Pontifícia Universidade Católica do Rio de Janeiro

Patrícia Torres Pereira Carrion

Virtual Reality for remote work:

Exploring the acceptance of VR technology for meetings and business-related contexts

Doctoral thesis

Thesis presented to the Graduate Program in Design at PUC-Rio in partial fulfillment of the requirements for obtaining a degree of Doutora em Design.

Advisor: Maria Manuela Rupp Quaresma

Rio de Janeiro
April 2021

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Abstract

Carrion, Patrícia; Quaresma, Manuela (Advisor). **Virtual Reality for remote work: Exploring the acceptance of VR technology for meetings and business-related contexts.** Rio de Janeiro, 2021. 146p. Tese de Doutorado – Department of Arts & Design, Pontifical Catholic University of Rio de Janeiro.

Virtual Reality is the term used to describe a computer-generated environment that people can, under the sense of immersion and presence, explore and interact with. This thesis aims to investigate how the presence of people in collaborative scenarios, such as work meetings, can be mediated in a beneficial way by the use of Virtual Reality (VR) technologies. In this sense, we believe that VR, if used as a tool to assist fully remote and hybrid work meetings, provide greater involvement and engagement of people during the activity. Our research was partially developed concurrently with the COVID-19 pandemic. Therefore, we argue about the relevance of investigating forms of interaction amid rules of social distancing. For a theoretical basis, we first formalized the concepts of reality and virtuality and covered the evolution of VR technologies and applications. Here, we demonstrated how three-dimensional immersion environments can impact the human experience and have been adopted by several industries beyond the universe of games. After the literature review, we defined research techniques to address several research questions. We started with an exploratory work on movement and interaction in VR, followed by semi-structured interviews and a web-based survey. The latter two focused on investigating people's perceptions of the physical and remote settings of work meetings. At last, the final experiment sought to apply a modified Technology Acceptance Model (TAM) to measure the acceptance or rejection of VR as a tool for hybrid work meetings.

Keywords

Virtual Reality, Work meetings, Remote work, Technology Acceptance Model, User Experience.

Resumo

Carrion, Patrícia; Quaresma, Manuela (Advisor). **Realidade Virtual para trabalho remoto: Explorando a aceitação da tecnologia de VR para reuniões e contextos relacionados a negócios.** Rio de Janeiro, 2021. 146p. Tese de Doutorado – Departmento de Artes & Design, Pontifícia Universidade Católica do Rio de Janeiro.

Realidade Virtual (ou VR, do inglês *Virtual Reality*) é o termo usado para descrever um ambiente gerado por computador que as pessoas podem, sob os sentidos de imersão e presença, explorar e interagir. Esta tese tem como objetivo investigar como a presença de pessoas em cenários colaborativos como reuniões de trabalho pode ser mediada de forma benéfica pelo uso de tecnologias de Realidade Virtual. Neste sentido, acredita-se que aplicações em VR, se utilizadas como ferramentas para auxiliar reuniões híbridas, proporcionam maior envolvimento e engajamento das pessoas durante a atividade. Esta pesquisa foi parcialmente desenvolvida durante a pandemia de COVID-19 e argumenta sobre a relevância de investigar formas de interação em meio a regras de distanciamento social. Para uma base teórica, os conceitos de realidade e virtualidade foram formalizados e a evolução das tecnologias e aplicações de VR foi delineada. Aqui demonstrou-se como ambientes de imersão tridimensional podem impactar a experiência humana e têm sido adotados por diversas indústrias além do universo dos jogos. Após a revisão da literatura, foram definidas técnicas a fim de responder a uma série de questões de pesquisa: primeiro, um trabalho exploratório sobre movimento e interação em VR, seguido por entrevistas semiestruturadas e um questionário. Os dois últimos se concentraram em investigar as percepções das pessoas sobre as configurações físicas e remotas das reuniões de trabalho. Por fim, o experimento final buscou aplicar um Modelo de Aceitação de Tecnologia para medir a aceitação ou rejeição de VR como ferramenta para reuniões de trabalho híbridas.

Palavras-chave

Realidade Virtual, Reuniões de trabalho, Trabalho remoto, Modelo de Aceitação de Tecnologia, Experiência do Usuário.

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1
Introduction

Virtual Reality (VR) technologies have moved from a science fiction concept to a broad consumer device market and have gained traction in several fields as computer hardware has become more powerful and accessible (Hilfert and König, 2016). When trying to create three-dimensional immersion environments that allow people to move to an alternative reality, VR applications span domains that range from the more conventional, such as games, to applications for a better online shopping experience (Glazer et al., 2017); in the field of medicine and healthcare, for the cognitive training of stroke patients (Gamito et al., 2017); and in education, for collaborative learning (Greenwald et al., 2017), to name a few. Although they fit different levels of immersion, VR enabled devices are already accessible to a portion of consumers. From inexpensive devices, made of cardboard or plastic, to mid-level devices that work with high-performance smartphones, to more expensive headsets and controllers that may require floor space and motion sensors for an enhanced experience.

Despite the enthusiasm and the consequent growth of the VR market, there are several challenges to be faced for greater adoption. Among the challenges related to the technology itself are the cost of hardware and mobility. Moving around is one of the most essential aspects of interaction in a virtual environment, but just as VR technology must allow people to be mobile in a virtual environment without boundaries, it still needs to ensure that they move safely and within limits in the real physical space. Another relevant issue is the generation of content for VR applications, in addition to the market's difficulty in establishing a real justification for people to consume technology beyond ephemeral enthusiasm (Nield, 2017; Wiltz, 2017).

In the field of Design, challenges regarding the user experience include aspects such as criticism of the social impact exerted by technology, the human sensory limitations to the virtual environments and interactions, the direct and potentially harmful effects on the health and safety of the users, and the effects of motion sickness. With regard to social impact, for example, we can mention the concern with the negative influences of VR on users while gaming. This since, even when not completely immersed in a simulated virtual environment, players are still vulnerable to the effect of violence and the possibility of emulating similar behaviors in the real world (Greitemeyer and Mügge, 2014). At the same time, from the point of view of sensory limitations, there are design restrictions imposed by human sensory and motor physiology, which are related to visual, auditory, haptic, and synesthetic perception.

With its ability to involve people in a virtual yet safe world, the potential of VR can be applied in a variety of fields to benefit society. Some examples can be seen in the healthcare industry, where VR technology has become a method for treating post-traumatic stress, anxiety, phobias and depression (Freeman et al., 2019; Martens et al., 2019). In the field of arts and education, teaching and learning situations can also be improved by the technology, when people are taken on virtual field trips to museums, for instance (Pivec and Kronberger, 2016; Lee et al., 2020). Besides, in a mix of healthcare and education, Virtual Reality can be beneficial for children with special needs, such as Autism Spectrum Disorders (ASD), through the use of platforms to safely practice and rehearse social skills (Didehbani et al., 2016).

1.1
Coronavirus disease (COVID-19) pandemic

Since the coronavirus disease 2019 (COVID-19) pandemic hit the world in late 2019, along with the lockdowns that followed in early March 2020, people have faced a series of changes in their daily lives and work life is no exception. As governments urge social distance, isolation and quarantine measures, continuing to perform daily tasks remotely has required adjustments since companies and institutions are converting to online solutions. In this thesis, we argue the benefit of using Virtual Reality technologies to facilitate life at work, specifically in the context of remote meetings.

Before the pandemic, 15% of an organization’s time, collectively, was spent in meetings (both in person and remote), with the number increasing for people working in middle and upper management (35% and 50%, respectively) (Kolowich, 2014 apud Norenberg, 2020). With the possibility of working at home, it seemed feasible to imagine working hours unfolding more or less as before, since people could count on the help of communication tools already used to replace face-to-face interactions. However, remote work and the consequent loss of common workplaces most likely deprive people of habits that increase productivity, efficiency and collaboration, while also jeopardizing workers' mental health (Scheiber, 2020). In addition, we believe – and here sought to prove – that there are several dimensions of non-verbal communication that are lost in a virtual meeting environment compared to face-to-face interactions.

In the future, if and when the world goes back to what it was in pre-COVID-19 times, will companies focus on in-person communication? Or will the change brought about by the pandemic prosper and remote work permanently be a fundamental part of our lives? Given the wide availability and the ever-lower cost of electronic devices, once-experimental technologies have now become increasingly possible to improve people's lives. Virtual Reality consists of people who experience life, games, work and individual and group interactions on a virtual platform. Thus, at least conceptually, it involves, in the context of remote work, real people interacting in close to real scenarios, maintaining the team's dynamics and face-to-face communication patterns.

Over the next few chapters, we will argue to support the notion that Virtual Reality technologies, if used as a tool to help fully remote and hybrid work meetings, provide greater involvement and engagement of people during the activity. The fact is that the pandemic has caused unprecedented disruptions in professional life and, as a consequence, digital transformations have accelerated and will continue to accelerate at the speed of light. The current reality creates radical changes, considering a world where everything needs to be done and accessible from home. This emphasizes a new hybrid work model, with the work culture establishing a renewed focus on smart and human collaboration, which we believe can be largely mediated by VR technologies and environments.

1.2
Doctoral candidate’s contextual perspective

More traditional approaches to science are often based on pure neutrality and objectivity. In contrast, especially when it comes to sociological methodologies, researchers not only face “special limits”, but are also hampered “by a distorted and idealized picture of practices in the ‘hard sciences’” (Lieberson and Horwich, 2008, p. 1). This thesis, developed over four years, was influenced by two different geographical contexts, in addition to undergoing changes in scope due to the ongoing pandemic of coronavirus disease. In this sense, we somewhat relate to the phenomenon of *implication analysis*, which considers that the mere presence of the researcher as an observer already changes the object of study to different extents. After all:

> The linkage between theory and evidence is far more difficult than we want it to be (as is often the case with the way the social sciences are taught and the assumptions under which we operate), and the practitioner has to deal with this reality [...] recognizing the limitations that social research often encounters. (Lieberson and Horwich, 2008, p. 2)

First, in December 2018, for personal reasons and following a job offer, the doctoral candidate moved to the city of Trondheim, Norway. With the relocation, both the candidate and the advisor have committed to maintaining communication and guidance remotely. At the time, the scope of the research work was already to argue Virtual Reality in the context of remote work meetings and other business-related contexts. However, it was still grounded on a world view that disregarded the unknown scenario brought about by the pandemic and its consequent challenges. Thus, next, although the global context has not completely altered the research problem statement, it has in fact expanded its justification and applicability. Furthermore, the candidate’s specific contextual change influenced the procedures of the research methodology. Initially committed to carrying out the techniques only with Brazilian people, the author expanded the range of research subjects to also include Norwegians, given the uncertainty of how much face-to-face interaction would be required from that moment on in the development of the thesis. The adaptations mentioned here are apparent from Chapter 5, when we introduce the research procedures and, more specifically, during the subchapters that present the semi-structured interviews, the web-based survey and the subsequent experiment. The description of these and other chapters of the thesis are detailed as follows in the thesis summary.

1.3
Thesis summary

As this research is exploratory in nature, based on empirical data, the chapters that follow the introduction aim to address the theoretical basis for the research design (Table 1.2). In Chapter 2, entitled "Paths to Virtual Reality: The concepts of reality and virtuality", we formalize the term Virtual Reality, first defining the concepts of reality and virtuality separately, and, later, discussing how the combined term has been argued and grounded in the literature. To this end, we explored how Virtual Reality has been addressed in two specific moments in history – in Robert Barker's panoramic paintings during the Romantic Age in the 19th century; and in the scenario of the Evil Demon, by René Descartes, exemplified in the 1999 film The Matrix by the Wachowski brothers (nowadays only The Wachowski) – the two moments being forerunners of what we now know as VR.

In Chapter 3, "Immersive technologies: The evolution of devices and experiences in Virtual Reality", we provide a brief historical context. Starting from the advent of the first Virtual Reality devices and prototypes in the 1830s, going through technological predictions worthy of science fiction, to the practical and functional devices that preceded the current VR market, as we will outline in the first two subchapters. Next, we discuss exclusively the current theories and technologies of the remaining decades, focusing on both existing and potential VR applications.

In Chapter 4, we present the research design, discussing the research topic, the problem statement, and the research object with regard to empirical verification, in addition to proposing a series of research questions (Table 1.1). The questions guided the selection of techniques applied to this research and were duly answered until the conclusion of the doctorate. To investigate the problem statement and assess the validity of the research questions, in the section "Research method, techniques, and procedures" (Chapter 5), we seek to elucidate the details on the planning of the techniques. In short, the methodology consists of, first, an exploratory work on movement and interaction in VR. In sequence, we demonstrate how we conducted semi-structured interviews and a web-based survey in order to understand the context of remote work that would potentially benefit from the use of VR technologies. Finally, we show an experiment involving a modified Technology Acceptance Model (TAM), designed to measure the adoption and use (acceptance or rejection) of Virtual Reality based on people's attitudes.

Table 1.1 – Research questions with their corresponding applied techniques

Research questions	Applied techniques
RQ 1. What are some of the overall challenges regarding human experience and sensory limitations to VR environments?	Exploratory work (Subchapter 5.1)
RQ 2. Can these challenges be mitigated, and design solutions be customized to provide a better experience to people?	
RQ 3. How work meetings take place, what types of remote or hybrid environments they might take place in?	Semi-structured interviews, web-based survey (Subchapters 5.2 and 5.3)
RQ 4. What is the perception of people involved in these contexts?	
RQ 5. Which are the different profiles of people in the context of fully remote or hybrid work meetings?	
RQ 6. Can VR technologies provide greater involvement and engagement of people in work meetings whilst in fully remote or hybrid settings, and, by extension, be adopted and used in these contexts?	Technology Acceptance Model (TAM) experiment (Subchapter 5.4)

In Chapter 6, we will treat the results of this study individually and, in a later analysis, parallel and comparatively. We seek to relate the results of the final experiment to the findings of the other techniques. Finally, in Chapter 7, we will present the conclusions about the thesis as a whole, answering our research questions, and explaining the potential consequences of this research study, followed by the "References" (Chapter 8) and the Appendices.

Table 1.2 – Extended thesis summary

<table>
<tr><th>Chapters</th><th>Descriptions</th></tr>
<tr><td>Introduction
1.1. Coronavirus disease (COVID-19) pandemic
1.2. Doctoral candidate’s contextual perspective
1.3. Thesis summary</td><td>It presents the motivation for conducting the research study – by highlighting its importance and providing the background that justifies it. It contains a brief literature review, outlining the research topic, and its relevance to the field of Design. It explains to the reader the candidate’s geographical context and the global event that influenced the thesis.</td></tr>
<tr><td>Chapter 2
Paths to Virtual Reality: The concepts of reality and virtuality
2.1. The immersive experience of panoramic paintings
2.2. Collective reality simulation: The Matrix as an alternative reality</td><td>It explains Virtual Reality under the following approach: first, it defines the concepts of reality and virtuality in isolation; then it argues about the terms together. Historically, it explores the precursor discussions of VR.</td></tr>
<tr><td>Chapter 3
Immersive technologies: The evolution of devices and experiences in Virtual Reality
3.1. First experiments and prototypes
3.2. VR as a new reality: From science fiction to serious practical attempts
3.3. The new age: 21st century VR theories, technologies and applications</td><td>It presents the historical contextualization of VR technologies and devices, starting from initial prototypes to technological predictions worthy of science fiction, and to the practical devices that preceded the VR market today. It describes the current VR enabled devices and how its applications have been used in the most diverse fields.</td></tr>
<tr><td colspan="2">Chapter 4
Research design
4.1. Research topic
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4.3. Research object
4.4. Research questions
4.5. Research purpose</td></tr>
<tr><td colspan="2">Chapter 5
Research method, techniques, and procedures
5.1. Exploratory work on movement and interaction in VR
5.1.1. Scenario, types of movement and equipment
5.1.2. Final iteration
5.2. Semi-structured interviews
5.2.1. Interviews’ method
5.2.2. Interviews’ results
5.3. Web-based survey
5.3.1. Survey method
5.3.2. Survey results
5.4. Experiment: TAM for VR
5.4.1. Experiment proposal and research questions
5.4.2. Experiment design</td></tr>
</table>

Chapter 6 Results and discussion 6.1. Perceived Ease of Use (PEU) 6.2. Perceived Usefulness (PU) 6.3. Intention to Use (IU)	It presents and discusses the results of the final experiment, while relating them to the findings made from previous research procedures.
Chapter 7 Conclusion and future work	It presents the set of the most relevant conclusions of the thesis, answering to the proposed objectives and research questions. It describes the synthesis of what we intended with the research study, without extrapolating the scope of the data obtained.
Chapter 8 References	
Appendices	

2
Paths to Virtual Reality: The concepts of reality and virtuality

Through the use of specific hardware and software, Virtual Reality (or simply VR) technologies today assist in the replication of an imagined universe based on some notion of reality. The goal of VR is to create a sensory experience for people, whether for entertainment, health and education, or work and business-related purposes. However, several approaches to virtual reality date from a time when computing technologies and devices that we now know in the 21st century were not yet feasible. Examples of visual confusion between real or illusory things can be found in many different eras and cultures, as we will show in the upcoming pages.

In a nutshell, virtual reality means experiencing things and senses that do not exist, through mechanisms and tools such as computers. From this definition, the notion does not seem particularly new. After all, if we consider this broad spectrum of what entails virtual reality, then, when we look at a work of art, listen to a song, watch a movie or read a book – or even when we dream – we experience a notion, albeit abstract, of reality. This is because, in all of these contexts, we are somehow transported to a new environment.

A common conception of *virtual* is often the one used as a synonym for *digital*, that is, the computational capability of an artifact. Beyond that definition, the term can be explained as something latent, that is visible, but it does not exist, exemplified as the reflection of our body in the mirror. In this sense, *virtual* would be something either close to, concealed, or even masked as reality. In summary, we argue that *virtual* is the lack of perception of technology or interface mediating human mental absorption and the technologically reflected "thing". (Veszelszki and Benedek, 2017)

We may add that the association of *virtual* and *digital* not only is valid but also helped evolving the meaning of virtuality, since, while the first used to express a state of "almost" or "as good as" reality, today it encompasses the essence of what is simulated (Shields, 2003). In this sense, instead of an incomplete form of reality, *virtual* presupposes an alternative to what is real and can even be considered "better than reality" (Lister et al., 2009). As virtuality does not oppose the idea of reality, but rather defines a new type of it, what can we actually define as *reality*?

The way we as human beings comprehend the world occurs through the senses and systems of perception. Primarily, there are five basic organs of sense: sight, hearing, touch, smell, and taste. These are, however, only the most obvious sensory organs. The truth is there are many and more complex senses, such as, for example, the vestibular system, a structure that helps the human body to maintain balance. The integration of the different senses occurs automatically, and it is rare for humans to experience perception as a result of a single sense or sensory organ. The various sensory inputs ensure that human beings are able to receive a rich flow of information from the environment that surrounds them. In this respect, there is such a thing as an objective reality, independent of any conscious entity observing it. Nevertheless, it is impossible for this reality to be perceived exactly as it is, or even in a similar way by different individuals. Through the senses, human beings create their particular notions of reality, which results in what we call subjective reality. (Jerald, 2015)

If we consider reality as subjective, one may say that we never experience the physical world directly, but only a consciousness of reality. Thus, the perception of our surroundings goes beyond the limits of the "real" world, as virtual reality implies the brain acts as both a processor of a so-called objective reality but also as a generator of alternative subjective ones. In this chapter, we seek to discuss how the concept of Virtual Reality was approached at two specific moments in history. At first, through panoramic paintings from the end of the 18th century. We discuss how unlike conventional painting, which presupposed a single ideal point of view, the circular panorama invited a collective circulation of spectators, providing an immersive experience that preceded VR experiences today. Secondly, we reflect on Virtual Reality from the perspective of the Evil Demon, by René Descartes (Goldberg, 2016), exemplified in the 1999 film The Matrix, by Wachowski (Wachowski and Wachowski, 1999); and how the concept of presence in VR is linked to the state of consciousness when people are immersed – or not – in a virtual environment.

2.4
The immersive experience of panoramic paintings

Taking into account the strict scope of virtual reality as an illusory way of being present in a world of imagined things, it is worth examining panoramic paintings, extremely popular in the late 18th and early 19th centuries. After all, even though today a person in a hermetically sealed image illusion space – like a head-mounted display technology – seems like the precursor of virtual realities, VR itself is part of the core of humanity's relationship with images.

Virtual realities are based on artistic traditions that, in the course of history, have suffered ruptures and discontinuities. In the context of art, a panorama, or panoramic painting, was a large circular painting, a 360-degree mural, which aimed to fill the entire visual field of the spectator. This technique provides the same experience of being physically present in a painted scene. Coined by Robert Barker, the term panorama results from the combination of the Greek *pan*, or all, and *horama*, vision. The word explains the artist's enormous invention, a painting stretched horizontally along the inside wall of a cylindrical building, patented in 1787 (Huhtamo, 2013). The perfect fusion of the painting's edges, added to the hidden upper and lower margins, and the control of the incidence of light, culminated in a representation of an illusory environment:

> No device, to which the art of delineation has given birth, has approached so nearly to the power of placing the scene itself in the presence of the spectator. It is not magic; but magic cannot more effectively delude the eye, or induce a belief of the actual existence of the objects seen. There is a kind of infinitude in the form of a circle, which excludes beginning and ending; there is a kind of reality which arises from the spectator's ability to inspect every part in turn [...]. (Taylor, 1810 apud Huhtamo, 2013, p. 3–4)

The cylindrical aspect of panoramic paintings – which when viewed from the center offered a sense of a simulated world – provided an experience of spatial and temporal mobility. In this perspective, spectators were allowed to move in order to see the environments completely, represented in a perimeter that both involved and placed the viewer in the center of the exhibition (Hillis, 1999).

Finite visual environments prevent the spectator from external visual impressions, weakening the sense of immersion. With regard to panoramic paintings, however, by installing an artificial world capable of making the space of the image a totality, or at least filling the spherical visual field, it makes it possible to integrate people in a space of illusion and immersion (Figure 2.1). Here, immersion is described as an intellectual process in which the transition from one mental state to another occurs, shortening the distance between what is *seen* and the emotional involvement in what is *believed to be seen*. (Grau, 2003)

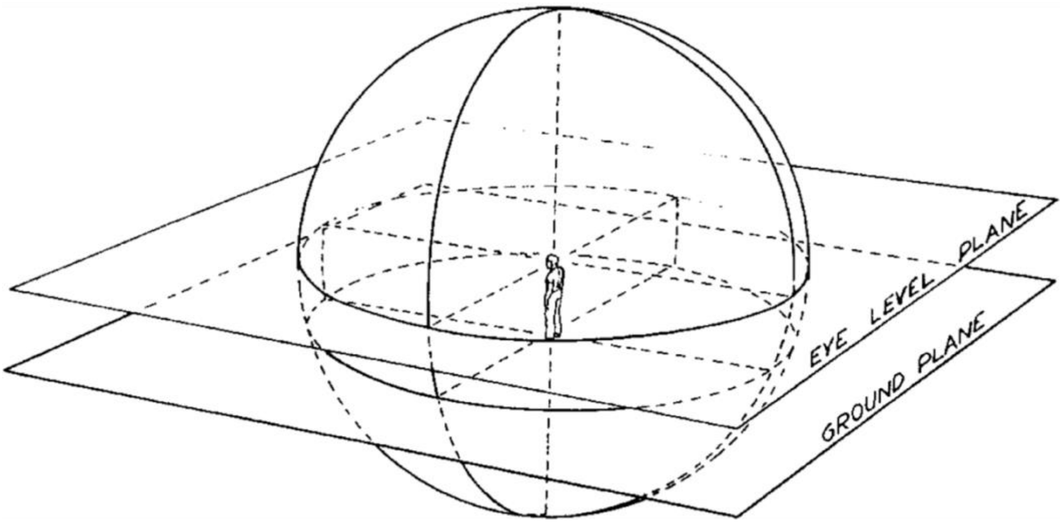

Figure 2.1 – Spherical visual field
Source: Wonders (1993 apud Grau, 2003)

Crucial to approach an immersive experience, the panoramic canvas should be painted and organized in such a way that the spectator is able to see a perfect representation of reality while taking a complete turn through the canvas. Thus, most of the patent for the Barker panorama specifies a layout including lighting arrangements, observation platforms, stairs, entrance, and even ventilation (Wood, 2016).

The first building by Barker was Rotunda, in 1793, designed by Robert Mitchell, and opened in London's Leicester Square, with two corridors and two observation chambers (Figure 2.2). The first chamber, the Large Circle, was 90 feet in diameter (about 27.5 meters) and 40 feet high (12 meters), and was capable of displaying panoramas of 10,000 square feet, that is, of about three kilometers. At this spot, the visitor was completely surrounded by the illusionist painting that hung from the circular walls of the building. The second chamber, the Upper Circle, accommodated a 2,700 square foot panorama (just over 820 meters). An inverted cone skylight lit the upper panorama, and a glazed annular ring the lower one. (Grau, 2003; Markus, 2013)

When Barker's patent expired, other artists started painting panoramas, but while other panoramic exhibitions were built, Leicester Square's offered the most realistic exhibits. This is because the building was designed to disorient people with regard to the perception of reality, since both the illusionist landscape and the panorama surrounded the viewer with pictorial images, creating an effect of the person being immersed in a real landscape (Grau, 2003). As shown in Figure 2.2, visitors to the Rotunda had to walk down a long dark corridor and climb stairs before emerging on the observation platform. This transition alone was already disorienting, and some people felt nauseous as a result of visiting Leicester Square.

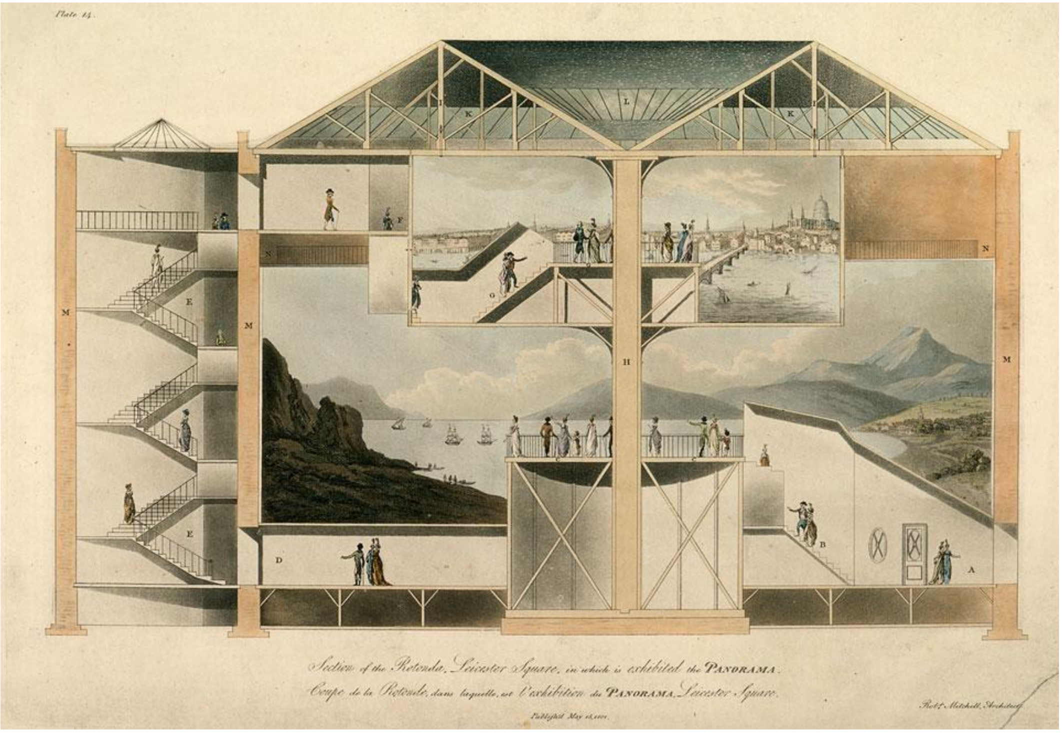

Figure 2.2 – Cross-section of the Rotunda of Leicester Square, showing the internal stairs and the observation platforms of the panorama (1801)

Source: British Museum[1] (2018)

Some critics have described the panorama as a "misleading" experience. The panorama's inability to transmit transient events, and other senses such as hearing, impaired the perfect illusion, resulting in a conflict between "what it seems to be" and the "truth" – a conflict that induces indisposition. In fact, the contradiction between corporeal reality and the illusion of artificial image is a challenge to rationality. The incongruity between the real and the virtual, in this context, causes

[1] British Museum. Retrieved May 18, 2019, from https://www.britishmuseum.org/

what is known as “simulator disease”, which compromises motor control, vision and gastric functions, in addition to causing apathy, disorientation, migraine, indisposition, and vomiting. (Grau, 2003)

Over the years, panoramic images have been adapted for photographic and cinematographic cameras, making them easily activated with digital devices. Since then, Barker’s concept of immersive panorama has been weakened, either by sometimes only indicating an elongated rectilinear composition (Figure 2.3) or by not adding new meanings and perception systems to the illusion.

Figure 2.3 – Example of panoramic photographic image today
Source: Gravity[2] (2018)

In short, the panorama entered the world not as a visual format, but as a claim to attract viewers to a particular relationship with their visual environment (Uricchio, 2011). Considering Barker’s creation from a contemporary perspective, we can deduce that it is close to what, at the end of the 19th century, we describe as Virtual Reality. This since Barker’s objective was to create a state of immersion for the viewer, albeit almost exclusively through visual means. However, although Barker’s conceptual formulation had a lot to offer with regard to Virtual Reality at the time, we argue that today the notion of VR includes the concept of panoramic, and not the other way around. Despite this, we consider it worthwhile to highlight

[2] Gravity. Retrieved May 18, 2019, from https://www.gravity.ir

the panorama when discussing VR for two main specific reasons: first, for its highly developed character of illusionism, through traditional methods of painting and architecture, and second, for its intended and intentional effect, a pre-calculated result of the use of technologies based on physical, physiological, and psychological knowledge.

2.5
Collective reality simulation: *The Matrix* as an alternative reality

The main objective of Virtual Reality technologies is to enable people to the illusion of being present in an alternative environment in contrast to their usual reality. This illusion is feasible when such an alternative environment is perceived as a credible place. There are two main factors that describe the VR experience from a biological and psychological point of view: *immersion* and *presence*. *Immersion* relates to the physical setup of the interface that mediates the human relationship and the simulated environment. In the case of panoramic paintings, for example, the interface is the whole apparatus that physically contributes to immersion, such as murals, lighting, observation platforms, among others. We can classify these interfaces, or VR systems, as fully immersive, semi-immersive or non-immersive, and these classifications relate to how much humans can perceive the real world while in the simulated environment. (Gutierrez et al., 2008)

Presence, on the other hand, is a subjective concept, associated with "user psychology", that is, with people's state of consciousness when feeling – or not – immersed in a virtual environment. The feeling of presence first happens when the human brain processes multimodal simulations, such as imagery, sounds, and haptic feedback, from the artificial environment. Then, it understands these as being coherent in a universe where one is capable of performing tasks and other interactions. In summary, people achieve a state of presence while conscious, deliberately or not, of being in a virtual environment. In this perspective, a clear sign of presence is when people behave in the simulated environment in a similar way to how they behave in the real world. (Gutierrez et al., 2008)

The concept of presence raises the question of Virtual Reality being tightly related to the scenario of the Evil Demon or Evil Genius, by René Descartes (described in *Meditations on First Philosophy*, 1641). Descartes' scenario is centered on the possibility of an evil demon that systematically deceives the human mind, stimulating it in order to provide sensations and experiences that seem normal. The scenario further explains that the evil genius acts under conditions where there is no world beyond its evil mind. (Goldberg, 2016)

Descartes' Evil Demon or Evil Genius hypothesis, in turn, was the premise that underpinned the 1999 Wachowski film *The Matrix*, in which the entire human race was placed in giant tanks, feeding a virtual reality from the hands of an evil artificial intelligence – ironically the result of the creation of humans themselves. An extreme hypothesis of the existence of an Evil Demon lies in a person who inhabits a world that consists only of themselves and a demon who is dedicated to deceiving them (Goldberg, 2016). In this alternative reality, nothing physical exists, and all human experiences are caused directly by the demon, which can be understood as some sort of entity with artificial intelligence. These experiences, which, in exchange, seem to prove the existence of an external world of physical objects – including the human body –, only give rise to systematically erroneous beliefs about said world.

In *The Matrix*, the main character, Thomas Anderson, or Neo, a daytime programmer who leads a second secret life as a hacker, discovers that the world he lives in is not real. There, he and all the other human beings on the planet were put into some sort of suspended animation with an advanced virtual reality simulator. The film centers on the concept that the world and the known reality are an illusion since they were destroyed in consequence of a war between humans and machines with artificial intelligence. In a nutshell, the entire human race is involuntarily trapped in a system called The Matrix. The goal of it is to make humans feel that they are in fact living an active life so that the energy they produce is used to feed the mechanical beings that really rule the world. (Wachowski and Wachowski, 1999)

In a clear correlation with Virtual Reality technologies, even in a fantastical nightmare scenario, humans are kept unconscious, and literally immersed in vats or tanks covered with liquid, connected to a central computer (Figure 2.4). What kept mankind perpetually submerged was a neurological interface with a simulation of collective reality (the so-called Matrix). In this state of immersion, humans experience a world in which everything – other people, objects, senses – is part of a complex computer-generated virtual reality. Everything they see, smell, and hear is part of this virtual construction, which, it is worth noting, does not exist. This shared virtual platform has become the alternative human reality, in which a computer program just stimulates humans' brains and deceives them into believing that everyone is living a normal life. Premise similar, therefore, to the scenario of the Evil Demon proposed by Descartes.

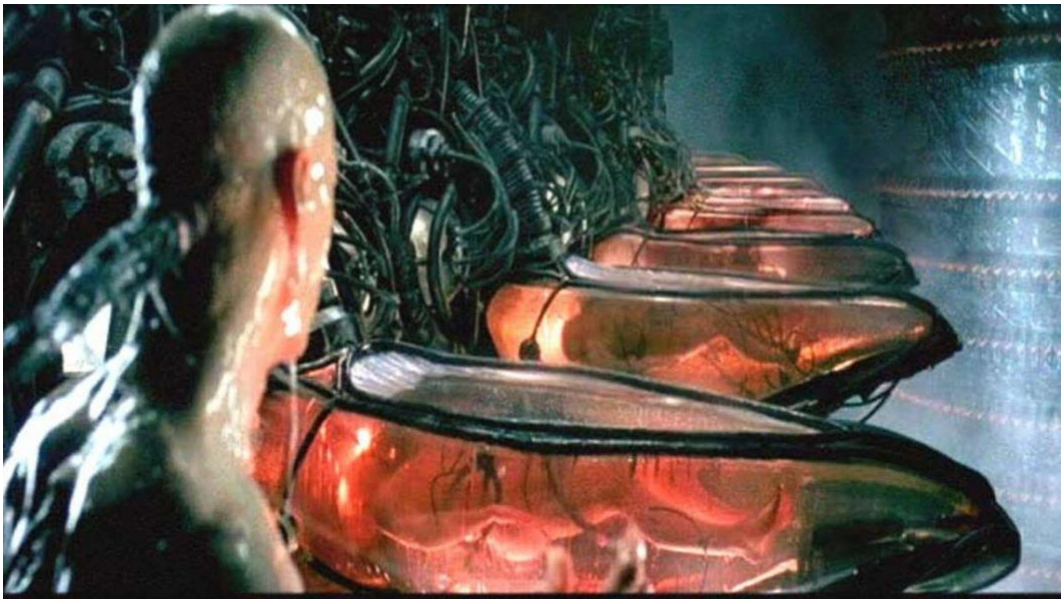

Figure 2.4 – Neo, the main character, "wakes up" and regains awareness of a virtual reality
Source: Wachowski and Wachowski, 1999

The film's central theme examines the idea that people, when exposed to certain stimuli, can become confused, or like in the extreme case of Wachowskis' work, even lose consciousness of reality. Accepting the possibility of the abstract concept of *The Matrix* really materializing involves many leaps of faith since there are no machines today (more than two decades after the film has aired) that reach levels of sensitivity like those portrayed by the film. This, in fact, is one of the most surreal things in the movie script, precisely because it is dubious to believe in a simulated reality that looks so much like the current reality.

However, advances in Virtual Reality happen daily. The VR scenario presented in the film is an extrapolation of existing technologies, but it allows us to reflect on areas of contemporary life where technology has already made artificial realities possible (Díaz-Diocaretz and Herbrechter, 2006). In this chapter, we discussed how the term Virtual Reality encompasses a number of complex meanings and leads to questions about the difference between reality and virtuality.

In the introductory paragraphs, we found that the *virtual* is not opposed to the *real* but an alternative reality that can be even better than what is real. The existence of a virtual reality presupposes an intellectual process of immersion, and, by immersion, we argue that the history of Virtual Reality begins with panoramic paintings.

In the 19th century, panoramic paintings became a place in which the viewers could immerse themselves in another perception of reality. In this context, the immersion factor, inherent to user experiences in VR, results from the physical setup of the interface that mediates humans and the simulated environment. Still in the topic of the user experience in VR, we briefly discuss the abstract notion of presence. Presence manifests itself when the human brain processes sensory stimuli and interprets them as coherent in a universe similar to the real one. An example of how presence is achieved is in the cinematographic science fiction *The Matrix*, that assumes the human race living and experiencing sensations, while absorbed, through technological devices that simulate virtual reality. In retrospect, the reflections shown here argue that Virtual Reality, more than a technology, is a concept based on theories about the human desire to escape the limits of the “real world”.

3
Immersive technologies: The evolution of devices and experiences in Virtual Reality

Until recently, the notion of wearing specific glasses and headphones and being virtually transported to an alternative reality belonged only to the realms of science fiction. Now, however, that is no longer the case, although the history of Virtual Reality goes back to various periods of time. To discuss the use of virtual reality devices and technologies, first, we decided to make a brief historical outline of the emergence of the first technologies, going through the stereoscopic instruments of the 19th century to the VR equipment of today.

3.1
First experiments and prototypes

One of the first devices to propose the transfiguration and visualization of images in three-dimensional objects date from 1830 to the 1950s in the 20th century, the period of the emergence and evolution of the first stereoscopic devices (Zone, 2014). These consisted of a pair of lenses through which an image was perceived in a three-dimensional way, being unintentional prototypes of today's three-dimensional (3D) glasses.

The word *stereoscope* derives from the Greek terms *skopion* and *stereo*, and is translated as "to see solid". The first type of stereoscope was invented by Charles Wheatstone – the "Father of 3D Technology and Virtual Reality" (King's College London, 2016) –, in 1838, and used a pair of mirrors at 45 degrees from the eyes, each reflecting an image located on the side. As a result, two flat images were superimposed on top of each other, and a volume (3D) image was created, thus making it possible "to see solid" under a three-dimensional effect (Figure 3.1). The Wheatstone stereoscope preceded the invention of photography and was produced using line drawings as images. (Zone, 2014)

Figure 3.1 – Stereoscope by Charles Wheatstone, 1838: stereoscopy creates the illusion of three-dimensionality from flat images by adjusting small changes in the angle

Source: King's College London (2016)

The word *stereograph*, or *stereography*, though, was first used by the American writer Oliver Wendell Holmes only in 1859, who explained the stereoscope as "an instrument that makes surfaces solid" (Holmes, 1859 apud Zone, 2014). Holmes, in partnership with Joseph L. Bates, was responsible for the accessible and mobile version of the equipment (Figure 3.2), known as the classic stereoscope used by millions of people during the golden age of stereography, from 1870 to 1920.

> By means of these two different views of an object, the mind, as it were, feels round it and gets an idea of its solidity. We clasp an object with our eyes, as with our arms, or with our hands, or with our thumb and finger, and then we know it to be something more than a surface. (Holmes, 1859 apud Zone, 2014, p. 12)

Figure 3.2 – Holmes and Bates stereoscope: affordable portable device
Source: Wikipedia Commons[3] (2018)

Holmes' unpatented creation was the most widespread stereoscope of the 19th century and, over time, new inventions were and still are being created as more sophisticated ways to stimulate sensory organs and human perception. This, especially, with the advent of electronics and computing technologies in the 20th century.

3.2
VR as a new reality: From science fiction to serious practical attempts

In 1929, Edwin Link developed the first commercial flight simulator for the purpose of providing sufficient manual experience for pilots in controlled environments. Completely electromechanical, the *Link Trainer* consisted of a stationary flight replica, with a motion drive platform that reproduced the actual movement patterns of a flight (Page, 2000). In World War II, more than half a million aviators and pilots used it to train and improve their flying skills (Ennis, 1981). Link' creation – him who believed that flight could be taught safely, on the

[3] Wikipedia Commons. Retrieved May 25, 2019, from https://commons.wikimedia.org

ground, through simulation – provided the first practical personification of VR (Nugent, 1991).

Years later, in 1935, the sci-fi tale by the American writer Stanley G. Weinbaum, *Pygmalion's Spectacles* (Figure 3.3), became the first fictional model to explore the notion of Virtual Reality. The story describes a system based on people wearing a pair of glasses that allows the human experience to take place in a fictional world that combines holography, touch, taste, and smell (Martirosov and Kopecek, 2017).

> First my liquid positive, then my magic spectacles. I photograph the story in a liquid with light-sensitive chromates. I build up a complex solution – do you see? I add taste chemically and sound electrically. And when the story is recorded, then I put the solution in my spectacles – my movie projector. I electrolyze the solution, the story, sight, sound, smell, taste all! (Weinbaum, 1935:2015)

Figure 3.3 – *Pygmalion's Spectacles*, Weinbaum's concept of VR
Source: Medium[4] (2018)

Although Weinbaum's tale was a science fiction story worthy of a cinematographic work, it was only in 1955 that Virtual Reality entered the world of cinema through the hands of writer and filmmaker Morton Heilig. Through the book *The Cinema of the Future*, Heilig explained for the first time his vision of an apparatus capable of stimulating multiple senses. In 1960, he received the patent for a first Virtual Reality Head-Mounted Display prototype (HMD, like the VR

[4] Medium. Retrieved May 22, 2019, from https://medium.com

glasses known today), the *Telesphere Mask*, and two years later, he also patented his *Sensorama* prototype. (Heilig, 1962; Thierer and Camp, 2017)

Both patents used stereoscopic effects in conjunction with other stimuli - via sound, smell, and touch - to grant users an immersive cinematic experience, simulating a scenario as if they were present in the film (Thierer and Camp, 2017). Sensorama, in particular, was a cabinet that enabled multisensory stimulation (Figure 3.4). The invention consisted of mechanical devices, speakers, a three-dimensional display, fans, odor generators, and a vibrating chair (Heilig, 1962). None of the technologies envisioned by Heilig materialized during his lifetime, but both helped to lay the groundwork for the VR revolution.

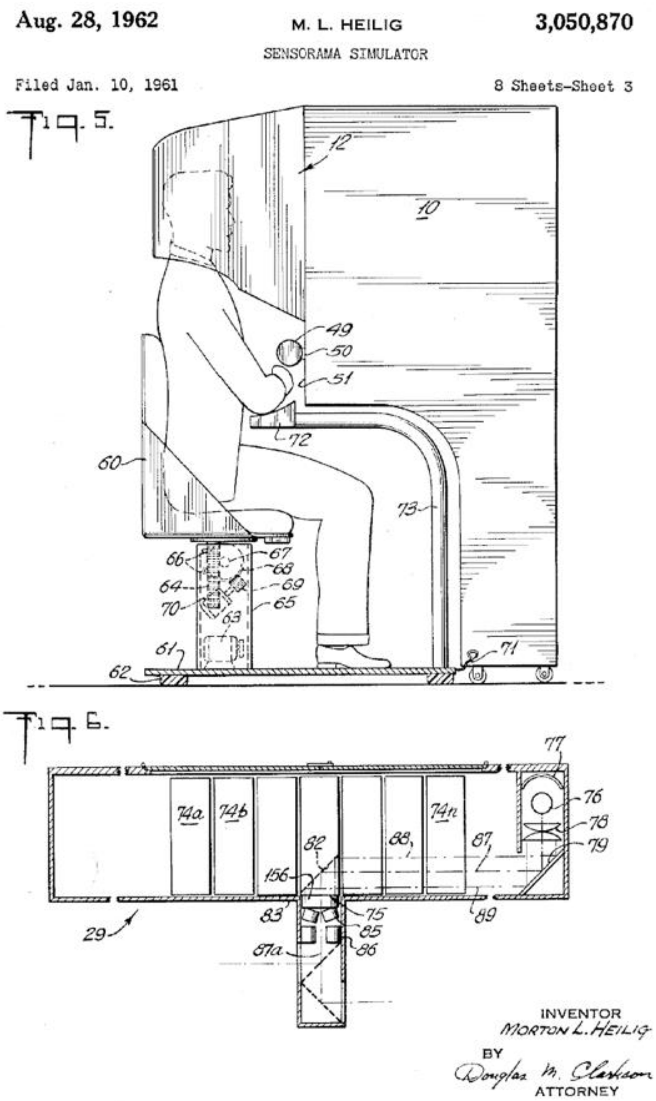

Figure 3.4 – Illustration by Morton Heilig for the *Sensorama* patent
Source: Heilig (1962)

The first real, functional HMD was created in 1968 by computer scientist Ivan Sutherland (Sutherland, 1968), one of the most important figures in the history of computer graphics. He developed the revolutionary *Sketchpad* software, which paved the way for tools such as CAD (Computer-Aided Design) (Earnshaw, 2014; Huang and Chen, 2017).

Described by the creator himself as the "Ultimate Display", the invention promised a Virtual Reality experience by connecting the HDM stereoscopic to a computer system. This system was able to show simple structure forms, while the technology incorporated in the device performed the head tracking, changing the person's visual field based on the movements of the head (Sutherland, 1968). However, the size and product design of the device provided an awkward user experience, since the weight of the device required it to be suspended from the ceiling by a mechanical arm, such as a periscope (Figure 3.5).

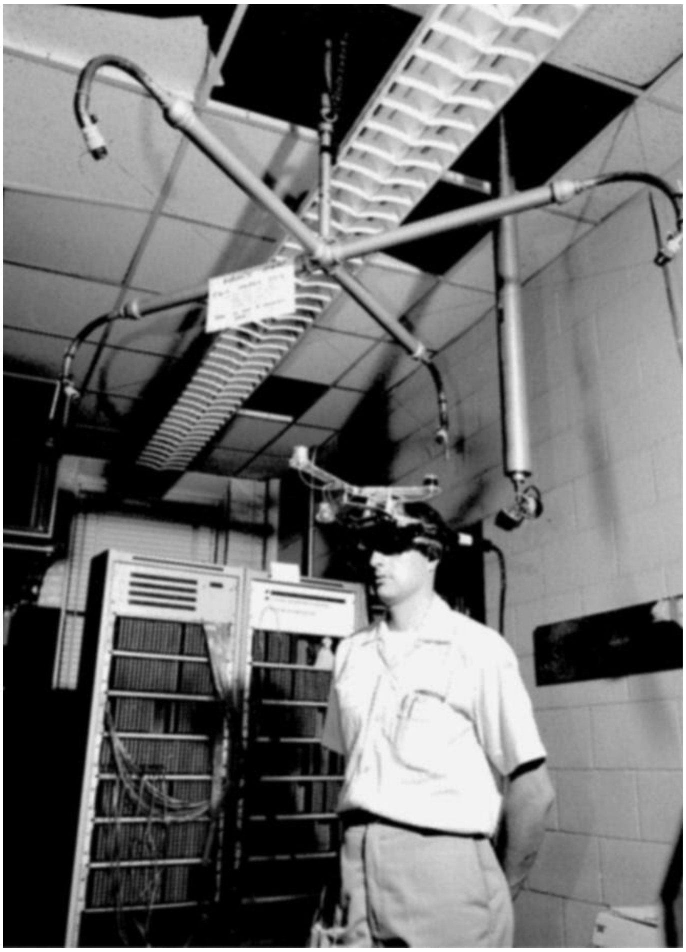

Figure 3.5 – The "Ultimate Display", by Ivan Sutherland
Source: Sutherland, 1968

Although concrete ideas about Virtual Reality, such as those by Ivan Sutherland – and, later, by VR pioneer Myron Krueger –, existed since the 1960s, technology began to take off only decades later (Faisal, 2017). Nevertheless, findings made at the time about an ideal interface to mediate human interactions with VR systems are proving to be more feasible, and more current than ever.

In 1969, computer artist Myron Krueger stated that the "final computer interface would be to the human body and its senses" (Biocca and Levy, 2013, p. 63). This statement has an even greater impact today when we consider that, in virtual environments, the computer makes use of the natural way in which humans interact with the physical world, by using intuitive movements and actions, to carry out commands. In this perspective, any and all types of body movement, conscious or unconscious, would be a possible input for a computer system (Biocca and Levy, 2013).

We can add to Krueger's idea of an interface by corroborating with what many theorists view as the ultimate goal of VR: to be a medium without an interface, or at least without a noticeable interface (Sherman and Craig, 2018). This, given that, in an ideal scenario, the human experience with VR would be designed in such a way that the frontier between people and the virtual world would be apparently non-existent. The interface would then emulate precisely how each person experiences the real world, without the need for new patterns or extra invasive devices in the interaction.

3.3
The new age: 21st century VR theories, technologies and applications

> Because of my liberal arts background, I had a much different idea about what computers were for, and so I imagined a more romantic search for a relationship between a human and a machine. I decided to try to find the essence of interactivity. [...] I just imagined what it would be like to use a computer in the extreme, sort of, and I thought that being able to move around physically was one of the things. I don't know why I thought all of this was important, but it just seemed to me that I was important and the computer wasn't. (VR pioneer Myron Krueger apud Schnipper et al., 2015)

The premise of Virtual Reality has always been based on an escapism in which people could get rid of real-world restrictions by being instantly transported anywhere. But "born of technology, virtual reality at its core is an organic experience", because although it happens when humans use a machine, "what happens is strictly within the mind" (Schnipper et al., 2015).

In 1970, Masahiro Mori, a robotics professor at the Tokyo Institute of Technology, wrote an essay introducing a concept called the *uncanny valley*. At the time, disregarded, today it applies to animated videos and video games and, by extension, is closely associated with the field of VR and most other media and experiences that visually depict humans. In his theory, Mori explained that when human replicas physically and behaviorally resemble real human beings, they can evoke feelings of strangeness and disgust, rather than increased affinity. That is where the "valley" in question resides (Figure 3.6). The professor explained the nuances in people's reactions to robots on a graph of *affinity* versus *human likeness*. In robots designed primarily based on functionality – industrial robots with rotating arms, but without faces or legs, for example –, there is little or no feeling of affinity – "whether they look similar [to humans] does not matter". On the other hand, when robots designed as toys focus more on human physical appearance, they consequently gain the attachment of children. (Mori, 2017, p. 2)

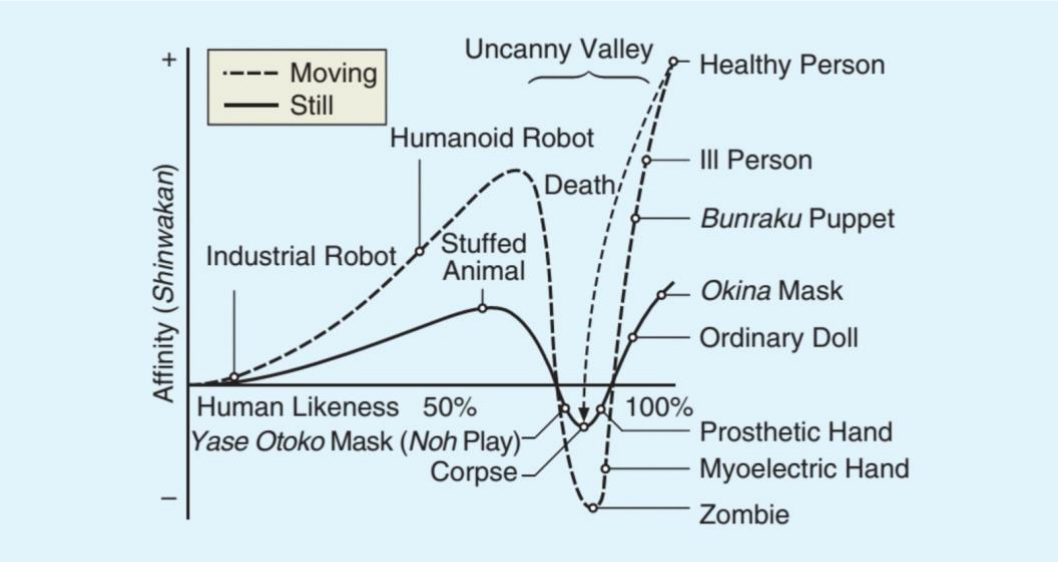

Figure 3.6 – The effect of movement in the uncanny valley graph
Source: Mori, 2017

The graph shows that as the *human likeness* (x) increases, so do *affinity* (y), and as a result, we can prematurely conclude that realism is good. However, this is only true to a certain extent. The peak of the *uncanny valley* can be noticeable when, in a highly realistic representation of a person, a handful of non-human aspects stand out, such as skin that looks like plastic, unreal facial expressions, or unnatural movements. When this happens, viewers tend to focus on those aspects and, at that point, the representation becomes disturbing. However, when a representation intentionally adds human characteristics, like expressive eyes, voice, or even character development, but without fully adhering to realism, viewers can connect emotionally with it.

Over the years, as computer graphics make dramatic progress in creating almost perfect representations that are barely distinguishable from reality, research is looking for ways to avoid the *uncanny valley* effect in virtual character design (Schwind, Wolf and Henze, 2018). In parallel, another theory expands the *uncanny valley* concept to an *"uncanny valley of mind"*, in which human likeness and attractiveness may result in people attributing emotions and social cognition to non-human entities (Stein and Ohler, 2017). Besides, in the field of linguistics, specifically in human-chatbot interaction[5], an experimental study showed that people experience fewer negative and intense psychophysiological reactions with bots designed with simpler text than with more complex animated avatar chatbots (Ciechanowski et al, 2019). Although it was not initially presented from a rigorous scientific perspective, Mori's hypothesis remains relevant today.

In 1975, while computer artist Krueger continued to iterate and bridge virtual realities and human interactions, his VIDEOPLACE piece was shown to the public, being considered the first interactive VR platform. Exhibited at the Milwaukee Art Center, in the United States, the platform used computer graphics, projectors, cameras and video monitors and position detection technology to generate silhouettes of real-life people, emulating their movements and actions previously recorded on the camera. It was an artificial reality that combined "a participant's live video image with a computer graphic world." (Krueger, Gionfriddo and Hinrichsen, 1985)

A few years later (1978), students at the Massachusetts Institute of Technology (MIT) created a virtual reality mapping environment called Aspen Movie Map, designed to replicate streets and buildings in the city of Aspen,

[5] A chatbot is a software tool that simulates human conversations. It is designed to interact with people through natural languages via text message or audio chats. (Ciechanowski et al, 2019)

Colorado (Figure 3.7). The system allowed people to go through a virtual experience, using an interface with a series of navigation buttons placed over the analog video image, which was the predecessor of systems like Google's Street View. Although both were serious attempts at immersive experiences, neither the VIDEOPLACE nor the Aspen Movie Map used glasses or any type of HMD as part of their setup. (Naimark, 2006)

Figure 3.7 – The Aspen Movie Map being experienced in the "Media Room" of the Architecture Machine Group, at MIT, in 1980

Source: Naimark, 2006

In the years that followed (1979–1987), VR initiatives continued to evolve when the VITAL visual simulator system helmet, the first suitable example of Virtual Reality HMD, began to be used outside a laboratory. The device used computer-generated images to assist US military pilots during flight simulation (Arbak, King and Adam, 1988). In addition to the growth of HMD technology, so-called data gloves, also known as wired gloves, cyber gloves or VR gloves, have started to emerge in the late 1970s. Wearable input devices with various hand movement tracking sensors, data gloves were connected to a computer system, and optical sensors were used to detect finger movement. Considered as precursors to gesture recognition, the gloves were first created around 1977, under the name Sayre Glove. However, one of the first gloves to be commercially distributed was only made available to home users a decade later, with the Nintendo Power Glove. (Zimmerman, 1985; Sturman and Zeltzer, 1994)

Even after all the development in VR technologies, there was still no comprehensive term to describe the field. Until, in 1987, computer scientist and VR pioneer Jaron Lanier coined, according to popular belief, the term *Virtual Reality*. Lanier was the founder of the short-lived VPL (Virtual Programming Languages) Research, Inc. (1984–1990), one of the first companies to develop and sell VR-related products (Figure 3.8). Along with NASA (National Aeronautics and Space Administration), VPL was responsible for the creation of DataGlove, a device that uses a glove as a form of input, and EyePhone, an HMD unit used to visually immerse its users in a virtual environment. Both the gloves and the HDM are still the most popular representations of the VR industry today. (Churchill, 2011; Basu, 2019)

Figure 3.8 – VPL Research equipment being used in the 1992 science fiction film *The Lawnmower Man*, which had VR as its central theme[6]

Source: Leonard, 1992

In the 1990s, when companies like Nintendo and Sega forayed the consumer market with the ill-fated Sega VR and Virtual Boy systems (Basu, 2019),

[6] *The Lawnmower Man* is centered on Dr. Lawrence, a scientist who believes he can increase human intelligence using virtual reality. To test his theory, he conducts a series of VR-related experiments in Jobe, an intellectually disabled lawn mower. Jobe learns to play simple VR games before developing telepathic skills that cause strange hallucinations in their virtual worlds. (Leonard, 1992)

respectively, the technology also became a milestone in the healthcare industry. This happened since, in 1997, researchers from Georgia Tech and Emory University in the United States began testing the *Virtual Vietnam VR* scenario with Vietnam War veterans who were diagnosed with Post-Traumatic Stress Disorder (PTSD) (Rizzo el al., 2015). VR was an important aspect of PTSD treatment and research at that time and remains so today, since controlled exposure to traumatic triggers provides a safe environment for treating the symptoms of the disorder.

Examples of the use of immersive technology in healthcare can be observed in research to help people who have suffered trauma following physical aggression (Freeman et al, 2013), or to predict the occurrence of PSTD symptoms (Freeman et al, 2014). Meanwhile, there are also notable investments in the field, such as that of the US National Science Foundation, which awarded a US$1.2 million grant to a team of researchers from Georgia Tech, Emory University, and the University of Rochester to help develop a computational assessment toolkit for PTSD patients and their physicians (Mitchell, 2019). Virtual reality simulation has also aided in the acquisition of robotic surgical skills (Bric et al., 2016), for instance, where VR-based navigation environments were found to improve the performance of participants in surgical training (Cagiltay et al., 2019).

In the 2000s, Google improved its map service by introducing Street View (2007), with web-based 360-degree panoramic views of street-level imagery. Highly effective in simulating an immersive experience, the images were, only a few years later, rendered using a stereoscopic 3D mode (2010). Then, people could move to almost any part of the world and look around as if they were physically present in the chosen location. (Anguelov et al., 2010; Basu, 2019) (Figure 3.9)

Figure 3.9 – Neuschwanstein Castle in Schwangau, Germany, is one of the 3D destinations in Google Earth VR

Source: Google Earth VR[7]

Following Google's initiatives, in 2012, Palmer Luckey, co-founder of the pioneer *Oculus*, created a project on *Kickstarter*[8] to raise funds for the development of his *Oculus Rift*, a new VR headset designed specifically for video games that intended to change the way people think about gaming (Figure 3.10). The device was intended to provide a truly immersive experience that would allow its users to "explore new worlds like never before". Luckey's project was extremely successful, raising nearly US$2.5 million from around 10,000 contributors – having initially asked for US$250,000 (Luckey, n.d.). Two years later, *Oculus* was purchased by Facebook[9] for US$2 billion (Solomon, 2014), creating a divide between the commercial failures of consumer VR in the past and its modern revolution, ushering a new era of VR HDMs.

[7] Google Earth VR. Retrieved July 20, 2020, from https://arvr.google.com/earth/

[8] *Kickstarter* is a global crowdfunding platform that allows users to start campaigns to raise money for their projects. Kickstarter: https://www.kickstarter.com/

[9] Facebook Technologies, LLC: https://www.oculus.com/store-dp/

Figure 3.10 – *Oculus Rift* prototype from Palmer Luckey’s crowdfunding
Source: Luckey, n.d.

By converging technological advances in small, high-resolution monitors and motion detection devices, several companies started to bridge the gap between cutting edge research labs and the general public. As the cost of Virtual Reality headsets started to drop, the technology became practically mainstream, from *Google Cardboard* (2014), where users can experience virtual reality in an affordable way, to *Samsung Gear VR* (2015) – released in collaboration with *Oculus* –, and *PlayStation VR* (2016), to name a few.

Figure 3.11 – *Google Cardboard* (2014), a fold-out cardboard viewer into which a smartphone is inserted

Figure 3.12 – *Samsung Gear VR* (2015) (left), and *PlayStation VR* (2016) (right)
Sources: Google Cardboard, Samsung Gear VR and PlayStation VR[10]

In 2018, standalone VR headsets, with built-in screens, processors and storage, start to emerge. Since they do not require setting up external sensors or devices, they are relatively inexpensive and affordable when compared to previous headsets. The first standalone device from Facebook after acquiring *Oculus* was *Oculus Go* (Figure 3.13), with built-in spatial audio and an integrated microphone that allows people to experience maximum immersion, as spatial audio creates 360-degree sound around the listener. A year later, in 2019, the company released *Oculus Quest*, along with significantly more immersive and interactive content. Unlike *Oculus Go*, which is better suited for static experiments due to limited tracking capabilities, *Quest* offers full features in this area – with tracking both in the head and in the hands –, normally reserved for next-generation VR headsets connected to external devices.

Oculus Quest 2 is the successor to *Oculus Quest* and was launched in October 2020, with incremental updates that generated positive reviews. However, a mandate requiring users to log in with a Facebook account to use the headset and *Oculus* services was met with scrutiny. The *Quest 2* device was used in this thesis

[10] Google Cardboard, Samsung Gear VR and PlayStation VR. Retrieved on February 5, 2020, respectively, from

https://arvr.google.com/cardboard/
https://www.samsung.com/global/galaxy/gear-vr/
https://www.playstation.com/en-us/explore/playstation-vr/

as mediating equipment for our final experiment and will be shown and better described in Subchapter 5.4.

Figure 3.13 – *Oculus Go* (2018), an all-in-one headset: it contains all the necessary components to provide VR experiences and does not require a connection to external devices

Source: Oculus Go[11]

As Virtual Reality technologies and their reachability have progressed significantly and, as a consequence, are now being used in various ways, the expectation is that the emergence of new competitors in the market will make the technology even more accessible. From providing immersive gaming experiences to helping to treat psychological disorders and teaching new skills, VR has proven to benefit a wide range of sectors. In the automotive industry, for example, Jaguar Land Rover has used the technology to allow engineers to view life-size 3D models of components and simulate the performance of the entire vehicle long before physical parts are available for testing. (Land Rover, 2020). In retail, eBay launched the world's first VR department store in partnership with Australian retailer Myer.

[11] Oculus Go. Retrieved on April 3, 2020, from https://www.oculus.com/go/

In 2016, the two stores offered customers the opportunity to receive their own *shopticals* (Figure 3.14) – specially designed VR viewers available for free on eBay's website[12] – to start their VR shopping experience (eBay, 2016).

Figure 3.14 – eBay and Myer's VR *shopticals*
Source: eBay, 2016

Finally, VR apps have also been used to mediate common human interactions, such as job interviews, as happened in the recruitment process for Lloyds Banking Group, a British financial institution, in 2017. The organization became the first to use Virtual Reality in evaluating candidates, as people were introduced to a fully computer-generated environment, where they could move freely, pick up and drop virtual objects and participate in various scenarios to prove their professional skills (Lloyds Banking Group, n.d.).

In addition to the business field, VR apps are available for social networking through communities like *AltspaceVR*, *High Fidelity*, *Oculus Rooms* and *Oculus Parties* and *VRChat*[13]. On these platforms, people can host virtual meetings that

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[12] eBay – Virtual Reality Products: https://www.ebay.com.au/VR

[13] AltspaceVR, High Fidelity, Oculus Rooms and Oculus Parties, and VRChat. Retrieved on August 5, 2020, respectively, from

https://altvr.com/
https://www.highfidelity.com/
https://www.oculus.com/experiences/go/
https://www.vrchat.com/

mirror the real-life experience, moving from group chats to one-on-one conversations in virtual spaces, as would happen in face-to-face environments. Social VR communities also allow people to watch live shows, attend work meetings, classes and explore virtual worlds with others from anywhere in the world. Although VR, since its inception, has focused mainly on providing the senses of presence and immersion in a simulated reality, evolving VR experiences now seek to enable these similar senses, but now in shared and collaborative environments with groups of people.

4
Research design

4.1
Research topic

The presence of people in collaborative and interactive environments, such as work meetings and other business-related contexts, mediated by the use of Virtual Reality technologies.

4.2
Problem statement, justification and applicability

4.2.1 COVID-19 and its effects on work-life

At the end of 2019, we were surprised on a global scale with the start of a pandemic[14] that took on unimaginable proportions. In December of that year, in the city of Wuhan in China, the SARS-CoV-2 virus, a severe acute respiratory syndrome, was first identified in humans. The virus generates a rapidly spreading newly discovered infectious disease commonly known as coronavirus disease[15] (or COVID-19), which is transmitted through droplets of saliva or discharge produced in the airways of infected people. With flu-like symptoms and high lethality, it spread quickly across the planet. (World Health Organization, 2020a)

Numerous coronaviruses, first discovered in the 1930s, cause respiratory, gastrointestinal, liver, and neurologic diseases in animals, however only seven of these viruses are known to cause disease in humans. In the last two decades, three

[14] A pandemic is defined as "an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people" (John, 2001).

[15] On January 30, 2020, the outbreak of COVID-19 was declared a Public Health Emergency of International Concern (PHEIC). On March 11, it was characterized as a pandemic. (WHO, 2020b)

variations of coronaviruses and acute respiratory syndromes caused major deadly outbreaks: SARS-CoV, which began in China at the end of 2002; MERS-CoV, identified in 2012 as the cause of the Middle East respiratory syndrome; and now SARS-CoV-2 (COVID-19). (Tesini, 2020)

As of June 2020, there was no specific vaccine or antiviral treatment for coronavirus disease and, as antibiotics have been shown to have no effect against the virus, treatment consists only of symptom relief and supportive care, while people with mild cases may recover at home. That month, however, the World Health Organization (WHO) gave China approval for experimental “emergency use” vaccines, that is, for limited use in the armed forces and for people in high-risk occupations. By then, clinical trials had not yet been completed. On July 28th, there were close to 16,5 million confirmed cases of COVID-19 worldwide – in 213 countries and territories –, with over 650,000 deaths (Worldometer, 2020; WHO, 2020a). Among the preventive measures indicated by the government and health agencies are social distancing, the widespread use of surgical face masks in the vicinity of other people, frequent handwashing, and avoid touching the face with unclean hands. While cough etiquette, use of face masks, and social distancing are deemed crucial to limiting droplet transmission, hand hygiene is important to prevent indirect contact transmission. (Norwegian Institute of Public Health, 2020)

In early December 2020, the United Kingdom became the first western country to allow mass inoculations against the disease and, by then, COVID-19 had already killed more than 1.4 million people worldwide (Mueller, 2020). From the moment this first coronavirus immunization program started until February 15, 2021, over 175 million doses have been administered, from at least seven different vaccines. Nevertheless, the impact of COVID-19 inoculation in the pandemic will depend on several factors. These include the effectiveness of the vaccines, the speed with which they are approved, manufactured, and distributed, and the possible development of other variants of SARS-CoV-2, since it is not uncommon for viruses to change and mutate. (WHO, 2020c)

Constantly tracked, the virus has been suffering variants, which may draw out the pandemic or make vaccines less effective. The phenomenon is spreading around the world, with variants being identified and notified since the beginning of 2021 in the United Kingdom, South Africa and the Brazilian city of Manaus, as some examples. All of these variants have been associated with an increase in the number of cases in the localities and may be leading to reinfections. This means that a variant may be able to overcome part of the immunity conferred by previous infections. To make matters worse, some of these new coronaviruses appear to be more infectious than others already in circulation. Thus, physical social distancing is still the most effective way to slow the spread of COVID-19, and self-isolation is an important measure taken by those who have symptoms to avoid infecting others in the community, including family members. (Centers for Disease Control and Prevention, 2020; Corum and Zimmer, 2021; WHO, 2020a)

Social distance implies that people are physically separated, keeping at least one meter away from others. This is a general measure that everyone should take, even if they are symptom-free and well, with no known exposure to COVID-19. Isolation, on the other hand, means separating people who are ill with symptoms of COVID-19 – and may be infectious –, to prevent the spread of the disease. Finally, quarantine means restricting activities or separating people who are not sick, but who may have been exposed to the virus. The goal is to prevent the spread of the disease at a time when people have not yet started or have just begun to develop symptoms. (WHO, 2020a)

Due to the need for distance or social isolation, different levels of so-called lockdowns began in the early days of March 2020 around the world. Lockdowns are a requirement for people to stay where they are, due to specific risks to themselves or to others. At the end of that same month, it is estimated that close to one-third of humanity was already experiencing some type of social isolation due to the coronavirus. In May 2020, altogether 94% of the world's workers were living in countries with some type of workplace closure measures in place. (United Nations, 2020a)

As a result of the pandemic, huge losses of working hours are expected, equivalent to approximately 305 million full-time jobs worldwide (UN, 2020a). Therefore, in the search for a "new normal", that is, a new stable and safe way of living in times of pandemic, society has been discussing policies for remote work. This is because working from home would be a crucial facilitator of commercial and economic continuity in the days of COVID-19, while also having the potential to play a part in future emergency scenarios, especially now that it has been proven that such a thing can happen (Farrer, 2020).

Although for many professions the possibility of remote work is minimal, there are activities that can easily be done outside the usual workplace, ranging from the field of accounting and finance, including careers in IT, sales, marketing, and customer service, to the medical and healthcare sectors (Bloom, 2020). But even for companies whose employees are already comfortable working remotely and using digital channels, the age of social distancing may require entire teams to work remotely full-time. Technologies for remote communication, in this sense, may have to replace not only team meetings but even the serendipitous small talks during coffee break.

Teleworking[16] has been around since the 1970s, due to the development of Information and Communication Technologies (ICTs). When ICT-based mobile work came later, people were able to work not just from home, but from virtually anywhere. Covering communication tools, from the most rudimentary like radio and television to mobile phones, computers and devices enabling video conferencing and distance learning, over the past 20 years ICTs have become ubiquitous (Arshad, 2020). Although highly flexible cloud-based work, accessible from anywhere on the planet via smartphones, for example, makes the term *telework* seem outdated, the fact is that the use of ICTs has profoundly changed the processes and procedures of almost all business forms. To that effect, some might have expected that at some point in the future people would be mostly working remotely, albeit the challenges in working outside the company office during the pandemic proved that this is still not a general practice for all workers. (Eurofound and the International Labour Office, 2017).

4.2.2 Virtual Reality for remote work

As previously shown in the literature review, several research studies were conducted arguing the use of some kind of virtual environment to benefit people beyond entertainment purposes. For example, a study sought to explore how design reviews can be supported by pre-meeting virtual reality environments, using a non-

[16] It refers to a work arrangement that allows for employees to work during any part of regular paid hours at an approved alternative worksite (e.g., working at home), and it is generally referred to as remote work. (U.S. Office of Personnel Management, n.d.)

immersive tool running on a laptop – and not requiring a head-mounted device. In the prototype developed for the study, a virtual environment allows people to browse individually and comment on an ongoing project before a design review meeting. (van den Berg, Hartmann and de Graaf, 2017)

Another work advocated the use of virtual reality avatars beyond the gaming world, suggesting digital twinning[17] as a way for people to visually appear as themselves when inside a virtual environment (Figure 4.1). This feature would be especially valuable for applications that involve interaction between people where they would like to represent themselves, not alter egos, as would happen in a virtual work meeting. In this study, the avatar prototype is limited to a visual similarity of the person, but ideally, in the future, it would also allow to replicate the way people walk and talk. (Ross, 2016)

Figure 4.1 – Example of digital twinning being used to design, test and calibrate products and processes in the virtual world

Source: Siemens[18]

[17] A digital twin is a digital replica of a living or non-living physical entity, such as an object or a person, being a bridge between the physical and the digital world. (Ross, 2016; Güner, 2020)

[18] Siemens. Retrieved July 21, 2020, from https://new.siemens.com

In addition, investigations into the use of Virtual Reality and mixed media to allow fully remote or hybrid meetings have been going on for more than two decades. In 1999, a patent of a system for implementing multiple simultaneous meetings in a virtual reality mixed media meeting room was issued (McNerney and Yang, 1999). The patent claimed a telecommunications system in the form of a mixed media virtual reality conference interface, able to manage the participation of conferees each equipped with a different terminal device (Figure 4.2). The system presented people with a visual representation of a conference room and its equipment, while emulating the physical appearance and presence of conference participants. In this scenario, people were able to switch between multiple virtual reality mixed media conferences that were simultaneously active, panning or traveling down a corridor that connected the various virtual rooms. Besides being able to move between the rooms, people could, at any selected conference, share and participate together in modifying conference presentations and materials.

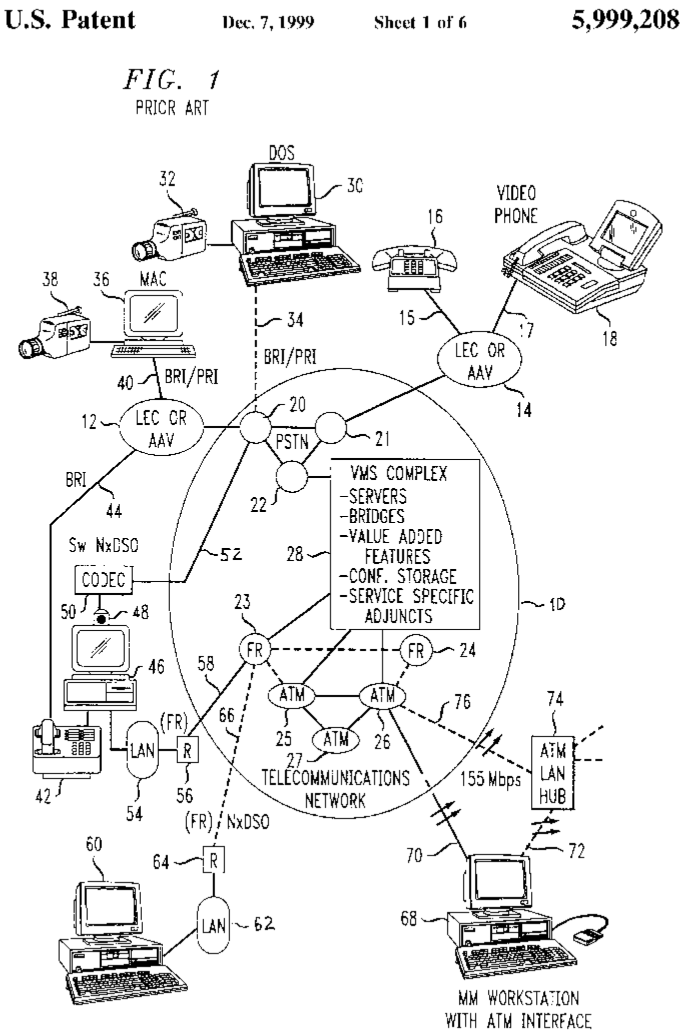

Figure 4.2 – Patent for a system for implementing multiple simultaneous meetings in a virtual reality mixed media meeting room

Source: Google Patents[19]

Still in 1999, scientists defended a 3D virtual space for casual communication and meetings, to be held in a networked community called *FreeWalk*. The virtual environment of the meeting intended to provide a common 3D space where people could meet and chat freely, and represented the participants as polygonal pyramids, in which each of their live videos was mapped. For evaluation purposes, the study compared the communications carried out both on *FreeWalk* and, separately, on a conventional desktop videoconference system and in a face-to-face meeting. The results showed that the 3D virtual space is effective for casual meetings, as it allows people to explore and enjoy human interaction freely in a relaxed environment. However, the study also found that participants tend to focus less than in immersed virtual environments than in other environments. (Nakanishi et al., 1999)

Today, social VR spaces that enable people to collaborate and communicate remotely in a single virtual environment – as if each person is sharing the same physical location – are a possibility, although not necessarily mainstream. There are examples such as the use case of the *rumii*[20] platform, which covers the use of VR for educational, business and military defense purposes. Promoting itself as a way of connecting institutions with their teams in virtual private spaces, *rumii* maintains partnerships with Harvard University and the United States Air Force. In the case of Harvard, the platform allows students and instructors, each with their own avatars, to explore the pyramids and related sites on the Egyptian Giza plateau using VR headsets.

[19] Google Patents. Retrieved June 16, 2020, from https://patents.google.com

[20] rummi: https://www.dogheadsimulations.com/rumii

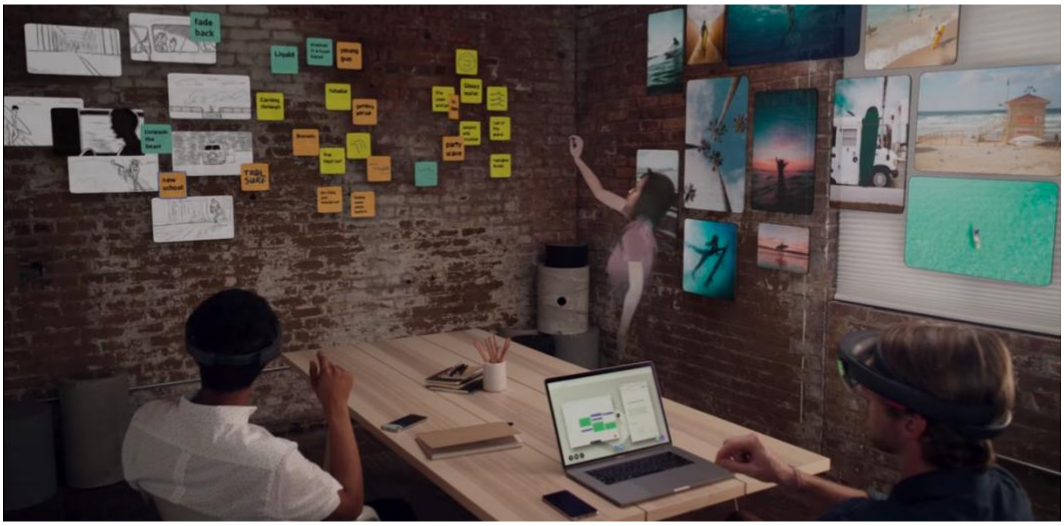

Figure 4.3 – From different physical locations, or using distinct devices, people collaborate with each other, organizing their ideas with virtual sticky notes

Source: Spatial

Meanwhile, with *Spatial*[21] (Figure 4.3), people can not only create their own realistic 3D avatar, rendered from a single two-dimensional (2D) image, but also enter virtual rooms from different types of devices. In this sense, the platform makes it feasible for teams to meet in a hybrid environment, where some can be physically together in the same physical space, while others can participate via: *Oculus Quest*, a standalone VR headset; *Microsoft HoloLens*, mixed reality smart glasses; *Magic Leap*, a wearable spatial computer suited to applications in Augmented Reality (AR); and via desktop computer or mobile phone (Figure 4.4).

[21] Spatial: https://spatial.io/

Figure 4.4 – Hybrid work meeting, with people participating from different physical locations and devices

Source: Spatial

Taking into account the context of virtual work settings, and more specifically those based on VR, an industrial case study sought to apply this technology in the teaching of daily Scrum[22] meetings (Yilmaz, 2018). To carry out the meetings, the study set out to create a virtual environment with virtual characters in order to enhance the learning experience of software professionals (Figure 4.5). Because Scrum requires well-functioning social interaction patterns to be effective, the research argued that using VR could help people feel immersed and engaged in the activity. This would be especially true with the integration of 3D virtual characters who have the ability to imitate verbal and non-verbal behaviors and convey distinct personality characteristics (Figure 4.5).

[22] Scrum is a framework for effective team collaboration in which a team can address complex adaptive problems in the product development, delivery and sustainability phases. A daily Scrum meeting is a 15-minute time-boxed event where people plan the work to be done for the next 24 hours. (Sutherland and Schwaber, 2017)

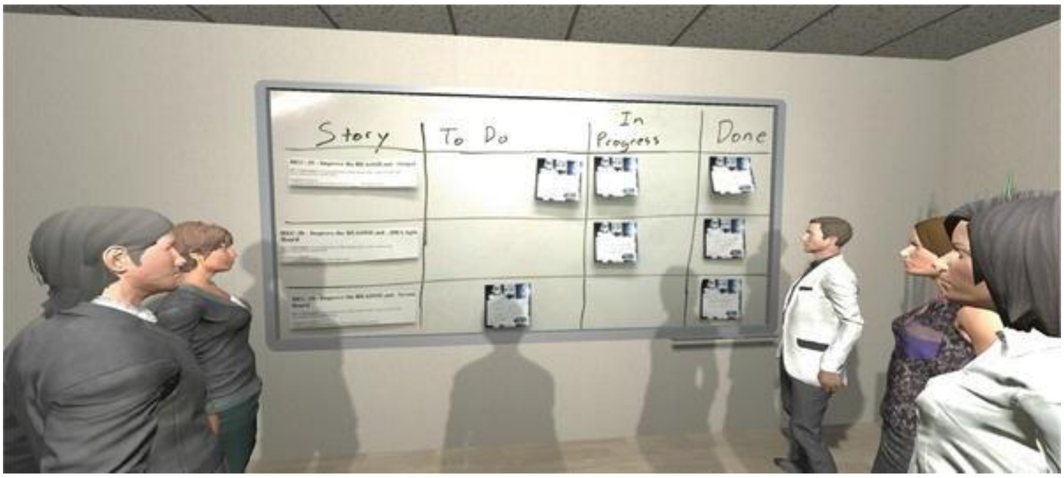

Figure 4.5 – A daily scrum meeting in a Virtual Reality environment
Source: Yilmaz, 2018

For the purposes of the study, five different virtual personas were designed. They were available to be selected by the real-life meeting attendees as avatars for the daily scrum meetings. The five personalities of the personas were based on the Ten-Item Personality Inventory (TIPI)[23] scale. The results observed that Virtual Reality significantly helped to improve daily scrum meetings in an agile development team. In addition, although first-time VR users experienced some stress during the orientation phase (before the meetings themselves), all the research subjects subsequently felt somehow immersed. Finally, even though the use of virtual personas and environments were considered to be engaging, the study highlighted that VR devices and applications still have some reachability issues. (Yilmaz, 2018)

In summary, with the advent of the COVID-19 pandemic, together with working life increasingly converging to environments such as remote offices, this thesis defends the idea of Virtual Reality as an alternative tool to today's digital solutions, potentially enhancing new work dynamics.

[23] TIPI is a brief assessment of the Big Five personality dimensions: (1) Extroversion, (2) Agreeableness, (3) Conscientiousness, (4) Emotional Stability, and (5) Openness to Experience. The items are rated on a 7-point satisfaction scale from 1, strongly disagree, to 7, strongly agree. Examples of the items to be rated include, "I see myself as extroverted, enthusiastic" (Extroversion) and "I see myself as dependable, self-disciplined" (Conscientiousness). (Science of Behavior Change, n.d.)

4.3
Research object

The ways in which people collaborate and interact with each other through the use of Virtual Reality technologies.

4.4
Research questions

Considering our problem statement, justification and applicability, we scoped them down and converted them into a set of workable research questions. This would mobilize our research purpose described in sequence.

RQ 1. What are some of the overall challenges regarding human experience and sensory limitations to VR environments?

RQ 2. Can these challenges be mitigated, and design solutions be customized to provide a better experience to people?

RQ 3. How work meetings take place, what types of remote or hybrid environments they might take place in?

RQ 4. What is the perception of people involved in these contexts?

RQ 5. Which are the different profiles of people in the context of fully remote or hybrid work meetings?

RQ 6. Can VR technologies provide greater involvement and engagement of people in work meetings whilst in fully remote or hybrid settings, and, by extension, be adopted and used in these contexts?

4.5
Research purpose

This thesis has the general objective of investigating if the presence of people in collaborative and interactive environments, such as work meetings and other business-related contexts, can be mediated in a beneficial way by the use of Virtual Reality technologies. To this end, we worked with the following specific objectives:

- To formalize the concepts of virtuality and reality, and how these terms relate to Virtual Reality;

- To understand what are some of the challenges related to human experience and sensory limitations to VR environments and how these challenges can be mitigated with the help of design solutions;
- To investigate how work meetings take place, what types of remote or hybrid environments they might take place in, and the perception of people involved in these contexts (human experience and technical difficulties);
- To establish if Virtual Reality technologies are able to provide greater involvement and engagement of people in work meetings whilst in fully remote or hybrid settings;
- To measure the acceptance or rejection of VR technologies as tools for fully remote or hybrid meetings.

5
Research method, techniques, and procedures

This exploratory research sought to establish that Virtual Reality technologies if used as a tool to help fully remote and hybrid work meetings, provide greater involvement and engagement of people during the activity, both in the in-person and in the geographically remote settings. Research of this nature aims to provide more information on a given subject, which may eventually lead to the formulation of one or more hypotheses or to the discovery of a new type of approach to the subject (Prodanov and Freitas, 2013). We chose to conduct this research in an exploratory way precisely because of the flexibility of its planning. We considered the transient context of COVID-19, our goal for discovering ideas and thoughts based on research questions, the nature of our research process being unstructured and our sampling non-probabilistic. Exploratory research design is suitable for studies that are flexible enough to provide an opportunity to consider all aspects of the problem. The quantitative and qualitative techniques and the procedures applied to answer our research questions are specified hereby.

In terms of first understanding the technical implications that influence the human experience in VR environments, we carried out exploratory work on VR movement and interaction. As it might happen with technical limitations in fully remote and hybrid meetings using video conference, this stage of the research was crucial to determine some of the technical aspects that people would potentially deal with when using VR technologies.

Then, we decided on conducting semi-structured interviews, to explore the issues related to work meeting settings in detail before formulating survey questions. To triangulate data, we carried out a web-based survey, as we intended to produce a larger amount of data in a short time period. The breadth of many people aimed to increase the likelihood of obtaining findings based on a representative sample, thus generalizable to a population. This led us to a better understanding of what the different profiles of people are in the context of work meetings, and to the recruitment of research subjects for our final experiment.

Finally, to establish whether and how VR technologies are able to provide greater involvement and engagement of people during these meetings, we conducted an experiment involving a modified Technology Acceptance Model (TAM). The experiment was designed to measure the adoption and use (acceptance or rejection) of VR technology based on people's attitudes. Originated from the psychological theories of reasoned action and planned behavior, TAM is a key model in understanding the human behavior that determines the potential acceptance or rejection of a technology (Marangunić and Granić, 2015). Details on the theoretical foundations of TAM and its application in this thesis will be further explored in Subchapter 5.4 (Experiment: TAM for VR).

5.1
Exploratory work on movement and interaction in VR

For the purpose of understanding challenges regarding the user experience and human sensory limitations to VR environments, including the effects of motion sickness, we decided to carry out exploratory work on VR movement and interaction. This preliminary study was conceived during the second semester of 2018, in the course *Tópicos em Computação Gráfica IV – Realidade Virtual* (Topics in Computer Graphics IV – Virtual Reality), taught by professor Doctor Alberto Barbosa Raposo, from the Department of Informatics at PUC-Rio.

The main objective of this exploratory work was to conceive a form of movement and way of interaction considering a simulated virtual space larger than the user's actual physical space. The results we obtained here help to substantiate the challenges to be worked on future developments of VR applications, including the ones to be faced in this thesis final study by our research subjects (Subchapter 5.4 – Experiment: TAM for VR). In short, we defined:

1. The scenario – both the simulated virtual environment and the user's actual physical –, the equipment, and the initial suggestions for movement and interaction.
2. The description of the final movement – defined after iterations on the initial suggestions –, the mechanisms to trigger it, and the interfaces and feedback provided to the user.
3. The changes made to the final movement, as the last iteration.

The development process of this work occurred through assessment sessions with eight people (including students, instructors, and the professor) over the course of a semester, in order to improve the applied techniques.

5.1.1 Scenario, types of movement and equipment

The use case scenario is set to be a simulated virtual city, already developed in the VR laboratory of the Department of Informatics. For greater flexibility in the choice of movements and interactions, we defined that the scenario in question would be a space city, in which the user – an explorer –, under the premise of low gravity, would be able to “float” in the simulated environment.

We envisioned three types of movement (Table 5.1) to be explored. These suggestions were determined during a brainstorming session between the course instructors and students. The user orientation and positional tracking, thus the actual physical space occupied by the research subject, were with the person standing or sitting. We did not incorporate movements that included the feet and legs since we wanted to guarantee the subject would remain in the same spot, and not compelled to move around the physical room. The equipment used for the experiment was the *Oculus Rift* head-mounted display, and the movements with hands and arms should be done with *Oculus Touch* controllers.

Table 5.1 – Description of the types of movement for the first iteration

Types of movement		Descriptions
	Swimming mode	To move forward, the person should make movements with both arms, as if they were "swimming" in the air
	Hook mode	The person would point the controller at a location they would like to go to and then press a button to trigger the action
	Directional mode	To change the direction of travel, the person should make a head movement, looking in the direction they wanted to move

Images' source: Sensoryx[24] (2020).

5.1.1.1
Swimming mode

For the first proposed type of movement, the swimming mode, the research subject should do movements with both arms – as if the person were "swimming" in the air. Such behavior would be registered only when both hands were simultaneously pressing a specific button, one in each *Oculus Touch* control. To cease the movement, the button should no longer be pressed.

The benefit of this type of movement lies in the fact that it is not affected by the size of the actual physical space in which the user finds him/herself, since the person is able to travel by only moving the arms, without dislocating around the physical room. However, a relevant negative factor to be addressed relates to

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[24] Sensoryx. Retrieved June 1, 2019, from https://www.sensoryx.com

tiredness, due to the strain put on the arms and muscles. The fatigue concerns the prolonged use of repetitive gestures with the upper limbs, which is required for the interaction. This factor was predicted in the preliminary empirical research discussed in class at the beginning of the semester, and also pointed out in the evaluation and demonstrations session.

Among feasible existing ways to mitigate the tiredness of the arms – while keeping the idea of "swimming" in space –, we found solutions like the *Space Fabric*[25] and the *Arm Swing*[26] movements. In the first one, the person enables the action by "grabbing" the air (as if it were a spatial tissue) and propels themselves in the opposite direction to the movement of the arms. In the second one, the person simulates the motion of arm swing, wherein each arm swings with the motion of the opposing leg. The bright side of the latter is that swinging arms in an opposing direction with respect to the lower limb is a motion naturally produced during walking.

5.1.1.2 Hook mode

In hook mode, the research subject should point with only one of the controllers to the location to which they would like to move. In the simulated environment, a visual cue would signal that the desired target is within range. To aid the aim, a light beam, commonly referred to as ray cast, would point to the target, and to initiate action, the person should press a control button. Based on the hook idea, we considered two variations of the movement, which were dubbed *Batman's* and *Spiderman's* hook modes, both described in Table 5.2.

A benefit of any of these alternatives for the hook movement is that, over long distances, they require less physical effort from the person, when compared to the swimming mode. One possibility would be to combine both swimming and hook modes, since, when switching between them during the VR experience, the person would have the possibility to rest their arms if convenient.

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[25] VRemedy Wants To Solve VR's Movement Problem (2017). Retrieved September 12, 2019, from https://uploadvr.com/vremedy-wants-to-solve-vrs-movement-problem

[26] Demonstration video of the Arm Swing movement (2017). Retrieved September 12, 2019, from https://www.youtube.com/watch?v=W1IM20Q3_ZQ

The disadvantage of the hook is that it puts the person at a greater risk of suffering from motion sickness, due to the rapid change in speed that occurs when they are “pulled” or “thrown” when the movement is initiated.

Table 5.2 – Description of alternatives for the *Hook mode* movement

Types of movement	Descriptions
Batman’s hook mode	By pressing a button, the person would be “pulled” at constant speed, through an imaginary line, being moved to the designated location. They would not need to keep the button pressed to maintain movement
Spiderman’s hook mode	After selecting the target, the person would keep the button pressed and make a movement to first “pull” the control as if to take the impulse to then “throw it” to the chosen location. The user should release the button to cease the action

5.1.1.3 Directional mode

We proposed the directional mode as a type of movement to help the subject to change the direction of travel. To activate this mode, the person should either make a movement with their head, looking in the direction to which they wish to move; or press down the joystick (a kind of analog lever) of the physical control, moving it left or right to rotate the virtual world.

The advantage of locomotion using the head movement is the fact that it is a more “natural” behavior to people. However, this mode would prevent the subjects from observing the landscape without accidentally changing direction during movement.

In turn, the use of the joystick would leave the person’s head movement free. It would also not interfere with hand and arm motions since it would require the pressing of the button before proceeding with the movement. On the other hand, it is our assumption that moving with the aid of a joystick is a less “natural” behavior for people, which could potentially hamper immersion.

5.1.2 Final iteration

After suggesting the movements, we began the implementation process, when we decided to focus on the hook mode, for displacement. We reasoned that it is a movement that enables the subject to reach great distances in the virtual city, at the same time that it requires less physical effort and promotes entertainment.

In this context, we anticipate two main scenarios (Table 5.3) likely to trigger the phenomenon of motion sickness in the user experience, namely:

- The change of speed at the moment of the displacement and its subsequent discomfort, amplified during accelerated descent;
- The abrupt stop against an obstacle (e.g., a city building).

The decisions we made when implementing the movement, therefore, sought to address these points and mitigate their effects, as far as possible.

Table 5.3 – Scenarios and potential design solutions to mitigate the effect of motion sickness

Expected scenarios	Design solutions
Displacement and change of speed, with emphasis on accelerated descent	• Include vectors (arrows or similar visual cues) in the UI, indicating the acceleration before it occurs. This would seek to avoid an unexpected acceleration stimulus • Include small periods of acceleration and deceleration before and after displacement but keeping most of the travel at constant speed
Abrupt stop against an obstacle	• Make the person reappear in a position close to the previous one right after the impact occurs – for this purpose, add: ○ Visual cross-fades like fade-out and fade-in, techniques by which the image disappears and reappears gradually ○ Particles on impact (e.g., smoke, dust, etc.) ○ Or both combined • Or just prevent the collision from occurring

The implementation started with the definition of the travel period when people moved around the scene. After some experimentation, we opted for the movement to last a fixed period of 10 seconds. The travel speed would undergo a small acceleration at the beginning of the movement and decelerate at the end. The duration of the deceleration would be relative to the distance covered in the given fixed period.

To trigger the movement, the person should point to the desired location using any of the *Oculus Touch* controllers, with either hand, pressing the side trigger. At first, we tried to use the joystick as a trigger, but we ended up changing that decision. Bearing in mind that several factors make people's hands different, for example, grip and hand size, we find it unlikely that the comfort level would be similar for most or all subjects using the joystick. For this reason, we chose the side trigger, as it requires only a small amount of pressure to activate it. (See triggers in detail in Figure 5.1)

In addition to choosing the trigger, we established that the light beam (or ray cast) should exhibit a visual cue when directed at a specific target. We decided that the light would turn green when the desired location can be reached and red when it cannot (Figure 5.2). In this prototyping stage, the maximum distance that the person could travel by activating the hook mode would be 100 meters.

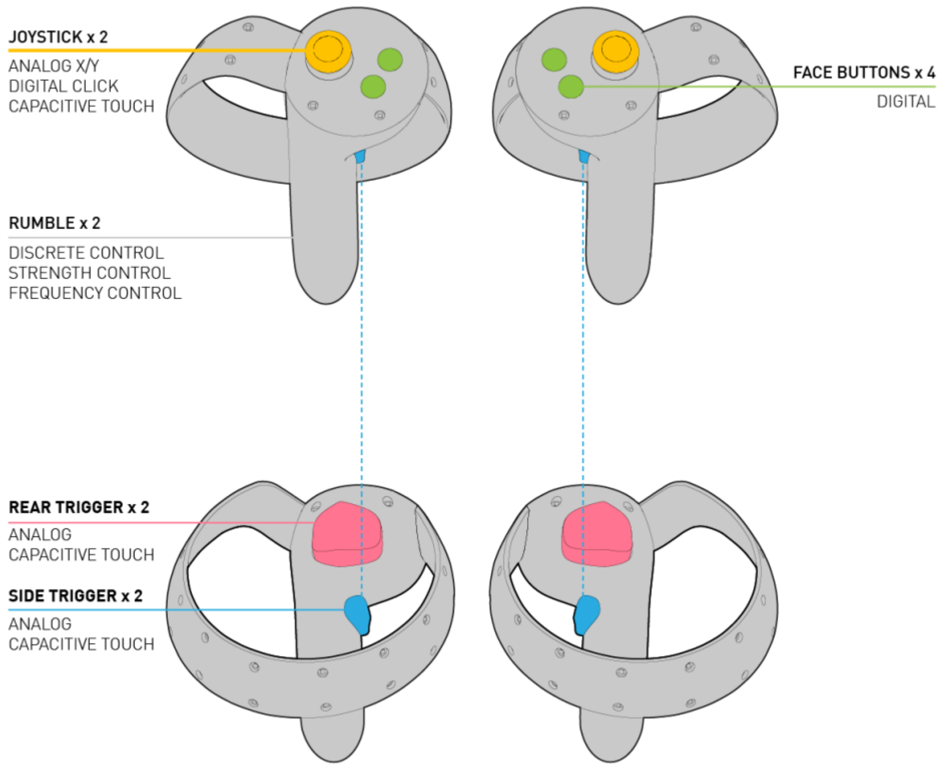


Figure 5.1 – *Oculus Touch* controllers' triggers
Source: Metanaut[27]

[27] Metanaut. Retrieved June 5, 2019, from https://metanautvr.com

Figure 5.2 – Light beam logic: when the movement is enabled, that is, within the maximum distance limit, the light beam remains green (left); if the target is too far away, the light turns red (right)

Source: Author’s own

During the experiment, we tested the speed of movement, considering that we wanted a change from acceleration to deceleration that could help to mitigate the feeling of motion sickness. In short, the motion curve would show an acceleration to the inflection point – a point on a continuous plane curve –, where we would end the movement with a slight deceleration.

Still, according to the research subjects, although the motion curve was considered comfortable when the displacement was stabilized in the course of the travel, the initial acceleration was still a sudden change in speed, which resulted in nausea. For this reason, we consider it necessary to develop ways to prepare the person for the start of the acceleration movement as soon as the movement is triggered. We proposed to create a “recoil” curve, in which the user would first be thrown slightly backward and then undergo acceleration, a movement similar to that of a slingshot. The speed of the recoil would be relative to the total distance traveled.

We tested a prototype of this VR experience during the last assessment session when we collected the analysis of the research subjects. Table 5.4 describes the problems addressed by the evaluators and the solutions developed for the final iteration before the end of the course.

Table 5.4 – Problems discussed during the assessment session and design solutions for final iteration

Problems' descriptions	ToDos	Design solutions
When moving around the scene, the person could accidentally collide with buildings and other obstacles, causing discomfort	Determine a way to avoid collision with buildings and other objects	We defined an invisible barrier around the objects, which would be the shortest possible distance that the person would be able to approach the limits of those objects to avoid a collision
Over short distances, the speed of the recoil before acceleration proved to be very fast and noticeable to the subjects	Change the speed of the recoil, at least for short travels	After unsuccessful attempts to customize the speed of the recoil according to different travel lengths, we tested and approved a fixed recoil, lasting one second, regardless of the distance traveled
In the specific case of the sudden change of speed in the hook mode, subjects suggested adding other cues besides the recoil to help to prepare people for the acceleration	Add visual or auditory feedback to the user interface, as they can potentially fill the cognitive gap of the lack of tactile experience	We chose to include a fast, wind-like sound, starting just before acceleration. In addition, we added background audio to help immerse people in the VR experience
When selecting a location to travel, the person was not sure whether the desired location was selected correctly	Include some kind of UI element to provide adequate feedback on the selected location or object	When aiming at an object (a building, for example) or place to which they wish to move, the person would receive visual feedback in the form of a light tower illuminating the selected item from above
In cases where the person wanted to direct the movement to a location out of sight (behind the back, for example), using only the directional mode required an extreme turn of the head, increasing the chances of motion sickness	Include another form of rotation, in addition to head movement in directional mode	We added a directional mode to be triggered with the controllers

With the results of this work, we gathered insights on how part of being truly immersed in a simulation is via realistic sounds; and how changes and additions in the visual UI and in the travel speed and length, for instance, can provide powerful feedback and mitigate discomfort. Several research initiatives have been widely conducted on these topics. When it comes to sound, the improvement of immersive Virtual Reality environments can also be achieved via hardware, featuring wireless speakers with location recognition for the configuration of VR equipment, as well as conventional surround sound systems (Lee, 2017). Meanwhile, with regard to people's sensitivity to speed mismatch in VR, this problem can be solved through software solutions. By accelerating and decelerating users as they move around in the virtual world, aligning them with their position in the real world, it is possible to offer people a seamless VR experience (Weser et al., 2016).

This exploratory work in VR helped us to better understand how the technology works, how environments, forms of movement and general interactions are built and what are the challenges in relation to human experience and sensory limitations that can be expected when dealing with VR applications. Besides, it challenged us to design customized solutions to provide a better experience for our test subjects. Following this stage of our study, we proceeded with our research purpose investigating how people co-exist in collaborative and interactive environments, but now, specifically, during work meetings and other business-related contexts.

5.2 Semi-structured interviews

5.2.1 Interviews' method

Conducted conversationally with one respondent at a time, the semi-structured interview is a qualitative data collection strategy in which the researcher initiates a conversation through pre-established topics. This method employs a mix of closed and open questions, for about an hour – which is considered a reasonable maximum duration, in order to minimize fatigue. It also allows delving into issues totally unforeseen by the researcher. (Adams, 2015; Given, 2008)

We opted for saturation as a criterion to discontinue data collection and analysis of the interviews. In this sense, we determined that saturation should be consistent with the proposed research questions and that, when similar instances and patterns start to emerge repeatedly, we consider the topic to be saturated.

The criteria established for the interview recruitment was that the research subjects should be currently employed in small to large companies in any sector and that these people should hold or attend meetings as part of their work routine. In regard to the aspects of the work meetings, they could be of any purpose, as long as the subjects have held or attended them also in fully remote or hybrid settings. By hybrid meetings, we refer to the ones in which a subset of the attendees is located together in the same place, and the other people join the meeting by conference call or web conference, for example.

The interviews were semi-structured to grasp an overview of how work meetings take place during day-to-day work environments, to then delve into the topics of remote and hybrid meetings, and its advantages, limitations, and challenges. We addressed the topics to determine:

- The size of the team with whom the interviewees work regularly and directly;
- The frequency of meetings the interviewees host and/or attend, both with team members and external parties, and how long they usually last;
- How many people, in general, attend said meetings;
- Where said meetings take place, including a brief description of the physical room and equipment;
- If there is sharing of material with the attendees, and via which media;
- The advantages of remote and hybrid meetings;
- The limitations and challenges of remote and hybrid meetings – what do they miss the most when compared to in-person meetings, and what would be best if they were physically present with the other attendees, among others;
- If they could envision a technology that could help them overcome the challenges of remote and hybrid meetings – what this technology would be able to do.

5.2.2 Interviews' results

For this part of the study, we interviewed six people, two from Rio de Janeiro, Brazil, and four from Trondheim, Norway, between January and March 2020

(Table 5.5). Before the start of the interview sessions, we asked the interviewees to sign a Research Informed Consent Form (Appendix A).

Table 5.5 – Research subjects from the semi-structured interviews – From January to March 2020

Interviewees	Age	Position	Location
I.N.	29	Business Manager	Trondheim, Norway
S.T.	24	Design Consultant	Rio de Janeiro, Brazil
T.A.	32	Software Developer	Trondheim, Norway
V.I.	37	Software Developer	Trondheim, Norway
S.B.	40	Product Designer	Trondheim, Norway
M.C.	31	IT Analyst	Rio de Janeiro, Brazil

According to I.N. (Personal communication, January 2020), a 29-year-old business manager from a Norwegian multinational telecommunications company, a combination of remote and in-person meetings are not uncommon, especially within a global organization. This specific setting helps to keep distributed offices connected on a weekly basis, and it usually consists of larger meetings between eight to ten people, "always with a screen involved". With the team divided, half working remotely and the other half with her in the local office, "one of the parties share the screen with a common document or a webpage with the Kanban board[28]". When not participating in these two-hour meetings with a large group, I.N. gathers most of the time in-person with smaller parties, for one hour, two to three times every week, and once a month alone with her manager, who attends remotely from another city.

Regardless of size, all of her remote and/or hybrid work meeting settings share some similar challenges: she considers it easier to misunderstand her remote co-workers, and vice-versa, due to "often things needing to be repeated because people talk at the same time over each other's (voices)". In other cases, the audio might be cut out due to bad broadband internet connection, or people are unaware if they are being understood and heard properly, due to technical difficulties.

[28] A Kanban board is an agile project management tool designed to help visualize work, limit work-in-progress, and maximize efficiency. (Rehkopf, n.d.)

"There is always some kind of delay in audio and video sharing, or people typing or talking off-screen without muting the audio, which makes everything noisier and more unclear." When it comes to larger meetings, she states that there is also the question of switching the attention among several people, in which the conversation does not flow "naturally". "Sometimes you just don't know who is the one speaking, and there is constant interruption." To add to the challenge, sharing visual content with the group can sometimes add friction in the communication. This is because, as reported by I.N., when a person is talking while sharing something, "*[sic]* some stuff gets lost, because of hand gestures (being hard to identify), and the face of the one speaking appearing in a small screen next to the (shared) document."

S.T. (Personal communication, January 2020), a 24-year-old newly graduated design consultant working for a start-up in Rio de Janeiro, Brazil, shares similar views with I.N., particularly in regard to engagement among people. "While in remote mode, we lose a bit of the personal, human connection, which is bad, because this is something highly appreciated by the company."

As she attends work meetings on a daily basis, either in-person at the local office, or remotely or in a hybrid way, S.T argues that when people are in a remote setting, the communication gets a little "stiffer". For her, there are two sides of the same coin: "On one side, people tend to get to the point, it can really feel more efficient, but there is also way less discussion, thus less exchange of knowledge and ideas. Everyone tends to get quieter, and (the conversation) concentrates on the same specific people."

S.T.'s usual physical setting when in her local office is a large meeting room with monitors placed on one of the walls. Her co-workers and her sit in a circular table facing the screens, where they can see their peers working from home, or stakeholders, during a demo presentation, for example. For her, as the number of people in remote mode increases, more problems surface, and the meeting tends to get "crazy": "(Depending on the meeting) it can be three to four people, but it can be up to 20. Then, you don't see the faces anymore, and it's crazy to follow. You just know that people are there, but you don't know what they are doing, and if they care (about what is being said or shown)."

The impersonal aspect of remote meetings was something also pointed out by both T.A. (Personal communication, March 2020), and V.I. (Personal communication, March 2020), 32 and 37-year-old software developers. Sharing open office space, on a daily basis, with 15 co-workers in an interdisciplinary team, they miss the in-person interaction when working from home. V.I. claims that, when she needs to work remotely, e.g., due to family logistics, she gets bothered by the imbalance between people talking over each other in juxtaposition with the lack of engagement from her and some of her peers. “People interrupting is the worst, it should be possible to just have one person finishing (a sentence) and another starting to talk, (...) but I know it is not people’s fault, it’s more because of latency.”

She explains, however, that, when the conversation becomes particularly difficult, she and some of the others end up shutting down as a result. This happens organically, either to make things easier or simply because of people being unable to follow the discussion: “When I decide to talk, sometimes they can’t hear me, my audio is lost, they keep on talking and then I’m lost! *[sic]* It’s just easier to try to listen (to them).”

Both interviewees attend a variety of meetings throughout their jobs – once a week with the whole team; several smaller ones to solve operational issues every other day; one-on-one monthly appointments with their managers; and board meeting sessions every other month. For most of these encounters, there are at least one or two people calling in via web conference, and visual content being shared, at a minimum, from text documents, slides presentation, boards with cards and sticky notes, and even lines of code. According to T.A., that’s when the challenges begin, even before the meeting starts. “*[sic]* First, not everybody can set up the equipment, then properly see what is being shown, (because) it’s blurry, or too small. (...) If the person sharing is not in the same room, it’s even harder, because what they see (in their screen) is not exactly what we see (in ours)”.

T.A. explains that among the challenges related to content sharing are the type of content being shared; the lack of compatibility of operating systems and software (e.g., sharing a Google Docs file with non-Google users); and different broadband internet connections (Table 5.6). That is why, as for him, “screen sharing happens once in a full moon.” “I don’t like when there is a lot of text, it’s much easier when the presentation is custom made for that purpose. In these cases, we normally only talk. (...) Also, if I can get the link to the presentation, it’s better, because my connection is faster than the one being shared”. He concludes that sharing of audiovisual content or any other materials should not interfere in the communication but help to mediate the meeting: "It doesn't matter how I show some code or if I share a URL, the alterations are not on the fly, so the exchange, the human part, they are the most important."

Table 5.6 – Technical limitations and challenges of fully remote and hybrid meetings, as reported by interviewees – From January to March 2020

<table>
<tr><th colspan="2">Technical difficulties</th></tr>
<tr><th>Limitations and challenges</th><th>Descriptions</th></tr>
<tr><td>Response delays and lack of synchronism</td><td>Audio and video being cut out due to bad broadband internet connection and latency</td></tr>
<tr><td>Problems first accessing the meetings via audio/video</td><td rowspan="2">Either due to lack of knowledge of the sharing tools or, e.g., due to lack of software compatibility
Besides overall nuisance during the meeting, it also wastes time, since the attendees must learn on how to use the features
Visual aids deemed too blurry or too small to comprehend</td></tr>
<tr><td>Problems accessing and sharing visual aids</td></tr>
</table>

Furthermore, when it comes to sharing visual aids, S.B. (Personal communication, March 2020), a 40-year-old product designer from a consultancy company, highlighted the frustration when attempting collaborative design team activities. "Writing in post-its in a virtual board is not the same as in regular boards. There is the voting part[29], the writing, things that you like to do in private, and then share. These are all missed (when on fully remote or hybrid mode), people are not as engaged." S.B. reasons that, to him, in-person meetings are always better, because "*[sic]* it's nice to have paper and people, you can explain as you go what you mean, (...) it's just less contrived."

Another limitation of fully remote and hybrid meetings relates to the impossibility of "milling around in a room", where one can choose to chat with a group of people and move from one group to another. S.B. pointed out this as an option worth considering when he envisions ways of improving web conferences, as not every work activity entails "sitting, talking, and looking at a screen." M.C.

[29] It refers to *dot voting*, a Design Sprint method to achieve group consensus around a single idea to address the Design Sprint focus. (Google, n.d.)

(Personal communication, March 2020), a 31-year-old IT Analyst to a multinational technology company, resonates with this thinking. On top of it, he emphasizes how the nuances of body language are easily ignored and difficult to decode across (usually) small screens (Table 5.7).

"*[sic]* When and how to react when someone is speaking, without disturbing? Should I wave? Maintaining a fluid conversation is challenging. (...) I guess, for me, the worst part is that when I speak on video, all people will see is my face, and I don't like to be on the spot(light)." M.C. is not alone in his concern, as I.N. also expressed similar feelings of self-consciousness: "It's distracting (to look at my own face), I keep imagining how other people are perceiving me."

M.C. also brought up the dichotomy of being too exposed and the disadvantage of being too hidden. "When I mute myself and turn off the video, I stop paying attention at some point." V.A. complements by stating that, once muted, it is possible to get all kinds of distractions while still listening to whoever is talking, to the point that "we are all just attending but not really participating anymore." She also explains that, by hiding, people accidentally create a scenario where no one keeps a record of who is at the meeting, which touches upon the matter of privacy. According to her, in large meetings, any person with access could join without being noticed, creating the risk of private information falling into the wrong hands if entry to the remote meeting is not adequately protected.

However, there are those who find that the challenges here observed might also work in their favor. M.C. admits to finding limitations of the remote communication, such as bad broadband internet connection, to be positive because it allows him to turn off the video without causing what he calls a "professional discomfort". "I don't want to seem antisocial, so if I can use this (bad connection) as an excuse, I will. I prefer not to use a camera."

Table 5.7 – Human experience limitations and challenges of fully remote and hybrid meetings, as reported by interviewees – From January to March 2020

Human Experience	
Limitations and challenges	**Descriptions**
Difficulty understanding and maintaining simultaneous conversations	• People talking at the same time, over each other, prone to misunderstandings • Hand gestures and other nuances inherent in body language being hard to identify • Noisy and unclear communication, e.g., when people forget to mute their audios
Lack of engagement	• Conversations that do not flow "naturally" • People shying away from participating, and the focus concentrated on the same specific individuals – resulting in less discussion, thus less exchange of knowledge and ideas • "Mute button effect": when someone is muted (e.g., in order to avoid noise) and is less present at the meeting as a result • Loss of a more personal and human connection
Interaction limited to a screen	Unlike physical meeting rooms, people are unable to walk around and move from one group to another
Fear of exposure	• Feeling uncomfortable about being the center of attention on a screen, or self-conscious of being able to see themselves • The risk of private information falling into the wrong hands if access to the meeting is not adequately protected

In summary, all six interviewees agree that even though challenging (Tables 5.6 and 5.7), remote and hybrid meetings allow for several advantages. First, they are great simply because they make it possible to interact with people from any geographical distance. Besides, for I.N., with remote meetings, it is easier to manage and schedule work appointments, and even to wait for the person if there is a delay or traffic. "If I'm the one working remotely from my computer, I can just do other activities while I wait, and then *[sic]* I can jump to the next meeting without needing a break to switch rooms."

S.T. bolsters this thinking by adding that remote or hybrid meetings are a convenient way to connect with external parties, not only in respect of time management – "they help to get people together without the trouble of actually synchronizing everyone's schedule" –, but also when the physical space is limited:

"We don't have a large conference room, so bringing everyone to the office would be difficult". V.I. adds that the possibility of meeting remotely means less travel and comfort, and to be allowed to acquire knowledge in a way that otherwise would not be feasible. "I actively participate in tech talks with my peers, which helps me to keep updated and visible in the industry."

At last, when asked to envision a future or technology that could help them overcome the challenges of remote and hybrid meetings, I.N. suggested for "a device or computer that could be positioned to view the entire body, in a suitable room." S.B added that it would be imperative to enable ways of collaborating creatively – and simultaneously – thorough writing and drawing, with the aid of image sharing tools. All that together with the ability to move around in the meeting room, interacting separately with a single person, small groups, or with the whole group. S.T. then concluded that the ideal future would involve a technology that could provide a greater immersion "so that people would not be restricted to just a small computer screen."

5.3 Web-based survey

In order to expand the results of semi-structured interviews, we decided to conduct a web-based survey. In doing so, we could follow up on the initial findings from the interviews and, at the same time, accommodate the points of view of more people. Furthermore, a representative sample would assist us in recruiting meaningful participants as our experimental research subjects, based on both qualitative and quantitative research.

5.3.1 Survey method

We designed the survey using the SurveyMonkey[30] online service, and the audience was reached by the service itself based on the target audience and the specific attributes defined by our study. This sampling method is called quota sampling. It is characterized as relatively simple and potentially representative,

[30] SurveyMonkey: https://surveymonkey.com

although the sample chosen may not be representative of all other characteristics that were not considered by the study. Respondents from the target population were drawn in Norway, as the subsequent experiment would also be carried out in the country, more specifically in the city of Trondheim. We aimed for responses from people of all genders, aged 18 years old and above, and who were employed in companies of any sector at the time the survey was to be conducted.

Before proceeding to the survey, we asked the respondents to answer the questions based on the experience in their current jobs. We requested them to evaluate the questions taking into account the coronavirus disease (COVID-19) outbreak and any changes that may have occurred in the workplace as a result of the pandemic. Thus, they were supposed to consider the previous five months of work when taking the survey. By accepting to participate in the study, the respondents agreed that their data would be used for research analysis and disclosed anonymously in this thesis and further academic publications.

The survey design covered three main topics in 13 questions (Table 5.8)[31]: general job and workplace information, meetings and collaborative work, and, in specific, fully remote and hybrid work meetings. The questions related to work in general sought to outline an overview of the respondents' work situation, such as the work environment, sector or main industry in which they work and the number of people with whom they work directly. When it came to meetings, we wanted to investigate the frequency, duration, setting and types of meetings, as well as people's preferred meeting methods. Finally, we divided the topic of meetings according to two remote work configurations, the fully remote and the hybrid meetings. We inquired the respondents on technologies and tools and their opinions on the pros and cons of such meetings.

We conducted 10 pilot tests prior to submitting the final survey and made main adjustments on grammar and question clarity. The estimated duration of the survey was approximately eight minutes.

[31] Some of the questions were reduced here for the sake of simplifying the text and making the chapter easier to read. The original version of this survey with its consent form can be seen in Appendix B.

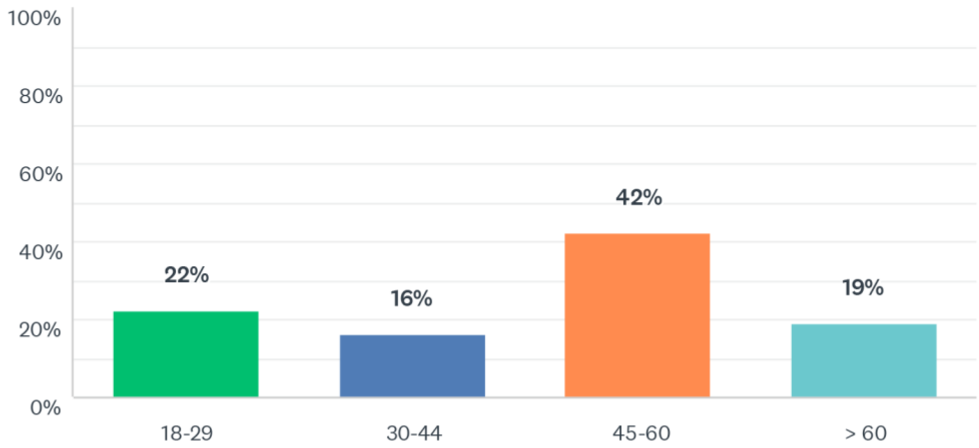
Table 5.8 – Survey design

Question	Type of question
General job and workplace information	
1. Which best represents the industry or core business of the company you currently work for?	Multiple choice questions (Maximum 2 options)
2. At work, what is your current position / title?	Open-ended question
3. Does your current company have more than one workplace?	Multiple choice question (Single answer)
4. Do you have the option of working from home?	Multiple choice question (Single answer)
5. What is the approximate number of people you work with directly in different physical locations?	Multiple choice question (Single answer)
Meetings and collaborative work	
6. How often do you attend meetings at work?	Multiple choice question (Single answer)
7. Most of the time, how is the setup of the meetings in your workplace?	Multiple choice question (Single answer)
8. In order of your preference, rate the ways in which work meetings occur.	Ranking question
9. What types of meetings do you have at work and what is the average duration of these meetings?	Matrix question
Fully remote and hybrid work meetings	
10. What technologies and tools do you and your team use during fully remote and hybrid work meetings?	Multiple choice question
11. In your opinion, which are the positive aspects and advantages of these meetings?	Multiple choice question
12. In your opinion, which are the negative aspects and disadvantages of these meetings?	Multiple choice question
13. What would you like to be able to do during these meetings, but that current technologies and tools have failed to help you?	Open-ended question

5.3.2 Survey results

The survey's completion date was July 21, 2020, with 108 responses completed. Our sample included 45 (~ 42%) women and 63 (~ 58%) men, aged 18 and over. The largest age group was between 45 and 60 years old, with 45 (~ 42%) respondents (Chart 5.1).

Chart 5.1 – Age group of survey respondents (N=108)



5.3.2.1 General job and workplace information

Regarding the core businesses in which people work, the responses were divided into 14 main sectors, in addition to other options – due to open-ended question –, including legal services, management consulting, real estate and full-time graduate students. The responses covered main sectors such as Health, Technology and Software, Education, and Marketing and Advertising (Table 5.9).

Table 5.9 – Core business of the company in which the survey respondents work (maximum 2 options) (N=108; descending order)

Core business or industry	
Answer options	**Responses**
Others (including legal services, management consulting, real estate and full-time graduate students, among others)	~ 26% (28 out of 108)
Health	~ 16% (17 people)
Technology and Software	~ 12% (13 people)
Education	~ 9% (10 people)
Marketing and Advertising	~ 8% (9 people)
Government	~ 7% (8 people)
Travel and Lodging	~ 6% (7 people)
Consumer goods	~ 6% (7 people)
Manufactured	~ 6% (7 people)
Retail	~ 6% (6 people)
Financial services	~ 5% (5 people)
Media	~ 5% (5 people)
Insurance	~ 4% (4 people)
Non-profit	~ 4% (4 people)
Logistics	~ 2% (2 people)

Approximately 73% (79 people) of our sample said that the current company they work for has more than one workplace. In this case, we consider companies that have people located in different physical locations, including those who work from home or located in different buildings in the same city or in different cities, states and countries. Also, during the COVID-19 pandemic, close to 55% (58 people) of the respondents claimed they had the option of working from home.

When it comes to the number of people with whom the respondents work directly in different physical locations, the majority (~ 79%, or 84 people) said they work with at least up to five people. Also, although 24 of the people (~ 22%)

claimed they never work with people based in different workplaces, 23 (~ 21%) do so with more than 25 co-workers. (Chart 5.2 and Table 5.10)

Chart 5.2 – Distribution of the number of people with whom the respondents work directly in different physical locations (N=108)

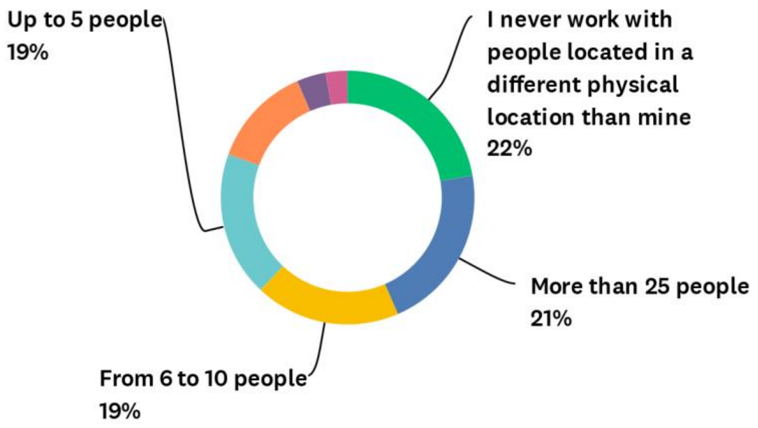


Table 5.10 – Approximate number of people with whom the respondents work directly in different physical locations (N=108; descending order)

Approx. number of co-workers in different physical locations		
Answer options	**Responses**	
I never work with people located in a different physical location than mine	~ 22% (24 out of 108)	
More than 25 people	~ 21% (23 people)	~ 79% (84 out of 108)
From 6 to 10 people	~ 19% (20 people)	
Up to 5 people	~ 19% (20 people)	
From 11 to 15 people	~ 13% (14 people)	
From 16 to 20 people	~ 4% (4 people)	
From 21 to 25 people	~ 3% (3 people)	

5.3.2.2
Meetings and collaborative work

Business meetings and other similar collaborative work are part of the routine of most companies and need not necessarily take place in a physical space where attendees meet face to face. Regarding the frequency of meetings among the respondents, considering a 5-day work week, approximately 73% (79 people) said that they attend one meeting at least once a month. Out of the 108 people, 36 (~

33%) claimed to attend one to four meetings during the week, while 26 (~ 24%) attend one or more meetings every day. (Table 5.11)

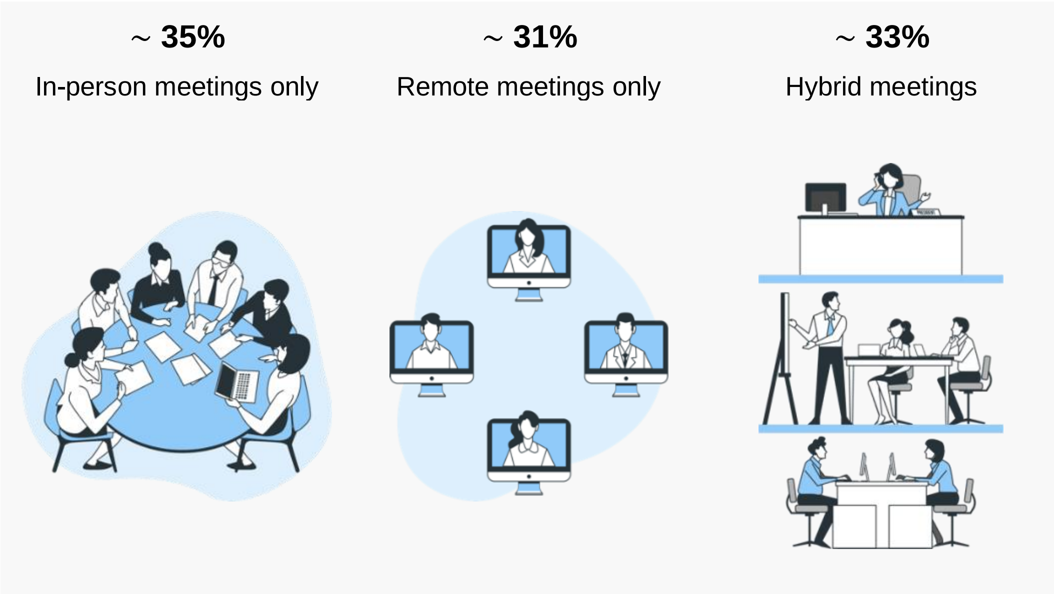
Table 5.11 – Respondents' attendance at meetings (considering 5 days a week) (N=108; descending order)

<table>
<tr><th colspan="3">Attendance at meetings (frequency)</th></tr>
<tr><th>Answer options</th><th colspan="2">Responses</th></tr>
<tr><td>I do not attend meetings often</td><td colspan="2">~ 27% (29 out of 108)</td></tr>
<tr><td>1 to 2 times a week</td><td>~ 20% (22 people)</td><td rowspan="5">~ 73% (79 out of 108)</td></tr>
<tr><td>Once a month</td><td>~ 16% (17 people)</td></tr>
<tr><td>More than once a day, every day of the week</td><td>~ 14% (15 people)</td></tr>
<tr><td>3 to 4 times a week</td><td>~ 13% (14 people)</td></tr>
<tr><td>Once a day, every day of the week</td><td>~ 10% (11 people)</td></tr>
</table>

In regard to the type of setting of the most frequent meetings, people's responses were evenly divided between the three answer options (Chart 5.3):

- 38 of the people (~ 35%) said to usually only attend in-person face-to-face meetings, that is, that occur in the same physical location – no participant is remote.
- 34 of the people (~ 32%) in only remote meetings, in different physical locations – all participants are remote.
- 36 of the people (~ 33%) in hybrid meetings, with two or more participants in the same physical location, and others remotely.

Chart 5.3 – Distribution of answers for the most frequent meeting setting (N=108)



Images' source: Storyset[32]

When asked to classify work meeting settings in order of preference (Table 5.12), face-to-face meetings were the first choice for most of our sample (~ 39%, or 42 people out of 108). However, as respondents were given five answer options and were asked to rank them from most preferred to least preferred, a hybrid meeting variation obtained the highest weighted average[33]. This variation consisted of the respondent attending the meeting in person, at the workplace, with the minority (less than half) of the participants attending in the remote mode. Fully remote meetings, in which all participants are physically present in different workplaces, were considered the least preferred setting by respondents (~ 47%, or 51 out of 108).

[32] Storyset. Retrieved October 21, 2020, from https://storyset.com/

[33] The weighted average takes into account the relative importance or frequency of some factors in a data set. In calculating a weighted average, weights were applied in reverse. In short, the respondents' most preferred choice (which they rate as # 1) has the highest weight, and their least preferred choice has a weight of 1. (SurveyMonkey, n.d.)

Table 5.12 – Ranking of work meeting settings preferred by respondents (N=108)

Answer options	Ranks					Score (weighted average)
	# 1	# 2	# 3	# 4	# 5	
Me, in person at my workplace, with the minority (less than half) of the attendees being in remote mode	~ 21% (23)	~ 37% (40)	~ 15% (16)	~ 20% (22)	~ 7% (7)	3.46 △
All attendees, including myself, in person at the same physical workplace	~ 39% (42) ▲	~ 18% (19)	~ 9% (10)	~ 7% (8)	~ 27% (29)	3.34
Me, remotely, with the majority (more than half) of the attendees being together in a same physical location	~ 4% (4)	~ 14% (15)	~ 55% (59)	~ 19% (21)	~ 8% (9)	2.85
Me, remotely, with a majority (more than half) of the attendees also in remote mode, separated from each other in different physical locations	~ 9% (10)	~ 25% (27)	~ 14% (15)	~ 41% (44)	~ 11% (12)	2.81
All attendees, including myself, remotely in different physical workplaces	~ 27% (29)	~ 7% (7)	~ 7% (8)	~ 12% (13)	~ 47% (51) ▼	2.54 ▽

△ Highest weighted average
▽ Lowest weighted average
▲ Most preferred choice (most times as 1st choice)
▼ Least preferred choice (most times as 5th choice)

In relation to the types of meetings and their average duration, the most recurring answer was 30-minute one-on-one meetings, in which, for example, manager and employee meet to stay informed and aligned and to evaluate the overall performance at work. These meetings were attended by almost half of the respondents (~ 48%, or 52 out of 108), followed by 1-hour team building meetings (~ 33% or 36 people) and 30-minute problem-solving and innovation meetings (~ 30% or 33 people), which may include brainstorming sessions, design sprints and workshops.

5.3.2.3
Fully remote and hybrid work meetings

Several tools of different technological capacities, from stationery to powerful software and hardware, allow the holding of fully remote and hybrid work meetings, in which all participants are separated from each other; or divided into remote groups and groups that are physically assembled. Considering these contexts, respondents were asked to inform which technologies and tools are used during their work meetings. Although about 90% of our sample (95 people) claim to use monitors to help with videoconferencing, about 15% (16 people) also connect with audio-only. Whiteboards and stationery, such as post-its and other types of paper, are used by approximately 81% (86 people). Furthermore, respondents are assisted by tools for storing and sharing files in the cloud (~ 28%, or 30 people), followed by tools for slide presentations (~ 25%, 26 people) and messaging (~ 22%, 23 people).

Respondents were also asked about the advantages and disadvantages of fully remote and hybrid work meetings, whether with regard to technical aspects or related to human experience. Regarding the advantages, comfort, convenience and flexibility were considered as the most positive aspects. On the other hand, people talking over each other and unclear communication in general, in addition to the loss of human connection, were considered the main disadvantages, as seen in Tables 5.13 and 5.14.

Besides the answer options available, respondents could also elaborate on other aspects. The more relaxed attitude and the camaraderie among participants in the face-to-face groups were mentioned as an advantage of hybrid meetings. However, some respondents argued that the downside of hybrid meetings is the fact that those who are physically present are, in most cases, prioritized over remote attendees. Considering the COVID-19 social distancing rules, the safety aspect was also mentioned, especially when it came to fully remote meetings.

Table 5.13 – Advantages of fully remote and hybrid work meetings according to respondents (N=108; descending order)

<table>
<tr><th colspan="2">Advantages of fully remote and hybrid work meetings</th></tr>
<tr><th>Answer options</th><th>Responses</th></tr>
<tr><td>Comfort, as they allow people to attend the meeting remotely, in the comfort of their own home</td><td>~ 62% (66)</td></tr>
<tr><td>Convenience, as they make it possible to interact with people from any geographical distance</td><td>~ 58% (61)</td></tr>
<tr><td>Flexibility, as they make it easier to manage and schedule work appointments</td><td>~ 48% (51)</td></tr>
<tr><td colspan="2">Other answers:
• Less physical space requirements, since part of the attendees is in remote mode (~ 34%)
• Greater attendance, as they offer an alternative to those unable to join the physical location of the meeting (~ 30%)
• Ease of sharing materials (e.g., slide presentations and other shared documents) with the attendees (~ 28%)</td></tr>
</table>

Table 5.14 – Disadvantages of fully remote and hybrid work meetings according to respondents (N=108; descending order)

<table>
<tr><th colspan="2">Disadvantages of fully remote and hybrid work meetings</th></tr>
<tr><th>Answer options</th><th>Responses</th></tr>
<tr><td>People talking at the same time, over each other, prone to misunderstandings</td><td>~ 59% (63)</td></tr>
<tr><td>Noisy and unclear communication (e.g., when people forget to mute their audios)</td><td>~ 50% (53)</td></tr>
<tr><td>Loss of a more personal and human connection</td><td>~ 32% (34)</td></tr>
<tr><td>Hand gestures and other nuances of the body language being hard to identify</td><td>~ 28% (30)</td></tr>
<tr><td>Conversations that do not flow “naturally”</td><td>~ 27% (29)</td></tr>
<tr><td colspan="2">Other answers:
• “Mute button effect”, when people are muted and less present at the meeting (~ 19%)
• Lack of discussion, since people might feel less motivated to interact (~ 18%)
• Discomfort about being the center of attention on video, or self-conscious of being able to see themselves on the screen (~ 14%)
• The risk of private information falling into the wrong hands if access to the meeting is not adequately protected (~ 14%)
• Interaction limited to a screen, with people being unable to walk around and move from one group to another in the meeting (~ 11%)</td></tr>
</table>

We consider it important to acknowledge that not all digital team collaboration happens in the same way: some people may agree that video conferencing is far superior to communicating only by audio or text message, while others may prefer less invasive means. However, being able to look at someone while talking to them is closer to a “real life” conversation than is feasible with most virtual tools on the market today. Our research has shown, so far, that the benefits of virtual communication are diverse, especially when we consider the context of distributed teams working constantly in different physical locations, such as at home, or in different buildings in the same city or in different cities, states and countries. Furthermore, remote work can be considered convenient, as it saves time, is flexible and can even save financial costs, as companies are able to use less physical space.

On the one hand, in theory, digital tools fit perfectly into an agile way of working, since employees can work remotely with ease, participate in virtual meetings, workshops and other forms of collaboration and interaction, while remaining fully connected with colleagues and the company. On the other hand, we argue that hybrid meeting environments bring very specific challenges to be faced, whether with regard to technical difficulties, but mainly, for the purpose of this thesis, with regard to human experience. Following the techniques hereby used, we proceed with the final experiment to delve deeper into our research questions.

We started to design this thesis’ research procedures based on a set of variables. When it came to Virtual Reality technologies as our first independent variable, we covered some of the human experience and sensory limitations in that context. We were faced with several concerns and concluded that they can be mitigated by applying custom design solutions. Following this exploratory work, we started to investigate our second independent variable. We divided remote work meetings into two main categories, totally remote or hybrid environments, and draw conclusions from our findings during semi-structured interview sessions and a survey.

Ultimately, the design and execution of the final experiment focused on the application of a modified Technology Acceptance Model (TAM) to measure the acceptance or rejection of VR as a tool for remote and hybrid work meetings. Throughout this and the processes described above, we describe the relationships between two independent variables and the dependent ones, as seen in Table 5.15.

Table 5.15 – Relationship between independent and dependent variables: research type, applied techniques and expected outcomes

<table>
<tr><th colspan="4">VR technologies (independent variable)</th></tr>
<tr><th>Dependent</th><th>Research type</th><th>Techniques</th><th>Expected outcomes</th></tr>
<tr><td>Human experience</td><td>Qualitative</td><td>Exploratory work</td><td rowspan="3">• Understanding of how the technology works and how environments, forms of movement and general interactions are built
• Problems’ descriptions and design solutions to mitigate them</td></tr>
<tr><td>Sensory limitations</td><td>Qualitative</td><td>Exploratory work</td></tr>
<tr><td>Technical difficulties</td><td>Qualitative</td><td>Exploratory work</td></tr>
<tr><th colspan="4">Remote work meetings (independent variable)</th></tr>
<tr><th>Dependent</th><th>Research type</th><th>Techniques</th><th>Expected outcomes</th></tr>
<tr><td rowspan="2">Human experience</td><td>Qualitative</td><td>Semi-structured interviews</td><td rowspan="6">• Problems’ descriptions with focus on limitations and challenges of current meeting environments, based on the participants’ real-life experiences
• Overview of the work meeting settings, number of participants, frequency and duration, and technologies and tools used</td></tr>
<tr><td>Quantitative</td><td>Survey</td></tr>
<tr><td rowspan="2">Sensory limitations</td><td>Qualitative</td><td>Semi-structured interviews</td></tr>
<tr><td>Quantitative</td><td>Survey</td></tr>
<tr><td rowspan="2">Technical difficulties</td><td>Qualitative</td><td>Semi-structured interviews</td></tr>
<tr><td>Quantitative</td><td>Survey</td></tr>
<tr><th colspan="4">VR technologies and remote work meetings (independent variable)</th></tr>
<tr><th>Dependent</th><th>Research type</th><th>Techniques</th><th>Expected outcomes</th></tr>
<tr><td>Technology acceptance or rejection</td><td>Qualitative</td><td>Technology Acceptance Model (TAM) experiment</td><td>Acceptance or rejection, based on the constructs of:
• Perceived Usefulness (PU)
• Perceived Ease of Use (PEU)
• Intention to Use (IU)</td></tr>
</table>

5.4
Experiment: TAM for VR

The Technology Acceptance Model (TAM) was designed to measure the adoption of new technologies based on human attitudes. The model originated from the *Theory of Rational Action*, a psychological hypothesis that suggests that people's behaviors are determined by their intention to perform said behaviors. This intention exists, in turn, as a result of a person's attitude towards subjective norms. The theory then evolved to comprise another one, the *Theory of Planned Behavior*. In summary, both notions are based on the premise that people make logical and informed decisions – evaluating the information available to them – before engaging in specific behaviors. (Ajzen and Fishbein, 1975; Fishbein et al., 1980; Weng et al., 2018)

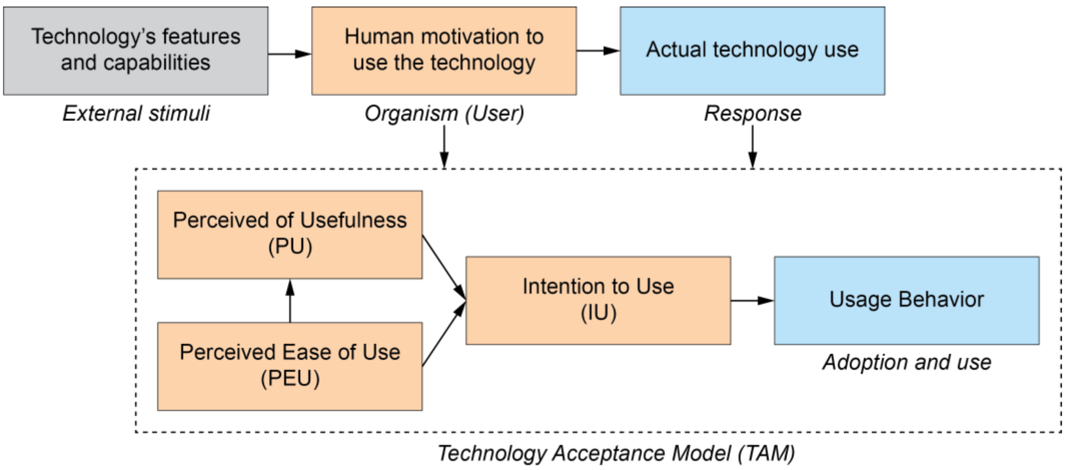


Figure 5.3 – The Technology Acceptance Model, based on the psychological Theories of Rational Action and Planned Behavior

Source: Author's own, adapted from figures by Marangunić and Granić, 2015

As seen in Figure 5.3, if and how people perform specific activities is determined by the individual's intention to engage (or, in the case of this thesis, Intention to Use, or IU), which can be influenced by the value the individual places on the behavior (Perceived of Usefulness, or PU), and the ease with which it can be performed (Perceived Ease of Use, or PEU). In 1985, Fred Davis proposed TAM as a conceptual model, suggesting that the actual usage, that is, the user acceptance of an Information Technology (IT), is a response that can be explained or predicted by user motivation. In turn, the latter is directly influenced by external stimuli, translated as system's features and capabilities. Since then, several research initiatives have used this model to understand the explanatory variables of human behavior in relation to the potential acceptance or rejection of a given technology. (Davis, 1985; Marangunić and Granić, 2015; Davis, Granić and Marangunić, 2021)

When choosing TAM as the scientific paradigm to facilitate the assessment of the adoption and use of VR technology during remote work meetings, we took advantage of the core variables of the model (PU, PEU and UI) as our main constructs that impact acceptance. Throughout the following subchapters, we will show TAM being used as a framework for qualitative analysis. In a nutshell, we use the model to qualitatively describe VR technologies as a remote work tool. At first, we inserted our research subjects in an immersive experiment, through five sessions, using VR and AR resources. After each session, they were asked to answer questionnaires, built from measurable items defined by the previously applied techniques. Although the sample size of the experiment was insufficient to derive quantitative data, the post-session questionnaires would help guide the discussion at the end of all sessions, when the subjects were invited to participate in a remote focus group with the experiment moderator.

5.4.1
Experiment proposal and research questions

The experiment of a hybrid VR meeting seeks to establish whether and how Virtual Reality technologies are able to provide greater involvement and engagement of people during work meetings in fully remote or hybrid environments. To this end, at this stage of the research, we measured people's acceptance or rejection of VR as a tool for such contexts. We defined the experiment as a qualitative study on the use of a collaborative platform for virtual meetings in VR and AR. The tool called *Spatial* will be better described in the following subchapters, but, in short, it is intended to provide virtual spaces and virtual objects to support users located remotely and separately to meet and work together.

The quantitative and qualitative techniques previously applied, and the results obtained with the triangulation of data from semi-structured interviews and web-based survey, will lead:

- Primarily, to the recruitment of our research subjects.

- Then, to the definition and the description of the experiment scenario and the subjects' roles in the given scenario.
- Followed by the definition of *user motivations* (measurable items), that would be under the influence of *external stimuli* (VR features and capabilities).

The experiment seeks to answer the following research questions about people while in remote and hybrid meetings mediated by Virtual Reality technology:

Table 5.16 – Experiment research questions according to subjects' roles in the given scenario

<table>
<tr><th rowspan="2">Research questions</th><th colspan="2">Subjects (or meeting attendees)' roles</th></tr>
<tr><th>Person using VR
(Meeting host)</th><th>Person not using VR*
(Meeting guest)</th></tr>
<tr><td>Does VR offer a sense of involvement and engagement with other people and with the activity?</td><td>▲</td><td>▲</td></tr>
<tr><td>Do people feel more connected with other people and with the activity than when they are in remote meetings without any use of VR?</td><td colspan="2" rowspan="5">▲ The same person tests both conditions: comparison between the types of experience within a hybrid VR-mediated meeting (the same person using and not using a VR headset)</td></tr>
<tr><td>Do people feel more or less uncomfortable with other people and with the activity than when they are in remote meetings without using VR?</td></tr>
<tr><td>What are the positive aspects of having VR being used in a meeting?</td></tr>
<tr><td>What are the negative aspects of having VR being used in a meeting?</td></tr>
<tr><td>What are the overall thoughts about the virtual environment?</td></tr>
<tr><td>What are the overall thoughts about the length of time using VR?</td><td>▲</td><td>▼</td></tr>
</table>

* But at the meeting together with at least one attendee using VR (as a meeting host)
▲ Research question can be answered
▼ Research question cannot be answered

Data analysis will be done following a within-subjects experimental design, since we will assign all test subjects to all the same experimental conditions. In this sense, considering the hybrid VR meeting setup, the subjects will alternate between being those who wear a VR headset, as the meeting hosts, or not, when being the meeting guests. As an example, considering the research question “Do people feel more connected with other people and with the activity than when they are in remote meetings without any use of VR?”, the within-subjects analysis measured a single person’s level of agreement or disagreement when comparing the types of experience within a hybrid VR-mediated meeting (the same person using and not using a VR headset).

The analysis was conducted based on the results of a focus group, in which themes related to the research questions were raised, in combination with the retrospective think-aloud protocol. In addition, the results of the analysis were compared with the responses to the post-session questionnaires. Each subject would answer the questionnaires only twice: once after participating in the session as Host and once after their first rotation as a Guest.

For the questionnaires, we defined the TAM constructs of Perceived Ease of Use (PEU) and Perceived Usefulness (PU) as the degrees to which the attendee of the virtual meeting believes that:

- **PEU:** Using VR-mediated technologies would be free of effort.
- **PU:** Their work meetings would be enhanced in terms of involvement and engagement while using virtual environments through VR-mediated technologies.

Intend to Use (IU) is directly affected by the two previous key variables – the easier, or effortless, the use, the more accepted the technology is, and the greater the usefulness, the more adopted. The acceptance or rejection of VR as tool for remote work meetings, and its consequence adoption or use (or lack of both) were measured twice during the experiment:

1. One, while subjects wore a VR headset, when as meeting hosts – and interacted with other remote attendees.
2. Other while subjects used a mobile device (e.g., smartphone), with the possibility of integrating AR features, when as meeting guests – and interacted with other remote attendees and a meeting host in a VR headset.

The measurement of PEU and PU comprises of five items each, defined to the context of this research as shown in Tables 5.17 and 5.18.

Table 5.17 – Perceived Ease of Use (PEU) measurable items

Construct	Operational definitions ▽	Measurable items ▲
Perceived Ease of Use (PEU)	PEU is the belief that participants in virtual meetings have that using VR-mediated technologies will be effortless.	1. The equipment and environment used for VR-mediated hybrid meetings is easy and quick to learn to use. 2. The equipment and environment used for VR-mediated hybrid meetings makes it easy and quick to share and create content. 3. The equipment and environment used for VR-mediated hybrid meetings are accessible anywhere at any time. 4. The equipment used for VR-mediated hybrid meetings is comfortable to use during the average meeting duration. 5. VR-mediated hybrid meetings do not present significant technical difficulties, such as response delays and lack of synchronism.

Table 5.18 – Perceived Usefulness (PU) measurable items

Construct	Operational definitions ▽	Measurable items ▲
Perceived Usefulness (PU)	PU is the belief that participants in virtual meetings have that their work meetings will be enhanced in terms of involvement and engagement while using virtual environments through VR-mediated technologies.	1. VR-mediated hybrid meetings enable people to have a more personal and human connection. 2. VR-mediated hybrid meetings allow people to use hand gestures and other nuances of the body language to communicate. 3. VR-mediated hybrid meetings allow for clear communication when talking. 4. VR-mediated hybrid meetings make me feel more present and motivated to interact with people and content. 5. Using VR technology would improve my sense of involvement and engagement during remote work meetings.

▽ An *Operational definition* is a description of something in terms of the procedures by which it could be observed and measured. In the course of this experiment, we will work with two operational definitions. As the same person tests both conditions, the outcome will be a comparison between the types of experience within a hybrid VR-mediated meeting (the same person using and not using a VR headset).

▲ The *Measurable items* were defined taking into account the advantages and disadvantages of fully remote and hybrid work meetings addressed in both the group interviews and the survey (Subchapters 5.2 and 5.3).

5.4.2 Experiment design

5.4.2.1 Subjects and scenario

In order to recruit the right experiment subjects and set the stage for the sessions, we consider it appropriate to take into account the results of the previously applied techniques. This approach helped us to determine the types of people exposed to the phenomenon under study and which meeting environment we would attempt to replicate throughout the experiment.

We started to filter and select the people who work in the Technology and Software sector, as it is the second area of activity most cited by the survey participants (Subchapter 5.3), excluding the Health sector. The reasons for excluding this target audience from the study were strategic. First, recruiting people from the Health industry would pose additional challenges due to the stricter restrictions of COVID-19 in that sector. The researchers would have to meet the subjects in person to assemble the VR equipment. Other minor concerns were related to adapting the experiment schedule to health workers' working hours and defining a theme to guide the hybrid meeting. The theme would need to be realistic and compatible enough with the real tasks and work environment of these subjects.

Therefore, in our recruitment, all participants would be selected from people in the Technology and Software sector. An additional reason for this choice is the fact that they were more accessible to the researchers. Furthermore, the advantage of gathering only people from the same sector is in eliminating new potential variables for the study, such as people with very different ways of working, confusing communication due to unknown industry terminologies, limited topics to discuss during a meeting, and other unforeseen variables. Besides, to ensure that participants had similar knowledge and usage patterns when it comes to IT, especially VR, we rejected frequent VR users and people who owned VR headsets at the time the experiment was being conducted. We also filtered people who work in companies that have more than one place of work, as this was an aspect pointed out by most of the sample in our survey. Another requirement was to have research subjects who may have, at least at some point, worked at home since the pandemic, or worked directly with co-workers from different physical locations.

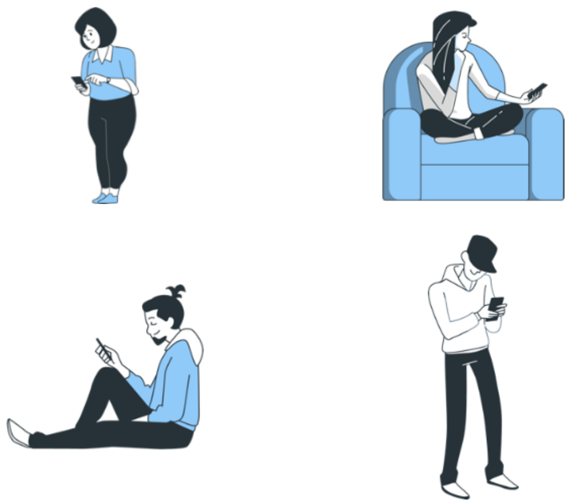
When it comes to the scenario for the experiment, the scope of the research lies in people holding work meetings in a fully remote or hybrid environment. Besides, considering the results of our survey, the hybrid scenario was the answer option that obtained the highest weighted average in relation to preference, hence our choice for this scenario. In conclusion, we chose to conduct the experiment with five people geographically remote from each but coming together in a hybrid way, that is, specifically, from different devices. We chose this number of research subjects for being in agreement with the findings of the preliminary study and for the ease of coordination. We decided to keep all people remote to comply with COVID-19 regulations. Moreover, we considered that, in their normal work environments, they would still attend meetings with their own personal devices, even when meeting in person.

The experiment was to be split into five sessions, so each person would alternate in the role of hosting the meeting with a VR headset. The other attendees would join via web or mobile, using their personal devices. Each meeting session would have a maximum duration of 30 minutes, as this was the average duration of the meetings reported in the survey. Extra time before the start of the session would be added for the meeting host to set up the VR equipment. We also took into account that the average session time for VR and AR devices in the United States in 2018 was approximately 38 minutes (Statista Research Department, 2021). The purpose of the meetings would be to conduct problem-solving and innovation sessions through brainstorming.

Some pilot tests were carried out so that we could detect possible limitations in terms of devices, operating systems and physical space. The tests also helped to define a more specific task list. The main finding from this procedure was to note that it would not be feasible for guests to enter virtual sessions only through a web browser on their desktops or laptops. This is probably due to the limitations of the software, as the platform chosen for the experiment does not seem to have adequate web support. Further details about the software can be seen in Subchapter 5.4.2.3 (Equipment).

As a result of the pilot tests, we decided that the Guests would connect to the meeting room through their own mobile devices and using a computer as a secondary support tool. This adaptation brought an interesting addendum to the experiment, as it made Augmented Reality available to the sessions. With the use of Android or iOS devices, Guests could switch between screen mode or AR mode during the virtual meetings. With AR, people can use the surrounding environment, for example, their home offices, as a backdrop and add layers of virtual objects to that location.

Table 5.19 – Experiment overview and research subjects’ roles

Meeting type	**Meeting duration**	**No. of sessions**	**No. of attendees**
Problem-solving and innovation meeting (Brainstorming sessions)	Minimum of 15 and maximum of 30 minutes each	5	5
Attendees’ roles*			
 1 Host joining with a VR headset and controllers	 4 Guests joining separately from their own mobile devices (Using a computer as a secondary tool, and AR mode as optional)		

* Attendees switched between Host and Guest roles, and each person was allowed to host the meeting once

Images’ source: Storyset

Lastly, to tackle the problem of lack of space awareness when using VR, we have included a floor mat as part of the equipment for the VR Host. We specifically chose a type of mat frequently used for yoga practice, which contains a non-slip surface. The mat acts as tactile feedback and prevents people from straying from safe boundaries and bumping into household objects while wearing the VR headset.

We also agreed to teach participants about the pass-through feature available in *Oculus Quest 2*. The feature allows the user to temporarily exit VR to have a real-time view of the world around them. The pass-through is triggered automatically each time the person leaves their defined security space within the application, but it can also be prompted by the user. When manually enabled, the pass-through mode is triggered when the user taps twice on the side of the headset. By double tapping the side of the headset again, the person is transported back to the VR environment.

5.4.2.2
Procedures and list of tasks

Before the beginning of the procedures, the research subjects were asked to sign a Research Informed Consent Form (Appendix C)[34]. Then, prior to the star of the experiment sessions, the five subjects were instructed to create their avatars using the *Spatial* mobile app. Avatars would be used as physical representations of the users during the experiment sessions. The procedure would be as follows:

1. They should upload a photo or take a picture of themselves with their mobile phone camera and confirm that the picture is satisfactory.
2. Then, they should choose a body type for the avatar – the options available were between a female or male body type.
3. At last, the photo would be rendered into a realistic-looking 3D copy of the subject' face and attached to a human torso. With the 3D avatar generated, the end result should be confirmed by the user. (Figure 5.4)

[34] In light of the current global pandemic of COVID-19, we took additional precautions to mitigate the risks of contamination, described in the consent form.

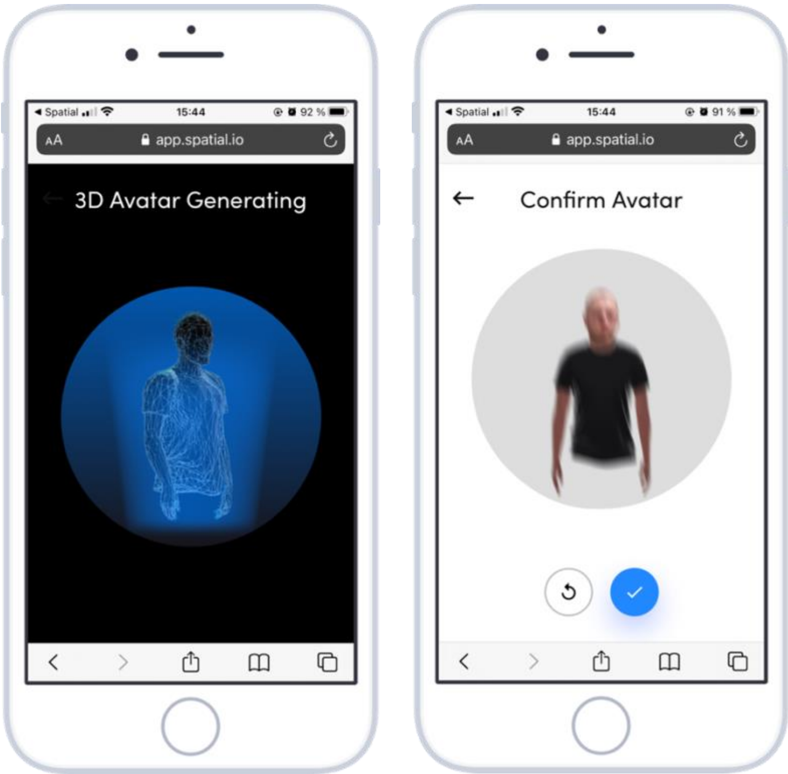


Figure 5.4 – Creating an avatar using the *Spatial* mobile app
Source: Author's own

Once at the start of each session, the meeting host should wear a VR headset and its controllers, then create a new space (meeting room) and send an invitation to the others to join. We describe the procedure as:

1. From their mobile device, the Host should pair the headset – the options were to pair with *Quest*, *HoloLens* or *Magic Leap*, but in this study, the available equipment was *Quest* (in particular, *Quest 2*).
2. Once paired and wearing the headset, they should add a new space in *Spatial* and enter a name for it. This would be the virtual meeting point for Host and Guests.
3. Then, they should invite the meeting guests, who would join the room from their mobile phones.

When all participants were present at the meeting, the Host would propose a short and simple design challenge to encourage a discussion and brainstorming session. The design challenge briefing should be provided to the Host in advance by the experiment moderator. The briefs for each session were generated randomly in a free design challenge generator called *Sharpen*[35]. Some examples of the challenges are "Invent a way to get help if lost that anyone can operate", or "Make a boardgame that explains global warming to children".

With the start of every brainstorming session, all attendees were encouraged to explore the resources of the virtual meeting room and discuss together how to organize their ideas. We explained to them that the results of the brainstorming sessions would not be relevant to the experiment but would act as an excuse to try the tools provided to them. Among the possibilities, users should try to add any type of content to the room wall – post-its, photos, videos and other files of various formats -, draw and scribble; and move around the room. The attendees were also informed of specific features to be explored according to their roles:

- **Meeting host** – wearing a VR headset and controllers:
    - The person could move around by physically walking to the desired position, or by using the VR controllers.
    - Both the hardware and the software chosen to be used in this experiment have support for hand tracking (Figure 5.5, on the left). The person could then use the feature to express themselves more clearly with hand gestures and replace the use of controllers.
- **Meeting guests** – on their mobile devices:
    - They could move around by physically walking to the desired position, or by using screen interactions in the smartphone.
    - They could explore the AR functionality, using their surrounding environment, for example, a wall in their home offices, as a backdrop and add layers of virtual objects to that location.

When using the VR headset, all participants were instructed to pay attention to the physical restrictions imposed by VR technology. That is, when trying to move freely, they should be limited to the edges of the floor mat (Figure 5.5, on the right). As an extra safety measure, they would be closely watched and assisted, if and when

[35] *Sharpen* was founded in 2017 by designers who worked at Google. The tool aims to make "high-quality practice briefs accessible and easy to get started with". According to *Sharpen*'s website, its design prompt generator is used by Google's on-site interview process to assess how potential employees approach open creative problem solving. Sharpen: https://sharpen.design/

needed, by the experiment moderator. In all sessions, the experiment moderator should be personally present with the participant using the VR device.

Figure 5.5 – Experiment subject testing the hand tracking feature in *Oculus Quest 2* (left) and standing on a mat as a safety measure (right)

Source: Author's own

At the end of each of their first sessions as Hosts and Guests, participants should answer a brief questionnaire evaluating the Perceived Ease of Use (PEU) (Table 5.20) and Perceived Usefulness (PU) (Table 5.21) measurable items. Both dimensions are the most important factor in measuring Intention to Use (IU). Each person would answer the same questionnaire only twice, once as the meeting host and once as the guest. The questionnaire measures each of the variables of TAM using a bipolar 7-point Likert scale ranging from −3 (Strongly Disagree) to 3 (Strongly Agree). Bipolar questions are those in which attitudes are on one side or the other of a neutral midpoint and should be used to assess both:

- Which side of the neutrality the subjects are on (if not neutral);
- Which degree to which they are mentally positioned on each side.

Table 5.20 – List of questions from the Perceived Ease of Use (PEU) questionnaire

Perceived Ease of Use (PEU) questionnaire	
PEU 1.	The equipment and environment used for VR-mediated hybrid meetings is easy and quick to learn to use.
PEU 2.	The equipment and environment used for VR-mediated hybrid meetings makes it easy and quick to share and create content.
PEU 3.	The equipment and environment used for VR-mediated hybrid meetings are accessible anywhere at any time.
PEU 4.	The equipment used for VR-mediated hybrid meetings is comfortable to use during the average meeting duration.
PEU 5.	VR-mediated hybrid meetings do not present significant technical difficulties, such as response delays and lack of synchronism.

Table 5.21 – List of questions from the Perceived Usefulness (PU) questionnaire

Perceived Usefulness (PU) questionnaire	
PU 1.	VR-mediated hybrid meetings enable people to have a more personal and human connection.
PU 2.	VR-mediated hybrid meetings allow people to use hand gestures and other nuances of the body language to communicate.
PU 3.	VR-mediated hybrid meetings allow for clear communication when talking.
PU 4.	VR-mediated hybrid meetings make me feel more present and motivated to interact with people and content.
PU 5.	Using VR technology would improve my sense of involvement and engagement during remote work meetings.

After all sessions were conducted, the participants and the experiment moderator would join in a remote focus group session using the retrospective think-aloud protocol. To do this, it would imply that we would all meet in a virtual room similar to those of the experiment sessions so that they could better remember and talk about the feelings they had throughout the process. The experiment moderator would drive the discussion by inquiring on the findings of the post-session questionnaires and on the themes related to the research questions.

5.4.2.3
Equipment

5.4.2.3.1
Hardware: Oculus Quest 2

The hardware chosen for the experiment was *Oculus Quest 2*, a VR headset from *Oculus*, a brand of Facebook. It is the successor device to the *Oculus Quest* (see Chapter 3 for chronology). The equipment was selected not only for its availability to the researcher, but also for its convenient advanced all-in-one hardware. In that sense, this means that Quest 2 is wireless and requires only a mobile app and the VR hardware in itself, with a headset and controllers (Figure 5.6). The use of a PC (Personal Computer) is optional.

According to the technical specifications of *Oculus Quest 2,* the headset tracks the movement of the user's head and body, translating them into VR with "realistic precision", and no external sensors are required. The 3D positional audio from the hardware is integrated directly into the headset, which implies that surround sound can be experienced from behind, above and below the listener. Being an *Oculus* product, it requires a Facebook account to log in. (Oculus, n.d.)

Figure 5.6 – *Oculus Quest 2*, powered by Facebook
Source: Oculus[36]

[36] Oculus. Retrieved December 10, 2020, from https://www.oculus.com/quest-2/

5.4.2.3.2 Software: *Spatial*

The software chosen for the experiment was *Spatial*[37], a collaborative platform. The application was designed for the context of digital meetings and similar activities such as, for example, brainstorming sessions, both remote and hybrid. Under the premise that "your room is your monitor, your hands are the mouse", it allows the user to pick up virtual elements and work with both flat media, like text, images and videos, and 3D objects. *Spatial* includes support for hand tracking, so people can virtually shake hands and express themselves more clearly with manual gestures. Among other features, users can type with a virtual keyboard or write by hand with a pen.

The hybrid aspect of the platform is possible since it supports users attending meetings with *Oculus Quest*, *HoloLens*, *Magic Leap*, or via web and iOS and Android mobile devices. The platform was selected from more than 30 tools and applications for digital meetings with VR, deeply researched and summarized in a guide from *Immersive*[38], a Swedish website for knowledge about Virtual and Augmented Reality. The guide was divided into different categories, according to the main purposes of each application. The list is constantly updated to accommodate reviews after testing and user feedback, and includes the status of the app, informing which VR meeting platforms have been discontinued. The categories range from "Apps for social VR", "Constructive: 3D interaction in VR" and "Rec room" to "Platforms for productive VR meetings", the one that is in the scope of this thesis.

In summary (see Table 5.22), with *Spatial*, people can create their own realistic 3D avatars, generated from a single selfie in seconds. For those who join via desktop or any other device without a headset, the platform claims to have a good browser participation mode. Users can use the device's cameras to navigate the virtual space through a screen. In addition, a mobile app for both Android and iOS is in beta version, and lets people activate the AR mode to display the meeting in their own surroundings. The platform can also be used without the context of a

[37] *Spatial* was first described in this thesis in Chapter 4.

[38] Immersive: https://immersive.ly/

group activity, but as an individual space to organize thoughts and ideas and to work in a more immersed and focused manner. (Spatial Systems, n.d.)

Table 5.22 – Summary of *Spatial* platform specifications

Device support	**Features**	**No. of users per virtual room***	
		With VR	**Without VR**
Cross-device and mixed-reality platform: • *Oculus Quest* • *HoloLens* • *Magic Leap* • Web • Mobile (iOS and Android)	• Add content, such as notes (post-its), photos and videos in real time (for example, photos taken instantly with the mobile device's camera), and files of various formats (including 3D models) • Draw / scribble • Embedded search – users type or speak a term and *Spatial* displays an assortment of search results in the shape of 2D images or simple 3D objects (from Google and *Sketchfab*[39], respectively) • Integrate with other collaborative work platforms, such as Slack and Google Docs • Create an avatar • Switch to Avatar View, or to Automatic Speaker View – where the viewpoint follows the person who is speaking • Move around the room either by: (1) physically moving to the desired position; (2) using the VR controllers; or (3) using screen interactions in the smartphone • AR mode • Change environment (for example, *Boardroom Lounge* or *Auditorium*) (see Figure 5.6)	30 (maximum) 1 (minimum)	30 (maximum) 1 (minimum)

* *Spatial* customer support recommends that if people are mixing devices, a maximum of 15 to 20 should join with VR headsets and the remaining seats should preferably be filled with people joining from the web app

[39] *Sketchfab* is a platform to publish, share, and discover 3D content on web, mobile, AR, and VR. Sketchfab: https://sketchfab.com/

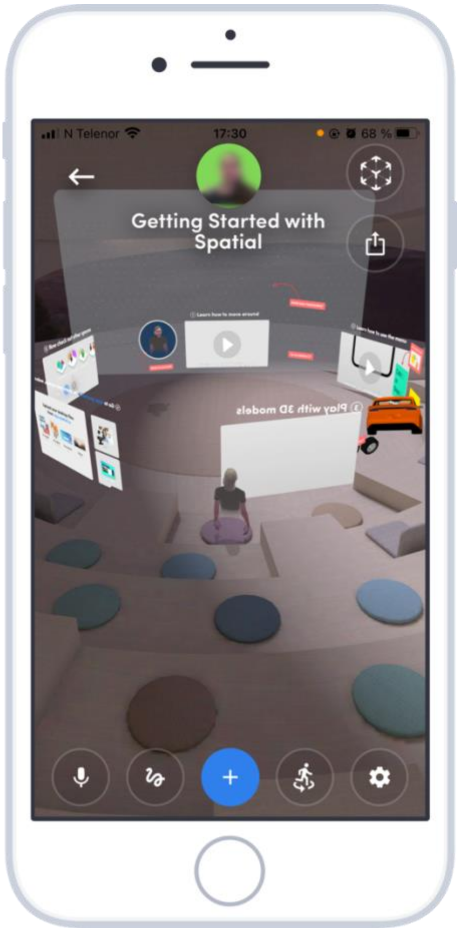


Figure 5.7 – The *Auditorium* environment as the backdrop for a meeting room, with the user being connected to *Spatial* via the iOS app

Source: Author’s own

6
Results and discussion

We used the Technology Acceptance Model (TAM) as a framework to qualitatively describe VR technologies as a remote working tool. The method consisted of an experiment divided into five sessions, in which the subjects alternated in the roles of Host and Guest, either using a VR headset and controllers or attending the meeting through their own mobile devices and personal computers, respectively.

The subjects answered two post-session questionnaires, and, at the end of all virtual sessions, a focus group was also conducted on the *Spatial* platform, replicating the same environment as the previous meetings. The focus groups used a combination of discussion and think-aloud strategies. The questionnaire topics led to a theoretically oriented analysis based on TAM to determine people's feelings about the Perceived Ease of Use (PEU) and Perceived Usefulness (PU) of VR-mediated hybrid meetings, to finally assess the Intention to Use (IU).

The experiment was carried out with five people, three men and two women, aged between 28 and 47 years (mean: 36.8) (Table 6.1). Subjects are residents of Trondheim, Norway, and were all employed in the Technology and Software industry at the time the sessions were conducted. They all work for different companies or for different departments within the same company. This research study lasted approximately 3.5 hours spread over two weekends, from the end of January to the beginning of February 2021. The hours were divided into five sessions of about 30 minutes (mean: 25.8), added to a focus group session of one hour.

Table 6.1 – Research subjects from the experiment – From January to February 2021

Subjects*	Age	Sex	Position	Sessions				
				1st	2nd	3rd	4th	5th
Magnus	42	Male	Software Engineer	H	G	G	G	G
Anne	37	Female	Product Manager	G	H	G	G	G
Kjell	47	Male	Service Designer	G	G	H	G	G
Jonas	28	Male	Software Engineer	G	G	G	H	G
Ingrid	30	Female	Systems Analyst	G	G	G	G	H

* We selected random pseudonyms to ensure the confidentiality and anonymity of the subjects in the experiment, and at the same time, to make it easier for readers to remember them

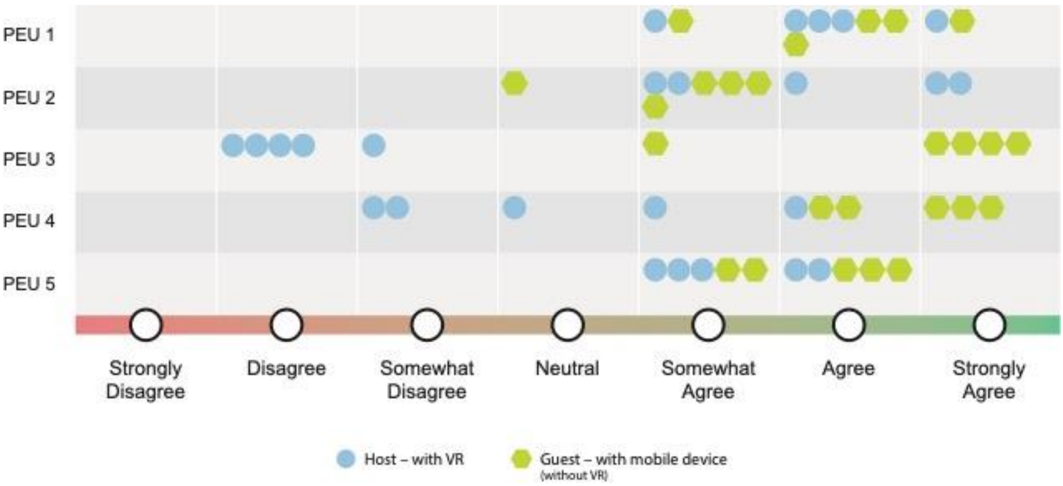
■ Subject attending meeting as a Host – with a VR headset and controllers
□ Subject attending meeting as a Guest – with a mobile device and personal computer

In our analysis, we used TAM to assume the acceptance of VR technologies for remote meetings is determined by two main variables, Perceived Ease of Use (PEU) and Perceived Usefulness (PU), which lead towards Intention to Use (IU). We argue the results of the experiments against the topics raised by the participants of the three previous techniques conducted in this research. The TAM experiment was carried out considering two scenarios per participant, one while people were using VR headsets and controllers when they were *Hosts*, and another while they were using a mobile device and personal computer, with the possibility of integrating AR resources, when they were *Guests*.

6.5
Perceived Ease of Use (PEU)

The Perceived Ease of Use (PEU) construct is the degree to which attendees in virtual remote meetings believe that the use of VR-mediated technologies will be free of effort. To measure effortlessness, we asked our participants how the equipment used, and the hybrid meetings mediated by VR are in terms of ease, learning, accessibility (availability), comfort, and simplicity (or little to no technical difficulties) (Chart 6.1).

Chart 6.1 – Perceived Ease of Use (PEU) of VR-mediated meetings, by subjects attending as Hosts and Guests (N=5) – From January to February 2021



PEU 1. The equipment and environment used for VR-mediated hybrid meetings is **easy and quick to learn to use**.
PEU 2. The equipment and environment used for VR-mediated hybrid meetings **makes it easy and quick to share and create content**.
PEU 3. The equipment and environment used for VR-mediated hybrid meetings are **accessible anywhere at any time**.
PEU 4. The equipment used for VR-mediated hybrid meetings is **comfortable to use during the average meeting duration**.
PEU 5. VR-mediated hybrid meetings **do not present significant technical difficulties**, such as response delays and lack of synchronism.

One topic that brought up conflicting perceptions between people when Hosts and when Guests is related to comfort during the average length of the meeting (PEU 4). During our first research technique, when we conducted exploratory work on VR movement and interaction (Subchapter 5.1), we gathered insights about the discomfort associated with using VR headsets. Now, the subjects in the TAM experiment reported a similar experience. When it comes to comfort when using the headset during the average duration of the meeting, three out of five people landed on the *Disagree* to *Neutral* side, that is, at the neutral midpoint or at the negative end of this midpoint (see PEU 4, blue circles ●, in Graph 6.1). This discomfort is clear when compared to how the subjects reported their perception about the same item, but while participating in the meeting without a VR headset, as meeting Guests (see PEU 4, green hexagons ⬢, in Graph 6.1). In that case, people either agreed or strongly agreed that the equipment (their own mobile devices) would be comfortable to use throughout the meeting.

When asked to delve deeper into the notion of comfort, Magnus, a 42-year-old Software Engineer, explained that while feeling immersed and having fun from the beginning until the middle of his session as a meeting host, he was each more and more tired by the end of it: “It was fun until I felt like I needed a break. It’s a feeling that I usually have at the end of a working day, but [on the day of the session] I did nothing but the meeting”. Although he reported a rapid recovery from tiredness after the session ended, the sensation described was that his eyes “felt like they didn’t blink for an hour”.

Anne, a 37-year-old Product Manager, and Ingrid, a 30-year-old Systems Analyst, reiterated the experience of fatigue and added in describing the discomfort with the hardware, specifically with the straps that attach the headset to their head and face. When the latter said: “It was a relief [removing the headset], because I started to feel it was a bit heavy and my face was feeling hot and sweaty”; the first reckoned: “It may be a tad awkward to jump to the next meeting with red marks [caused by the adjustable head strap] on my face!”. In the remainder of the discussion on this topic, all subjects agreed that, although the VR equipment was not exactly uncomfortable to use, the length of time would definitely make a difference over the course of a day or even a week of work. They also explained that their eyes and brains would likely need a break from VR-mediated activity. For example, Jonas, a 28-year-old Software Engineer, agreed with the headset being comfortable, but also clarified:

> I didn’t bother during my session and could stay longer, but thinking about it, it would not be feasible to do this back-to-back during work hours. […] Maybe in some specific times, like a workshop? I think it works for special occasions, to make [the work] more exciting.

The feedback was different when people attended the meeting as Guests, using a mobile device and AR resources. In this case, all the five subjects hit either the *Agree* or *Strongly Agree* points on the scale, claiming that the experience was positive with regard to comfort when using the equipment during the meeting. For Kjell, a 47-year-old Service Designer, the session as a Guest seemed easier because it felt more like a day-to-day meeting and gave him the freedom to walk and use other devices as work tools. “Using VR was exciting, I felt like I was in a game, but I like the freedom to have my notes private, to write things, to use all [devices] at the same time. [...] I like multitasking”. His feelings resonated with the other participants, but Magnus added that, although he agreed that working with the mobile phone was comfortable, “because that’s what I use every day”, it also seemed “complicated” and “distracting”. “When I used AR, [...] it was reflecting the content on my wall and then I was working on my computer while trying to see people on the phone [screen]". In that sense, while as Host, with a VR headset, Magnus stated, "*[sic]* I was more *there* [as in more immersed], the other times [without VR, as Guest] I had more distractions, which can be tiring".

During the semi-structured interviews, focused on how work meetings take place during day-to-day work environments (Subchapter 5.2), the topic of technical difficulties was widely addressed. Interviewees talked about the problems when trying to attend meetings via audio and video for the first time on new hardware or software, and the general lack of knowledge of the tools, as some examples. With VR equipment being relatively new to all the subjects from the TAM experiment – only Jonas claimed to have tried a headset and controllers similar to *Oculus Quest 2* before, to play games with friends –, issues of ease, learning and simplicity were discussed during the focus group. We discussed simplicity explicitly in the sense of little or no technical difficulty.

In all three items (PEU 1, 2 and 5), people landed on the positive extremities from the neutral midpoint, from *Somewhat Agree* to *Strongly Agree*, both as Hosts and as Guests, except for one person. In relation to the equipment used in the meetings as a Guest, Anne hit the *Neutral* point of the scale when considering how easy and quick was to share and create content (PEU 2). For her, despite having managed to accomplish the task, she felt challenged to work on a small screen, even when using the resources of AR:

> I put the post-its [reflected on the wall], but I still needed help typing, I needed to use my keyboard. So, it didn't seem easier or faster than it would be with other [technologies] [...] But when I was just watching other people, it was amazing both ways [with and without VR], because it's visually better than just see some slides on the screen.

The consensus was that the equipment used in both meeting modes, with and without a VR headset and controllers, was easy to use and quick to learn to use (PEU 1), with all the subjects reporting positive experiences. Regarding technical difficulties (PEU 5), people agreed that hybrid meetings mediated by VR do not present significant problems, at least not when compared to other types of remote meetings. As Jonas pointed out, "it's not like there are no problems, but I didn't feel that they were bigger than with other technologies. If my internet is bad, it won't work, but it won't be VR's fault either, right?".

The biggest discrepancy in the Perceived Ease of Use construct between Hosts and Guests was in the matter of accessibility (availability), when we measure the degree to which people agree that the equipment and environment used for VR-mediated hybrid meetings are accessible anywhere at any time (PEU 3). While as Guests, using their own mobile devices and other equipment of their choice, four out of five subjects strongly agreed with ease of access. On the other hand, Kjell said he only somewhat agrees that his phone will be accessible at any time because he considers it unlikely that he will have the device 100% available for use by just one application (in this case, the *Spatial* app) during a meeting. "It's accessible in the sense that it's always with me, but I wouldn't like to have it blocked in this one function [only using the app]. If I receive a call or need to read an SMS, can I still consider the tool available? I'm not sure".

As for the availability of VR headsets and controllers, all subjects disagreed that the equipment was accessible anywhere and anytime. The main reasons were the costs of having an entire team using one device each, and that the equipment requires a specific configuration of the environment to be used safely. As Anne explains:

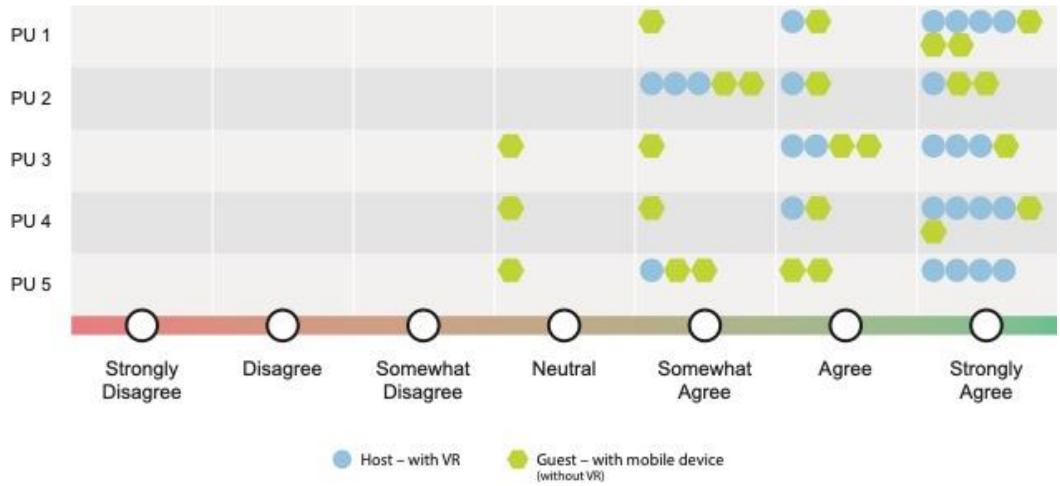
> The price itself [of a VR headset] is not necessarily high, considering the budget of a large company. But if we take into account the cost in relation to the time of using the equipment on a daily basis, it's expensive. I use a computer every day all day. How many times would I use a VR headset? It's not yet part of our culture [to use VR in large scale].

Ingrid adds that even if companies invested in VR equipment, "some kind of office setup would probably be needed as well". Working in an open office space when she is at the company's headquarters, she explains that some safety measures would be necessary, such as placing the yoga mat on the floor, preventing people from leaving safe boundaries. "We could sit while using the headset, of course, but we would still need to follow some safety measures", she says. Jonas evaluates: "Yes, we are never fully aware of the surroundings. And now that we all work from home, the company would probably like to make sure that people are safe there, too". At the end of the discussion on the topic, people agreed that VR can be considered easily accessible when one has in mind the aspect of the mobility of the equipment and the range of possibilities it offers. In this respect, Kjell concludes: "If money weren't a problem, then I think the possibilities are endless. You can take it anywhere and try new things, new apps. You can find a way to make it useful for anything".

6.6 Perceived Usefulness (PU)

The Perceived Usefulness (PU) construct is the degree to which attendees in virtual remote meetings believe that their work meetings will be enhanced in terms of involvement and engagement while using virtual environments through VR-mediated technologies. Thus, to measure usefulness, we asked our participants how the hybrid meetings mediated by VR are in terms of human connection, communication (body language and clarity), and overall feelings of immersion and presence (Chart 6.2).

Chart 6.2 – Perceived Usefulness (PU) of VR-mediated meetings, by subjects attending as Hosts and Guests (N=5) – From January to February 2021



PU 1. VR-mediated hybrid meetings enable people to **have a more personal and human connection**.
PU 2. VR-mediated hybrid meetings allow people to **use hand gestures and other nuances of the body language to communicate**.
PU 3. VR-mediated hybrid meetings allow for **clear communication when talking**.
PU 4. VR-mediated hybrid meetings make me **feel more present and motivated to interact with people and content**.
PU 5. Using VR technology would **improve my sense of involvement and engagement** during remote work meetings.

These measurable PU items are closely related to the findings of semi-structured interviews and follow-up survey. In relation to the challenges reported by the subjects in the two techniques, aspects such as difficulty in understanding and maintaining simultaneous conversations, lack of engagement and mobility and loss of human bond were addressed. In addition, face-to-face meetings were the first choice of preference for most of the sample in our survey, due to the more relaxed attitude and the camaraderie among people in this context. With our experiment, we hoped to find out if the VR equipment and environment can help mitigate the disadvantages of regular virtual meetings conducted exclusively by audio and/or video.

When comparing the perceptions of our experiment subjects about hybrid meetings mediated by VR, there were no significant discrepancies between the experience as Hosts or Guests. In brief, all subjects' attitudes fell either at the neutral midpoint or at the positive end of this midpoint, from *Neutral* to *Strongly Agree*. As Hosts, people claimed to have a positive experience when using VR equipment, especially when it came to having a more personal and human connection, feeling more present and motivated to interact with people and with content, and feeling that the VR would improve their senses of involvement and engagement. Four out of five subjects strongly agreed with these items. (see PU 1, 4, and 5, blue circles ●, in Graph 6.2).

Anne explained that, in both scenarios, as a Host and as a Guest, she felt that she interacted more with people than when in regular videoconferencing meetings because "it felt more like everyone was in the same place". "*[sic]* I've been working from home for so long, you kind of get used to talking to a black screen. I get easily distracted when that happens, especially when they're not really talking to me". Magnus expressed a point of view similar to Anne's, explaining that the avatars with the attendees' faces were useful to keep the attention on people: "They were kind of funny at first, they looked kind of clumsy. [...] But it was easier to recognize people and follow them around during the meeting". Jonas added that having their own avatars adds to the convenience factor, as it gives them the possibility of appearing "physically present" at meetings, even when they are not dressed in "work-appropriate clothes", for example.

The subjects' observations are somewhat related to the "mute button effect" mentioned in the previous steps of this thesis methodology and refers to when people are muted and less present at the meeting. By having avatars, accompanied by hand gestures, the possibility to walk and touch objects, and to divide attention to different virtual walls with various contents, "it's impossible not to be present", Kjell adds.

> The biggest difference from a normal [virtual meeting] is that here [VR-mediated meeting] you always have something to do, instead of just watching. [...] I think it depends on the purpose, but if I want people to participate and see things, using these [tools] makes perfect sense.

Concerning the use of hand gestures and other nuances of the body language to communicate, the subjects felt a slight difference when being Hosts using VR controllers, and when being Guests (compare blue circles ● and green hexagons ⬢ in PU 2, Graph 6.2). The reason was because they had some level of difficulty using hand tracking, a feature that allows people to use their hands in place of touch controllers. “It’s not that it was bad [using the controllers], but I wasn’t really gesticulating, I was more pointing to things and where to go”, Ingrid justified. In addition, Kjell explained that, for him, the disadvantage of using the VR devices instead of other technologies lies in restrictions on general body mobility and the use of hands. “Nowadays, it’s more natural for me to do something like ‘pinch’ to zoom in or out, or ‘drag’ or ‘slide’. And, of course, typing on the computer. So, using the controllers was less [natural]”. All other participants agreed.

Finally, regarding the use of VR technology as a way to improve the feeling of involvement and engagement during remote work meetings (PU 5), most subjects strongly agreed with the statement. They cited as positive examples of the use of VR aspects such as the design and ambience of the virtual rooms, the presence of people through physical representations (avatars), the way the content is visually displayed and shared, the availability of numerous work tools similar to real life, among others.

For Magnus, the experience of entering a virtual room using a headset was immersive thanks to the quality of the design of the environments. “The rooms were bright and open, and I really felt like I was standing there. You get used to this atmosphere very quickly and it’s as if you have space to move [around] and work”. Jonas argues that the immersion aspect also is beneficial, “especially when your physical space doesn’t reflect that [same atmosphere]”. “My home office desk is shared with my partner and it can get messy, so it’s nice to go to any place you choose and work from there”. Physical benefits of VR, such as freeing up desk and meeting room space, and giving people a wider and more customizable work area, were widely discussed by all the subjects.

Anne pointed out that the meeting rooms available in a VR environment are a step up from what was already happening in her company's offices before the pandemic, with people working with various devices, and with monitors and whiteboards scattered around the workplace. "We are very data-driven, so before [COVID-19], we had information anywhere we were looking at [in the office], we worked very cross-functionally and shared everything. Now we are back [working] alone and in isolation". In this perspective, Ingrid agrees that the tools provided by the VR application can help to emulate physical collaboration between people, which was previously more feasible in shared offices. "I like how all content can be organized in different walls and I can go and meet people in one corner or the other. That was the biggest difference for me [when using the VR headset]: it was more like being at the office, and less 'Google Docs'!".

Another advantage is the fact that the tangible materials shared in the VR rooms, as if people were in person in the same physical location, can be kept virtually and revisited any other day, unlike what happens in a "real meeting room".

> It's cool that the whole room becomes a live document. When we have a sprint session or something, I usually photograph these results on the wall [post-its, scribbles, etc.]. But here [in the app], I can go back to see them without taking up real physical space.

Although the perception of VR technologies is quite favorable, the benefits were outweighed by some negative criticisms. While people claimed that wearing a headset made them fully focused on the task, which was considered positive, it also made them feel less aware of their external real-world environment. As Magnus exemplified: "You feel stuck. This part, I don't know if I completely like [it]. I think it gives a lot of possibilities and things to do in that moment [in the meeting], but it also blocks me a little from everything else". Subjects agreed and said they would likely use *Quest 2* pass-through shortcut – triggered by users to temporarily exit VR viewing –, often during the experience. "The immersion hurts a lot [when pass-through is triggered], it's probably the 'mute' version of the computer, but for virtual reality. But it definitely makes you feel safer and catch a glimpse of real life".

6.7 Intention to Use (IU)

Our results confirm that a qualitative approach to TAM, through the use of a focus group session, provides a valuable theoretical model to help understand and explain people's acceptance of VR technologies in the context of remote work meetings. According to TAM, user acceptance of any technology, measured by a person's Intention to Use (IU) it, is determined by two constructs, Perceived Ease of Use (PEU) and Perceived Usefulness (PU), which mediate the effects that external variables have on the usage intention.

The results of this empirical study demonstrate that VR technologies, represented here by the *Oculus Quest 2* headset and the *Spatial* application, are relatively easy to use, since:

- The experiment subjects quickly became adept at using hardware and software, without significant technical difficulties.
- The experiment subjects were able to interact together in the proposed task, exploring ways to create and share content.

The Perceived Ease of Use, in turn, had a positive effect on the Perceived Usefulness. By exploring the virtual environments, the subjects were able to draw comparisons about the benefits of VR-mediated meetings in relation to regular remote ones, and about the use of VR headset and controllers as opposed to participating in the same meeting, but without the VR equipment. In summary, meetings mediated by VR, and the use of VR equipment in specific, are considered capable of providing:

- The feeling of immersion in the remote meeting.
- The feeling of presence and human connection during the remote meeting.

With this qualitative research approach, we cannot make quantitative inferences, but we can effectively describe the factors that lead to Intention to Use and, as a result, the acceptance or rejection of VR technology. The description of the factors that guide people's attitudes towards acceptance, that is, the potential benefits of VR usage in remote meetings can be seen as follow in Table 6.2.

Table 6.2 – Potential benefits of VR usage in remote meetings

Potential benefits of VR	**Descriptions**
Immersion in fully dedicated activities	• Partially blocked from external distractions, people are more inclined to focus on the activities of the meeting, its peers and the room environment first • The ability to walk and touch objects helps people to act as they would in the real world, instead of standing in a stationary position in front of a computer
Presence and human connection	• Instead of seeing just people's faces (or "black screens", when their videos are off), or a set of slide shows, people are immersed in an inviting environment close to real life, populated with full-body avatars • The use of avatars, accompanied by hand gestures, makes it easier to recognize and interact with others and vice versa • People can be physically present on their own terms – even without suitable for work clothes or appearance, and without the need to show their home or private work areas • It can help people feel less alone and isolated
Renewed interest and enthusiasm	• VR technology is considered fun and can help everyday activities feel more like games and less like work • It is suitable for "special occasions" that require more participation and collaboration than regular remote meetings
Less physical boundaries and customizable work area	• Instead of physically limited workspaces, people can move around the conference room of their choice, integrated with various types of media and tools • People can divide their attention on several virtual walls in the same room and easily mix between different groups of people, as they would in a face-to-face workshop, for example • People can choose to work in places that are better than their reality
Convenience	People have the experience of being present in the workplace, while the company saves travel time and transportation costs
Virtual 3D archive	Unlike real-life meeting rooms that eventually need to be cleaned, VR environments and their content can be maintained and revisited at any time

As for ease of use, we proceed with caution when suggesting that the results are potentially replicable with other populations. Among the participants in the experiment, all were well versed in the use of ICTs, as they worked in the Technology and Software sector. Through deeper learning in this field of work, transferable knowledge is likely to develop, which includes both experience in using computer-based technologies and procedural knowledge of how, why and when to apply that knowledge to solve problems in that subject. For this reason, we have chosen not to include ease of use alone as a potential benefit of using VR in remote meetings. At last, the description of the factors that guide people's attitudes against acceptance and towards rejection of VR usage in remote meetings can be seen in Table 6.3.

Table 6.3 – Potential drawbacks of VR usage in remote meetings

Potential drawbacks of VR	**Descriptions**

Discomfort due to meeting duration and equipment	• Fatigue and dry eyes
	• Hardware discomfort:
	  ○ Heavy and tight on face and head
	  ○ Heat and sweat
	• Not feasible for continuous and prolonged use

Lack of space awareness	Lack of awareness of the real physical world, resulting in people feeling insecure about stumbling onto objects or ignoring any external signals
Inability to multitask	• The use of VR equipment restricts the movements of the body and hands • The use of VR equipment limits or even makes it impossible to use other equipment and tools outside the VR application (e.g., mobile devices, computers, paper and pen, etc.)
Equipment cost and availability	• High cost compared to daily use • It requires specific office setup, a renewed focus on ergonomic design, and security measures (both at the company location and at home)
Lack of conventional standards	Gestures and body movements are not as common, conventional or standardized as those with other work tools (e.g., typing on a keyboard, using micro-interactions on the smartphone)

We treat acceptance and rejection as separate notions because we argue that they are not simply two opposite ends of the same spectrum. This means that both may have different implications and be of differential importance. Throughout this thesis, we work continuously to support the notion that VR, if used as a tool to assist fully remote and hybrid work meetings, provide greater involvement and engagement of people during the activity. In that respect, we believe that the benefits of using VR in remote meetings outweigh the drawbacks, as these are more associated with technical restrictions that can be lessened and do not automatically invalidate the advantages that lead to acceptance.

If we take for example the factor of lack of spatial awareness, it can be mitigated by design solutions, such as the one developed by *Oculus*, with its pass-through feature, in which people can switch between real-world and VR views. Furthermore, the reduced use of equipment alleviates discomfort, while the cost and availability of equipment continually changes for the better, with lower prices and more options of products for sale as the sector grows. The benefits of using VR, on the other hand, directly meet the needs of people in the context of remote meetings, which is the scope of the entire methodology of this thesis and, in particular, the aggravated needs to cope with isolation in times of COVID-19 pandemic.

7
Conclusion and future work

Often, when we think of technology, we consider it to be the latest innovation that directly affects our lives: from ordinary light bulbs to machines for medical and heavy industry use, from household appliances to increasingly smaller and more mobile computers and other personal devices. It was technology that allowed our world to become more and more interconnected as it is today. Even more so, artifacts with computational capability in specific have become such a fundamental part of personal and professional life that we cannot imagine functioning without them. However, more than tools and machines, technology encompasses a range of ideas whose existence and advancement are guided by purpose.

In this thesis, we argued Virtual Reality first as an idea. We brought the theories about *reality* and *virtuality*, which, from rudimentary experiments, came to become devices of simulated experience. Today, these devices seek to replicate safe imaginary universes based on some notion of reality. When the COVID-19 coronavirus pandemic began in late 2019, reaching its first peak worldwide in March 2020, a new sense of reality emerged. As a result, life as we knew it is now in a state of suspended animation: measures of social distance and lockdowns impose an acute and involuntary brake on the lives of millions of people. This scenario means that a large part of the workforce is unable to commute and attend the workplace physically, to mitigate the spread of the virus. Fortunately for many people, several employers have adopted remote work, offering their employees the option of working partly at home or even entirely remotely, without a physical location. But while these solutions allow employees to keep their jobs during these difficult times, they also brought new, extremely impactful challenges for companies and people in a negative way.

Among the disadvantages of remote work, we have examples such as increased feelings of isolation, lack of relationship between co-workers and increased distractions at home, resulting in decreased focus and involvement at work. When considering these disadvantages, it is essential to think of ways to provide people with a work reality similar to the times before social distance, and, at the same time, prioritize health and safety measures. In this respect, we believe that Virtual Reality technologies can, in the present and in an imagined post-pandemic future, help to simulate and connect people in and to a reality that is close to or better than before.

Although its official term was only coined in the 1980s, VR technology itself is not a new issue, as it has existed as a man-made technology since the 1800s. However old it may be, it continues to evolve, and its purpose is redirected to different applications. We mentioned throughout this research that VR is used in fields ranging from games, shopping experiences, medicine and health, arts and education, to automotive and other heavy industries. As for this thesis, we argued VR in the context of business meetings, taking into account changes in the work context since the advent of ICTs in the 1970s, and adding the current scenario of the pandemic, which challenges many people to work almost exclusively from home. To arrive at the results of this doctoral research, we applied quantitative and qualitative techniques to support the notion that Virtual Reality technologies, if used as a tool to help fully remote and hybrid work meetings, provide greater involvement and engagement of people during the activity, both in the in-person and in the geographically remote settings.

In a first step, we sought to understand what the challenges are in interacting with VR devices and simulated environments. This experimental process was critical for the understanding of the technology under two parameters, human experience and sensory limitations. We continued our methodology focusing on the matter of work meetings and remote work, maintaining the discussion on similar parameters, with sensory limitations expanding to cover technical difficulties. Through semi-structured interviews, we investigated how work meetings take place, in what types of remote or hybrid environments can occur, and the perception of people involved in these contexts. This technique was followed by a web-based survey, seeking to extrapolate our limited sample size of six interviewees, and validate the results with a larger number of people, that is, with a more representative sample.

At last, our final experiment combined two variables, Virtual Reality technologies and remote working meetings, through the application of a modified Technology Acceptance Model (TAM). The experiment was designed to measure the adoption and use of VR technology based on people's attitudes. It was our way of studying the cause-and-effect relationship between VR and remote meetings, and other variables such as human experience, sensory limitations, technical difficulties and acceptance or rejection of technology.

As we reach the end of our research methodology, with the final results leading to the acceptance of VR technologies as beneficial tools for remote work, we also concluded that our research questions were answered. From our sampling, we found that the use of VR equipment and its environments provided greater involvement and engagement of people during the remote work activities. In addition, we consider that the potential benefits of using VR in remote meetings outweigh the potential disadvantages discovered, as VR provides both a sense of immersion and a sense of presence and human connection. Therefore, by extension, we believe in the prospect of VR technologies being adopted to mitigate the negative effects of social distancing and remote work in general.

However, responding appropriately to our research questions does not exclude the possibility of expanding the work so that hypotheses are raised. One can argue that VR, if used as a tool for remote work meetings, creates greater discrepancies among people in the workplace, if we consider, for example, the cost of equipment and the low availability. We can also dispute that this doctoral research had its number of limitations, one of its drawbacks being the sample size. Although the qualitative results generated relevant findings in response to the research question, we believe that limiting the number of people in the sample – especially due to the COVID-19 pandemic – may have prevented a more robust design of the TAM experiment.

For future reference, this experiment design can be improved with the inclusion of counterbalance when participants switch between different roles during sessions. Counterbalancing is a procedure that allows researchers to control the effects of variables in experiments where the same people are repeatedly subjected to various measures, conditions or stimuli. All things considered, to expand the results of this thesis, other experiments can be conducted by increasing the sample and, more significantly, including a larger demographic variation within the sample. Future studies may include, but are not limited to, people working in different sectors, a larger age group, people with different levels of technology acumen and expertise, and so on.

Another approach to studies focused on VR can be related to the level of immersion of the experience and can include VR equipment and different virtual environments in real-life contexts to evaluate non-immersive, semi-immersive and fully immersive simulations. Also, when it comes to the technology in question, its field commonly overlaps with that of AR and mixed reality. Several separate studies could be planned in this regard: how would people behave if all meeting participants were attending remotely using VR equipment? Or, at the other extreme, if everyone were physically present in the same location, but had AR resources mediating the activity? Moreover, studies may target human perceptions of the duration of the immersion experience. Is VR the right technology to be used for long periods of time over the course of a week, for example? How does it compare to AR in this respect? These types of experimentation could potentially be combined in comparative studies, in which each experiment could first be analyzed individually and then compared considering the same parameters.

Here, we argued the benefits of VR to society in terms of human experience in meetings and business-related contexts. Our main contribution was to bring experimentation with the technology considering the challenges brought by the contemporary need for remote collaboration, especially in the difficult times of the COVID-19 pandemic. Against this background, we prove that VR is capable of promoting feelings of immersion, presence and human connection, of bringing a new interest and renewed enthusiasm in the face of formerly mundane activities, of reducing or even extinguishing physical boundaries, of allowing customization of workstations, of bringing convenience, and of transforming work meetings into virtual 3D archives. Nevertheless, although this thesis was mainly centered around people, several technical problems were encountered and addressed with respect to software and hardware limitations. For this reason, the study of the potential and capabilities of VR should not be exclusive to a single domain, as it can be approached from a sociotechnical perspective, covering several fields of research.

At last, in this thesis, the contribution to the scientific field of Design lies also in adapting the research methods, as occurred with the final experiment based on TAM. The design of the experiment was not only modified with a focus on qualitative data analysis but was empirically adapted as a result of the transformations brought about by the pandemic of COVID-19.

8
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Appendix A – Research Informed Consent Form for the interviews

Pontifícia Universidade Católica do Rio de Janeiro

Research Informed Consent Form

Semi-structured interviews for academic research on face-to-face and remote work meetings

PRIMARY RESEARCHER

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A. PURPOSE OF STUDY

You are being invited to be a voluntary participant in a semi-structured interview session for academic research purposes. The doctoral thesis aims to investigate how the presence of people in collaborative scenarios, such as work meetings, can be mediated in a beneficial way by the use of technology. The specific phase of the study in which you will participate aims to grasp an overview of how work meetings take place during your day-to-day work environments, to then delve into the topics of remote and hybrid meetings, and its advantages, limitations, and challenges.

B. PROCEDURES

The semi-structured interview session will have a maximum duration of 1 hour and will be held remotely via videoconference. You will be asked, but not exclusively, to:

- Explain a little about the context of your work environment, such as workplace location and setup.
- Freely discuss topics such as the size of the team with whom you work regularly and directly, the frequency of meetings you host and/or attend, both with team members and external parties, and how long they usually last, as examples.
- Express your feelings about advantages and limitations and challenges of different types of meetings, like face-to-face and remote ones.

C. RISKS

We do not anticipate any risks for you participating in this semi-structured interview session.

D. BENEFITS AND COMPENSATION

You will have no benefits or financial compensation from participating in this semi-structured interview session.

E. CONFIDENTIALITY

Every effort will be made by the Primary Researcher to preserve your confidentiality including assigning code names/numbers for participants that will be used on all research notes and documents.

All material collected will be treated as confidential and restricted for academic purposes. By signing this consent form, you authorize the use of the data collected in the semi-structured interview session – without revealing your face or identity – for academic purposes. Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. Please check the waiver below.

- ❑ I authorize the videoconference to be recorded for future note-taking purposes only.

F. CONTACT INFORMATION

If you have questions regarding your rights as a research participant, or you have questions at any time about this study, you may contact the Primary Researcher whose contact information is provided on the first page. If problems arise which you do not feel you can discuss with the Primary Researcher directly, contact the Research Advisor at the following email address mquaresma@puc-rio.br.

G. VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign this consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Date:

Participant's name:

Primary Researcher's name:
Patrícia Torres Pereira Carrion

Participant's signature:

Primary Researcher's signature:

Appendix B – Web-based survey with Consent Form

Work meetings and other similar business-related contexts

Hello, thank you for participating in this survey! This research aims to investigate how people collaborate and interact together during remote business meetings.

The duration of this survey will be approximately **8 minutes**.

Answer the following questions sincerely based on your experience in your current job. Assess the questions taking into account the current pandemic of Coronavirus disease (COVID-19) and any changes that have occurred in your workplace. So, consider the last 5 months of work when taking the survey.

By accepting to participate in this survey, you agree that your data will be used for research analysis and disclosed anonymously in academic publications.

* 1. Which of the following options best represent the industry or core business of the company you currently work for?

(Maximum 2 options)

- ☐ Technology & Software
- ☐ Marketing and Advertising
- ☐ Financial services
- ☐ Education
- ☐ Health
- ☐ Media
- ☐ Travel & Lodging
- ☐ Logistics
- ☐ Telecommunication
- ☐ Consumer goods
- ☐ Government
- ☐ Videogame & Mobile game
- ☐ Insurance
- ☐ Manufactured
- ☐ Non-profit
- ☐ Retail
- ☐ Others. Please specify (only one):

* 2. At work, what is your current position/title?

* 3. Does your current company have more than one workplace? That is, do you work with people from the same company located in different physical locations?

For example, people working from home, or located in different buildings in the same city or different cities, states, and countries.

◯ Yes

◯ No

* 4. Do you have the option of working from home?

◯ Yes

◯ No

* 5. What is the approximate total number of people you work with directly in different physical locations?

Consider that you are working from home or the office and all other colleagues are working in different physical locations than yours.

◯ Up to 5 people

◯ From 6 to 10 people

◯ From 11 to 15 people

◯ From 16 to 20 people

◯ From 21 to 25 people

◯ More than 25 people

◯ I never work with people located in a different physical location than mine

Next

Work meetings and other similar business-related contexts

Meetings (Collaborative work)

In relation to work meetings, answer the following questions:

* 6. How often do you attend meetings at work?

Consider 5 days per week.

- ◯ More than once a day, every day of the week
- ◯ Once a day, every day of the week
- ◯ 3 to 4 times a week
- ◯ 1-2 times a week
- ◯ Once a month
- ◯ I do not attend meetings often

* 7. Most of the time, how is the setup of the meetings in your workplace?

Consider the meetings you have most often.

- ◯ Only **in-person meetings**, in the same physical location – no participant is remote
- ◯ Only **remote meetings**, in different physical locations – all participants are remote
- ◯ **Hybrid meetings**, with two or more participants in the same physical location, and others remotely

* 8. In order of your preference, rate the ways in which work meetings occur.

Place the option that appeals most to you at the top and the one that least appeals to you at the bottom.

- All attendees, including myself, in person at the same physical workplace
- Me, in person at my workplace, with the minority (less than half) of the attendees being in remote mode
- Me, remotely, with the majority (more than half) of the attendees being together in a same physical location
- Me, remotely, with a majority (more than half) of the attendees also in remote mode, separated from each other in different physical locations
- All attendees, including myself, remotely in different physical workplaces

* 9. What types of meetings do you have at work and what is the average duration of these meetings?

	30 minutes (half an hour) or less	60 minutes (1 hour)	120 minutes (2 hours)	180 minutes (3 hours) or more	Does not apply / I do not attend this type of meeting
1-on-1 meetings (e.g., evaluation meetings between manager and employee)	○	○	○	○	○
Demo sessions and information sharing meetings (e.g., sharing results with stakeholders)	○	○	○	○	○
Planning and status update meetings	○	○	○	○	○
Problem-solving and innovation meetings (e.g., brainstorming sessions, design sprints, workshops)	○	○	○	○	○
Team building meetings	○	○	○	○	○

Prev Next

Work meetings and other similar business-related contexts

Fully remote and hybrid work meetings

Hybrid work meetings are the ones in which part of the attendees is located together in the same physical location, and the other people join the meeting by conference call or web conference.

Fully remote work meetings are the ones in which none of the attendees is together in the same physical location.

In relation to fully remote and hybrid work meetings, answer the following questions:

* 10. What technologies and tools you and your team use during these meetings?

- ☐ Papers
- ☐ Post-it notes
- ☐ Whiteboards
- ☐ Monitors/screens
- ☐ Cloud file storage and sharing tools (e.g., Box, Dropbox, Google Drive, OneDrive)
- ☐ Online collaborative whiteboards (e.g., Miro, Sketchboard)
- ☐ Annotation tools (e.g., Google Docs, Evernote)
- ☐ Messaging tools (e.g., Chatwork, Facebook Workplace Chat, Slack)
- ☐ Planning tools (e.g., MeisterTask, Trello)
- ☐ Slide presentations (e.g., Google Slides, Visme)
- ☐ Video and web conferencing (e.g., Appear.in, Google Meet, Skype, Zoom, Webex Cisco)
- ☐ Others. Please specify:

* 11. In your opinion, which are the positive aspects and advantages of fully remote or hybrid work meetings?

- ☐ Comfort, as they allow people to attend the meeting remotely, in the comfort of their own home
- ☐ Convenience, as they make it possible to interact with people from any geographical distance
- ☐ Flexibility, as they make it easier to manage and schedule work appointments
- ☐ Greater attendance, as they offer an alternative to those unable to join the physical location of the meeting
- ☐ Less physical space requirements, since part of the attendees is in remote mode
- ☐ Ease of sharing materials (e.g., slide presentations and other shared documents) with the attendees
- ☐ Others. Please specify:

* 12. In your opinion, which are the negative aspects and disadvantages of fully remote or hybrid work meetings?

- ☐ People talking at the same time, over each other, prone to misunderstandings
- ☐ Hand gestures and other nuances of the body language being hard to identify
- ☐ Noisy and unclear communication (e.g., when people forget to mute their audios)
- ☐ Conversations that do not flow "naturally"
- ☐ Lack of discussion, since people might feel less motivated to interact
- ☐ "Mute button effect", when you or someone else is muted and less present at the meeting as a result
- ☐ Loss of a more personal and human connection
- ☐ Interaction limited to a screen, with people being unable to walk around and move from one group to another in the meeting
- ☐ Discomfort about being the center of attention on video, or self-conscious of being able to see yourself on the screen
- ☐ The risk of private information falling into the wrong hands if access to the meeting is not adequately protected
- ☐ Others. Please specify:

* 13. At last, what would you like to be able to do during these meetings, but that current technologies and tools have failed to help you?

Prev Done

Appendix C – Research Informed Consent Form for the experiment

Pontifícia Universidade Católica do Rio de Janeiro

Research Informed Consent Form

Academic research experiment using a VR headset and controllers

TITLE OF STUDY
Virtual Reality for remote work: Exploring the acceptance of VR technology for meetings and business-related contexts

PRIMARY RESEARCHER

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Phone: (+47) 902 29 976
Email: patriciatpc@gmail.com
Advised by Maria Manuela Rupp Quaresma, Ph.D. (Research Advisor, email: mquaresma@puc-rio.br)

A. PURPOSE OF STUDY

You are being invited to be a voluntary participant in an academic research experiment using a VR headset and controllers. The doctoral thesis aims to investigate how the presence of people in collaborative scenarios, such as work meetings, can be mediated in a beneficial way by the use of Virtual Reality (VR) technologies. In this sense, we believe that VR, if used as a tool to assist fully remote and hybrid work meetings, provides greater involvement and engagement of people during the activity. The specific experiment in which you will participate aims to apply a modified Technology Acceptance Model (TAM) to measure VR acceptance or rejection as a tool for remote work meetings.

B. PROCEDURES

The experiment will be split into five sessions. In one of these sessions, you will have the role of hosting the meeting with a VR headset and controllers. In the other sessions, you will join via web or mobile, using your own personal smartphone/mobile device. Each meeting session will have a maximum duration of 30 minutes. Extra time before the start of the session will be added for when you are the meeting host – you will have help of the experiment moderator to set up the VR equipment. In summary, among your tasks, but not exclusively, you will be asked to:

- Sign up to an app and create an avatar, by uploading a photo or by taking a picture of yourself with your own smartphone/mobile device.
- Use a VR headset (*Oculus Quest 2*) and controllers.
- Use your own smartphone/mobile device.
- Freely explore the resources of the virtual meeting room and discuss together with other participants on how to organize ideas during a brainstorming session.
- Freely express your opinion on the Virtual Reality experience during a remote focus group with other participants.

C. RISKS

To enter Virtual Reality, you must use a headset (*Oculus Quest 2*) that will completely block your view of your real location and partially prevent you from hearing the outside world. As a security measure, the Primary Researcher will be personally present with you in your real location at all times, to closely observe and assist you, if and when necessary.

Due to the unpredictable nature of the human response to VR (dizziness, disorientation, nausea, fear of heights, bumping into objects, etc.), participation in this experiment carries certain inherent risks that cannot be eliminated regardless of the care taken to avoid injury.

Please check the waivers below and sign this consent form releasing the Primary Researcher, the Research Advisor and the research institutions named in this document from any liability related to the use of *Oculus Quest 2* headset and/or any of the other equipment that accompany the headset.

- ❑ I am using the VR equipment voluntarily.
- ❑ I acknowledge these risks and assume responsibility for my participation in the VR experience.

D. COVID-19 SAFETY MEASURES

Please read the following statements carefully and feel free to ask questions if anything seems unclear.

During the current COVID-19 pandemic, participation in this study is only open to individuals who do not have a weakened immune system, and who do not have one or more of the COVID-19 high risk medical conditions. Furthermore, if you are uncertain about your risk level, you are required to seek medical advice before participating to determine if you are in a high-risk category. If you are in a high-risk category, you may not be able to participate in the study.

The physical location in which this experiment will take place is up to you. The only time you will meet someone in person will be during just one session when you will need to use a VR headset and VR controllers. All other sessions will be conducted remotely. For the face-to-face session, you will need help setting up the equipment and will be observed and watched closely throughout the session as an extra security measure.

In order to help reduce the risk of spreading COVID-19, you and the Primary Researcher must follow the public instructions and information from Trondheim municipality and the Norwegian government, in addition to taking the following safety precautions:

- The day before the face-to-face session, the Primary Researcher will ask you to confirm that you do not appear to have symptoms, using your preferred contact method (phone call, SMS, email).
- On the day of the face-to-face session, no more than an hour before, you must confirm again that you do not appear to have symptoms. If this is not the case, you should contact the Primary Researcher to reschedule your appointment.
- You and the Primary Researcher will be required to wear a face mask at all times, except you, when using a VR headset. A mask will be provided to you, if necessary.
- The Primary Researcher will ensure that the high-contact surfaces and/or shared equipment are sanitized between participants' appointments.
- You and the Primary Researcher must maintain a physical distance of 2 meters or more, unless some experiment procedures require a closer distance or contact (for example, fitting the VR headset).

In addition to the above, you will be contacted in cases where you may have been exposed to COVID-19 at the experiment site. We also ask that you follow the procedures outlined below. Do everything you can to follow these health-related procedures and guidelines to protect yourself and others:

- Avoid touching your face with unwashed hands.
- Avoid physical contact with other individuals to whatever extent possible.
- Advise the Primary Researcher if you believe a safety measure is not being taken, or if you feel that safety is at risk.
- Attend the experiment site alone.
- If taking public transit for this visit, please follow all guidelines from the transit service and public health, such as wearing a face mask and hand sanitizing.
- If you are feeling unwell or experiencing any potential COVID-19 symptoms, then please stay home and notify the Primary Researcher that you cannot attend. Contact information can be found on this consent form.

E. BENEFITS AND COMPENSATION

You will have no benefits or financial compensation from participating in this experiment.

F. CONFIDENTIALITY

Every effort will be made by the Primary Researcher to preserve your confidentiality including assigning code names/numbers for participants that will be used on all research notes and documents.

All material collected will be treated as confidential and restricted for academic purposes. By signing this consent form, you authorize the use of the data collected in the experiment sessions – without revealing your face or identity – for academic purposes. Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents.

G. CONTACT INFORMATION

If you have questions regarding your rights as a research participant, or you have questions at any time about this study, or you experience adverse effects as the result of participating in this study, you may contact the Primary Researcher whose contact information is provided on the first page. If problems arise which you do not feel you can discuss with the Primary Researcher directly, contact the Research Advisor at the following email address mquaresma@puc-rio.br.

H. VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign this consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Date:

Participant's name:

Primary Researcher's name:
Patrícia Torres Pereira Carrion

Participant's signature:

Primary Researcher's signature:

Patrícia Torres Pereira Carrion