds change informative but considers permanence redundant. . . . [in the exile] the lack of redundancy does not allow the flood of information to be received as meaningful messages. Because it is unusual, exile is unlivable. One must transform the information whizzing around into meaningful messages, to make it livable (Flusser, 2002b, p. 104).

In a certain sense, Flusser's description of the exiled as someone who does not have a home and experiences everything as unfamiliar resounds with Wilson's and Sloterdijk's claims on the house as this apparatus that fosters concentration by separating the usual from the unusual. Sloterdijk (2016) suggests *en passant* a metaphor that illustrates the discussion: that of the dwelling-as-filter[39]. Before going any further, I would like to explore this metaphor a little more.

A filter[40] is an apparatus that separates elements. It consists of a first chamber where the mixed elements are poured on, a filtering medium, and a second chamber where the filtering results are deposited. The water filter, for instance, uses a ceramic element and/or activated carbon to separate the physical impurities of the water so that it becomes potable. The filtering process takes time, and the impurities accumulate in the filtering medium, making the process increasingly inefficient. In addition, the filtering medium needs to be cleaned or replaced with a new one from time to time. In a certain sense, it can be said that the filtering medium interfaces the filtered, the unfiltered, and the residue.

[39] The suggestion is found at the page 484 and 491 of the *Spheres III* book.
[40] Since our focus is not the filter itself, the discussion here will be limited to physical filters, not considering other types of filters, such as the digital and mathematical ones.

It seems tempting to identify which parts of the house are responsible for filtering and what they filter. Somehow, there are several efforts in this direction, including the architects and engineers who dedicate themselves to environmental comfort studies. These professionals can calculate and specify materials for a particular building according to their filtering capacities. However, the point is not to build the most efficient filter possible but to decide what should be filtered and to what extent. Unlike the water filter, the house not only filters physical impurities, such as dust, rain, etc., but it acts mainly as a filter of stimuli that the dweller ultimately perceives.

The reduction of 'external' stimuli fostered concentration and, by consequence, privacy. In this sense, "the unexpected positive advantages of a materialization of privacy helped set the scene for an expansion of creativity and the achievement of high levels of creative skill and performance" (P. J. Wilson, 1988, p. 176). Nonetheless, the metaphor of the filter demands us to look at other elements of the filtering process. In doing so, we might ask: what becomes a residue and is deposited on the filtering element at the interface between the non-filtered and the filtered?

At first glance, it seems that the building pathologies are part of this residue in a certain sense. The water infiltration, the cracks, the paint peeling, the dust, the wind blowing under the doors, etc., can be seen as part of this residue that appears when the filter fails. Nonetheless, other less material residues can also escape the filter: the sounds of neighbours in their intimacy, the smell of smoke coming out of the cars, the heat of a hot summer afternoon, as well as some of the curious glances of the passersby, and the radio and Wi-Fi signals from all around.

On the other hand, the filter element ideally does not let what has been filtered out mix back in with the unfiltered. However, as we mentioned above, part of what was filtered escapes the house as sound, smells, radiation and returns to be part of what we call the 'external environment'.

Here the notion of the filtering medium as an interface becomes evident, as something that simultaneously "divides and connects two very different worlds . . . . The interface denotes a difference and connection" (Zielinski, 2018, p. 48). In this sense, it can be said that

> it is the dwelling that makes its inhabitants capable of existence by equipping them with the first differentiation that makes a difference: that between the habitual and the exceptional, between those things that remain in the background as familiar and those that stand out from it because they are noticed for being unusual. (Sloterdijk, 2016, p. 486)

As Vitruvius's version of the myth points to, the houses exist as a series of houses, where one relates to the others. This version includes technical aspects of the house, such as construction techniques, materials, etc., but it also includes the house as an object located at a particular spatial position of the environment. This system of houses organized as villages and later as cities can filter other types of 'particles', complicating the filtering process. However, I propose that we leave the metaphor of the dwelling-as-filter for a while and return to the immersion experience.

If we look again at the phenomenon of immersion in digital technologies, it is possible to perceive that it also involves a process of filtration. For a user to perceive immersion, s/he needs to be presented only the adequate stimuli. In this sense, the VR HMDs, for example, can be regarded as a filtering medium that separates (or partially blocks) the 'real' stimuli for the wearer.

Nonetheless, the stimuli filtering process is only a part of immersion in both architecture and VR. If we look at the nature of the stimuli before and after filtering, it can be said that there is no difference between them. Therefore, it could be said that the medium from where one emerges or immerges to experience architecture and VR can be considered the same.

Unlike what happens, for example, in the rite of baptism, when I enter a dwelling or wear an HMD, it is possible to say that my body does not change from one medium to another from an objective standpoint. However, my perception changes and I experience both as different, which leads me to question what is it that changes in the experience of immersion in architecture and VR? Could this be what brings the immersive experiences in architecture and VR closer together, allowing us to classify both as technologies for immersion?

4.7. Experience of immersion, experience of atmosphere

In Chapter 2, I have presented the experience of immersion as something that entails a change of medium and that our body is an immersed body from gestation to death. However, as described in the last paragraphs, entering architecture or wearing a VR HMD seems to be an experience of immersion that, in a certain sense, is not related to a change of the medium.

It looks tempting to approach the perception of these differences through reason, measuring the elements, discovering proportions, evaluating the materiality of the construction, and even calculating the number of *lumens* in an environment. However, this type of approach that seeks a particular 'geometry of the sensation' is limited by its own premise, which attributes to the object a certain power that can be tamed through numbers. On the other hand, one can have a subjective and even psychologizing approach to the experience, which could inscribe the difference as an 'internal' process of the subject, independent of any 'external' counterpart.

In this sense, approaching the experience of immersion from an objective or subjective perspective does not seem adequate. This points to a third possibility, which locates the perceptive experience as neither an exclusive property of the object nor of the subject but to something that happens *in between.* In this sense,

> The elements of the environment are not only causal factors which affect human beings as organisms but they produce an impression on their feeling (*Befindlichkeit*). And what mediates objective factors of the environment with aesthetic feelings of a human being is what we call *atmosphere*. The atmosphere of a certain environment is responsible for the way we feel about ourselves in that environment. (Böhme, 2016, p. 1)

As Griffero and Moretti (2018) illustrate,

> The impressive entrance hall of a major banking institution will express an aggressive atmosphere of power for those who venture there in search of a loan, while expressing, on the contrary, a quiet atmosphere of proud belonging, not even clearly felt, for an employee who has developed a strong *esprit de corps*. And yet, what generates both atmospheres (conscious aversion and overwhelming awe or unnoticed sense of wellbeing and pride) is still the same spatial-emotional quality of intimidating vastness. (Griffero & Moretti, 2018, p. 82)

I contend that the atmosphere can answer our question on what changes in an immersive experience. Therefore, it seems necessary to rectify our claim that there is no medium change in immersion experiences in architecture or VR. Atmospheres are just about mediation. They fill spaces and are perceived as emanating "from things, constellations of things, and persons" (Böhme, 2016, p. 25). Thus, atmospheres are mediums, and for this reason, they can be approached in two different ways: "from a perception aesthetics or a production aesthetics viewpoint" (Böhme, 2016, p. 2).

This double path implies that our relationship with atmospheres is not just incidental, pointing to the possibility of producing atmospheres intentionally. Wigley (1998) even suggests that the central objective of the architect is the construction of atmospheres: "To construct a building is to construct such an atmosphere. . . . [and] to enter a project is to enter an atmosphere. What is experienced is the atmosphere, not the object as such" (Wigley, 1998, p. 18).

However, as the example presented by Griffero and Moretti (2018) shows us, the same spatiality can irradiate different atmospheres, depending on how (and when) the subject finds it. This seems to be a limitation to the intentional production of atmosphere. If the same spatiality can afford the perception of antagonistic sensations, is it possible to design an atmosphere whose effects are predictable? A possible answer is related to the atmosphere's nature, its in-betweenness, in the sense that there is no atmosphere without a subject to feel it with her/his body. Therefore, architects can manipulate only the objective part of the equation, producing the spatial conditions from which the 'intimidating vastness' can be perceived, as in Griffero and Moretti (2018) example. As Griffero teaches us, the resulting atmosphere of a building is "thus the circular intertwinement of the repertory of architectural gestures (e.g., verticality/horizontality, here/there, and inside/outside distinctions, as well as fluctuations between felt-bodily contraction and expansion) with the repertory of the user's felt-bodily and spatial experiences" (Bressani, 2019, p. 88).

If we return to Sloterdijk (2006/2011) affirmation that architecture is an art of immersion, it is possible to perceive how the notion of the atmosphere is intertwined with the phenomenon of immersion. Thus, for instance, the contemporary architect Peter Zumthor (2006) considers that the quality of a building is directly related to its atmosphere, to the first impression that is perceived almost instantly through our emotional sensibility.

However, this 'first impression' that derives from the perception of the atmosphere "recedes in favour of the opportunities of the specific situation, articulated in anticipation of typical patterns of movement and occupation" (Leatherbarrow, 2015, p. 141). As someone engages in activities that require attention, the atmosphere ceases to be global to be marginal and tacit, as Leatherbarrow (2015) puts it.

This characteristic of atmosphere perception shows a little more the intertwining of immersion and atmosphere. Leatherbarrow (2015) seems to describe precisely the movement of a subject that seems to cease to be immersed in an atmosphere, diverting her/his attention to other activities. It is possible to say that a similar event happens in the phenomenon of immersion in VR. For instance, when an immersant plays a game in VR, s/he can be caught by narrative or a task that needs to be done, which somehow displaces immersion from the atmosphere to other activities within the immersive experience.

Nonetheless, when the atmosphere recedes, it is not eliminated. On the contrary, its presence as 'background' for other activities contributes, to a certain degree, to the experience, as well as the physical environment where we perform our daily activities affects us, even marginally. Thus, if we look into gaming in VR, for example, where the player has to perform a series of actions to progress, it seems possible to say that one can experience immersion *in* immersion, being atmosphere, in this case, something like the 'first degree' of the experience.

However, it is possible to distinguish a 'second-order immersion' in VR and architecture. This distinction seems to be related to a certain level of predetermination and task orientation of VR experiences, or in other words, with its programming.

Programming is not strange to architects, but its meaning is distinct from the programming used in VR. Regarding the programming used in digital environments, including VR, it is a procedure that aims to describe a task that is ultimately executed by the computer. The 'programming of buildings', on the other hand, relates to the specification of the rooms, equipment, and areas of a building that are usually presented as a list of design constraints (Vasconcelos, 2015).

In this sense, regarding predetermination, it could be said that VR programming is usually much more restrictive than in architecture. As discussed earlier, everything needs to be programmed with a certain behaviour to maintain the experience's coherence. This leads us to the point of VR's programming. However open it is, it has an orientation that defines what could or could not be done. As Coyne (2007) suggests, it is unlikely that a VR flight simulator enables me to sit on a bench and simply watch birds, as well as it is unlikely that any specific simulator will allow me to behave in a way that is far outside from what its programming has prescribed. This limitation does not mean that one cannot act in ways not foreseen by the programmer. To return to the previous example, someone could use a multiplayer flight simulator to hold a business meeting or even race on the ground with other players, but these activities deviate only marginally from the simulator's 'goals'. It is somehow only possible to perform these activities because they somehow fall through the 'gaps' in the programming itself.

On the other hand, architecture can rarely establish a set of allowed behaviours that one cannot escape. It does not mean that architecture cannot prescribe behaviour: it does. For instance, one cannot play football properly in an operating room or perform surgery properly on a football field. The 'properly' here is fundamental since one can play football or perform surgeries virtually anywhere, but not adequately. However, any architecture is inserted in a political, social, economic and cultural system with its programs, which supplement what should or should not happen in specific spaces.

In any case, both in architecture and in VR, the programming ultimately leads to creating an atmosphere. Therefore, it seems interesting to investigate atmospheres creation to deepen our discussion of this and the phenomenon of immersion. Böhme (2016) suggests that to talk about the atmosphere is to talk about its character, and the "character of an atmosphere is the way in which it communicates a feeling to us as participating subjects" (Böhme, 2016, p. 28).

4.8. The production of atmospheres

From the side of production aesthetics, Böhme (2016) suggests that it is possible to rationalize atmospheres in its 'intangibility' and that the 'art of stage set' is a possible way to investigate the matter since it relates essentially with the production of atmospheres for a wider audience. Making an atmosphere is not related to producing a 'thing' but to "setting the conditions in which the atmosphere appears" (Böhme, 2016, p. 30).

The author explains that with the mastery of sound and light through electricity, the stage design could develop beyond the stage space itself, spilling out into the auditorium and other presentation spaces. Nonetheless, Böhme (2016) explains some of the distinctions of the 'design of atmospheres':

> The making, as long as it concerns a shaping and establishing of the geometrical space and its contents, cannot therefore relate to the concrete qualities possessed by the space and the things within it. Or, more precisely: it does not relate to the determinations of things, but to the way in which they radiate outwards into space, to their output as generators of atmospheres. Instead of properties, therefore, I speak of ekstases – that is, ways of stepping outside oneself. . . . We are concerned, therefore, with ekstases, with the expressive forms of things. (Böhme, 2016, p. 32)

To approach architectural design from the perspective of creating atmospheres, having the art of stage design as a paradigm seems something foreign to conventional practice. This understanding does not mean that architects are unaware that the spaces they produce are imbued with an atmosphere or, more commonly used, with a certain *ambiance*. As an architect, I can say that it is more familiar to us to approach architectural design through the mathematical rationalization of spaces by their geometry, measures, proportions, materiality, etc. That is, by the properties of that space and its elements. In a way, it seems that architects lack adequate tools to investigate these sensitive aspects of space. On the other hand, considering the architectural design only as an 'orchestration of effects', as Leatherbarrow (2015) criticizes, seems to obscure other issues that permeate and limit the architectural design itself.

Often what generates the need for architectural design is a demand that presents itself, as in the program we described above, as an 'objective' list of items to be contemplated by the project. Still, suppose we divert our attention outside the restricted field of recognized architects. In that case, the day-to-day demands tend to be even less poetic and less open to a more sensitive approach: minor renovations with a reduced budget, overly restrictive urban regulation, resolution of construction problems, etc. As the very suggestion of adopting scenography as a reference for a more sensitive approach insinuates, it seems to be easier to deal with architectural issues in that way in extraordinary spaces that are in some way on the edge of everyday life of a significant part of people, such as in the designing of museums, cathedrals, libraries, mansions, etc.

However, the notion of atmosphere persists even in everyday spaces. That is, would not it be precisely these ordinary spaces, where we spend most of our lives, that should be approached more sensitively? Moreover, from the designer's point of view, would there be any cognitive advantage in designing environments from this deeper layer, so to speak, that permeates and emanates from geometry, function, and the elements that compose a space, which is the atmosphere? From the user's point of view, what are the advantages of living in places designed from the prominence of the atmosphere?

However, it is essential to note that assuming a correspondence between a space's design and a subject's capacity does not seem adequate for this discussion. Thus, the question is not to create spaces that will supposedly make subjects more creative or insightful but to understand if and how they can contribute to the subject’s general experience. In this sense, it is possible to admit that

> There is clearly no simple correspondence between environment and thought. The theories of situated cognition do not suggest direct mappings between thoughts and architectural interventions. So we can dismiss the idea that architects can create places that make the inhabitants more intelligent, thoughtful, passive, active, better behaved or creative. . . . Environment and cognition involves a much looser fit. (Coyne, 2007, p. 31)

As we discussed earlier, primarily through Varela et al. (1993), Maturana (2008), and Clark (1997), the environment is part of our cognitive system, so there is a fit between both. It would be interesting to discuss if this fit is loose, as Coyne (2007) affirms, or if its 'looseness' can vary depending on the spaces or the activities being performed. However, in the scope of this work, it seems more accurate to focus on discussing this 'fit' to understand whether the approach to design by the atmosphere can cognitively impact a subject.

4.8.1. Environment and cognition

If we return to any of the presented versions of the primitive hut or house myth, it is possible to glimpse how the environment, and more specifically architecture, can participate in our cognition. The primitive man thought about constructing his hut or house by looking around her/him, evaluating the materials available and building a solution from what was available. At another time, this human was able to talk to other humans to understand how their equals had dealt with the same issues, and from there, they developed other better solutions. The domestication of humans placed us at another level, technological and cognitive, allowing us to perform other activities, especially those who demanded concentration, as Wilson (1988) claims.

Clark (1997) proposes that we "manage our physical and spatial surroundings in ways that fundamentally alter the information-processing tasks our brains confront" (Clark, 1997, p. 63). The author calls this manipulation of surroundings the *cognitive niche construction*, defined as "the process by which animals build physical structures that transform problem spaces in ways that aid (or sometimes impede) thinking and reasoning about some target domain or domains" (Clark, 2008, p. 62).

To illustrate his point, Clark (2008) refers to the Elizabethan and Jacobean theatrical practices. To deal with very demanding schedules, which involved presenting up to six different plays a week, actors relied on an interplay between their ability to recall and "the specially engineered spaces and social practices of the early modern theater" (Clark, 2008, p. 63). These theatres' playing platforms were usually accessed by a multiplicity of stage doors, from where the characters entered and left the scene. Each play had a plot, a manuscript that contained a kind of a map of the overall play, describing the character features, entrances and exits, sound cues, etc. Its massive size and presence on the backstage, usually hanging from a wall, allowed the actors to have a grasp of the general structure of the play. In addition, the actors received a minimal personalized script which contained their specific speeches, and the instructions for entrances and exits. As the author explains,

> None of these resources, taken on their own, looks sufficient to do the job. But working together, using multiple physical cues in the physical space of the theater and guided by the overlearned practices and conventions of the day, they provided the minimal scaffolding[41] needed. (Clark, 2008, p. 64)

In the same direction, Kirsh (1995) affirms that space can be considered a resource that can facilitate the planning and solution of everyday problems. As he explains,

> How we manage the space around us, then, is not an afterthought; it is an integral part of the way we think, plan and behave, a central element in the way we shape the very world that constrains and guides our behavior. . . . To make it easier to stay in control of activity, we rely on techniques which reduce the memory load of tasks, the amount of internal computation necessary, or which simplify the visual search and categorization that is inevitably involved in performance (Kirsh, 1995, pp. 31–65).

The environmental impact on the performance of a given activity can be perceived, for example, in a shopping situation in a supermarket[42]. This type of space is usually conceived and organized around the idea of buying items, which includes finding where the item is located and paying for it at the cashiers. However, other 'minor' activities can be unfolded from that. For instance, the buyer should evaluate first if s/he will need a cart or a basket to hold the items during the buying. Then, s/he will guide her/himself through the supermarket using the signs that point for a specific corridor or by looking at a product on a shelf and deducing what types of other products might have been grouped in the same category and that can be located in that aisle. For example, let us consider that the buyer is looking for a no-fat yoghurt, so s/he goes to the dairy products section and find the shelf where these products are located. S/he scans visually through the products until s/he finds the one that interests her/him, then s/he can evaluate if the price is fair and proceed to the cashiers. Now let us imagine a second situation that involves this same buyer at the same supermarket. However, now there are no signs, and the products are displayed on the same shelves, but without any categorization, so the no-fat yoghurt can be virtually anywhere.

This example shows that even an everyday activity that can be considered easy and demands low-cognitive processing can become much more complicated if the spatial arrangement is modified.

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[41] The notion of scaffolding here refers to the external elements where an organism can 'lean' to perform better regarding cognition or not. For more see Clark (1997).

[42] Here I am referring to supermarkets located mainly on the outskirts of Brazilian cities to serve lower-income audiences. Gourmet supermarkets, geared towards a posh audience, are certainly the exception rather than the rule in this example.

In a certain sense, in the example above, the environment's organisation decreased the number of distinctions needed to perform a given task, which increased the efficiency of the operation.

While this example allows us to understand the fit between environment and cognition better, it is limited by space's very nature in question since the supermarket is a single-purpose space. The design of the space is thought out to provide the right environment for shopping. However, it is hard to separate the physical environment from the social, cultural, and economic aspects to determine humans' behaviour. Furthermore, Coyne (2007) considers this kind of space as 'cognitively deficient', or *non-places*. According to the author non-places

> are either the interstitial, underdesigned spaces where nothing much is meant to happen, or they are those over-designed, over-controlled, monosemic or mono-functional spaces in which the chief cognitive demands are following directions, tracking a bureaucratic procedure, or parting with money. (Coyne, 2007, p. 32)

However, there seems to be a contradiction in the example of the supermarket. How can it be simultaneously a cognitively deficient space and a place that makes intelligent use of space? The emphasis here seems to be on the term 'intelligent'. It is not the focus here to discuss the notion of intelligence or to establish criteria for considering something as intelligent or not. Instead, both authors seem correct, and it is more interesting to understand from what perspective they are looking to consider something as intelligent.

For Kirsch (1995), intelligence is related to performance, with a certain efficiency in the use of space. Thus, it seems reasonable to consider the strategies that diminish an agent's cognitive load as intelligent. It is noteworthy that his study focuses on understanding how "agents set up their *workplace* for particular tasks, and how they continuously manage that workplace" (Kirsh, 1995, p. 1). There are situations where managing the space for a task is essential for better performance, such as preparing the *misé-en-place* for cooking, organizing the parts of a machine before assembling it, or buying at the supermarket. However, the agent who manages the space in the supermarket's case is 'hidden' and the spatial organization made by her/him subjects the buyers to behave in a certain way. Thus, it can be said that the rationalization of the supermarket space and the planned organization of products in the shelves and aisles are cognitively deficient for the buyers, which are restricted to act within a spatial organization that they have not even participated and that they cannot interfere. On the other hand, for the supermarket workers, who restock and organize the products, the use of space can be considered as intelligent, since its organization facilitates to some extent their work.

It seems important to note that the predicate intelligent here is applied to the use that an agent gives to that space to facilitate or improve their performance in a given task. This use is different from classifying the space itself as intelligent. The notion of intelligent spaces comes from the studies on ubiquitous computing (Weiser, 1991, 1993) and can be defined as those equipped with sensors and actuators that can perceive and understand what is happening there (J.-H. Lee & Hashimoto, 2002). Although we can discuss whether the 'intelligent' adjective makes sense in this case, for our discussion, it seems sufficient to say that an agent can make intelligent use of intelligent spaces, but the sensors and actuators do not automatically imply more intelligent uses of space.

Returning to the issue of non-places,

> If we assume the individual as the unquestioned agent of thought, then non-places tell us what to think and what not to think. More precisely, in the language of situated cognition, non-places implicate a limited range of human action, being and engagement. Thought is not encouraged beyond the limits of the space's own particular cognitive project, typically limited to basic wayfinding, getting crowds from A to B, carrying out certain transactions (purchases) and herding people through a process (such as getting on a plane). (Coyne, 2007, p. 33)

In opposition, places are those

> physical environments in which there is a ready complicity between culture, sociability and human practices. . . . [where the] architecture and the artifacts within it provide the memories, the significations, the signs, the visual and spatial languages and the sounds, through which all the other social, cultural and linguistic components can operate. In other words the ensemble that is place is conductive to the operations of thought, appropriate to the condition in which the human finds herself in that place. For the worker, a place is a space for thinking with, or, in the language of situated cognition, a space in which the cultural, social and physical scaffolding is in place for effective thought to occur, by whatever agency. (Coyne, 2007, p. 32)

Nonetheless, the question remains regarding the relation between cognition and space in those spaces where the task is not as well defined as those illustrated in the examples above. If we still consider that the environment is part of cognition, does it affect a writer's writing, the composition of a musician, or the designing of an architect? Is there an intelligent use of space when dealing with *wicked problems* in the sense that the spaces can contribute to the problem's very formulation[43]?

4.9. VR and the formulation of atmospheres

Throughout this chapter, we have gone through many issues, which I would like to recap briefly. We started with the study of the ideas that were somehow important for the notion of VR. It was possible to understand how other fields, such as literature, cinema, and photography, played a crucial role in developing the idea of being immersed in an interactive experience that involves the whole body. Furthermore, it was possible to see how the notion of programming was present since the early examples, even though this was not yet about computing and how this concept runs through all VR development. With the progress of computers, the paradigm for developing devices for immersion migrated from mechanically based (e.g., Pygmalion's Spectacles, Sensorama, and the stereoscope) to computer-based (e.g. Damocles Sword), as envisioned by Sutherland (1965). This paradigm change implied creating other strategies to incorporate the body within the experience to enable its digital presence. Then, the cognitive possibility of VR was explored, which took us to perceive how the body participates in the cognitive process, taking possession of the digital parts and building unity from them. Additionally, we saw how the notions of distinction and reversibility were fundamental for the experience of VR.

We then analyzed the recent developments in VR technologies to understand how they relate to the body's characteristics. It was possible to see how these new technologies are pointed to an increase of 'resolution' or an escalation and refinement of the captured data. Some of the

[43] The notion of 'wicked problems' was developed initially by Rittel and Webber (1973) in the paper *Dilemmas in a general theory of planning.* Wicked problems are, by definition, ill-defined, and are the opposite of tame problems, which are well defined, so to say. Tame problems are those with defined rules and clear goals, such as solving an equation, playing chess, etc. The solution of wicked problems depends on its own formulation. In this sense, it depends on what, who, and how one perceives the problem. As the authors explain: "The information needed to *understand* the problem depends upon one's idea for *solving* it. That is to say: in order to *describe* a wicked-problem in sufficient detail, one has to develop an exhaustive inventory of all conceivable *solutions* ahead of time" (Rittel & Webber, 1973, p. 161). The distinction of tame and wicked problems is not a consensus and was contested by Coyne (2005). The author affirms that all problems are wicked, and what varies is the degree of 'wickedness' of the problems.
In the context of this work, the notion of wicked problem is relevant because it pushes us away from the comprehension of problem as something that we should get rid soon. Rather, the focus should in experiencing possible solutions for the problem and reformulating it several times. Therefore, it is not the negation of the problem, but in a certain conversation that can be established between the problem and the solver.

possibilities opened by this data captured in VR experiences were presented, along with its capture's risks. The current phase of surveillance capitalism, which has big-tech companies as its leading players, led us to emphasise the risks since the most critical company for VR today – Facebook – is also the company that benefits the most from capturing and manipulating its users' data.

Following, we turned our gaze to architecture by introducing one of the architectural foundation myths, that of the primitive hut, which served – and in some sense, still serves – as a reference to architects and theorists concerning a particular 'essence of construction'. Then, a supplemental or alternative myth was presented: the primitive house associated with cultivating the land. It was possible to see how architecture was the first cultural move that transformed the landscape physically. We presented the idea of houses as attention enhancers that enabled or contributed to activities that demanded concentration. Houses were also compared with filters, interfaces that separate the usual from the unusual and, consequently, establish the inside and the outside domains.

Going back to the immersion experience, we discussed the concept of atmosphere as something that fills and emanates from space and things. In the context of this work, the atmosphere is what changes in the immersive experiences of VR and architecture. It was possible to see the potentialities and limitations that approaching architecture creation from the perspective of atmospheres' production can entail. The scenography was considered as a possibility for investigating atmospheres since it deals, in essence, with creating atmospheres for plays. Then, we reflected on how it seems more 'natural' to work with extraordinary spaces from the perspective of atmospheres and suggested that everyday spaces should be approached similarly.

Lastly, we looked into how space can contribute to cognitive processes, participating in the solution of everyday problems. It was possible to see how even a simple activity, such as going to the supermarket, can be cognitively challenging if space is not organised correctly. The intelligent use of space seems to diminish the cognitive load of its users. However, it also appears that monofunctional spaces, such as supermarkets, can be organized in more specific ways to serve their function better. Therefore, we proposed that it would be necessary to investigate the relationship between cognition and environment in other spaces, where the tasks to be performed are, in essence, nonspecific, such as those related to creation.

To investigate these questions from a conventional scientific perspective is a challenging task complicated for several reasons. To enumerate a few, I will focus on designing since it is the focus of this work. Designing an experiment that can be replicable involves restricting several variables that can impact the experiment's results. If we focus briefly on the definition of the subjects involved in the experiment, we can perceive the task's complexity. For instance, how is it possible to define which designers will be observed when designing? Should the participation be restricted based on gender, or age, or social and economic background? How to assess the subjects' design abilities to ensure that they will have the same level of proficiency in the activity? And so on. Nonetheless, these difficulties say little to the relevance of the proposed questions, but they point to a certain limitation of the 'hard' scientific method for these types of problems.

The atmosphere's very nature makes the issue even more complex since it is perceived as something that emanates not from one element but from a series of spatially organized elements. Furthermore, it seems to be of little use to try to define what composes the set of components that can produce an atmosphere since they vary and each element that is placed or removed from an environment, be it animated or inanimate, contributes to some extent to the perception of that atmosphere.

Still, working from this logic of producing effects and sensations through space is not unprecedented for architects. For instance, the Austrian architect from the late-19th century, Adolf Loos, wrote in his text *Das Prinzip der Bekleidung* (1898) a paragraph on how architects should approach their task from the effects they wish to produce:

> But the artist, the architect, first feels the effect that he intends to produce, and then sees with his spiritual eye the spaces that he wants to create. The effect that he wants to exert on the viewer, be it fear or horror, as in the dungeon; fear of God, as in the church; awe of state power, as with the government palace; piety, as with the tomb; feeling at home, like at home; happiness, like in the drinking room - this effect is caused by the material and the form. (Loos, 1898, para. 4)[44]

[44] Original: "Der künstler aber, der *architekt*, fühlt zuerst die wirkung, die er hervorzubringen gedenkt, und sieht dann mit seinem geistigen auge die räume, die er schaffen will. Die wirkung, die er auf den beschauer ausüben will, sei es nun angst oder schrecken, wie beim kerker; gottesfurcht, wie bei der kirche; ehrfurcht vor der staatsgewalt, wie beim regierungspalast; pietät, wie beim grabmal; heimgefühl, wie beim wohnhause; fröhlichkeit, wie in der trinkstube – diese wirkung wird hervorgerufen durch das material und durch die form."

It is interesting to note how Loos (1898) suggests that space is created 'internally', using imagination that can, in a certain sense, translate a feeling to space, giving body to a sensation through material and form. This excerpt can give the impression that the process is somehow simple: I feel a sensation, imagine a space, and that is it. However, between the lines lies a process that can be very demanding from the cognitive perspective. It is possible that someone can emulate a feeling through imagination, making her/his heart beat faster and even sweating, such as we do when dreaming, but is this a simple task to do while awake? Let us suppose that a talented architect perceives this feeling created by the imagination in a crystalline and sustained way. How many choices would still be necessary to arrive at the materials and forms suitable for that feeling? If we take this approach radically, is it possible to write it mathematically, such as, 'feeling a = material x + form y'?

The architect mentioned earlier, Peter Zumthor, poses the atmosphere's question differently, relating quality in architecture as something that can 'move' him. And he asks:

> So what moved me? Everything. The things themselves, the people, the air, noises, sound, colours, material presences, forms too – forms I can appreciate. Forms I can try to decipher. Forms I find beautiful. What else moved me? My mood, my feelings, the sense of expectation that filled me while I was sitting there. . . . But then I perform an experiment: I take away the square – and my feelings are not the same. An elementary experiment, certainly – please excuse the simplicity of my thinking: I remove the square and my feelings disappear. I could never have had those feelings without the atmosphere of the square. (Zumthor, 2006, p. 17)

If in Loos (1898) the feeling was generated 'internally' and moved to the 'outside', Zumthor (2006) offers a description of something that moves him as coming from 'outside'. Both emphasize the importance of form for the experience, but the latter lists other aspects: people, air, and sounds. Furthermore, Zumthor (2006) also explicit the '*in-betweenness* aspect of atmosphere as this effect occurs when a subject is affected by something that seems to be irradiated from the environment.

However, it is also important to consider that Loos (1898) refers to the production of atmospheres and Zumthor (2006) to its experiencing. From this perspective, the former's account can be supplemented by the aspects brought by the latter as elements of the experience. However, the other elements of the atmosphere brought by Zumthor (2006) add extra layers of complexity to the task of producing atmospheres through imagination, as suggested by Loos (1898).

Let us shift our attention once more to VR. As we discussed, state-of-the-art VR equipment can present high-resolution stereoscopic images and sounds that react to the presence of an observer in (quasi)real-time. The controlling interfaces also present sub-millimetric precision, although they are still somewhat limited in terms of haptic feedback. Unfortunately, the other senses are generally absent from VR, except in specific cases, with gadgets that are usually not part of off-the-shelf products.

If we consider what these and other authors presented[45] as components of the architectural atmosphere, it is possible to see that VR can simulate a significant part of them. Furthermore, VR can include a considerable part of our body and its movements in the experience, making us feel 'present' (which is the main objective of VR). It can be said that some of the elements of the atmosphere that are not yet possible in VR simulations, such as the movement and humidity of the air, temperature, smell and taste, contribute marginally to the atmosphere's perception in most of the spaces that interest architects. To a certain degree, even people can be simulated in VR using 3D models or inviting other immersants to a multiuser experience. However, the use of a digital environment is limited by its lack of materiality. Thus, one cannot sit on a digital chair or lie on a digital hammock using her/his physical body. Nevertheless, the use of spaces seems to be related to a second moment, coming after the first impression that characterizes the atmosphere.

Still, it could be said that VR can be used to reduce the cognitive load of imagining atmospheres. Considering that the environment is part of our cognitive system and that we can manage space as a resource that enables us to perform better, it is possible to argue in favour of an intelligent use of VR for architects.

4.10. Towards an intelligent use of VR for architectural design

To argue for an intelligent use of VR seems to imply that some uses are less intelligent. However, what I intend to debate has more to do with the notion of 'intelligent use' as described by Kirsh (1995), that is, as an use that can "simplify our cognitive and physical tasks" (Kirsh, 1995, p. 32). In this sense, even the more conventional uses that architects already make of VR, such as presenting a design, can be considered intelligent since VR helps present and explain a design to a client. However, this use does not seem intelligent from the perspective of the task of designing.

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[45] (Böhme, 2016; Griffero & Moretti, 2018; Leatherbarrow, 2015; Loos, 1898; Wigley, 1998; Zumthor, 2006)

Architects are already using VR in their design processes to test solutions, layouts, or even to make the architectural project compatible with other disciplines, such as structural, electrical projects, etc. From a designing standpoint, it is an intelligent use of VR, but it still seems significantly associated with a logic of designing that is linked to a search for the most 'correct' solution. It seems evident that this use can result in interesting projects with their atmosphere, but the resulting atmosphere is still incidental.

Creating something from the order of atmosphere using VR demands an engagement from the subject from a distinct order, an embodied engagement. In this sense, the tools of reason – numbers, angles, quantities – seem to have little to contribute to an atmospheres' construction. This does not mean that architects should abandon their tools and dedicate themselves to designing in a new way, using just their sensibility. The possibility of experimenting in VR from a more sensible standpoint can allow architects to perceive aspects of their designs that were, until then, hidden by a strictly rationalized logic of designing. It is not a matter of choosing this or that way of designing. Instead, designing can be regarded as an activity that should (ideally) connect the rational and sensible poles.

A strictly rational architect, whose decisions are founded on 'objective' data, can see with disdain the notion of sensible and even consider that it is a waste of time and effort to dedicate to architecture's subjective aspects. Nonetheless, no matter how rational her/his approach to architecture is, s/he inescapably end up producing something of the sensible order, an atmosphere. As Wigley (1998) affirms: "The very rejection of atmosphere constructs a particular atmosphere" (Wigley, 1998, p. 29).

On the other hand, schools do not directly train architects in atmospherics, and to a certain point, this is justifiable. In addition to the vast and indispensable technical content that schools have to teach, the atmosphere "escapes the discourse about it" (Wigley, 1998, p. 29). Nonetheless, architecture students learn to work with atmospheres in different degrees. For instance, if we look at the presentation drawings made by students in their studio practices, are they simply aiming to represent a building or simulate an atmosphere? One thing is intertwined with the other.

I suggest that an intelligent use of VR should be related to its use as a medium to support imagination, especially in the early phases of designing, to enable the designer to experience and adjust the atmosphere of her/his creation. From the cognitive standpoint, if we return to Loos'

(1898) and to his way of working, that is, to have a feeling of the intended atmosphere and then imagining the spatiality needed to achieve that effect, it is possible to see how VR can help in the process.

VR is not a substitute for imagination, but it institutes another way of imagining. It helps shift a high-demanding cognitive activity – the imagination and support of the mental image of a given environment – to a cognitively less demanding activity, that is, the operation of the software and hardware necessary for the experience.

However, learning to operate as an architect in the VR ecosystem is not something trivial. The practice studies that I have developed have been essential to understanding better the difficulties involved in producing VR experiences. I intend to discuss these difficulties in-depth in Chapter 6, but for now, it seems necessary to say that these obstacles are counterpoints to what could be a naïve adoption of VR as a problem-free solution.

Nonetheless, VR can add to the design process the benefit of having an 'outsourced mind's eye' to produce persistent, shareable, and manipulable environments. From the moment the designer becomes versed in VR software and hardware operation, her/his creative efforts can move around the environment, searching for the proper tuning for a specific spatiality. In this sense, I contend that the intelligent use of VR in the architectural design process should, at least during the conception phase, displace the architect's efforts from what should be represented by hand to how to produce a particular atmosphere to a body.

5. Representation and the production of architecture: techniques and the movement between enhancement and enchantment

This chapter presents and discusses the developments regarding representation techniques in architecture from the 16th century to the present. This discussion seeks to understand how the possibility of the geometric representation of space was primarily responsible for forming architecture as a profession as we know it. We are interested in understanding the representation techniques themselves and unveiling the very reasoning that enabled the appearance and development of these techniques. We intend to investigate how the architect's engagement with designing changed from the systematization of technical representation to the development of BIM software. At the end of the chapter, we will discuss the notion of efficiency in the design process, taking into account the use of technology. Finally, we will analyze our suggestion for using VR in the design process in light of the concepts of enhancement and enchantment.

The discussion starts by looking at the transformations that representation went through, especially during the period that goes from the 16th to 18th century. The development of the perspective method opened up a new range of possibilities for imagination and contemplation since it allowed the world to be understood through geometry. During this period, scientific reasoning gained traction and provoked transformations in society, economy, and politics. The logic of science stimulated the systematization of knowledge that affected the very organization of professions, including architecture.

The role of Jean-Nicolas-Louis Durand in the transformation of architecture is discussed through his theory and teaching strategies at the *École Polytechnique*. His efforts significantly directed architecture towards a path linked to efficiency, especially through the instrumentalization of drawing. In a sense, Durand successfully standardised a way of approaching architecture, from conception to its representation.

In the sequence, a discussion on the use of computers in architecture is presented. The analysis begins in the 1960s with Ivan Sutherland's Sketchpad, which can be considered the 'grandfather' of CAD software. The appearance of AutoCAD in the 1980s is presented as well as a discussion on how it transformed architecture, not only the design process but also the very architecture offices. The passage from hand drawing to digital drawing is discussed regarding its cognitive consequences for the architects.

Thus, the role of sketching in the architectural design process is presented. At that point, sketching is approached as a way to think visually, as a means for conversation (Schön, 1983), and as a process described by Goldschmidt (1991) as the 'dialectics of sketching'.

The appearance of Sketchup in the mid-2000s is also discussed since it became the architect's preferred 3d modelling software. It is possible to see how the operational logic of Sketchup presents similarities with the architect's way of drawing and how it has a complementary role in terms of cognition. Then, the discussion moves to BIM software, analyzing how the change from drawing to modelling impacts designing. The complexity of BIM software is discussed as well as the benefits and problems of its use.

The second part of the chapter discusses the notion of efficiency in designing. The very notion of efficiency is discussed, relating to scientific reasoning, intending to understand its limits and even its pertinency for designing. In a way, efficiency is possible in contexts where subjective aspects are not present or are diminished. Durand's propositions are revisited in light of this discussion. It is possible to see how the notion of efficiency in designing has reduced the body's participation in this process, diminishing it to just its representation.

The last part of the chapter discusses how efficiency is something that permeates our existence and that there are even personal advantages in operating efficiently. Efficiency is presented as part of the process of 'disenchantment of the world', which relates to the possibility of understanding the world mathematically (Weber, 2004). Nonetheless, the notion of disenchantment is put into perspective when we see that it is possible to have experiences of enchantment by means that depend on efficiency, such as immersive experiences in VR.

To conclude, the design process is discussed as something that can navigate between enhancement, linked to the logic of disenchantment, and enchantment itself. These aspects are analyzed not as opposites but as complementary, using as support for discussing the notions of tool and medium presented by Glanville (1992). The last chapter's suggestion of using VR as support for imagination is reanalyzed in the light of the present chapter discussion and how its use can counterbalance, to some extent, the pervasiveness of disenchantment.

5.1. The emergence of instrumental representation: from 16th to 18th century

The period from the end of the 16th century to the beginning of the 18th century is traditionally associated with the establishment and development of modern science and the beginning of its leading role in modern culture. During that epoch, European society was taking the first steps towards rationally understanding the universe. The development of technology and the importance of observation and mathematics were fundamental to produce this displacement in the notion of science. The natural phenomena and their metaphysical explanations were questioned, and new theories were developed based on the recent developments in chemistry, physics, and other fields (Applebaum, 2005).

If we look just into how the study of space was transformed, it is possible to imagine how the other fields were affected. Until the 16th century, the theories of space were developed within certain theoretical frameworks, usually limited by theological arguments. Some theories were problematic from a theological standpoint because they bumped into core issues of the Catholic religion, such as divine omnipotence (Grant, 1981). For instance, those theological questions led the bishop of Paris to promulgate, by request of Pope John XXI, the Condemnations of 1227, defining some parameters to 'frame the discussion' through censorship of some particular ideas. This document established the principle of "*potentia Dei absoluta*", or God's absolute power to do whatever He pleased, as long as there was no logical contradiction (Casey, 1997; Grant, 1981). To escape persecution, the natural philosophers – the scientists of that time – had to abstract space from its physicality, creating the notion of imaginary spaces, the space that "could not be apprehended by the senses, but by reason alone" (Bakker et al., 2018, pp. 240–241). Based on Aristotle's works, some Jesuit groups conceived imaginary spaces as equivalent to void space, non-dimensional non-real entities from where God created the world, in contrast to the three-dimensional and real space (Grant, 1981; Leijenhorst, 1996).

The work of René Descartes (1596-1650) and Isaac Newton (1643-1727) contributed to change significatively that panorama. Among their contribution to the scientific methods, they introduced the possibility of studying motion, space, and places through the idea of referential, making it possible to question and relativize the very observation of phenomena from an observer's position in space. Other theorists such as Gottfried Wilhelm Leibniz (1646-1716) developed this idea further. According to Casey (1997), Immanuel Kant (1724-1804) was who gave the decisive step into admitting the role of this embodied referential in the "emplacement of things in regions is that of providing these things with a directionality they would lack when considered merely as occupying positions relative to each other" (Casey, 1997, p. 205). Kant (2002), in his essay *Concerning the ultimate ground of the differentiation of direction' in space*, from 1768, relates the way we form our concept of directions in space – above, below, left, right, front, and back – with the intersection between our bodies and three orthogonal planes that constitute physical space. An in-depth analysis of the changes that took place between the 16th and 18th centuries, starting with the emergence of a more rationalized world view, can be found in Applebaum (2005), Funkenstein (1986), and Toulmin (1992).

This transitional period was shaped by a standard search for “order and certainty in an environment dominated by fragmentation, relativism of values, skepticism, and pessimism” (Vesely, 2004, p. 176). The response to that search was based on the belief of a mathematical nature that ruled the world order, which ultimately creates for the first time in history a mode of representation that claims to be universally appliable and fully independent, considered as “the most significant change in the representation of reality” (Vesely, 2004, p. 176). However, as the author points out, any representation is inevitably partial, and there is always a residuum of reality that is left out and has to find a way to represent itself. The result of this process can be described as “divided representation” (Vesely, 2004).

This division in representation identified by the author refers to a historical tension between the “symbolic-communicative and the instrumental-noncommunicative representations of reality”, in which perspective played a decisive role (Vesely, 2004, p. 178). As he adds

> In a perspectival setting it is possible to idealize a whole sphere of reality, to see reality in terms of precisely identifiable elements that are comparable not only in their content but also in their formal qualities and relationships. The given reciprocity of visible reality and vision is here transformed into an idealized representation, with the visible content and its meaning depending more on the nature of vision than on the things represented. . . . The tendency to reduce that larger context to a fixed point of view or “mind” and to a “picture” is the most explicit characteristic of perspective representation, and also its chief contribution to the formation of divided representation. (Vesely, 2004, p. 178)

The perspective method enabled the geometrization of the space in all its scales, from cosmic space to everyday spaces, such as streets, buildings, and interiors. In this sense, the perspective entailed a new way of imagining, enabling the conception and contemplation of anything and everything in its ideal existence or nonexistence. According to Vesely (2004), this contemplation was fundamental for the emergence of Cartesian thought, which “became the dominant mode of modern thinking and shaped the modern representation of reality” (Vesely, 2004, p. 193). Furthermore, the Newtonian synthesis, a proposition of the unification of celestial and terrestrial physics, preconizing that the same laws could be applied in either realm, impacted modern culture. The possibility of representing natural world phenomena through apparently universal mathematics helped to fulfil a desire to understand to some level the "incomprehensibility of the cosmic movement and the problem of infinity, and thus to understand the mystery of the world order" (Vesely, 2004, p. 230). This new paradigm of knowledge triggered by the Newtonian synthesis influenced, according to Vesely (2004), the orientation of the modern culture "toward progress, toward a new sense of time and history, and toward an unlimited faith in the perfectibility of human nature" (Vesely, 2004, p. 231)

In this sense, the philosopher of science, Alexandre Koyré (1957), points that:

> There is something for which Newton – or better to say not Newton alone, but modern science in general – can still be made responsible: is the splitting of our world in two. I have been saying that modern science broke down the barriers that separated heavens and earth, and that it united and unified the universe. And that is true. But, as I have said, too, it did this by substituting for our world of quality and sense perception, the world in which we live, and love, and die, another world – the world of quantity, of reified geometry, a world in which, though there is a place for everything, there is no place for man. Thus the world of science – the real world – became estranged and utterly divorced from the world of life, which science has been unable to explain – not even to explain away by calling it "subjective" (Koyré, 1957, p. 23).

5.2. Representation and the formalization of architecture domain

This new epoch, marked by a gradual change into increasingly scientific reasoning, affected the architectural field directly. In terms of education, the traditional guilds were substituted by academies or special centres where architecture was part of a broader curriculum that involved other disciplines such as civil engineering, mechanics, and others, indicating that theoretical knowledge was gaining prominence. Furthermore, the development of projective and descriptive geometry, that formed the basis for establishing technical drawing, transformed architecture into a highly formalised discipline, following modern science and technology (Vesely, 2004).

In France, for instance, during the sixteenth and seventeenth centuries, architects usually received only informal training through an architectural mentor. In 1671, the *Académie Royale d'Architecture* was founded, and its first director, François Blondel, proposed a curriculum that included "geometry, arithmetic, engineering, military architecture and fortifications, and perspective; and were sent to labour on construction sites to gain first-hand knowledge of stone-cutting, masonry and carpentry" (Benhamou, 2008, p. 187). The *École des Arts*, founded in 1743 by Blondel's nephew, Jean-François Blondel, approached architectural education as a full-time activity, contrasting with the four-hour week activities at the *Académie*. Students should undergo a routine from 8 am to 9 pm every weekday, with just an hour for lunch (Collins, 1979). Their curriculum included

> architectural theory (which Blondel expanded to include history, space planning, construction techniques, landscaping, furniture design, and ornament); mathematics (calculus, solid geometry, and algebra); surveying and map-making; engineering and hydraulics; art (history, life-drawing, and landscape); physics and optics; graphics (drafting, perspective, and model-making); construction (stone-cutting and carpentry); and business (estimating and billing). (Benhamou, 2008, pp. 189–190)

As the curricula of both schools show, architecture was taught as a combination of theoretical knowledge and new modes of representation. This approach transformed architecture into a highly formalized discipline, oriented by the belief that "the true order of reality was mathematical and that mathematical language thus provided the most adequate representation of reality" (Vesely, 2004, p. 238).

Consequently, the traditional symbolic representation based on cosmology was substituted by the promise of modern instrumental thinking, that is, a promise that "what was indeterminate and vague could be replaced by an unambiguous and precise mathematical equivalent" (Vesely, 2004, p. 240). According to Vesely (2004), instrumentality cannot be combined with symbolism due to its opposite characteristics. While the latter is reconciliatory and could serve as a means to participation, understanding, and global meaning, the former serves as an instrument of domination, control, and autonomy. Thus, the desire of autonomy of the field of architecture coincides with the elevation of instrumentality (*techné*) to a universal.

The *École Polytechnique*, established in 1795 in Paris, had a vital role in consolidating this systematic and rationalized approach to knowledge. The *École* was founded by Gaspar Monge, considered the father of descriptive geometry, a discipline whose objectives are related to the representation of three-dimensional objects on a two-dimensional surface, from where its properties can be deduced (Gafney, 1965). Monge was able to rationalize the techniques of projection used by stonecutters and master-carpenters, which made "descriptive geometry into a relatively powerful tool for solving problems" (Picon, 2000, p. 27). It was described as a language "necessary to the man of genius who conceives a project, to those who must direct its execution, and finally to those artists who must themselves execute its different parts" (Monge apud Picon, 2000, p. 27). The invention of descriptive geometry was

> a crucial step in achieving a systematic mathematization of *praxis*; it subjected the arts and crafts to the goals of technology and was instrumental in the genesis and development of industrialism and rational building during the nineteenth century. It is necessary to stress that the geometry of the new architects and engineers graduating from the *École Polytechnique* (and of most practicing architects ever since) was the geometry invented by Monge. (Pérez Gómez, 1983, p. 282)

It was under this tone of rationality given by Monge that the *École* was structured. Architecture was seen as a minor speciality that figured within other disciplines that engineers needed to master, assuming a subordinate role in this new organization of knowledge and education. At first, the architecture lessons were under the charge of Louis-Pierre Baltard, which proposed a curriculum adapted from Blondel's *Académie*, based on a tripartite division into decoration, distribution, and construction (Picon, 2000). The teaching of architecture at the *École* distinguished itself from the other schools with the changes proposed by the architect Jean-Nicholas Louis Durand.

5.2.1. The teaching of architecture at the *École* under J.N.L Durand

Durand wrote two theoretical works. The first one, *Recueil et Paralléle des Edifices de Tout Genre, Anciens et Modernes* (1801), presents a collection of examples drawn in the same scale and organized similarly to the comparative studies and taxonomies of contemporary sciences. The second work, the *Précis des Leçons d'Architecture données à l'École Polytechnique* (1802), is a summary of the contents of his courses at the *École* (Pérez Gómez, 1983; Vesely, 2004).

In the opening paragraphs of his *Précis*, Durand (2000) praises engineers as those with more opportunities to design buildings of first importance, such as hospitals, prisons, barracks, etc., suggesting that architects were primarily responsible for building private houses, a minor role. Curiously, Durand's starting point for developing his architectural theory is to consider it as something, in principle, less important, almost marginal compared to the supposed greatness and importance of engineering. The author considers architecture as the most expensive art and proposes a structure for its teaching at the *École* that is based on efficiency since engineers "have very little time to spare for such a study. . . . therefore, it has been necessary to make their study of architecture, although extremely brief, nonetheless fruitful" (Durand, 2000, p. 73).

This search for efficiency is revealed even in the *Précis* organization, which follows the Cartesian method to the letter, dividing the 'problem' of teaching architecture into its most minor parts. In the first part of the book, Durand presents the 'Elements of Buildings' in three sections, the qualities of materials and their uses, forms, and proportions. In the second part, he presents 'Composition in General' in three sections, the combination of elements, the parts of buildings, and buildings as a whole (Durand, 2000). Inspired by the engineers' way of thinking, Durand's method for studying architecture supposes the building as an *assemblage* rather than construction, that is, a building – as well as a machine that could be disassembled to be studied or fixed – should be decomposable into its smaller parts. Nevertheless, Durand (2000) was not only interested in studying architecture, but also in producing buildings according to his theory, whereby he adopts the same Cartesian strategy once more, that is, to design a building from the combination of its parts:

> But before disposing any edifice, before combining and assembling its parts, the parts must first be known. And they, in their turn, are combinations of other parts that may be called the elements of buildings, such as walls, openings, supports both engaged and detached, raised foundations, floors, vaults, coverings, and so on. (Durand, 2000, p. 88)

Thus, the smaller parts should be combined into bigger and more complex ones, which should be recombined until the building is finished. To consider the building as an object that could be assembled or disassembled evidence the mathematical reasoning that oriented Durand's thinking, a logic where the edifice corresponds precisely to the sum of its parts and nothing else.

The mathematical pragmatism that serves as the basis for Durand's theory presented a rupture from earlier theorists, rejecting any transcendental justification for architecture. As Pérez-Gómez (1983) notes, Durand positions his theory in opposition to the widely accepted belief that the fundamental objective of architecture was to use decoration and imitation to please the sight. For Durand (2000), architecture can never have pleasure as its aim. It should aim to provide "public and private utility, the happiness and the protection of individuals and of society" (Durand, 2000, p. 84). According to the author, architecture should be as fit as possible for its purpose and be built in the least costly way. Thus, fitness and economy should be the only principles that should guide architecture. By fitness, Durand (2000) means solid, salubrious, and commodious. In summary,

> To be solid, it had to be built with materials of high quality and proportioned with intelligence. To be healthy, it had to be placed on a well-chosen site. And to be comfortable, the forms and dimensions of its parts had to be 'in the most precise possible relation', considering the use for which the building was designed. (Pérez Gómez, 1983, p. 299)

In terms of economy, Durand (2000) prescribed that the forms that comprise a building should be symmetrical, regular, and simple. He even suggests that one should prefer a circle instead of a square since its perimeter is less, and thus, more efficient. Furthermore, Durand (2000) emphasizes that whichever is not necessary for a building should be forbidden.

However, there was a subjective aspect of architecture designing that also needed to be addressed by Durand, or his theory could be undermined. According to Vesely (2004), the perception of architecture as an autonomous field, able to produce its independent judgment, put the architect as the sole reference for his art. Therefore, during the 18th century, the notion of genius as "a power of inspiration, invention, and creativity derived either from the divine or from nature" was attributed to certain architects perceived as possessing these qualities (Vesely, 2004, p. 262).

In order to neutralize, or at least to minimize, the personal and subjective aspects that emanated from the notion of genius, Durand tried to reduce architect's talents to the ability to solve two problems:

> (1) in the case of private buildings, how to make the building as fit for its purpose as possible for a given sum; (2) in the case of public buildings, where fitness must be assumed, how to build at the least possible expense. (Durand, 2000, p. 86)

To solve these problems and reduce the subjectivity of the design process, Durand proposed an approach that is simultaneously a way of thinking and a way of representing. Before analyzing Durand's design method, I would like to deviate a little to discuss the subject Durand briefly.

5.3. Durand: an *assemblage* that fits his own time

When we study a figure like Durand, especially through what he wrote in his *Précis*, it is possible to perceive a subject with a consistent theoretical background but who understands architecture in a way that departs from this backdrop. As a man of his time, Durand seems enchanted by the social and technological advancements in French. It is noteworthy that he was living in an agitated period in a country passing through several transformations. In terms of economy, French was becoming increasingly industrialized, and socially and culturally, it passed through the French Revolution, which he saw at the age of 29.

Durand's worldview was inevitably constituted by this atmosphere, where technics was getting more and more relevant. It can be said that Durand's admiration for engineering and the engineers' way of thinking was partly because it was a discipline more in tune with the anxieties of that time.

As Vesely (2004) explains, "Engineering disciplines enjoy the privilege of ignoring the phenomenal world to concentrate only on elements relevant to their narrow viewpoint. These are mainly the structural and material parameters of the envisaged structures and the criteria of performance" (Vesely, 2004, p. 306).

Curiously, Durand (2000) did not deny architecture's subjective aspects and recognized that architecture could give pleasure. However, he subjects this aspect to other, less enchanted, that of efficiency achieved by following what he calls the true principles of architecture, namely, fitness and economy (Durand, 2000). In a certain sense, what he claims as the ideal architecture is something that we still see today in the descriptions of buildings in architecture magazines, websites, and in the discourse of architects, professors, and students: the search for an architecture that is both beautiful and functional.

As a student, Durand was under the supervision of the visionary architect Etienne-Louis Boullée (1728-1799). In contrast with his student, Boullée's (1976) interest in architecture was elsewhere. For him, architecture is

> this product of mind, this process of creation, that constitutes architecture and which can consequently be defined as the art of designing and bringing to perfection whatsoever. Thus, the art of construction is merely an auxiliar art which, in our opinion, could appropriately be called the scientific side of architecture. (Boullée, 1976, p. 83)

Boullée (1976) understood architecture as something related to the study of nature and whose principles can be derived from this study. In his book, *Architecture, Essay sur l'art,* the author even proposes that architects should be aware of the character of a building, a notion that is close to our understanding of atmosphere:

> Let us consider an object. Our first reaction is, of course, the result of how the object affects us. And what I call character is the effect of the object which makes some kind of impression on us. To give a building character is to make judicial use of every means of producing no other sensations than those related to the subject. . . . The real talent of an architect lies in incorporating in his work the sublime attraction of Poetry. How is that possible? Through the effect of the masses; character derives from them; and the result is that the onlooker experiences only those sensations that truly derive from the subject. (Boullée, 1976, p. 89)

It is interesting to note how Boullée's approach seems almost opposed to his pupil, Durand. The former was interested in how his creations could be perceived by a subject, which effects they could have, as the latter seems strictly interested in what Boullée has called the scientific side of architecture or the art of construction and its constraints. However, the influence of Boullée is undeniable in Durand's work. This influence led Durand to reflect on some of the concepts proposed by his master, which guided him to develop "a repertoire of formulas and programs that he would attempt to systematize, not long afterwards, in the *Recueil et parallèle*" (Picon, 2000, p. 6).

However, by following his master, Durand arrived in a completely distinct place. For instance, his understanding of 'character' was devoid of any symbolic sense. Instead, it resulted from a "direct mathematical relation postulated between the final form of a building and the organization of its plan. Thus, the architect's only concern should be to achieve the most appropriate (useful) combination of the different parts of his building in plan" (Pérez Gómez, 1983, p. 302)[46].

5.4. Durand's enhancing system: drawing and the *mécanisme de la composition*

Durand's architectural theory depended on the relocation of the function of drawing in the architectural production. The drawing was considered an obstacle for the architect since it takes time to master and could impair the efficiency of the production process.

Therefore, having efficiency as the north for his theory, Durand (2000) advocated against and even forbade any drawing that was not limited to representing just what was strictly necessary. At a certain point of his *Précis*, the author pointed out the 'risks' presented by an expressive drawing:

> That, in the attempt to produce an effect in the geometric elevation, the designer will add unnecessary parts and sometimes remove necessary ones. If anyone is so then unfortunate as to be misled by the charm of the drawing, the refinement of the line, or the purity of the tints into executing such a design, then not only does the mind of a rational observer remain unsatisfied but the architect's own eye is offended by effects and masses totally different from those he expected. We shall not enlarge upon the ruinous consequences of the abuse of geometric drawing in architecture; suffice it to say that this kind of work does irreparable harm to young men whose talent has survived the obstacles set in their way by a senseless routine: they are robbed of much time that might more wisely have been used to expand their knowledge. (Durand, 2000, p. 75)

Durand's (2000) recommendations for drawing advocated not only to a simplification of the drawing to its essential and simplest elements, devoid of any expressive whim but to the very

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[46] Picon (2000) proposes a less-critical approach to Durand's work. According to him "Durand was opening up new paths for the architectural imagination even while he was rejecting others. He followed his former master, Boullée, in providing scope for a methodological examination of the nature of the architectural project. Most importantly, however, these critics [Pérez-Gómez and Joseph Rykwert] overlook the sheer attractiveness of his theoretical work: it is both coherent and ambiguous, both introverted and open to the new questions that were being asked in its time". (Picon, 2000, p. 54)

organization of the various drawings in a single sheet (FIG. 35), which should contain “the largest possible number of objects, so that, most of the lines that represent them being shared, a considerable number can be drawn in no more time than it would have taken to draw any one of them separately” (Durand, 2000, p. 75)

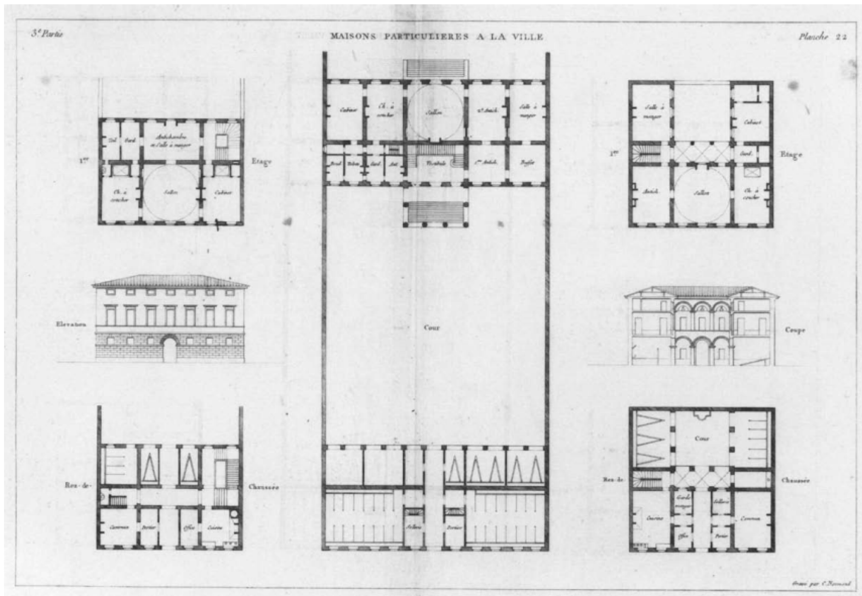

Figure 35 – A sheet of a technical drawing made by Durand. J-N-L Durand. 1802 circa. “Plate 22 – Principal Kinds of Building. From: Précis of the Lectures on Architecture, p.267”.

Therefore, Durand (2000) was able to transpose the ‘obstacle’ of drawing by disciplining its production through rigid rules to extirpate any personality and expressiveness of the drawings’ author and limit the types of drawings permitted (only orthographic projections). From there, the author could move forward, proposing a method for the architectural design process, the second element of his system.

The process of architectural design – like any other design process – is rarely efficient. As Lawson (2006) points out, to consider the design process as a sequence of activities that follows a specific order is, at least, questionable: “It seems more likely that design is a process in which problem and solution emerge together. Often the problem may not even be fully understood without some acceptable solution to illustrate it” (Lawson, 2006, p. 48). The process of design could be characterized as a kind of negotiation between problem and solution, a reflective conversation, that happens in a non-linear way, where a particular solution may highlight a part of the problem that was not evident until then, forcing the designer to reframe the problem and rework his solution in a recursive and iterative process (Schön, 1983).

Durand, undoubtedly aware of these characteristics of the design process and how it is oriented by criteria that are not efficient or economical, developed a method for designing, which he called *mécanisme de la composition* – mechanism of composition. It may seem that Durand was constantly oriented by certain pettiness in search of perfect efficiency, but his reasoning to get to the *mécanisme* is strictly rational and reasonable. As he states:

> A project can be well conceived only if it conceived all at once; and this can be done only through long familiarity with all the parts that must enter into its composition; otherwise attention is distracted by details and drawn away from the whole, and the imagination cools, producing nothing but poor and feeble ideas, and often losing the capacity to produce anything whatever. (Durand, 2000, p. 131)

It is interesting to note how the preference for the engineer's way of thinking, mathematical and rational, is evident in Durand's proposal. His understanding of the designer as this person who is familiar with 'all the parts' and that conceives 'all at once' suggests an image for the architect as someone who seems to be assembling a kind of machine, where each part has its predetermined place for it to work efficiently. Furthermore, the very name he chooses for his invention – the *mécanisme* – is inherited from engineering and is close to the notion of the machine.

To justify the adoption of his *mécanisme*, Durand (2000) presents several reasons to prove his point. To list a few, he considers: the expensiveness of architecture, the human desire for comfort, how painting and sculpture were more efficient in pleasing the eye than architecture, that imitation could not be considered a paradigm for architecture, the many characteristics of different materials, the role of each element of architecture, and others. As Pérez-Gómez (1983) summarized, the *mécanisme* consisted of

> the use of a grid to solve the fundamental problem of disposition, or arrangement of the elements in plan. Columns were to be placed at the intersections, walls on axes, and openings at the centers of modules. Durand showed how to apply this method to all parts of a building, and these parts would then be combined in a specific project. Although the solution of the plan was always the primary concern, the application of combinations to facades, general volumetric studies, roofing, and *parti* generation was also taught. Combinations were the means by which any architectural problem could be solved, which is another way of saying that the method *was* the theory. (Pérez Gómez, 1983, p. 304)

Furthermore, the *mécanisme* transformed the grid into "an instrument whose *sole* value was as a tool in a technological process", that is, the grid became the generator of the plan. This solution homogenized all spaces into a geometrical space that was certainly easier to work with and to solve the architectural 'problems', but which also implies considering that the spaces do not differ qualitatively (Pérez Gómez, 1983, p. 308).

The displacement of the role of drawing in the design process proposed by Durand (2000) and his approach to the design process as a method with well-defined rules and steps inscribed a critical rupture within the representations of reality. Nevertheless, his belief in the potency of instrumental representation to efficiently control the production of spaces turned out to be very effective, rooting itself in the *modus operandi* of architects and planners to the present day.

In my early days as an architectural undergraduate in the mid-2000s, the disciplines supposed to initiate the student into technical drawing were organized, following, at least in part, what Durand preconized. At that moment, CAD software was already the choice of most Brazilian architecture offices. However, we were taught to draw on the drawing board. As well as the courses offered at the *École* by Durand and his colleagues in the 18th century, we were presented to the main architectural elements one by one, learned to represent them using orthographic views, to, at the end of the semester, produce our first project which consisted of a collection of plans, sections, and elevations of a house reasonably drawn. The mechanical aspect of producing those drawings – already discussed by Ferro (2006) and Arantes (2012)– was accentuated by the compliments sometimes made by teachers to the best students: you draw like a printer! It would be unfair not to mention that we also learned some techniques for drawing perspectives, where we could use more expressive features, such as colours, shading, etc., which was not allowed in the other types of technical drawings.

The influence of Durand's way of producing architecture and architects remains present, to some extent, in the daily life of architecture schools and offices. Le Corbusier, the most influential architect and theorist in the 20th century, updated part of Durand's theory with his notion of the 'house as a machine', his praise for the 'aesthetics of the engineer'. As Pérez-Gómez (1983) notes, Durand's *mécanisme* was the inspiration for Le Corbusier *tracés régulateurs*, the regulating lines, that consisted in a more refined and less dogmatic way of conferring a formal order to a design.

5.5. The ascension of computing in architecture

The actual context for the production of architectural drawings is certainly distinct from that of the 19th century when Durand lived. Architectural drawings have gained the status of a legal document. In the Brazilian context, in general, any real-estate development done in urban areas requires the registration and evaluation of the architectural project by the control agencies for the construction to be approved. In addition, each regulatory agency has its requirements for presenting architectural projects, defining the types and minimum quantity of drawings needed quantitative information (such as room areas, for example), and even the colours and symbols allowed to be used. In this sense, it is understandable why architects have adopted software that supposedly allows them to have greater control over producing the necessary drawing documents. On the other hand, these demands and restrictions imposed by regulatory agencies created a niche market linked to the production and approval of projects in these instances, creating space for the emergence of 'bureaucratic architects', intermediaries between the architects responsible for the project conception and the regulatory agencies, a subject that was studied in the Brazilian context by Bernis (2008).

It could be said that for the majority of architects, responsible for the production of ordinary spaces, where everyday life occurs, the legal aspects and restrictions have a significant weight in the architectural creation process, which appears somewhat disenchanted, and which leads us to ask whether there is room under these conditions to approach architecture as the creation of poetic atmospheres.

Several authors present a panorama of this process of disenchantment of architectural representation that inevitably points to Durand's work as a kind of reference for the way we produce architecture today (Pérez Gómez, 1983, 2012; Perez-Gomez & Pelletier, 1992; Vesely, 1985, 2004). As Pérez-Gómez (2016b) affirms:

> The cultural and epistemological transformations that took hold in Europe during the early nineteenth century and prompted architecture's scientific reduction greatly explain why, as architects entered the age of computation, the tools chosen have been those that work in a totalizing abstraction: software such as Autodesk's AutoCAD and Revit. . . . While dedicated architectural software affords the architects the means to produce seductively appealing renderings and facilitates formal innovation, there remains an uncritical assumption, inherited from the nineteenth century, concerning the univocal relationship between the drawings (or, at present, the digital model) and the building to come. (Pérez-Gómez, 2016b, p. 207)

In any case, it seems essential to understand the development of CAD software and how it is intertwined with VR's development. The history of computing and architecture is much broader than the history of drawing and information management software such as AutoCAD and Revit, as Cross (2001) and Negroponte (1970, 1975) show. However, in this work, the discussion will focus on the development of CAD and BIM software due to its almost omnipresence in architecture offices and schools worldwide.

The *Sketchpad*, mentioned in Chapter 4, can be considered as the precursor of AutoCAD. It was developed by Sutherland (1963/2003) in 1963, five years before developing *The Damocles Sword,* the precursor of AR/VR HMDs. As Blackwell and Rodden (2003) reminds us

> The Sketchpad program itself had limited distribution – executable versions were limited to a customized machine at the MIT Lincoln Laboratory – so its influence has been via the ideas that it introduced rather than in its execution. . . . After 40 years, ideas introduced in Sketchpad still influence how every computer user thinks about computing. It made fundamental contributions in the area of human-computer interaction, being one of the first graphical user interfaces. (Blackwell & Rodden, 2003, p. 3)

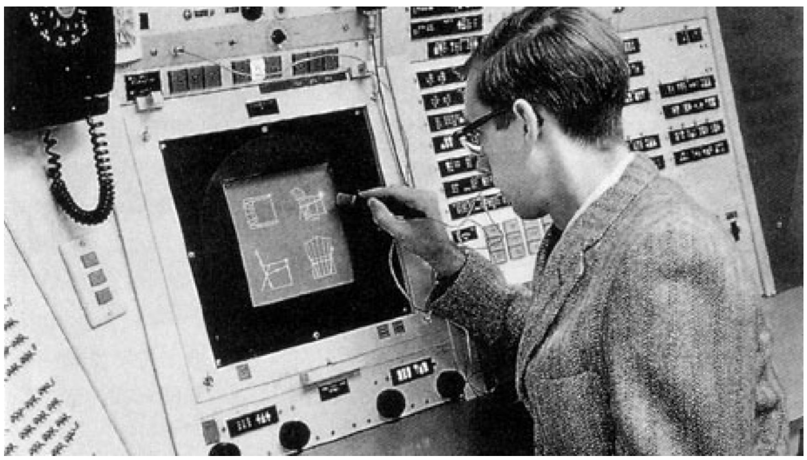

Figure 36 - Ivan Sutherland operating the Sketchpad with the lightpen. BIM A+. 1963 circa. Retrieved from: https://bit.ly/3xdIU5c. Accessed on 25 Mar. 2021.

Sutherland's invention (FIG. 36) aimed to establish a novel way of interacting with computers without the necessity of typing statements, substituting typing for line drawing using a pen. In a video demonstrating the Sketchpad[47], professor Stephen Koons from MIT says to the reporter:

> John, we are going to show you a man actually talking to a computer in a way far different than it has ever been possible to do before. [Reporter] Surely not with his voice. [Professor] No, he is going to be talking graphically, he is going to be drawing and the computer is going to understand these drawings. (Spoken, 2012)

[47] Video "Ivan Sutherland Sketchpad Demo": https://bit.ly/35lMsXD.

The drawing system was obviously inspired by the good old-fashioned pen and paper, but rather than building a 'pen-and-paper simulator', Sutherland (1963/2003) envisioned a system that explored possibilities that were absent or were impossible before:

> It has turned out that the properties of a computer drawing are entirely different from a paper drawing not only because of the accuracy, ease of drawing, and speed of erasing providing by the computer, but also primarily because of the ability to move drawing parts around on a computer drawing without the need to erase them. (Sutherland, 1963/2003, p. 8)

The Sketchpad also included the notion of constraints in the drawing, meaning that the lines could be either manipulated as a sole entity or as a group of entities that could be copied, rotated, scaled, etc. Furthermore, the user could work with 'master' entities that could be used in other drawings and, if the master gets modified, it is coherently modified wherever it is present, a notion that is very similar to 'blocks' in AutoCAD. Another similarity with AutoCAD is the 'infinite zoom' system, where the user could approach or distance the drawing infinitely as if s/he was working on an infinite piece of paper. Sketchpad was an experiment that combined hardware and software, an assemblage that involved a lightpen, an oscilloscope used as a display, dozens of buttons, knobs, and levers used to operate the invention. Nonetheless, the basic ideas for further development in CAD systems were present.

Several researchers updated Sketchpad to include other features, such as manipulating 3D primitives and the simultaneous display and coherent manipulation of the orthographic projections of a 3d solid. Sketchpad did not take long to inspire other initiatives in using the computer as a graphical interface.

One of these initiatives was the PYGMALION, developed by David Canfield Smith as part of this doctoral thesis in 1975. Smith (1977) was one of the first developers that considered the cognitive aspects of using computers creatively, having as a goal of PYGMALION to "develop a computer system whose representational and processing facilities correspond to and assist mental processes that occur during creative thought" (Smith, 1977, p. 6). In terms of cognition, the author was interested in investigating how a computer display could be used as an extension of short-term memory by reducing mental fatigue and providing a "convenient medium for visualizing and transforming concepts" (Smith, 1977, p. 155).

PYGMALION was one of the first systems to incorporate the recently invented 'mouse' as a device to interact with the interface. The operation of PYGMALION started with the user-facing the 'design space', a primary environment where six icons were present: world, menu, mouse, mouse value, remembered, and smalltalk (Smith, 1977). The author was very interested in the study of language and its relationship with images. His approach to language was primarily influenced by the Gestalt psychologist Rudolf Arnheim (1904-2007). Arnheim (1969) considered that using visual imagery was better than using words due to its superior descriptive power:

> . . . . concepts are perceptual images and thought operations are the handling of these images. . . . Nobody denies that language helps thinking. What needs to be questioned is whether it performs this service substantially by means of properties inherent in the verbal medium itself or whether it functions indirectly, namely, by pointing to the referents of words and propositions, that is, to facts given in an entirely different medium. . . . The visual medium is so enormously superior because it offers structural equivalents to all characteristics of objects, events, relations. . . . The principal virtue of the visual medium is that of representing shapes in two-dimensional and three-dimensional space, as compared with the one dimensional sequence of verbal language. This polydimensional space not only yields good thought models of physical objects or events, it also represents isomorphically the dimensions needed for theoretical reasoning. (Arnheim, 1969, pp. 227–232).

Thus, when Smith (1977) named PYGMALION's initial screen as 'design space', he was probably referencing this space described by Arnheim (1969), where visual language could occur, representing physical objects or events and providing the conditions for visual reasoning. To deal with this metaphor of space, Smith (1977) proposed a system of bidimensional coordinates where the upper left corner of the display was the 'origin', or the point (0,0). This system of coordinates based on an origin was adopted since then. Other developers have included a third axis to allow the representation and location of three-dimensional objects, and this system is still used in any CAD, BIM, or 3D modelling software today.

The operation of PYGMALION is described as the following:

> The programmer performs computations in this environment by pointing with the mouse cursor to operations in the menu and then selecting operand from the data structures in the design space. At times an operation may request linear data, e.g. a number or string, which may be input from the keyboard. The result of every operation is immediately displayed; if it is not what was intended, other operations can be executed until the desired state is achieved. . . . Instead of trying to *imagine* what data objects are being passed around, the PYGMALION designer manipulates the *actual* objects. And instead of *telling* the machine the sequence of operations to perform by putting them down on paper, the

> PYGMALION designer *does* them himself, and the machine records them. (Smith, 1977, p. 86)

Compared to Sketchpad, PYGMALION seems like a much more complex system to operate but can lead to greater complexity outputs. Nonetheless, they are programs with distinct objectives and similar strategies, and both are relevant for the development of architecture-related software, as we will see further. Another noteworthy point is that, in a certain sense, these software introduced a way of engaging with computers with our bodies that is still the rule today. Since the early 1960s, a significant part of our interactions with computers is done when seated, through our fingers and movements with our arms and hands translated as coordinates on a bidimensional screen.

Many of the aspects discussed above form the basis from which the software used by architects was developed. In particular, the CAD software was developed from ideas that go back to the 1950s, as Weisberg (2006) demonstrates. However, the discussion of digital drawing software – or digital drawing boards – will focus on AutoCAD for two main reasons: AutoCAD was the software architects adopted worldwide since the 1980s in their offices, and the history of Autodesk, the company behind AutoCAD, has some intersections with VR history.

Autodesk was founded in California (USA) in late-1981 by a dozen programmers interested in developing software in their spare time. The team was led by John Walker, an engineer and developer interested in computer-aided manufacturing, and Michael Riddle, a developer involved since 1977 with Frank Lloyd Wright Foundation. Riddle was developing an accounting system for that foundation, and there he could observe architects' design process. The recently started company's leading software was INTERACT, a solo project led by Riddle. In early-1982, INTERACT became MicroCAD and then AutoCAD. In late-1982, the company participated in the COMDEX conference, and the newborn AutoCAD-80 was awarded as 'best of the show' (Weisberg, 2006). In 1985, Autodesk sold more than 25.000 units and had gross revenue of 27 million dollars. In addition, AutoCAD was becoming the standard solution for CAD software worldwide.

Walker (2017), one of the founders of Autodesk, wrote a memo in 1988 named *Through the looking glass* presenting his view on what could be the subsequent development on user interactions. The memo described five generations of computers and how the user can interact with each one. In summary, in the first generation of computers, the interaction was made through knobs and switches. The second generation of computers refers to those equipment operated through punching cards that contained a program. The cards were handled by an operator that inputted them into the computer. Later on, the cards were returned along with a printout containing the program result. The third generation was a little more friendly, and the user interacted with it through a keyboard in a 'conversational' way: commands were inputted line by line and processed by a computer, which responded almost immediately. The interaction with fourth-generation computers aimed at the non-expert users was marked by introducing menus, where commands could be selected. The fifth generation of computers introduced graphics that allowed the creation of many metaphors, and the screen could

> be turned into a desktop complete with pieces of paper which can be shuffled (windows), accessories (tools), and resources (applications). The provision of pointing devices such as a mouse allows direct designation of objects on a screen without the need to type in names or choose from menus as in earlier systems. (Walker, 2017, p. 443)

Walker (2017) saw the fifth generation computers as a return to the first generation ones. In a sense, the users of the former were interacting with computers similarly to how the latter used to interact, that is, through a "virtual control panel on a glowing screen filled with slide pots, radio buttons, meters, all providing direct and expressive control over what's going on inside the computer" (Walker, 2017, p. 444).

Therefore, the author questioned if this return to the original mode of interaction was not a sign that a limit has been reached in terms of interaction. He considers that the most significant barrier "between the user and the world inside the computer is the system designer's failure to comprehend that he's designing a world and to adequately communicate his vision of that world to the user" (Walker, 2017, p. 445). The author points out that the solution should be a technology that can take the user 'through the screen', entering a world

> in which the user can interact with three-dimensional objects whose fidelity will grow as computing power increases and display technology progresses. The world inside the computer can be whatever the designer makes it; entirely new experiences and modes of interaction can be explored and as designers and users explore this strange new world, they will be jointly defining the next generation of user interaction with computers. (Walker, 2017, p. 446)

The answer proposed by Walker (2017) was VR, obviously, but he preferred to call it cyberspace. The author considered that Autodesk should invest in VR due to its affinity with its core business, which could put them ahead of possible competitors. At the end of 1988, Autodesk implemented the *Cyberia Project* to research VR solutions, giving traction to a new phase of VR, which was beginning to develop as an industry, alongside other players such as NASA and Jaron Lanier's VPL (Rheingold, 1991).

The VR revolution did not turn out as expected, but AutoCAD kept getting more and more popular. In a certain sense, the interaction with computers is still restricted mainly by the same barriers identified by Walker in 1988: keyboard, mouse, and graphics on a bi-dimensional screen. The AutoCAD software is still evolving, and there is no doubt that the work of architects became easier as the functionalities brought by newer versions enhanced the process of drawing. However, it is hard to say if there was any significant qualitative improvement in what architects could produce using AutoCAD. That is, are architects producing better atmospheres by using this software, or are they just increasing their productivity?

5.6. Looking into AutoCAD's black void: understanding some possible cognitive impacts of digital drawing

When I decided to become an architect, one of the first things I decided to learn was AutoCAD, even before enrolling at the university. In a certain sense, as I have always had an easy time with computers and difficulty with manual tasks, like drawing, I imagined that by learning AutoCAD, I could overcome some of my limitations. In the mid-2000s AutoCAD was already an essential requirement to get an internship. The first boss I had, and later my teachers at the university, emphasized how AutoCAD made architects' lives easier.

This boss once told me a story of when he worked as a draughtsman during the 1970s, still as an undergraduate student, and the whole office was designing a prison. His boss told him to draw a section that went through the prison corridor, where all the cell bars should appear in the drawing. Therefore, he started to prepare to draw the section, which involved copying the plan, overlaying it with a new paper, and drawing using the conventional tools: a set of rulers and squares, mechanical pencil, erasers, etc.

The rhythm of the task was slow and demanded a certain level of concentration not to make any mistakes. After a few days (and nights) of work, when the section drawing was almost done, his boss came to the drawing board to revise the work. Unfortunately, the boss saw that he forgot to draw some of the cell bars near the middle of the drawing, which caused him to redraw almost the entire drawing.

If AutoCAD was available at that moment, he could adjust the drawing in a much shorter time and without suffering too much. It is even likely that he would not have made this kind of mistake since repetitive drawings, such as the cell bars, can easily be copied and moved around the screen in AutoCAD.

Many other stories can follow this one. It helps us understand why AutoCAD became almost omnipresent in architecture offices worldwide: it optimized the production of drawings, helped to reduce errors, facilitated rework, homogenized designs, and has a smooth learning curve. However, on the other hand, AutoCAD adoption has changed the way of engaging with what is being designed, posing some questions related to the cognitive aspects of its usage.

If we look into the very setting where architects used to work, we can see how the introduction of computers changed the design process and the physical space where it takes place. Before architects started to design using software, architecture offices were usually wide spaces with dozens of drawing boards, a spatial organization mirrored in architecture classrooms. The reason was simple, each student, drafter, or architect needed a drawing board to work. Since drawings took a long time to be made, it was relatively common for architectural firms to have many employees.

The adoption of drawing software homogenized spaces in a certain sense. Regular desks substituted the drawing boards, and the office shrank in terms of space and people. In terms of organization, the architecture office became similar to any other office. If it was not for the sake of decoration, architectural offices could easily be mistaken by law or accounting offices.

In this sense, one of the consequences of adopting drawing software was the disappearance of drawings from office spaces. They did not disappear entirely since some architects still use printed drawings when reviewing or presenting to clients. Nevertheless, their material presence became less common. It could be said that the drawings acquired a different degree of presence, becoming primarily available through the computer's display, which means that they became less available to a sensorimotor understanding.

The way to bodily engage with the drawing was changed, and some readily available information has to be accessed in other ways. For instance, just by walking alongside the drawing boards, it was possible to see which projects were being worked on, what stage of development the projects were in, etc. Furthermore, just the size of the paper suggested, to some extent, the scale of what was being designed.

From the software developer's standpoint, the 'infinite zoom' present in AutoCAD, inherited from Sketchpad, is a smart solution to deal with drawings that should be printed in papers larger than the computer display. This feature allowed architects to draw in a 1:1 scale, and the building floor plan could be located side-by-side with the detail of a doorknob: to make one or another visible is just a matter of zooming in or out. However, the perception of scale as a concept and as a "matter of relationship between sizes of things and that of the human body" was, to some extent, impaired (Senagala, 2004, p. 305).

If we look at an architect representing something technically on paper, the way her/his body engages with the drawing points to the scale of what s/he is drawing. For example, if s/he is sitting straight and drawing using the full extension of the arm, the element being drawn is likely bigger than when s/he is drawing using just finger or hand movements. Indeed, there are cases where this situation can be reversed, but these are the exception.

It was also usual to see architects getting up to look at the drawing from another distance, tilting their heads, or looking to the drawing obliquely, literally changing their point-of-view of the drawing. It is interesting to note that from these changes of the relation between body and drawing, other perceptions could emerge, as if by distancing themselves from the drawing board, architects could also 'emerge' from the process of drawing and evaluate it critically, before 'immerging' again. In a certain sense, it could be said that the architect was trying to gain some knowledge, sensorimotor knowledge, of the drawing by moving around it as if s/he is seeking to reveal the invisible depth contained on the drawing surface.

Kirsh and Maglio (1994) describe an analogue situation involving an expert chess player that, when facing a challenging moment, stands up and change her/his spatial position. The player leaves the board intact and moves to a new vantage point "to see if otherwise unnoticed possibilities leap into focus, or to help break any mind-set that comes from a particular way of viewing the board" (Kirsh & Maglio, 1994, pp. 545–546). This type of actions, called epistemic by authors, are "not performed to advance a player to a better state in the external task environment, but rather to advance the player to a better state in his or her internal cognitive environment" (Kirsh & Maglio, 1994, p. 541).

Epistemic actions can be regarded as a way to gain sensorimotor knowledge over a situation. In both situations, that of the architect and the chess player, the intention is not related to its effects on the environment but on the effects on the agent itself. In terms of drawings, it could be said that physical drawings afford a broader range of possibilities of epistemic actions than their digital counterpart.

Computers usually offer fewer possibilities of engaging with it from a bodily perspective. For example, the drawings are produced through the same movements in AutoCAD software, despite their scale. Its operation is an alternation of mouse movements and clicks, with typing commands and numbers. Ideally, the eyes should always be on the screen to see the results of a command that appear in a blink. The movement of zoom, usually done with the mouse scroll, substituted our movement of approaching and distancing from the drawing to a significant extent. Most of the time, the distance from the screen is almost the same. What varies is the size of the drawing displayed on the screen, or in other words, the drawings move so the architect can remain still.

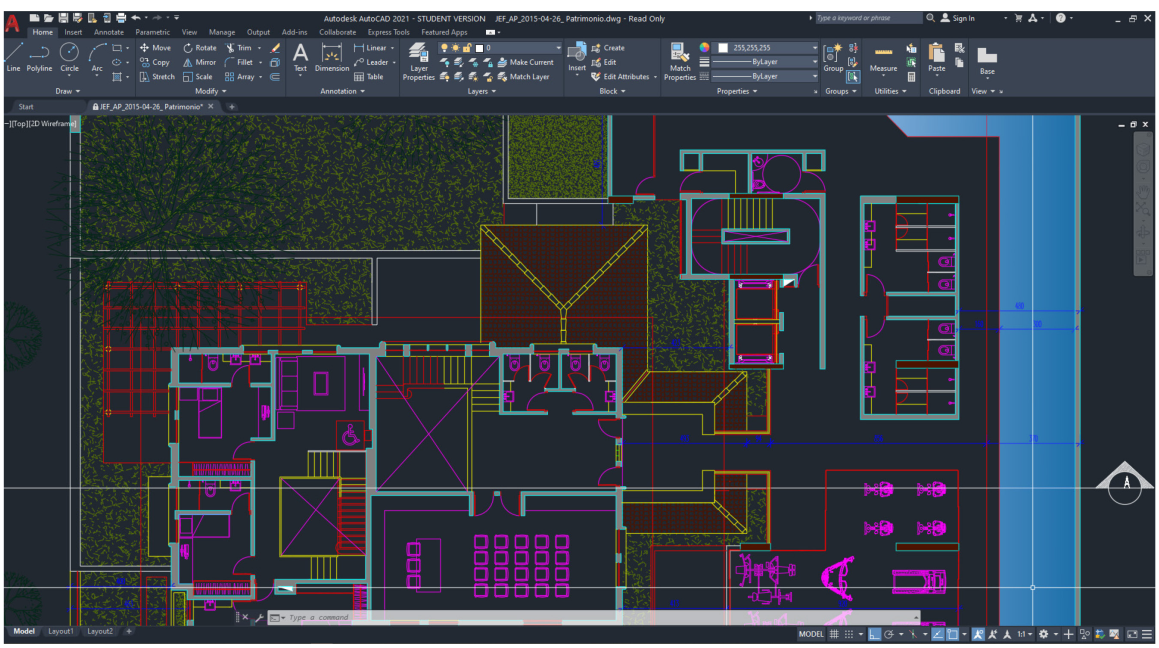

Figure 37 – A screenshot of Autocad 2021. Image by the author.

Another tricky aspect of AutoCAD operation is the correspondence of colours of lines on the screen to the width of these elements when printed. In the default configuration, AutoCAD starts with a dark screen which represents the 'design space', and the colours that are assigned to lines by default are all fluorescent to contrast with the dark background (a feature that probably came since the early versions of AutoCAD, when the colours available were minimal) (FIG. 37). So the user has to know that, by default, the 'red' colour on the screen corresponds, when printed, to a black line with 0.1mm of width and the 'magenta' to a 0.6mm black line. That is, the colours on the screen replaced the kit of pencils.

The list of differences between drawing on boards or AutoCAD is extensive, and it is not the point of this work to be enlisting all of them. The architect's emancipation from drawing boards and hand-drawing is a double-edged sword. CAD software has undoubtedly made the production of technical drawings more efficient, avoiding errors and optimizing processes. However, this does not mean that architects are producing better spaces or even that they are working less.

In terms of bodily engagement, computers afford fewer possibilities than the drawing board. On the latter, the architect engaged with the drawing with her/his body in many different ways. Many 'epistemic actions' were allowed, such as approaching and distancing, drawing using hand, arm or shoulder movements, moving around the drawing etc. Design using AutoCAD is a procedure limited by many aspects: screen size, keyboard and mouse, and the very design of the software used.

5.7. From sketching and SketchUp: when ideas gain (some) volume

The practice of sketching is not an exclusivity of architects, artists, and designers. It is an everyday activity between children and adults to produce several sketches to register something, organise information visually, or simply as a hobby. However, it can be said that architects have a particular type of identification with the process of sketching.

Even with the development of advanced software that aids and automates, at least partially, the design process, the practice of sketching persists, indicating that it is perhaps helpful in assisting architects' thinking process. According to Fish and Scrivener (1990), sketches "have the important function of assisting the mind to translate descriptive propositional information into depiction" (Fish & Scrivener, 1990, p. 118). During the Renaissance, Italian artists used to call sketches by the name of *pensieri*, which means thoughts, pointing to the strong relationship between sketching and cognition.

Among the drawings produced by architects, there are those made in the early phases of designing, which Goldschmidt (1991) categorizes as study sketches. These sketches differentiate themselves from those made from observation or memory since they do not aim just to represent something that is preformulated or that is 'there' in the physical world. Instead, this type of sketching can be regarded as a process of thinking visually. When designing, architects usually produce several sketches to 'find' something that initially s/he could not define precisely.

Sketching can be defined as

> the process by which the designer works on her problem, and as such it serves several purposes. She sketches to understand her design problem and what it requires of her, to explore its particular circumstances and problems that must be tackled, to experiment with different approaches to a solution, and to eventually work out her final design, among other purposes. (Gedenryd, 1998, p. 102)

In this sense, sketching can help in seeing something as something else, as Goldschmidt (1994) claims. Goldschmidt (1991) explains that the designer's interaction with sketching consists of a sequence of movements alternating between the reasoning modalities of *seen as* and *seeing that*. The author named this process the 'dialectics of sketching'. She explains it as: "The designer is '*seeing as'* when he or she is using figural or 'gestalt' argumentation while 'sketch-thinking'. When *'seeing that',* the designer advances nonfigural arguments pertaining to the entity being designed" (Goldschmidt, 1991, p. 131).

As we have presented in the first chapter of this work, Schön (1983) described this same process as a conversation with the situation, the process of 'reflection-in-action'. As he explains:

> the designer's moves tend, happily or unhappily, to produce consequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by forming new appreciations and understandings and by making new moves. He shapes the situation, in accordance with his initial appreciation of it, the situation 'talks back', and he responds to the situation's back-talk. (Schön, 1983, p. 79)

Several works approach sketching from analogue perspectives. To illustrate how prolific this field is, I will cite a few works, which I consider some of the most relevant: Fish and Scrivener (1990) approach sketching and its relation with mental imagery; Goldschmidt (1991, 1992, 1994, 2003) proposes to investigate sketching from the perspective of the dialectics of sketching and its unfolding; Goel (1995) study sketching as a process of thought that challenge the traditional computational model of cognition; Suwa and Tversky (1997) research on the intricacies of perception and sketching; and Lawson (2004, 2006) proposes an investigation on what designers know and how they work, evidencing the role of sketching in their processes.

When it comes to sketching using computers, Lawson (2004) contends that the traditional CAD systems are useless due to the very nature of their operation, which requires many clicks and commands to draw even a simple shape. During the 1990s, some attempts were made to develop sketching software aiming at designers. One of the most sophisticated software was the *Electronic Cocktail Napkin,* proposed by Gross (1994). It was a pen-based program for drawing that could read, recognize, and manage hand-drawn diagrams. Gross and Do (2000) presented *The Back of and Envelope*, a software which was, to a certain extent, an unfolding of Gross's previous work. Among other functionalities, this software recognised and named graphic symbols and model a 3d object from a bidimensional sketch.

Bayer et al. (2017) also developed two graphical user interfaces to introduce computers in the first phases of the architectural project, replacing the work with pen-and-paper. The two tools use diagrams instead of free-hand drawing to generate the initial design ideas. As the authors point out, although these tools look promising, further investigations are needed.

Until this point of the work, it may not have been clear that there is a distinction between AutoCAD and simply CAD. The latter is a category of software, the Computer-Aided Design category, while the former is one of the programs that are part of the CAD category. Therefore, it can be said that the examples presented until now, although quite distinct, can also be categorized as CAD software since they aim to aid the design process.

Some authors use the terminology CAAD – Computer-Aided Architectural Design – to refer to the programs used by architects (Dokonal et al., 2004; Koutamanis, 2005; S. Lee & Yan, 2016; Zhu et al., 2007). However, since this work aims not to discuss the pertinence or definition of either term, I will prefer to continue using CAD since it is a broader term and is widely used than CAAD[48].

The use of computers in the early stages of architectural design has been investigated by several researchers (Bayer et al., 2017; Dokonal et al., 2004; Salman et al., 2014; Zhu et al., 2007). However, some cultural and regional aspects related to software adoption seem to be a bottleneck for comparatively investigating the CAD software. For instance, Zhu et al. (2007) presented an experiment with students where they were asked to choose a CAD software to perform an assignment, and the majority of them chose a Chinese software (TScad), which does not appear to be available in other languages.

In the Brazilian context, one CAD software that became very popular among architects and students in the mid-2000s was SketchUp. It was developed by Last Software in the early-2000s and was sold to Google in 2006. At that time, SketchUp was available either as a free or professional version. Since 2008, SketchUp was integrated with a repository of free 3d models (Warehouse), making it even more attractive to architects. It was sold in 2012 to Trimble Navigation and, since then, the software has been updated annually.

Until the launch of SketchUp, architects found it somehow challenging to produce three-dimensional models of their designs. It was possible to produce 3d-models using AutoCAD or specific 3d-modelling programs such as FormZ or 3DSMax, but their operation was complicated, and the steep learning curve of these programs reduced their adoption by architects. SketchUp somehow managed to fill this gap with an easy to learn program compared to other 3d modellers[49]. Furthermore, there are plenty of free learning materials available online to support students and architects in adopting SketchUp.

Some studies have been done using SketchUp or other 3d modelling programs as tools for sketching and its use in the ideation phase. Wojctczuk and Bonnardel (2011) asked students to design a computer mouse using either a CAD system or manual modelling and compared the

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[48] In the Brazilian context, CAAD is a denomination that is practically absent, and due to the hegemony of AutoCAD, Brazilian architects refer to this program simply as CAD. That is, CAD and AutoCAD become synonymous.

[49] In Brazil the use of SketchUp is not restricted to architects. In fact, many other professionals adopted the software such as woodworkers, interior designers, hobbyists, etc. With the emergence and popularization of YouTube it is not uncommon to see even bricklayers or roofers using the program on their channels to solve problems graphically or to explain some method of construction.

results. They found that the objects designed using CAD systems were preferred in terms of aesthetics, originality, and marketability. Alcaide-Marzal et al. (2013) investigated the use of digital sculpting for generating 3d sketches. The authors found that paper-and-pencil still "more powerful than digital media to produce conceptual solutions, in terms of the number of concepts", but also that "individuals who were more used to 2D sketching performed better also in the 3D task" (Alcaide-Marzal et al., 2013, p. 278). The work of Lee and Yan (2016) investigates the impact of two 3d modelling programs (SketchUp and Silhouette Modeler) on the generation and transformation of design ideas. One of the aspects studied is related to how the use of the software transformed the way subjects sketch. The authors compared the manual sketches made before and after the experiment and found that "not only the shapes adapted to the modeling surface but the structure and annotations of the sketch were also modified to reflect the modeling process" (S. Lee & Yan, 2016, p. 70).

In this sense, it is possible to say that the adoption of 3d software by architects can contribute to their design process in terms of productivity, enabling the generation of a greater number of alternatives, and cognitively, changing, to a certain extent, the very way of making sketches (Bilda & Demirkan, 2003; J. Lee et al., 2018). Nonetheless, there are also several limitations in the use of 3d modelling software and SketchUp in special.

The first limitation is regarding SketchUp licensing. Since late-2020, SketchUp has been commercially available just through subscription, and the user should pay a recurring price to have the right to use the program. The standalone free version of SketchUp, widely adopted by students, was discontinued and substituted by a web-based version with more limited resources.

When using SketchUp, one starts to model from a single 'viewport' that presents a three-dimensional view of the initial scene (FIG. 38). This first scene is usually composed of a ground plane, a sky, and a two-dimensional representation of a person. Unlike other programs, where modelling usually begins with 'primitive' three-dimensional elements, such as the cube, cone, cylinder, etc., in SketchUp, it takes place through plane figures, such as rectangles, circles, and others.

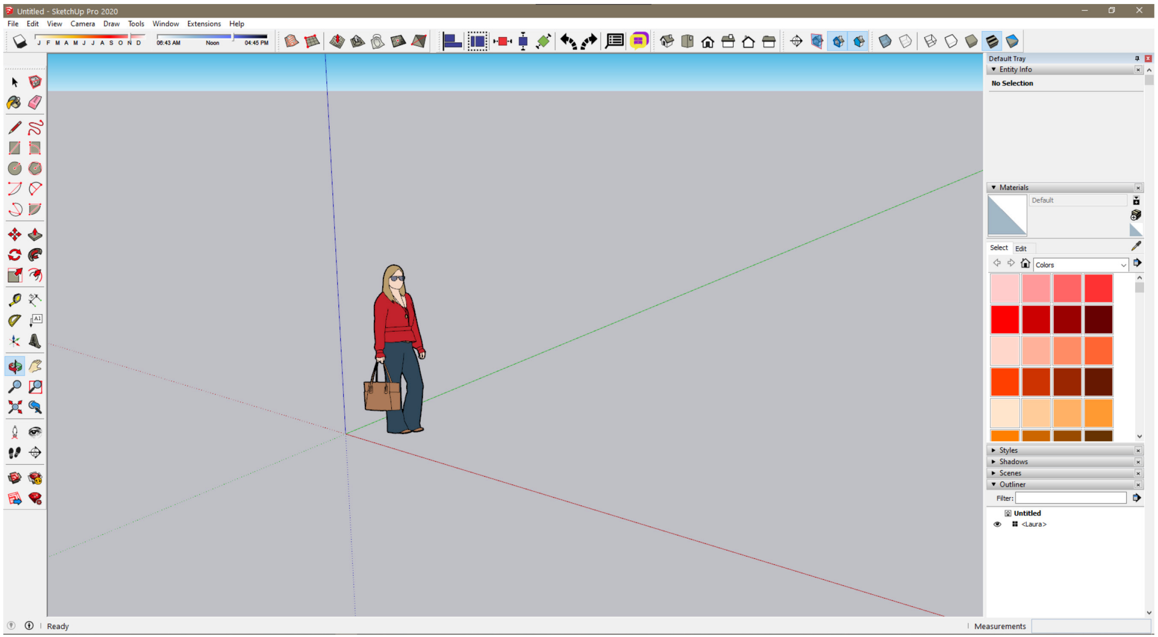

Figure 38 - SketchUp Pro 2020 interface: the floor, the sky, and the person. Image by the author.

The user can also draw lines that can be joined to form a plane. To build the volumes, the planes need to be extruded, pushed in a particular direction, or by drawing the several planes of a volume. This procedure is very similar to how architects used to draw their perspectives by hand. When architects and students start to define better the problem they are addressing through the initial sketches and diagrams, it is common that they begin to work with bi-dimensional projections that can be considered schematic versions of the orthogonal projections from technical drawings. From these schematic plans and sections, designers usually start to explore the volumetric aspects of their creations by adding line segments representing the third dimension to get a rough idea of the volume that the plan or section can generate (FIG. 39).

In this sense, the operational logic of SketchUp can be apprehended by students and architects almost with no difficulties. However, this is not equal to say that they operate the program immediately without obstacles or limits. On the contrary, as the work of Lee and Yan (2016) shows us, many participants were unable to reproduce in SketchUp their initial sketches. The authors even suggest that "CAD should be used for ideation only after its usage has been well-acquired by the users. Otherwise, novice users run the risk of adapting their ideas in terms of process as well as appearance" (S. Lee & Yan, 2016, p. 71).

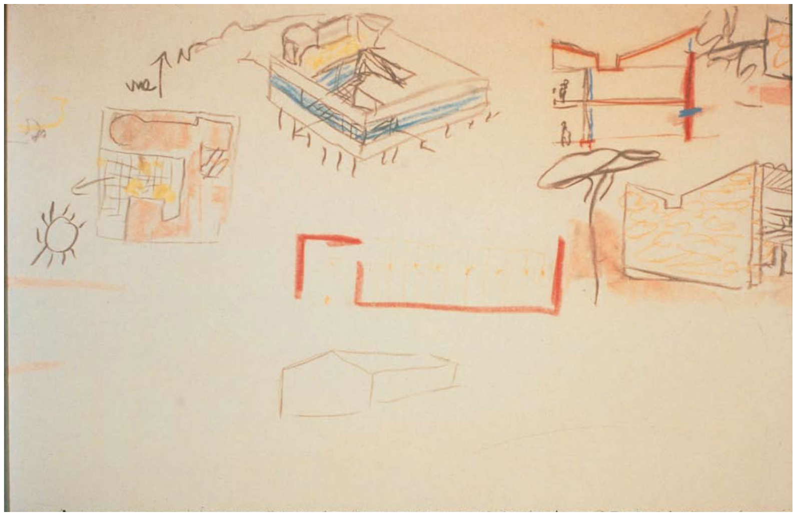

Figure 39 – Le Corbusier's sketches: the third dimension is added to the plan and section to evaluate volume. Le Corbusier. "Detail of a drawing for Princeton University lecture". 1935. Retrieved from https://bit.ly/3f5hGYo. Accessed on 27 Jul. 2021.

Although SketchUp can produce technical drawings, it is still mainly used to produce 3d models. Therefore, some of the limitations observed in AutoCAD are not present in SketchUp. For example, instead of translating colour lines on the screen to line weight, as one usually does in AutoCAD, a SketchUp user can rotate the 3d-model freely to assess if the elements are in the right place and with the intended dimensions. The user can 'paint' elements with textures to roughly comprehend the material aspects of what is being created. In a certain sense, designing having SketchUp as a medium can take the conversation a little further. If a designer produces a 3d-model of something drawn in two dimensions, it is possible to say that s/he will probably perceive other aspects of her/his creation.

This is partly obvious since SketchUp literally adds an apparent dimension to the conversation, and what was a surface becomes an apparent volume represented on the screen surface. In a sense, this discussion has to do with the one made in the previous chapter about the digital and physical apple. One of the distinctions that can be drawn here is related to the availability of the object. Unlike the apple with a physical correspondence, the design process generally deals with a kind of element that does not yet exist physically. In the first moment, the sensorimotor knowledge of what is being designed is challenged since the object is absent from the senses, but it is present to thought.

As we already discussed earlier, the idea of designing something entirely mentally and them representing it does not seem plausible for the majority of architects, as several authors demonstrate (Goldschmidt, 1991; Lawson, 2006; Schön, 1983; Suwa & Tversky, 1997). Instead, if designing can be seen as a conversation, it is necessary to recognize that mental imagery is crucial for this conversation. As Goldschmidt (1991) suggests, the act of sketching when designing can be regarded as interactive imagery, meaning that designers "make sketches because the sketch is an extension of mental imagery, and therefore has the freedom of imagery to retrieve previously stored images and to manipulate them rapidly" (Goldschmidt, 2003, p. 88). Therefore, it could be said that 3d-sketching through SketchUp is also part of this process of 'externalization' of mental imagery.

Furthermore, to 'outsource' the production and manipulation of 3d elements to the computer can relieve our cognition to work on other tasks that also demand concentration. However, the sensorimotor availability of the 3d model is still limited by the size and bidimensionality of the screen. In the case of architects, the model on the screen is always a scaled model. The architect's body is, concerning the model, always larger, which can hinder to some extent the spatial understanding of the model and how it would relate to this body if it were on a 1:1 scale. In addition, the possibility to manipulate the model with little effort, rotating, zooming in, moving parts, etc., is undoubtedly a significant gain to the design process. However, it is not uncommon to see that a significant part of the design work continues to be made from points of view that are not restricted to those that the body reaches.

When designing, one should always search for the most advantageous position to view where s/he is working. Not surprisingly, this point-of-view is usually from above, a bird's eye view. Before continuing, I would like to emphasize how the notion of body is not central to the operation of SketchUp or any other modelling programs. It can be said that the body in these programs is compressed to one point and exists as a single hovering eye, with all the bonuses and burdens that imply.

I will explore this reduction of the body to a single point further on. Another software category will be analysed in the following, which can be considered an 'evolution' of CAD software, the Building Information Modelling – BIM – software.

5.8. The logic of BIM software: Making Durand's Dream Great Again

BIM software can be seen as a subcategory of CAD software since it also 'aids designing', but its operation logic is so distinct from that of the conventional CAD software that it can be considered a category apart. For example, when using any CAD software, the user represents the elements in the digital space, an abstraction of the physical space. In this sense, each drawing part is located according to its position in the axes X, Y, and Z.

Each element is built using these coordinates and the geometrical relationships between elements. For example, to draw a line in CAD, one clicks on the line icon, sets an initial point on the screen, and a final point that gives the length of that segment. Let us suppose that this line is the initial representation of a wall in a plan consisting of two parallel lines. After drawing this first line, the user commands to duplicate it and move it parallel to the first a specific distance corresponding to the thickness of the wall. The user can change the colour of the line or even build a polygon that can generate a 3d representation of that wall. However, in the default use of CAD systems, the program cannot recognize that these two lines are, in fact, a wall. The information stored in these lines is relative to their position, colour (which corresponds to a line weight), the layer they are in, etc. Any element is built from the same commands and store similar information.

In BIM software, the user simultaneously creates the drawing and the 3d-model from the digital version of the elements used in construction. Therefore, to draw a wall, s/he needs to click on the wall icon and specify its characteristics, such as the core materials, the finishing on each side, thickness, length, height, etc. When 'drawing' a window, s/he will need to specify its length, height, sill height, number of panels, etc. Each element carries a set of specific information that can be extracted later on if needed.

According to Eastman et al. (2011), BIM can be defined as "a modeling technology and associated set of processes to produce, communicate, and analyze *building models*." (Eastman, 2011, p. 16). The building models are characterized by:

> Building components that are represented with digital representations (objects) that carry computable graphic and data attributes that identify them to software applications, as well as parametric rules that allow them to be manipulated in an intelligent fashion.
>
> Components that include data that describe how they behave, as needed for analyses and work processes, for example, takeoff, specification, and energy analysis.
>
> Consistent and nonredundant data such that changes to component data are represented in all views of the component and the assemblies of which it is a part.
>
> Coordinated data such that all views of a model are represented in a coordinated way. (Eastman, 2011, p. 16)

The authors argue that there are several advantages to the adoption of BIM in all phases of construction. As we focus mainly on designing aspects, I will cite the alleged benefits for this phase only. According to Eastman et al. (2011), BIM adoption can be of great value for architects since it allows the production of a building model in which any part is consistent with the whole model. In this sense, architects can modify any element in any view, and the changes will affect the whole model. In addition, since the design phase, BIM facilitates collaboration with other professionals from other disciplines, such as structural and electrical engineers, which can diminish errors and reduce compatibility problems between projects. The authors add that BIM can provide quantitative information about the building from the initial design stages, such as areas, material quantities, etc., allowing a more accurate assessment of cost estimates. In terms of sustainability and energy efficiency, BIM software can also allow the designer to evaluate these aspects since the conceptual phase of design (Eastman, 2011).

When one reads these arguments favouring BIM adoption, it is possible to see what BIM software wants to be: an all-in-one solution that centralizes the designing processes and agents from conception to construction. This pretension is made explicit by the software manufacturers themselves: "Revit is BIM software that brings all architecture, engineering, and construction disciplines into a unified modeling environment, driving more efficient and cost-effective projects"(*Revit Software | Overview*, 2021).

As an architect who started to work before the popularization of BIM, I needed to learn one software for each phase of the design process: SketchUp for conception/modelling, AutoCAD for documenting, V-ray for rendering, Photoshop for post-production, Excel for quantification, etc. In this sense, the idea of using one software for the whole design process seems very attractive. However,

> one of the common complaints about BIM as a design tool is that it requires too many decisions early in the process, interrupting creative flow with details the user isn't yet prepared to address (you want a wall, it wants to know what kind of wall). . . . Further, a BIM user interface is a bit like an airplane cockpit, a very complex environment dedicated to control. The complexity of that visual environment imposes a cognitive load on users. (Johnson, 2015, pp. 177–178)

If SketchUp, a software much more straightforward than any BIM, can limit creativity, as Lee and Yan (2016) discussed, what can be said about software as complex as Revit, ArchiCAD, or other BIM software? In part, it could be said that the complexity of BIM software is related to what

Denzer and Hedges (2008) called a change of paradigm of designing: “The activity of parametric modeling is fundamentally different from drawing, because the product is a database of information and relationships (new paradigm), rather than a set of abstract representations to be interpreted (old paradigm)” (Denzer & Hedges, 2008, p. 1).

Other authors complement it by saying that “BIM is a technology that not only affects how we construct buildings (the efficiencies and operations) but how we design as well” (Garber, 2014, p. 14). Some others will claim that this new way of designing and “the new emergent digital conventions of architectural communication will conceptually shift the production of architectural ideas and objects like nothing since orthographic and perspective projection in the fifteenth and sixteenth centuries” (Ambrose & Lacharité, 2008, p. 443). In another paper, Ambrose (2006) affirms that there is no need for representation in BIM since “There is no abstraction. The building is literally (virtually) constructed, the space is the space, and the forms are the forms. The plans, sections, and elevations, the traditional conventions of representation are an illusion. Plan is dead” (Ambrose, 2006, p. 184).

It seems that BIM is still a very recent technology, which does not allow us to verify that all these statements are valid. Architecture offices are adopting BIM worldwide, as Garber (2014) shows to us, but is BIM this panacea that could fill all the gaps between representation and production, or that could liberate architects from drawing? Or the question that should come before that: do architects want to be liberated from drawing?

It seems complicated to envision BIM as this technology that can transform everything in a country where most constructions are still artisanal, informal, and made without an architect's presence. On the other hand, the logic of optimization and efficiency that structures BIM either as a technology or as a process looks pretty adequate for large and complex works when managing multiple stakeholders and a large volume of documents is undoubtedly a problem. However, is this level of control over the process desirable for smaller projects?

Nonetheless, I am not affirming that BIM cannot transform the construction industry, nor suggesting that architects hold on to their pencils and AutoCAD. To return to the metaphor of the airplane used before about BIM’s complexity, it seems that architects were given an airplane that could allow them to travel faster and farther, but at the price of learning to read all the instruments and procedures needed to fly. An airplane is undoubtedly the best form of transport for long journeys, which would be impractical without its existence. Nevertheless, anyone who has travelled a short flight by plane knows that its use is not always the most efficient: travel to the airport, waiting for boarding, and all standard procedures until the plane get in the air. In addition, there are all procedures until landing, and finally, the travel by road to the final destination. However, except in specific cases, it seems that long flights (to continue with the metaphor) are the exception in the day-to-day life of most architects. That is, do architects need a plane to go to the bakery? It seems more reasonable to grab a bike, drive a car, or walk to the bakery, leading us to unexpected encounters, views, discovering new places, etc. In summary, should the logic of efficiency, control, and optimization guide architects no matter what they are working on?

In a certain sense, it could be said that BIM fulfils Durand's dream of efficiency. When operating BIM software, the architect should build her/his model by choosing between predefined categories of building parts, such as walls, doors, windows etc. Even the operation logic is similar to what Durand intended to teach at the *École*, that is, the building as an *assemblage* of parts (Durand, 2000).

As discussed earlier, Durand (2000) also considered drawing an obstacle for efficiency since architects needed to learn it, which takes time. His solution to this 'problem' was ingenious: to simplify the drawing, remove the expressive elements, and focus on representing buildings through their orthogonal projections, preferably on a single sheet of paper. The logic behind BIM also presupposes drawing as an obstacle, removing it even from the name of the technology, being substituted by modelling. In a certain way, BIM software reduces the significance of drawing as a process, as a medium through which one can think, leaving it just as a signal that a part of the design process has ended when the drawings are finally printed and delivered to the building site. Through BIM, drawing became a by-product of designing, a kind of remainder of the designing operation.

Regarding cognition, BIM software poses other questions. As Johnson (2015) explains, to eliminate the ambiguities inherent to 2D representations, the developers behind BIM software opted for working with the notion of semantic elements, components that represent what that element comprises. The logic of working with pre-constrained elements seems strange to architects since "most design and designers begin with a diagram of the problem as an idea, not as geometry, and gradually evolve towards geometry, a manipulation somewhat foreign to BIM" (Johnson, 2015, pp. 182–183).

Indeed, BIM software usually presents some conceptual design tools to produce a model containing some undefined aspects. However, even the conceptual tools are somehow subjected to the logic of efficiency and control that govern BIM programs. The notion of 'mass modelling', that is the output of some of these tools, is in some cases one of the products architects should deliver to their clients, usually as a part of the feasibility studies, which precedes the more formal design steps. The many optimizations present in these programs allow, even at such an early stage, to extract information such as the number of floors, built area, etc. Thus, it seems complicated to consider these conceptual tools as sketching tools since they already present this defined and objective character associated with the efficient production of a deliverable.

The pre-constrained elements available for architects in BIM software can also be challenging from a cognitive perspective. Contrary to what Ambrose (2006) and Ambrose and Lacharité (2008) argued, even a detailed model is still a representation, and as any representation, it is partial (Vesely, 2004). It should be considered in this way because it is incomplete in the sense that a representation is not the object itself, but at most a description of what can be perceived of the object, and because every representation is made from a specific standpoint and therefore carries, albeit surreptitiously, the values, prejudices, and ideas of those who produced it.

Thus, the building elements in BIM software are limited by the representation built by developers as attributes of the elements. The data contained centrally in a BIM element were scattered among the project stakeholders, which seems advantageous from a management point of view, but are there benefits in centralization beyond those related to control?

If we look at the operation of BIM software in terms of what and how inputs are needed for a certain outcome, it is possible to see that the steps needed to build a wall or a chair are similar. To explain a little better, if we return to our previous discussion on drawing, we will observe that the movements needed to draw a chair or a wall on the same scale engaged the body differently. This difference was reduced in the operation of CAD systems, and it is almost inexistent in BIM. To access any element in BIM software, the user clicks on its icon, defines some properties, and creates the element. Furthermore, its representation is always coherent to what was set by the user. It is true that after creating an element, it is available in all views – plans, sections, perspective, etc. – to be evaluated from all sides, and this could be very useful when designing, but it does not seem that this advantage is used in favour, for example, of building more interesting atmospheres, to return to our last chapter's discussion.

On the other hand, the BIM systems progressively incorporate native support to VR, allowing users to experience their creations on the fly. This is not possible in CAD systems due to the bidimensionality of drawings and can transform, to some extent, the process of designing in BIM. However, the use of VR in BIM is still limited, mainly to the visualization and presentation phases. Even if the body is incorporated in some way through VR, its participation is still marginal. The present body is still a passive body, with little agency over what is being presented. In this sense, the architect needs to 'enter' the space to see what s/he is designing, but s/he needs to 'get out to modify it. In part, this limitation to VR in BIM can be understood due to the large amount of data incorporated into the model. Any modification to an element requires reprocessing the entire model, which is very costly in terms of computer processing and would certainly undermine the VR experience. In a certain sense, it could be said that the presence of an embodied agent in BIM models is still interdicted: there seems to be no room for a body with agency amid so much data.

5.9. The displacement of the subject: from drawings to BIM

The first part of this chapter discussed the emergence of instrumental representation and how it was an essential aspect of the formalization of architecture as a field. The systematization of perspective as a method to geometrize space in all its scale fostered a novel imagination and contemplation. This new epoch, when scientific reasoning was gaining prominence, provoked a transformation of professions, and many guilds were substituted by academies with a defined curriculum.

Architecture was one of these professions. In 1743, with the founding of the *École des Arts*, architectural education became a full-time activity, with a rigid routine and comprehensive curriculum that mixed theoretical knowledge and new modes of representation. These new modes of representation were based on the premise that everything could be represented mathematically. Thus, the symbolic representation, based on cosmology (that was the rule at that time), was progressively substituted by other modes of representation, more in tune with the scientific aspirations of that time.

In this sense, J.N.L Durand was a key figure in implementing instrumental thinking in architecture education. His teaching strategies were based on the search for efficiency, as explained in his work *Précis.* Durand developed a theory to understand buildings that were based on understanding them as an *assemblage* of parts. Thus, he taught architects to understand buildings part by part, starting with the less complex elements and incrementally adding complexity until the building could be comprehended as a whole composed by the sum of its parts. Durand's strategy was related to eliminating the subjective aspects of architecture, which led him to develop his method of representing buildings, which was, at the same time, a method of composition. The *mécanisme* was composed essentially by a set of rules for composing and presenting drawings, including the prohibition of using expressive resources on drawings, such as colours, shadows, or rendering techniques.

Then we discussed how Durand was, in a certain sense, successful in his endeavour of instrumentalizing drawings, as they were raised to the status of legal documents. The work of architects began to be determined by constraints imposed by governmental regulatory agencies that established rules for building in urban areas and rules for architects to present their drawings to be approved by these instances.

In the following, we saw how drawings were introduced to computers, especially through Ivan Sutherland's Sketchpad in 1963, where it was possible to draw using a pen and a myriad of buttons, sliders, etc. The software developed by David C. Smith in 1975, PYGMALION, was also discussed, focusing mainly on how it established, to a large extent, how do we engage with computers even today. Although it was not a software for drawing, it was related to the path that led to CAD software as we know it.

AutoCAD appeared in the early-1980s, and it was becoming the standard solution for CAD software worldwide as soon as 1982. In 1988, Autodesk was already a successful company and was interested in looking for other opportunities regarding CAD software. One of its founders, John Walker, published a memo pointing to the possibilities that VR could bring to designing using computers, a possibility that has not yet materialized fully.

It was possible to understand how computers changed architecture discipline broadly, beyond just the design process, transforming the very spaces where architects work. Their offices diminished in area, and the physical presence of drawings was minimized. The cognitive consequences of the migration from analogic to digital drawings were discussed, assuming that the latter is less available to sensorimotor understanding. When drawings were handmade, what was being drawn and the body of the drawer were related. The body engaged differently when drawing in different scales.

In the use of CAD software, the body engages with the drawing production limitedly compared to hand-drawing. Features like the infinite zoom that AutoCAD inherited from Sketchpad can be disorienting since the drawings keep changing in size on the screen. Furthermore, other operations were equally demanding in cognitive terms, such as understanding that a property of a digital element, such as the colour of a line, corresponds to a specific line weight when printed. AutoCAD, and other electronic drawing software, were an advancement for the production of drawings, but one of its side effects is related to an impoverishment of the possibilities of bodily engaging with drawings.

In the following, we have discussed how sketching plays an essential role in the architectural design process. Sketching figures for architects as a way to think visually. The interaction of architects with sketches consists of a process called 'dialectics of sketching' (Goldschmidt, 1991) and is part of the conversation that architects establish through a medium, as discussed by Schön (1983). It was possible to analyze how CAD systems were inadequate for sketching, in part because they require too many operations to draw even simple elements.

The emergence of Sketchup as the preferred modelling software for architects in the mid-2000s constituted a significant milestone since it allowed architects to produce volumetric studies with a certain ease. The operational logic of Sketchup presents some similarities with how architects usually sketch three-dimensional elements, starting with bi-dimensional figures and extruding them, which is different from how traditional modelling software works, depending on 3d primitives to build models. However, although it is relatively easy to operate Sketchup, it can become an obstacle to creation (S. Lee & Yan, 2016).

Sketchup goes a step up in terms of sensorimotor understanding since the 3d model is available for interaction, but it is still limited to the screen size and bidimensionality. In cognitive terms, we argued that 3d modelling could complement sketching, providing a different medium that supports mental imagery.

Thus, we saw how BIM software is perceived as the possible next-big-thing with the potential to transform everything, from design to construction. In BIM, drawing was substituted by modelling, but it is not a conventional 3d modelling but a model constructed from its parameters. The building blocks of BIM software usually are pre-constrained elements that contain more data than just its geometry. In this sense, a wall in BIM contains its height, length, thickness and material, the floor it is located in, the finishing on each side, the core materials, weight, etc. Nonetheless, in BIM software, the model is always consistent with the documentation generated by the program, which is undoubtedly helpful in avoiding errors. However, this benefit comes with the burden of learning a software with many layers of complexity, with a steep learning curve, which can be an obstacle for experimentation, hindering creativity. BIM seems an adequate solution for some design cases of great complexity and multiple stakeholders, but it is hard to consider it suitable for all cases.

A caveat to that last statement regards the complexity of BIM software, which is not uniform among multiple software. ArchiCAD, for example, is a program that is not popular as Revit but is certainly less complex than it. We have been using ArchiCAD with first-year undergraduates with benefits that overcome the difficulties in learning the software in our school. Nonetheless, it is still a complex software that demands considerable time to be mastered, and I still think it is not adequate for low-complexity projects.

Regarding cognition, eliminating drawings' ambiguities distances BIM from how architects design, especially when sketching, when ideas were progressively forming through conversation. The ideology of control and efficiency that orients BIM rules everything, and in this sense, the process of conversation seems to be limited by 'conclusive unambiguous statements'. For example, when I model a wall in BIM, even without being sure whether that element should be a wall or not, it appears as a wall, with all the wall characteristics. This can contribute to making the process of reconsidering decisions, which is fundamental at the initial designing process, something more challenging. That is, when sketching, the designer can change her/his mind quickly since the very nature of the sketch is one of certain impermanence. Nothing seems definitive. In BIM, nothing is definitive, but it seems it is.

The body can be engaged to a higher degree when using BIM than CAD, but just in some specific cases. Usually, its use is less engaging since almost all elements are accessed and built in the same way by clicking icons and typing data about their characteristics. However, VR is being incorporated natively in some BIM software but under the same controlling logic. In the actual scenario, the user does not have much agency over the BIM model. It is partly due to the amount of information in the model that hinders the immersant from promoting changes in the model from the 'inside'.

In a certain sense, CAD and BIM software could be considered a continuation of Durand's idea of optimizing architecture production, especially the design process. It seems a mistake to discuss efficiency in architecture in a Manichean way, where everything efficient is bad, and everything that escapes that efficiency is good. In many cases, efficiency is a blessing, and there is no poetry in rework, in spending countless hours redrawing the bars of a prison, as my former boss had to do. In addition, the idea of producing models instead of drawings, as BIM software proposes, can promote an increase of quality in our constructions, avoiding errors in the building phase by allowing the simulation of construction solutions. In a sense, the idea of optimizing or enhancing has to do with a particular *zeitgeist* of our time.

It is naïve to consider that before computers, architects were not interested in enhancing the way they work, their processes of producing drawings, etc. In my short experience with drawing boards, I remember a teacher telling me that the final drawing should be made from top to bottom and left to right, first drawing the horizontal lines and then the vertical ones. What would that be if not an optimization technique?

Efficiency and optimization are not synonyms but related concepts. The former involves producing an effect using the minimum amount of resources – e.g. time, materials, labour, etc. – avoiding wasting (Cambridge Dictionary, 2021a). The latter can be defined as "the process of making something as good or effective as possible" (Cambridge Dictionary, 2021b). Therefore, both concepts relate to the effects produced by something or someone. However, a notion seems to underlie both concepts that appears only implied in its definition.

5.10. Efficiency: the mechanism to establish a safe distance from designing

The efficiency of an event can be assessed only by comparing it with another instance of that same event. Thus, it presupposes at least two other things, a repetition of events and an observer that observes the events happening. Repetition does not mean that the events need to occur in sequence, but each instance of the event needs to be observed from what is defined as the beginning of the event to its defined end. Thus, even if the events happen simultaneously, the observer must observe their entire development.

Then, it is possible to say that there must be a specific arrangement for this observation to happen, a specific structure. First, the observer needs to distinguish what s/he wants to compare. For instance, if one wants to compare the efficiency of two models of kettles in terms of the time needed to bring water to boil, s/he needs to define which models will be compared and define the means of comparison, in this case, time. Second, s/he needs to design a way to observe and compare the events. In our example, should the kettles be turned on simultaneously, or should the observation be made with one model and then the other? Third, the means of observation should measure what was chosen to be measured consistently, with minimum variation. In our case, the observer can try to count out loud the seconds to establish the time needed to boil water for each kettle, but s/he can be distracted, speeding up or slowing down the counting without realizing it alters the process outcome. Thus, s/he should use a 'scale' that will theoretically not be affected by subjectivities, such as a stopwatch. Fourth, s/he needs to use the measurement and observation to validate the comparison or repeat the process, make adjustments, etc., until the comparison can satisfy the conditions defined by the observer.

The reasoning behind comparison resembles or is part of scientific reasoning. The attempt to circumscribe the event to be observed and develop a method of observation that tries to remove any subjective contamination from observing is at the scientific experiment's roots. In a certain sense, the logic of these procedures can be regarded as an attempt to remove the traces of the observer from the observation. In this sense, the agent of the experiment presents her/his observations results as if s/he had no agency over the experiment, as if "the result of the *construction* of a fact is that it appears unconstructed by anyone" (Latour & Woolgar, 1986, p. 240). The implications of this way of proceeding or the social construction of scientific knowledge were widely discussed by Latour and Woolgar (1986) and Latour (1993). For our work, it suffices to understand that behind the supposed objectivity of efficiency exists a subject that defines or at least agrees with a particular definition of efficiency that has been socially constructed.

Thus, the efficiency discussed throughout this chapter is related to increasing the productivity of a given procedure, whether considering the time or the resources needed to reach a particular result. Again, efficiency is not good or bad in itself. For example, it makes no sense to think that advocating for our car engines to be less efficient is reasonable. Increasing the efficiency of our industrial processes seems vital on a planet with scarce resources. Even in the design process, as we have already mentioned, delegating to the computer the production of the final documentation of an architectural project or calculating material tables seems to be an intelligent decision precisely because it is more efficient.

Furthermore, efficiency is a concept attached to a situation, in the sense that what was efficient yesterday is not anymore. The question resides in the pertinency of searching for efficiency in processes where subjectivities are the rule, not the noise. I contend that this is the case of designing. If efficiency involves a comparison of two events, how one should circumscribe the design process to compare? It could be said that an architect 'A' designs much faster than an architect 'B', but to whom does it matter?

A project designed with promptness, using the best BIM software and highly efficient construction techniques will not necessarily be better under the scrutiny of a subject's experience in that space. So, again, what is the benefit of subjecting the design process to be guided merely by the efficiency criterion? From the architects' side, the supposed financial gains in efficiency are not sustainable for a long time since the same software and processes are virtually available to most architects. Therefore, it is a matter of time and choice before the architecture firms have the same efficiency level concerning the design process and project documentation.

Efficiency and obsolescence go hand in hand in the sense that the emergence of a more efficient process or program makes their predecessors obsolete. Furthermore, there is an aspect of repetition, which is needed for comparison, that is also problematic for designing. Designing is a situational process that depends on a set of things and conditions related to a particular time and space (Schön, 1992). The ill-defined nature of design problems allows architects to approach them differently depending on the situation. In this sense, it is possible to say that there are many solutions to a design problem as people are trying to solve it.

From this standpoint, we can perceive how Durand (2000) was ingenious in his propositions for achieving efficiency in designing. The *mécanisme* and the rules for its use aimed to establish objective criteria to create and evaluate design solutions. As Pérez-Gómez (1983) explains, "the methodology of descriptive geometry was used by Durand and his disciples to simplify the expression of architectural ideas and to make the relation between the projects and the physical reality of the buildings as immediate as possible" (Pérez Gómez, 1983, p. 308).

The process of reducing or eliminating the subjectivities of the design process also involves displacing the subject. In a certain sense, when Durand (2000) proposed to limit architecture representation to its orthographical projection, it could be said that he was trying to relocate architects' vision to another plane, establishing a new form of looking at buildings. It could be said that the technique of perspective also established a new way of seeing, but it has some critical differences from what Durand was proposing.

In a perspective drawing, the architect arbitrarily chooses her/his point-of-view according to what s/he wants to see or what s/he wants to be seen. The observer's distance from the object, the height of the eye, what should appear and what should be hidden, and the techniques used to render the perspective were decisions based primarily on subjective aspects. It could be said that the perspective offers the designer the possibility to experience the designed space 'as if' s/he is present there. By representing her/himself in the space through perspective, an architect can perceive and evaluate what s/he is designing from something that tries to emulate how her/his body would perceive that spatiality. It can be said that perspective gives a degree of presence to what is being designed, offering the architect a glimpse of the atmosphere of that space.

Thus, when Durand (2000) proposed to unify the process of creation and representation through the use of the *mécanisme*, he was, in a certain sense, determining that what is being designed always presents itself in the same form, angle, and distance from the architect. Using the rules of perspective makes it possible to affirm that the orthographic projections are similar to a type of perspective where the eye is parallel to what is being seen and is located far from the represented object, eliminating the very effect of perspective. If this somehow applies to elevations, drawings that represent the façade of buildings, plans and sections seem to be yet another type of drawing. A photo taken from a satellite of my house, which is far enough to eliminate the effects of perspective, does not correspond (obviously) to the plan of my house. A plan intends to represent the building as a parallel section to the floor at a specific height. Thus, its bidimensionality is not the same as the satellite photograph since it involves an abstraction of several building elements. So, is it still reasonable to consider that orthographic drawings displace the architect far from the building? Or it could be said that there is no room for a body in two dimensions?

What seems to come embedded in Durand's proposition of merging the processes of designing and representing to the same and single gesture of drawing using his *mécanisme* is a forced displacement of the architect to a 'safer distance' from what is being designed. Durand's approach to designing established its domain, and the notion of body is not included there. In this sense, the body loses its meaning as a reference for designing, and the architect becomes dependent and subjected to geometry.

As Vesely (2004) notes, the transformation of symbolic representation into instrumental representation is a consequence of modern thinking. It was through Durand's theory that

> number and geometry finally discarded their symbolic connotations. From now on, proportional system would have the character of technical instruments, and the geometry applied to design would act merely as a vehicle for ensuring its efficiency (Pérez Gómez, 1983, p. 311).

However, it is noteworthy that the body could not be entirely excluded from this domain. It is possible to say that it was reduced to just what is possible to be apprehended by mathematical reasoning, in this case, its representation. This becomes somehow evident in some attempts made by architects to include a body in designing processes. For example, Le Corbusier (1961) proposed a new kind of body to inhabit his architecture. The author argues that with the invention of mechanical machines, a new rhythm and speed were imposed on men, transforming their relationship with the world and other men. This transformation also rendered the usual measuring units obsolete since they were not adequate for the new pace, pointing out a need to develop a new universal measurement form across the globe.

Le Corbusier (1961) resorts to the measures that have guided human constructions throughout history, which constitute men's permanent instruments of measuring, that is, those that are part of the human body: the foot, the thumb, the hand, etc. However, as long as the men could circulate throughout the globe using high-velocity transportation, such as planes and locomotives, they got in touch with other bodies, and consequently other sizes of feet, thumbs, etc., pointing to the necessity of a standardized measure. As the author notes:

> The French Revolution dethroned the feet and inches and their slow and complicated calculations; but it was necessary to find another model. The sages of the Convention adopted a concrete measure so depersonalized and so dispassionate that it became an

> abstraction in a symbolic entity: the *meter*, the ten-millionth part of the quadrant of the earth's meridian.[50] (Le Corbusier, 1961, p. 19).

As it was called, the construction of this standardized body, le *modulor*, as it was called, was developed through mathematics, which the author extensively demonstrates in two chapters of his book. Therefore, the *modulor* could be seen as an attempt to reintroduce a body into the design process. However, it is a body to the same extent that the outline of a body made of chalk on the ground is a body. In a certain sense, the *modulor* was an attempt to objectify the notion of the body one step further by standardizing and measuring it. In short, it is possible to say that the *modulor* was not a body from where one designs, but a body-mechanism from where one could just measure, a different kind of ruler, but still a ruler.

5.11. Subverting the effects of efficiency: a way to enchant designing?

To some extent, it is possible to say that efficiency is something that permeates our very existence. We desire and actively search for efficiency, especially when dealing with ordinary, repetitive, and monotonous activities in our daily lives. In the design process, efficiency is welcome when managing and documenting information, notably when dealing with complex demands and generating quick visualizations of what is being designed.

The pervasiveness of efficiency is a consequence of a much broader process. According to Weber (2004), the rationalization and intellectualization brought by scientific reasoning and technology were responsible for disenchanting the world. As the author notes,

> the growing process of intellectualization and rationalization does *not* imply a growing understanding of the conditions under which we live. It means something quite different. It is the knowledge or the conviction that if *only we wished* to understand them we *could* do so at any time. It means that in principle, then, we are not ruled by mysterious, unpredictable forces, but that, on the contrary, we can in principle *control everything by means of calculation*. That in turn means the disenchantment of the world. Unlike the savage from whom such forces existed, we no longer have recourse to magic in order to control the spirits or pray to them. Instead, technology and calculation achieve our ends. This is the primary meaning of the process of intellectualization. (Weber, 2004, pp. 12–13)

[50] "La Revolución Francesa destronó los pies y las pulgadas y sus lentos y complicados cálculos; pero era necessário encontrar outro modelo. Los sábios de la Convención adoptaran uma medida concreta tan despersonalizada y tan desapasionada que se convertia em una abstración em uma entidade simbólica: el *metro*, la dizmillonésima parte del cuadrante del meridiano terrestre."

However,

> the sources of rationalization lie not in “scientific knowledge” as such, but rather in the uses of rational principles to order society, the uses of technologies, and the increasing understanding of one’s surroundings in terms of humanly created artefacts. Together, these factors have consequences for the “consensus”, shaping a mentality that assumes everything to function predictably and “rationally”. (Asprem, 2013, p. 14)

The question, thus, does not seem to be related to rejecting science but to recognize that the mentality of rationalization and predictability that is in significant part associated with science contributes to this disenchanted view of the world. As Bennett (2001) observes, the process of disenchantment is something to be celebrated and a cause to complain. The same process that promotes the refinement of our intellect, that denies superstition and holds the promise of transparency of knowledge, also produces a cold and uninspiring world. However, as the author explains, rationalization is an ongoing process, and there are aspects of our experience of the world that still can be seen as ‘enchanted fugitives’. Bennett (2001) explains that these fugitive bits are targeted as things that are yet to be grasped mathematically, such as perplexing phenomena, mystic experiences, and even eroticism.

Nonetheless, enchantment entails “a state of wonder, and one of the distinctions of this state is the temporary suspension of chronological time and bodily movement. To be enchanted, then, is to participate in a momentarily immobilizing encounter; it is to be transfixed, spellbound” (Bennett, 2001, p. 5). This moment can also be described as

> the essence of the moment of pure presence within wonder lies in the object’s difference and uniqueness being so striking to the mind that it does not remind us of anything and we find ourselves delayed in its presence for a time in which the mind does not move on by association to something else. (P. Fisher, 1998, p. 131)

Bennett (2001) adds that enchantment includes “a condition of exhilaration or acute sensory activity. To be simultaneously transfixed in wonder and transported by sense, to be both caught up and carried away – enchantment is marked by this odd combination of somatic effects” (Bennett, 2001, p. 5). In this sense, it could be said that immersive and enchantment experiences are related since both involve the perspective of a subject that has its perceptual apparatus mobilized in perceiving her/himself as being present somewhere else, as ‘being there’.

Nonetheless, it would be nonsense to consider all immersive experiences as enchanted, which is important for our discussion on VR. It seems complicated to consider that an architect using VR to check the design incompatibilities between different disciplines is experiencing wonder or another sensation related to enchantment. S/he can feel surprised for a while or feel tempted to explore other aspects of the experience, but in this case, the intended use of VR is essentially linked to efficiency, to perform a task better, make fewer mistakes, and in less time.

If we consider VR regarding efficiency, other questions appear. As a technology, VR becomes viable from the moment it becomes more efficient. Many of the recent developments discussed in the previous chapter, such as foveated rendering, or body-tracking improvements, are only possible due to the increased processing power of computers. Processing power is related to the number of instructions a computer can handle in a particular time, and instructions are, essentially, calculations: zeros and ones.

However, although computers are ultimately very efficient calculating machines, it is hard to find someone who has not experienced wonder while using computers, either for gaming, working, or other uses. Thus, this signs that it seems possible to perceive a technology based on efficiency – and for this reason associated with disenchantment – as enchanted. The anthropologist Alfred Gell considers that there is an *enchantment of technology*, or "the power that technical processes have of casting a spell over us so that we see the real world in an enchanted form" (Gell, 1994, p. 44).

Therefore, it is possible to say that disenchantment, even though it still is an ongoing process, is somehow limited in the sense that even in processes that offer the possibility of controlling the world by means of calculation, such as computers and VR, it still possible to be enchanted by them.

As we argued before, architecture is also a technology for immersion, and, in this sense, it can also be the means to the experience of enchantment. Nonetheless, as we saw, the tendency in the production of architecture is also related to the paradigm of efficiency through software that allows each time more control over what is intended to be built. Notwithstanding, it seems noteworthy that control and efficiency are related to the processes of conceiving, representing, and even building an object, but that they do not penetrate in our perceptive processes of this same object. When I visit a building, either physically or through VR, my experience is affected by the software, method, processes, etc. that was used to design that building? Even in most sophisticated practices, where digital fabrication takes place in the construction of 3d-printed houses, shells, and even bridges: do the process of its design and construction affect the subject's experience?

It could be said that it depends: if the subject is somehow interested in designing and construction processes, so, yes, it affects. However, this interest affecting the experience does not seem to be the 'first impression' of something. Instead, it seems to be a rationalization that can come just after that first moment of the experience. In a certain way, it could be said that even the interest in understanding how a certain spatiality was produced stems from the experience of that very spatiality. That is, why would someone be interested in understanding how a given space was produced if the experience of that space is uninteresting?

This question takes us back once more to the notion of atmosphere and its relevance for our discussion. In a sense, the effects of an atmosphere are unrelated to the processes that produced that same atmosphere. It appears as an aspect of architecture that remains enchanted, that resists rationalization, in the sense that a mathematical explanation and even the quantification of aspects of a certain atmospheric experience have little to contribute to producing new atmospheres. Even if someone measures the *lumens* that a particular environment receives, the area of each material used, the reverberation time, or any other aspect, one can just suppose the effects of the combination of these data on the perception of a subject. There are so many variables that it seems impossible to establish a formula that expresses the correspondence between 'objective' aspects of space and its effects on a subject. Alternatively, to summarize 'mathematically', the atmosphere of a space is more than just the sum of its objective properties.

Therefore, it seems that we have reached a kind of impasse between a way of designing based on the logic of enhancing, linked to control and efficiency, and a way of experiencing what is designed, which is closer to another logic, of enchanting, of what cannot be apprehended by measurement, but that still affects us. In a certain sense, this discussion goes a little deeper into what has been discussed in the last chapter, where I suggested that there would be an intelligent use of VR that would allow the architect to be affected by what s/he designs, ideally while designing. I would like to step back a little to analyze this suggestion.

Essentially, the difference between an architect using VR to conceive a spatiality from an embodied perspective or another using it to check for problems before starting construction is not on the technology. It is related to how the architect approaches technology and her/his objective, which does not mean that technologies are neutral. On the contrary, they "come loaded with both intended and unintended social, political, and economic leaning. Every tool provides its users with a particular manner of seeing the world and specific ways of interacting with others" (*TECHNOREALISM*, 1998).

Thus, as well as a computer mouse is designed to be used by a hand, which should hold it in predetermined ways, the design software and VR equipment also have embedded one (or some?) ways to be used. This relates to the notion of a tool as "things-physical devices, concepts, whatever-that help us carry out (pre-) determined tasks, and are intended and fitted (by design) for these particular tasks" (Glanville, 1992, p. 216). However, as suggested by the author, tools can be 'abused' when used for tasks they are unintended for, such as using a mouse as a paperweight or CAD software to write a book. Glanville (1992) suggests that computers are usually regarded as a toolbox, and only a "few dare to use these tools in unconventional ways to do unexpected things, extending their range and showing some considerable creativity in so doing" (Glanville, 1992, p. 217).

To contrast with this attitude of considering computing as a tool, Glanville (1992) suggests using computing as a medium, as

> something which helps us form out thoughts and ideas, and actions-which informs them. A medium is, thus, a participant in whatever action is taken—acting, thinking and forming (and communicating). It is no longer a simple mechanistic, causal agent, but it helps form (or, if you hate this concept, it perverts) what we try to do and how we try to do it, and, in so doing, it often change what we thought we wanted to do, or at least, it changes what we thought we wanted to do from aim α to achievement ω. (Glanville, 1992, p. 217)

Nonetheless, since the difference between using a computer either as a tool or as a medium is mostly a matter of how to approach computing rather than something that is hardware or software related, this distinction seems helpful in recognizing that computers can play a distinct role, one that can be "acting to liberate us to creativity" (Glanville, 1992, p. 217). The question to be answered then seems to be: how can architects treat computers as a medium?

Glanville (1992) suggests two answers. The first is to listen to the computer, "to watch, to leave myself open to whatever if offers (without censorship or even evaluation in the first instance), letting it take part" (Glanville, 1992, p. 220). The second suggestion is related to using computers as a medium, rather than attitudes towards it. In this sense, the author suggests a rather vague list of items that can orient the use of computers, such as "play; association; brainstorming. . .

.following rules to the bitter end; interaction" and many others, to which he resumes: "It's all about creativity" (Glanville, 1992, p. 221).

Nonetheless, the vagueness of both Glanville's suggestions relates to the challenging aspects of the question itself. The answer does not seem to be just 'about creativity'. Some boundaries are imposed by the context where architectural activities take place. For example, an architect can decide to use computers creatively even when dealing with sensitive issues, such as the production of legal documentation related to a given design, but does it worth it? On the other hand, when ideas start to appear during the conception phase, should the architect begin with calculations and spreadsheets of all sorts?

The use of technology as a medium must, ultimately, pay off. That is, for an architect to commit to 'turning the key' to use computers and VR as a medium, s/he must realize what advantages this change can bring her/him. Indeed, among the aspects to be evaluated are the competitive advantages related to the adoption of technologies. However, as we have seen, competitive advantages tend to be nil over time.

Regardless, as was already discussed, there were other advantages in adopting CAD and BIM. The cost-benefit of adopting these technologies were perceived as advantageous by architects. Their adoption pays off both in financial terms and in the advantages these technologies add to the design process, producing coherent documents, avoiding rework, etc. So, in part, the advantages of using these technologies have to do with what we call 'intelligent use', as Kirsh (1995) described, that is, with uses that simplify to some extent physical and cognitive tasks.

If we consider designing as a conversation, it seems essential to consider that efficiency is part of the conversation. In a way, efficiency subjects the conversation by constraining or establishing parameters to evaluate what is being discussed. In another way, the conversation should be efficient as a process, and what is spoken ideally should be understood without further effort. This double presence of efficiency seems to relate to the uses of computers either as a tool or medium. In this sense, a computer can be regarded as a tool related to its inherent efficiency to deal with calculations and as a medium when used to provide more efficient ways of communicating. Thus, although it appears that tool and medium are opposed, they can also be regarded as being complementary.

Even architect will alternate between the two modes of approaching computers as a tool, to enhance and optimize processes, or as a medium, to enchant designing, experimenting, and exploring possibilities creatively. Therefore, just as zero is not the opposite of one, the use of computers as a tool does not preclude their use as a medium. So also, it does not seem appropriate to consider enhancing as the opposite of enchanting.

To a certain sense, it is possible to relate tool and medium with enhancement and enchantment, respectively. On the other hand, it is not reasonable to suppose that this relationship is symmetrical because one can easily navigate from one to the other. The contingencies and abovementioned externalities and the mode of production that circumscribes and defines the working conditions of architects seem to force architects closer to the logic of enhancement. After all, we are departing from the assumption that we live in a world going through a process of disenchantment.

Nonetheless, our suggestion of reintroducing the body in the design process through VR attempts to counterbalance this asymmetry between enhancing and enchanting. The body offered to the presence in VR needs to be measured and objectified, but the effects the experience has on the subject can be evaluated only qualitatively. The intended use of VR is thus closer to enchantment or its use as a medium.

Thus, I believe that the importance of this type of use of VR relates not only to sensitizing architects to the subjective aspects of architecture and its effects on a subject but also to making them aware that there are other ways of dealing with the technological aspects of the design process. Thus, it is possible, at least, to try to escape from a tendency to use technologies in the way they were meant to be used.

However, it seems that a question remains: if VR is so advantageous, offering architects the possibility of working with atmospheres, facilitating the communication of ideas, and moving the body to a place of prominence in the design process, why has it not become part of architects' everyday lives yet?

5.12. Architects, imagination and VR

The answer to this question can be separated into subjective and material (or objective) aspects. In this section I will deal with the former and the latter will be covered in the next chapter. In this sense, let us suppose that the material limits (of space, equipment, software, etc.) have been overcome and that VR could be incorporated into architects' design process without major problems. Now that architects are unhindered from using VR, we cannot naively believe that overcoming material and technological difficulties is equivalent to transforming the architectural way of doing things. If we believed that this transformation would take place simply through the adoption and use of technology, we would be disregarding, for example, Durand's conceptual, methodological, and ideological work.

Under the current logic of production it seems reasonable to restrict VR to the presentation phase, as architects already do. VR is very efficient in convincing, seducing, and reducing critiques from clients. This use is perhaps the most advantageous for architects in quantitative terms, involving the minor investment for the greatest return.

If suddenly VR were massively adopted by architects, it will probably replace two-dimensional computerised images and videos, just as digital rendering replaced hand-rendering. Thus, VR could be inscribed as just an element in the series composed of the tools used by architects (hand-drawing, CAD, BIM, and VR) in a kind of logical sequence, as predicted to some extent by Walker (2017). However, the presence of VR in this series can be regarded as just a step further under the logic of efficiency, optimisation, improvement, or in other words, under disenchantment. In any case, if we consider this logic, any use that optimises architects' workflow could be considered *intelligent* in the sense argued in the previous chapters.

The architect's misfortune is to be content with these uses of VR for merely representative purposes, with increasingly 'realistic' simulations. The logic of disenchantment makes it appear that the attempt to reproduce the look and behaviour of the physical world is enough. The realistic simulation becomes enchanting enough, fitting architects' expectations without visible gaps or excesses.

This perception can be regarded as part of a process of instrumentalisation of architects' imagination. Moreover, this process is mainly responsible for shaping architects' perception of their education and practices within certain limits. In this sense, it would not be surprising if many architects despised any possibility of experimenting with improbable spaces and situations as mere exercise, naïve speculation, and waste of time.

It is common to hear this kind of comment from architecture teachers and students on architectural design courses with more experimental characters. Overall, they usually argue that these courses do not develop the skills needed (or expected?) by 'the market'.

One of the problems of restricting architects' education to only 'education for the market' implies assuming 'the market' as a quasi-divine entity. In this sense, it delegates to 'the market' the supposed power to deliberate inescapably over our personal and social desires and the very possibilities of futures. This perception disregards that 'the market' is guided only by economic criteria and that these are often not in line with ethics. In short, restricting the educational process to serving 'the market' is equivalent to accepting a disenchanted view of the world as the only possible way to see it.

Alternatively, by being aware of these limits and disregarding them, VR can occupy a different role for architects. In a sense, VR opens up an unprecedented field for creating and experiencing improbable atmospheric situations having the body as a central point of the experience, allowing the architects to abstain from the geometric rules that conventionally guide their work. However, the possibilities disclosed by VR are also concealed by it, which makes them harder to perceive. The immersive experience in VR seduces architects' clients and architects into believing in the sufficiency of what is being presented.

Therefore, besides the material questions regarding VR, there is a structural limitation that affects architects' imagination. This limitation hinders architects from noticing other possible uses of VR related to a non-instrumentalised imagination capable of producing improbable atmospheres.

In a sense, imagination, or "the faculty of representing things in thought, independent of reality" (Roudinesco & Plon, 1998, p. 385),[51] is always limited. The images produced by a subject's imagination[52] are situated and time-related, being conditioned to a certain extent to the subject's social, political, economic, and cultural contexts. Thus, imagination can be regarded as a relational process because the images produced are always images of something, which is limited by what

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[51] Original: "…a faculdade de representar coisas em pensamento, independente da realidade".

[52] It seems important to note that to consider imagination as a faculty that may involve the creation of mental representations it is not opposed or in contradiction with the perspective of enactivist cognition, which is largely not based on mental representations. As Hutto and Myin (2017) explains, a radical enactivist approach to imagination is complex and dual stranded: "It does not deny that *some* forms of imagining possess representational content; it denies that *all* imaginings do" (Hutto & Myin, 2017, p. 183).

the subject can perceive. However, if imagination is always limited by context and ultimately by the subject's perception, why can the imagination of architects be considered structurally limited in the current context?

The answer is related to a certain homogeneity and hegemony of what Tosel (2020) and Casara (2021) have called the *neoliberal imaginary.* The notion of imaginary can be defined, at least in principle, as the "set of images and representations produced and retained by individuals" (Casara, 2021, p. 283)[53]. As Tosel (2020) affirms,

> Neoliberal thought has invested the imagination and paralysed critical thinking by depriving it of the means of an imaginative sensitisation by taking over the imaginary. It is difficult to bring to life the idea that another world in this world is possible and even more to produce matrix images of this possible and hoped world. (Tosel, 2020, p. 170)

The very definition of neoliberalism is complex since it is used in so many ways that it has become a vague and imprecise denomination (Casara, 2021). Notwithstanding, one of the ways it can be defined is as

> more than a theory, an economic policy or an ideology, neoliberalism is a system built on a rationality claiming to totality and, for this reason, it seeks to structure and organise the actions of rulers and ruled, companies and of individuals, public institutions and private corporations. (Casara, 2021, p. 170)[54]

The ideas of neoliberalism can be easily adapted into distinct traditions and contexts, enabling them to spread worldwide. This pervasiveness constitutes a kind of *world reason*, or a "normativity and an imaginary with the intention (and possibility) of conditioning the entire world. . . . [through] images that lead to the idea that everything and everyone is negotiable and disposable objects in the search for profit" (Casara, 2021, p. 165)[55]

[53] Original: "… por um lado, essa função criativa (capaz de produzir uma relação dual entre o indivíduo que utiliza a imaginação para produzir imagens e o objeto a que se refere a imagem produzida) e, por outro, o conjunto de imagens e representações produzidas e retidas pelos indivíduos."
[54] Original: "… mais do que uma teoria, uma política econômica ou uma ideologia, o neoliberalismo é um sistema construído a partir de uma racionalidade com pretensão à totalidade e que, por essa razão, busca estruturar e organizar a ação dos governantes e dos governados, das empresas e dos indivíduos, das instituições públicas e das corporações privadas."
[55] Original: "… uma normatividade e um imaginário com pretensão (e possibilidade) de condicionar o mundo inteiro. . . . [através de] imagens que levam à ideia de que tudo e todos são objetos negociáveis e descartáveis na busca por lucro".

This rationality can be regarded as a prominent point inscribed in the logic of disenchantment. The totalising aspect of the neoliberal imaginary creates the feeling that it is impossible to imagine anything that escapes this supposed rationality. In a certain sense, we are immersed in atmospheres produced from this neoliberal imaginary, which can help to explain why it seems impossible to imagine alternatives to it[56].

Therefore, the limits that constrain architects' imagination is also affecting all aspects of life. However, in this system, architects take the place of spectators and producers of images, which puts them in a delicate and potent situation. Architects are conditioned to produce from a disenchanted rationality, imagining and designing *according to* and *for* the neoliberal imaginary. Their production becomes part of this imaginary, influencing other architects' production and, to some extent, 'enhancing' the system's functioning. In this case, to enhance the system is to increase its entropy or increase the chance of producing more probable images, atmospheres, and situations.

Even so, if by chance architects manage to produce images that deviate from this imaginary, the plasticity of neoliberalism would swallow up any attempt of resistance, turning it into yet another product. If, on the one hand, alternative images nourish and improve the system, on the other hand, giving up trying to imagine other possibilities means surrendering to the notion that '*there is no alternative'*[57].

Hence, it is up to architects to continue producing alternative imaginaries by investing in what points to the unlikely. Under this perspective, VR can figure as a medium in the sense proposed by Glanville (1992), representing an idea and participating in the idea's formation.

VR enables the experimentation of atmospheres that are unlikely or impossible of existing within this system, either because they are not economically viable, or because they inefficiently organise spaces, or even because they are just experiments without any intention to be built. Furthermore, VR enables the circulation of experiences among architects and non-architects, fostering discussions and inspiring the creation of other unlikely experiences.

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[56] The philosopher Mark Fisher uses a phrase that is attributed either to Fredric Jameson or to Slavoj Žižek to define what he called 'capitalist realism' and that can complement our argument: "it is easier to imagine the end of the world than it is to imagine the end of capitalism" (M. Fisher, 2009, p. 8).

[57] 'There is no alternative' or TINA was a slogan used by the British prime minister Margaret Thatcher. It is cited by Fisher (2009) as a "brutally self-fulfilling prophecy" (M. Fisher, 2009, p. 14).

Architects can contribute to disclose, little by little, the spatial manifestations of the limits of the neoliberal imaginary by creating and circulating these unlikely experiences. The notion of designing atmospheres, which necessarily includes the body, can be seen as part of this invention process. By offering experiences at the body level, VR can help architects reveal and discuss how even the most obvious decisions in the design process are related to these imaginary limits.

Lastly, by understanding these limits and how they affect our imaginaries, architects can try to 'move the fence' further, or to break the fence, or at least to look over it, beyond what is daily offered to her/him as sufficient, enough, or worse, as an illusion of totality.

6. Conclusion

The preceding chapters of this thesis discussed the phenomenon of immersion and its cognitive aspects regarding the experiences of architecture and VR. The possibility of an art of immersion, following Sloterdijk (2006/2011), was envisioned considering architecture and VR as technologies for immersion. Several immersive experiences were presented and analyzed to understand the distinct modes of engagement afforded by them. From an enactivist standpoint, it was discussed how the movements afforded by an immersive experience were relevant for affecting a subject's perception. Thus, the experiences of architecture and VR were compared and the notion of atmospheres as a possible connection between both was presented, arguing that architects should investigate the possible *intelligent* uses of VR as a means to produce and experience atmospheres. Then, the rise of instrumental representation was analyzed, focusing onhow architects have been producing architecture since then. The advantages and disadvantages of using CAD and BIM software and their possible cognitive impacts were also discussed. The notion of efficiency in the design process and its relationship to the disenchantment of the world was discussed to understand how architects are limited in great part by a rationality that extends beyond the architectural field, encompassing pervasively most life aspects Finally, it was discussed how architects could use VR to disclose the limits of the neoliberal imaginary.

This conclusion aims to re-examine some topics discussed throughout the work, as well as to present some of the research limits. At the end, some questions that are still open will be presented for further developments.

6.1. Revisiting methods

The development of this research did not start from a pre-defined method. There was only a preference to approach the research from a qualitative standpoint. With the advance of theoretical discussions, I realized the need to develop the two practice studies presented in this work.

At that moment, I felt the necessity to understand through practice the challenges involved in producing immersive experiences in VR. The design and production of these studies were essential to illuminate several aspects that were discussed theoretically. The presented comparisons between production and experiencing architecture and VR would have been hampered without these practice studies.

From an architect's standpoint, it was possible to perceive how the software available to the production of immersive experiences are unfriendly to architects' workflow. The investment of time and effort in producing the immersive experiences was much higher than planned. Each practice study demanded so many steps, switching between software, technical adjustments and hours of programming, that there would be no space or time in the design process, academic or professional, for this type of experimentation.This first-person approach to research is a valid and consolidated method of inquiry, as Seamon (2000) demonstrates. The investigation of experiences can be considered the goal of phenomenological inquiry, the most established qualitative research approach used in architectural research, according to Groat and Wang (2013). However, the phenomenological method can be criticized, especially for trustworthiness issues related to the criteria used to consider the descriptions and interpretations reliable (Seamon, 2000).

In this sense, I have tried to anchor my reflections in consolidated works and authors that gave theoretical support to my observations. Thus, the phenomenological method was used as a way to foster "a mode of seeing that cultivates both intellectual *and* emotional sensibilities, with the result that understanding may be more whole and comprehensive" (Seamon, 2000, p. 172).

However, among the limits of the first-person phenomenological approach, the difficulty in alternating the roles of observer-observed stands out. I tried to pay attention to possible cognitive biases that could lead me to confirm my assumptions, which led me to take special care in keeping the descriptions and analysis as honest and faithful as possible to what I was observing.

6.2. The perceived limits of producing VR practice studies

The two practice studies presented were produced after finishing the first three chapters of this thesis. The decision to present them after the third chapter was to establish a 'cut' under the thesis structure. That is, the practical studies are relevant enough to appear in the thesis body, even though, at first glance, they seem disconnected from the discussions. Nevertheless, the way they figure in this work – a collage and a link to an online video – are just a glimpse of the experience when wearing a VR HMD.

They were fundamental for ruling out possible naïve approaches to discussing the design of VR experiences by architects, as well as for the subsequent discussion that took place in Chapters 4 and 5. By conceiving, modelling, and programming the experiences I could perceive that the game engines require to its operation a kind of reasoning that is foreign to the architect. They do not work as CAD software, by drawing, nor by just modelling information as in BIM software. Instead, it demands modelling an element, texturing it and, to be brief, to add all the expected behaviour to that element. Thus, there are still software bottlenecks that are of great relevance to make it difficult for architects to adopt game engines in their design processes.

To illustrate, from the moment of choosing the software to develop the practice studies, it was possible to perceive how there were few options available: I could either adopt specific VR architecture presentation software (e.g., Twinmotion, Enscape, Lumion), or game-engines (e.g., Unity, Unreal) and professional 3d modelling software (e.g., 3dsmax, Blender). In other words, the options that involved escaping the moment of presentation were much more complex and non-specific for architects.

The software chosen for developing the practice studies was related to game development (Unity) and 3d-modelling (Blender). Despite their complexity, these programs were preferred due to their greater openness to customization and programming. However, the possibilities for interaction and creation were conditioned by the selected software's interface, programming, and operational logic. Thus, the expectation of designing more sensitively was occluded by manipulating sliders and adjusting variables that demanded new modifications with each new material or scene.

Nonetheless, the conversation between software is often truncated, sometimes requiring much reworking. For example, an object modelled in Blender, when exported to Unity, needs to be re-texturized practically all over again since the materials are calculated differently in each program. In other words, the current choice to use VR in pair with visualization and presentation software gains even more pertinence, from the standpoint of the efforts necessary for its use.

From the creation and experience of the VR practice studies, I could perceive something in common with being immersed in architecture and VR. Until then, this something that had no name was more related to the effects that a given spatiality produces on a subject than just to the elements that made up that spatiality. In this sense, the concept of atmosphere emerged and gained relevance in my work based on these experiences. On the other hand, the concept of atmosphere in architecture has little to do with narrative or interaction, so present in the practice studies.

Therefore, the production of new practice studies was halted to give way to a deeper theoretical investigation of atmospheres and other matters that unfolded from the production and experiencing studies themselves.

6.3. Atmosphere: a paradigm for architectural design?

The notion of atmosphere seems essential to any discussion on the phenomenological aspects of architecture. The pervasiveness of its effects on us contrasts with the impossibility of apprehending it rationally. If we extrapolate the boundaries of architecture, the atmosphere is what constantly pressures our bodies. However, to perceive this pressure, there needs to be a difference between our internal and external pressures, as happens, for example, when we dive into a deep pool and feel our ears tingle. In addition, we can perceive that the pressure exerted by atmospheres decreases as we increase our altitudes above sea level. In a metaphorical sense, this helps us understand why technical drawing is not ideal for designing atmospheres: the body is too far away to be affected significantly by any atmosphere.

Atmospheres are perceived as an immediate phenomenon, something that does not demand any conscious comprehension or reflection. Thus, the corporeal understanding of a building is based on this pre-reflective moment – a 'first impression'. On the other hand, the architectural design process presents itself as a reflective conversation, which poses a question: how to use a reflective process (design) to achieve a pre-reflective result (atmosphere)? In other words, how to design the first impression of a spatiality?

According to a sensorimotor approach to perception, the perceptual availability of objects and spatial elements changes as a subject moves through space, altering the perception of the atmosphere itself. Thus, atmospheres are not static and depend on the position of subjects and objects. Even subtle movements of either subjects' bodies, as moving the gaze or tilting the head, or objects, as the flickering of a candle or a moving curtain, participate in this dynamic revealing of atmospheres. For instance, the *promenade architecturale*, mentioned in early chapters, can be regarded as a procedure for disclosing atmospheres through movements in space.

To approach architectural design considering atmospheres, one should ponder that, regardless of the architect's awareness, the perception of the arrangement of elements in space produces effects on a subject as s/he moves through it. No matter how efficient or optimized the design process can be, an atmosphere is always produced. Even the most rational and functionalist approach to architecture will inevitably generate an atmosphere.

Under a logic of disenchantment, atmospheres can be regarded as something extra, a residue, or an excess. If this 'excess' of the atmosphere is incorporated as part of architectural design, we can broaden our very understanding of making architecture, expanding it beyond just attending to its functional and technical demands.

It is not a question of designing atmospheres instead of attending to these demands but an attempt to raise architects' awareness of this often-overlooked architecture aspect. The question of atmospheres reveals that even strictly technical decisions have effects that are only perceived from the experience of the designed spaces.

In this sense, there is an ethical dimension to architectural design decisions that is disclosed when atmospheres are considered. Therefore, architects should be able to experiment with their bodies at least part of the effects of their decisions, a task in which VR gains particular relevance. The architects' bodies should be engaged in designing – they should be included in the reflective conversation.

Therefore, the proposal to consider atmospheres in designing has to do with how atmospheres are perceived, that is, through a subject's body moving across space. The body included in the reflective conversation becomes a 'body-in-circulation', offering a distinct mode of engaging with designing. From this perspective, designing atmospheres can be regarded as designing the possibilities for unveiling objects from movement.

Architects would continue to arrange objects in space, define accesses, material finishes, etc., but in a way that enables them to perceive the effects of their decisions better. Their engagement with designing through this body-in-circulation can enable architects to perceive how the relationship between objects, other spatial elements, and subjects changes with movement. In this sense, architects can work by fine-tuning atmospheres, similarly to tuning a musical instrument: by observing the tensions between objects and changing them, affecting their consonance and dissonance effects.

6.4. The question concerning immersion in VR and architecture

Regarding atmospheres, we saw the inadequacies of the conventional software used by architects. In a certain sense, VR seems to shine as a solution for this question since it enables a glimpse of the atmospheric qualities of spaces. Through VR, an architect could, ideally, immerse in the space being designed to evaluate her/his decisions from within.

However, as Grau (2003) noted, the immersion displaces the subject too close to the object, making criticism difficult: it takes a certain distance from the object to criticize it properly. Therefore, the possibility of designing immersed on a 1:1 scale does not seem a viable option. Moreover, the excessive proximity to the designed object makes the act of criticizing a cognitive challenge. Still, as already mentioned, technical drawing is excessively distant from the designed object. These statements lead us to another question: is there an ideal distance for designing?

In this sense, it could be said that the phenomenon of immersion discloses several aspects regarding designing. The first aspect is that distance affects our way of designing. Each representation technique or software affords a domain of distances from what is being designed, determining which displacements are possible within that domain. For instance, a bi-dimensional drawing made using AutoCAD allows fewer displacements than a building model in BIM. It is possible mainly to zoom in or out and rotate elements in the former, as in the latter, it is also possible to perform three-dimensional displacements, such as 'entering' spaces, hiding 3d elements, etc. In a sense, these displacements allow architects to assume distinct vantage points to evaluate what is being designed. From this perspective, immersion in VR can open several possibilities for other displacements.

Although CAD and BIM software can represent three-dimensional spaces, architects are presented to these spaces through a bi-dimensional screen. Therefore, as discussed, the perception of space through conventional computer displays is limited by the screen and its superficiality. The depth, perceived as a third dimension through the screen, is just a resemblance of depth as experienced in the physical world.

According to Merleau-Ponty (1945/2012), depth is, more than the other spatial dimensions, what can elucidate the relation between subject and object, since it does not belong to things but to perspective itself[58]. As Gibson (1979/2015) adds,

> If *depth* means the dimension of an object that goes with height and width, there is nothing special about it. Height becomes depth when the object is seen from the top, and width

[58] The relationship between depth and perception has been debated to date. Based on the work developed by Merleau-Ponty, especially in the books *The Phenomenology of Perception* and *The Visible and the invisible* several authors took the discussion further and sought to contribute with other perspectives. For example, Bredlau (2010) discusses the notion of depth in relation to the perception of the world, focusing on the experiences of autists; Cataldi (1993) relates Merleau-Ponty and other authors, such as Gibson, to discuss possible consequences of this concept beyond spatial perception; and Foehl (2014) offers a psychoanalytic approach to depth and how it appears in the practice of analysis itself.

> becomes depth when the object is seen from the side. If depth means distance from *here*, then it involves self-perception and is continually changing as the observer moves about. (Gibson, 1979/2015, p. 140)

By including the body and its motricity into experience, the immersion in VR offers a simulation of an objective space that includes a ‘more convincing’ resemblance of depth, allowing the subject to displace through this space. Furthermore, the vantage points allowed by VR are located within the infinite digital space where the designed object can be perceived as present and explored as such.

Therefore, the ideal distance for designing is related to the situation at hand. For example, the ‘infinite’ distance of the technical drawing, which usually leaves depth out of consideration, seems adequate to situations where multiple agencies are demanded from the architect, such as in organizing spaces and flows, in the compatibilization of complementary systems, in understanding the relationship between floors and spaces that are not necessarily contiguous, etc. On the other hand, the immersion in VR seems appropriate in design situations where the body reaches what geometry falls short of. For instance, in understanding the effects of depth in perceiving spatial organization, understanding the process of unveiling spaces by movement, the perception and tuning of atmospheres, and others.

Immersion also discloses aspects related to the type of actions and their importance for designing. Although it is possible to modify the model while immersed in VR (depending on the software used), the importance of immersion for design is more related to epistemic actions than to pragmatic ones. By displacing her/himself through VR, the architect can make the task of designing more manageable from a cognitive standpoint. Some actions are taken “not for the effect they have on the environment as much as for the effect they have on the agent” (Kirsh & Maglio, 1994, p. 546).

The phenomenon of immersion also discloses the difference between digital and physical atmospheres. In VR, the immersive experience is primarily focused on vision. The senses of hearing and touching play a less significant part. Likewise, atmospheres are perceived correspondently. Even when immersed in VR, we continue to notice some of the elements that are currently not digitally representable but are present in our physical environment, such as smells, textures, temperature, the thermal conductivity of materials, etc.

When opening a door in VR, I do not feel the shape or weight of the doorknob, the cool touch of metal, or the scratching of mechanical parts that are tensioned by turning the handle. The simple experience of opening a door in VR reveals how immersion in architecture can be perceived as infinitely richer than any simulation available. However, this 'richness' of experiencing architecture stands out only in comparison with VR experiences. Nonetheless, this comparison leads to the perception that VR still lacks some realistic aspects and discloses the expectation that VR should be used to represent what exists or what is likely to exist physically.

This expectation assumes that our 'real world' experience comprises all possibilities of relevant experiences, serving as a sort of scale where what is closer to reality is perceived as better or 'richer'. However, even from this perspective, if we look at VR experiences that simulate architectural environments realistically, some aspects do not have a 'real' counterpart, such as teleporting, flying around, changing material finishes in a click, etc.

These aspects that escape the notion of simulating the 'real world' can be seen as just a glimpse of a field of possibilities still underexplored by architects. The immersion in VR can offer improbable – or even impossible – atmospheres and spatial situations to experimentation as if they are 'real', with effects of reality. In this sense, it is clear that it is not the experience of VR that is 'poor', but the idea of limiting its use to reproduce or simulate 'real' and likely experiences.

From this standpoint, the example of turning a handle to open a door in VR takes on another dimension. In comparison with what VR can offer, the experience of a simulation of a door in VR which looks and behaves like a physical door seems to make little sense. That is, what could this experience offer that is not already contemplated by its 'real' counterpart? The possible answers to this question seem to appear as we move farther from situations likely to be experienced physically.

The potency of immersion in VR for architects involves diverting efforts from reproducing the physical world to creating and experiencing unlikely atmospheres and spatial situations. Thus, the perception of the 'poverty' of immersion in VR is not a characteristic of the technology, but it discloses the limits of the imagination conditioning its use.

6.5. Imagining and looking through VR

If we look at how architects operate their tools, physical or digital, we can see how the former programs the latter and vice versa. Architects who worked on drawing boards resisted migrating to CAD software just as CAD architects resisted BIM. In part, this resistance has to do with the difficulty of reprogramming and being reprogrammed. There is specific reasoning for each technology, which must be seized so one can operate it skilfully.

Thus, just as CAD and BIM became part of the architects' programming, so does VR. The incorporation of VR reprograms architects' perception, who start to see the world as reproducible, digitizable, and modellable, in and for VR. Nevertheless, how to escape the temptation of reproducing the world and take advantage of the vectors opened by VR for experiencing improbable situations and atmospheres?

If we look at how digital technologies have changed architects' working environment, it is clear that computers have reorganised the offices, and consequently, how architects work. However, this reorganisation process is slow, and even today, drawing boards still coexist with computers in some offices and schools. VR equipment has only recently arrived at architectural offices, mostly since 2015. Until now, it cannot be said that there has been a significant reorganisation of workspaces due to its presence. The architecture offices I visited or know that use VR to some extent usually does so in improvised spaces, like in the corner of a meeting room. The equipment is not always ready to use and is typically assembled when a presentation to a client or partner demands it. The lack of spaces dedicated to the use of VR in most architecture offices indicates to some extent the current relevance of this technology for architects. In this sense, it would be interesting to investigate whether adequate spaces for VR would expand the uses of this technology among architects.

As mentioned before, another aspect that concerns our questions is related to the available software. Nowadays, if some architect wishes to incorporate VR in her/his workflow, there are mainly three possibilities. The first is learning to operate game-engines and modelling software – as I have tried to do with my practice studies. This path is undoubtedly the one that opens up most possibilities for experimentation, but it is also the costliest in time and effort. Moreover, one who follows this path will have to learn techniques and skills that are considered outside the architect's domain, such as C# or C++ programming, and advanced modelling techniques (e.g., retopology, UV Unwrapping, etc.).

Another possibility would be to learn how to model elements from within the VR using specific software (e.g., Gravity Sketch, Blocks, Tiltbrush). Besides the difficulties of creating spatialities while immersed, as already discussed, modelling in VR is slower than using a mouse and keyboard. This 'inefficiency' makes simple modelling operations laborious and excessively tiring. The third possibility, so far the most common among architects, involves using specific software for design presentation, which can import models from programs already used by architects, allowing adjustments in materials, lighting, vegetation, etc.

In other words, the available software is either too complex, requiring specialised knowledge, or too limited, restricting experimentation to the customisation of appearances and other presentation aspects. Furthermore, developing specific knowledge and skills to experiment consistently in VR is a difficult limit to overcome. The game engines work in a different logic from the one in which architects operate, demanding specific training, which is not always available or perceived as relevant or worthy.

Nonetheless, as discussed in the last chapter, if the material (and technological) obstacles regarding the use of VR are removed, there are still other aspects that could hinder the experimenting with VR. The pervasiveness of the neoliberal imaginary conditions both the educational process and the work of architects.

Thus, imagination plays a fundamental role. On the one hand, it is through imagination, instrumentalized by this disenchanted rationality, that we optimize the mechanisms that capture us and reduce our possibilities of action. On the other hand, the imagination can be mobilized to conceive other spaces, events, relationships, etc. which apparently expand the possibilities of action. Inevitably these efforts will still be contaminated by the neoliberal rationality, but the critical analysis of this production can disclose the limits imposed by this rationality, which can, in turn, expand the imaginary and with it the capacity for imagination itself.

It is in this direction that the use of VR by architects can gain relevance. The atmospheres that could be invented and shared by architects through VR might disclose the imaginary limits that constrain architectural imagination. As if these invented experiences could touch these limits in search of gaps that would allow us to see through. Moreover, in this attempt to see through, we can re-view our surroundings to transform them until the unlikely atmospheres can be perceived as inevitable atmospheres.

6.6. Notes for further research: challenging imagination

Throughout this work, it was possible to perceive that the possibility of simulating something in VR is just a tiny part of what this technology can offer architects. However, some 'objective' and 'subjective' aspects still limit or hinder alternative uses of VR. In this sense, an expected development of this investigation is to continue exploring new software and hardware related to VR to understand if and how the limits related persist.

Another aspect that needs further investigation is related to VR's spatial and technical demands. As mentioned before, it could be said that there is a lack of adequate spaces for VR experimentation in architecture offices. It is probable that most schools also lack these spaces. An adequate space for experimenting with this technology should ideally be physically closer to where designing takes place. It should be uncluttered and with enough room to move around risk-free, and the equipment should be ready to use, requiring minimal adjustments for operation[59].

However, it is not possible to affirm that only the existence of spaces for experimenting with VR will be sufficient to inspire architects to explore alternative uses for this technology. Without the assistance of technicians with experience in developing VR applications, likely, alternative uses of this technology will hardly prosper among architects. In this sense, further investigation is needed to understand what physical, software and personnel demands are necessary for the proper functioning of a VR experimentation space in an architectural context.

Another point for further investigation is related to understanding experimentally if and how the idea of designing atmospheres can change architects' approach to designing. In addition, it can be especially interesting to investigate how VR can contribute to understanding and applying the idea of designing atmospheres, especially with undergraduate students with minimal designing experience.

As future developments concerning architects' imagination, other researches are needed to investigate in greater depth aspects external or internal to the architectural field that may constitute and/or limit architects' imagination. Researches in this direction could clarify, for

[59] Not surprisingly, this description of an adequate space reminds me of the development spaces of the VR app-development companies I was able to visit in Europe (2018-2019) as part of the PLAID-UNIVERCEMIG research project. Usually, in these companies, each workstation was connected to a VR HMD, allowing the development team members (e.g., 3d-modellers, texturizers, developers, project managers, etc.) to experience what was being produced without too much difficulty.

example, if there is a way of imagining that is proper to architects. Furthermore, aspects regarding imagination should be investigated considering the relation between architectural imagination and: embodied cognition; representation techniques and tools; experience in designing atmospheres; and others. In any case, these questions suggest the necessity of investigating a particular phenomenology of architectural imagination, which points to the further requirement of discussing methods and experiments for this purpose.

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