META-SHOPPING: DESIGN FOR IMMERSIVE AND ENGAGING APPAREL SHOPPING EXPERIENCES THROUGH VR

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ABSTRACT

META-SHOPPING: DESIGN FOR IMMERSIVE AND ENGAGING APPAREL SHOPPING EXPERIENCES THROUGH VR

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Virtual reality aims to immerse its users into an alternate reality by making use of computer-generated stimuli. In so doing, it creates a controlled illusion of being present at an alternate place, possibly giving its user the feeling that they are performing a different activity than their current physical activity. In the context of apparel shopping, VR holds the potential to offer customers a more immersive, experiential and task-oriented shopping experience by blending the features offered by both online and physical stores. By eliminating issues related to physical shopping such as geographic location, time and transportation, VR enables customers to explore a virtual store anywhere and at any time. Further, it also bears the potential of making up for some of the disadvantages of online shopping such as the inability to "feel" the fabric of a garment, thus offering a possibility to construct a bridge between the physical and online shopping experiences.

This thesis explores the possible design strategies to design immersive and engaging apparel shopping experiences through virtual reality. Through the user tests conducted with VR headsets and follow-up interviews, this thesis explores users' reactions, interactions, behaviors and engagement with VR apparel stores in order to understand their main expectations, needs and hesitations while shopping for apparel through virtual reality.

Thus, the research aims to discover possible design solutions for smoother and well-structured VR shopping experiences that will address the utilitarian and hedonic needs of apparel shoppers.

Keywords: Virtual Reality, Apparel Shopping, Virtual Stores, Shopping Experience

ÖZ

META ALIŞVERİŞ: SANAL GERÇEKLİK İLE SARMALAYICI VE ETKİLEYİCİ GİYİM ALIŞVERİŞ DENEYLİMLERİ TASARIMI

Kumbasar, Ecem
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Sanal gerçeklik, bilgisayar tarafından üretilen yapay uyaranlar aracılığı ile kullanıcılarını alternatif bir gerçekliğe sürüklemeyi amaçlar. Bu sayede kullanıcılarına bulundukları yerden farklı bir ortamda bulundukları ve gerçekleştirmekte oldukları faaliyetten başka bir etkinlik gerçekleştirdikleri hissini vermeyi hedefler. Kıyafet alışverişi bağlamında sanal gerçeklik, müşterilere çevrimiçi ve fiziksel mağazaların sunduğu özellikleri bir araya getirerek daha ilgi çekici, deneyim ağırlıklı ve görev odaklı bir alışveriş deneyimi sunma potansiyeline sahiptir. Fiziksel alışverişin beraberinde getirdiği coğrafi konum, zaman ve ulaşım gibi sorunları ortadan kaldırarak müşterilerin her yerden ve her an sanal bir mağazada gezinti yapmalarını mümkün kılar. Ayrıca internet üzerinden alışverişin sebep olduğu malzeme ve dokuyu "hissetme" eksikliği gibi dezavantajları da telafi etme potansiyeline sahiptir. Böylece, fiziksel ve çevrimiçi alışveriş deneyimleri arasında potansiyel bir köprü niteliği de taşımaktadır.

Bu tez kapsamında yapılan araştırma çalışmaları, kullanıcıların sanal kıyafet mağazaları ile olan tepkilerini, etkileşimlerini, davranışlarını ve faaliyetlerini gözlemlemektedir. Sanal gerçeklik gözlükleriyle gerçekleştirilen kullanıcı testleri ve takibinde gerçekleştirilen mülakatlar aracılığıyla, kullanıcıların sanal giyim mağazalarındaki tepkilerini, etkileşimlerini, davranışlarını ve katılımlarını

inceleyerek, sanal gerçeklik aracılığıyla giyim alışverişi yaparkenki temel beklentilerini, ihtiyaçlarını ve tereddütlerini anlamayı amaçlamaktadır. Söz konusu araştırma sayesinde sanal gerçeklik giyim alışveriş deneyimini, kullanıcıların ihtiyaçları doğrultusunda daha pürüzsüz ve akıcıbir hale getirmek için olası tasarım çözümlerinin keşfedilmesi amaçlanmaktadır.

Anahtar Kelimeler: Sanal Gerçeklik, Kıyafet Alışverişi, Sanal Mağazalar, Alışveriş Deneyimi

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CHAPTER 1

INTRODUCTION

The integration of digital devices such as mobile phones and tablets into our lives, as well as that of internet, were corner stones in the history of digitalization. Although today's technology does allow for rapid and quick interaction with internet and digital gadgets, there still remains a friction caused by screens and keyboards. In a world which is transitioning from the internet of things (IoT) to the internet of life, virtual reality technology, along with augmented and mixed reality technologies, aims to one day remove all friction from our lives when interacting with the internet.

Virtual reality (VR), very briefly, is a graphically simulated three-dimensional world which allows its users to immerse into and interact with an environment- be it realistic or fantastical. It aims to immerse people into alternate realities where the friction created by screens and other digital devices is removed. Indeed, there were times where VR as a technology gained interest and others when it lost its popularity. Despite its history filled with set-backs and come-backs, we are at a time in history, once again, where virtual reality is beginning to gain popularity. There is a growing body of research in the field of VR with increasing number of companies investing in this technology.

Given the growing interest of both users and companies to explore this technology, VR holds the potential to one day cover a large part of our lives and even become a tool that will blend in with our everyday lives, very much like the mobile phones of today. Businesses and companies from various sectors are already strategizing on how to blend this technology into their business models. Military, medicine, tourism, media, education, entertainment, architecture, art and fashion are some of the sectors that have already started using VR.

Fashion is one field that is highly likely to exploit the potentials of VR in order to create more meaningful, engaging, informative and convenient shopping experiences for customers. VR's potential to transport users into realistic virtual shops where they can explore, observe, interact with and even virtually try on products turns virtual reality into a promising new avenue for fashion and retail brands. These possibilities also hold the potential of redefining customers' expectations, shopping behaviors and purchase behaviors, thus changing the overall shopping experience.

Among the various areas VR is used in, this thesis will specifically focus on how to use VR for apparel shopping purposes. The reason behind this choice is to examine whether and how VR can form a bridge between online and physical shopping experiences. Indeed, with the vast digitalization, fast paces of everyday lives and due also to the COVID-19 pandemic, online shopping is gaining increasing popularity as the days pass. Virtual reality holds the potential to create more engaging, interactive and immersive shopping experiences. However, in spite of the initial excitement indicated by consumers regarding VR, purchase rates of commercially available VR glasses show that this excitement hasn't successfully translated itself into purchase behavior (Hedges, 2024). This indicates that there still remains a need to provide value and to create more useful and meaningful interactions for VR (Hedges, 2024). This thesis will focus on what design strategies can be implemented while designing VR shopping experiences for apparel industry specifically.

Aim and Scope of the Study

For this reason, this thesis aims to explore design strategies that can be taken while designing *immersive and engaging apparel shopping experiences delivered through VR.* VR apparel shopping, unlike many other forms of VR shopping, bears another layer of challenge: haptics. What separates online shopping from physical shopping is largely the inability to explore a garment's fabric through touch. Online shopping, too, shorts fall on this account. VR apparel shopping, on the other hand, holds the potential to contemplate for this by creating more interactive, engaging and

experiential online shopping experiences. Although it may be difficult, and extremely expensive, with today's technology to integrate haptics into virtual reality gadgets, virtual apparel stores can provide alternate means to make up for this gap.

The main goal of this thesis is to find out how VR can turn the online shopping experience into a more interactive, fun and experiential activity, thus possibly covering the need to "touch" the garment to a certain extent. For this goal, the main objectives of this study can be listed as:

- to discover the potentials of design to create more engaging and simulating VR experiences
- to discover how design can be used to create more immersive, engaging and experiential apparel shopping experiences
- to discover how the need for touch during apparel shopping can be partially contemplated for through VR apparel shopping.

Research Questions

With these goals in mind, the following two research questions will be answered based on this research:

1) What are the dimensions to consider when creating immersive and engaging (apparel) shopping experiences through VR?
2) What design strategies can be followed to meet the hedonic and utilitarian needs of apparel shoppers by using the potentials of VR?

The literature research and the research studies were constructed to find answers to the above-given research questions. In line with this aim, this thesis contains six chapters. Below are brief explanations of what each chapter covers.

Firstly, Chapter 1, *Introduction*, mentions the potentials of VR in apparel shopping experience. It talks about the main motivations behind this research, its aims, scope and goals, as well as the research questions which shaped the overall research.

Chapter 2 of this thesis, *Literature Review on Virtual Reality*, starts by giving a brief definition to the terms "virtual", "reality" and "virtual reality", continued then with the perception of reality and the means to alter it. The topic of "reality" in the context of VR is then discussed, followed by the definitions of presence, immersion, interaction and imagination in VR. Virtual environments, avatars and designing interfaces for VR are then discussed.

Chapter 3, *Literature Review on Shopping Experience*, starts with a brief explanation of the utilitarian and hedonic aspects of shopping, followed next by some of the shopping motivations and different shopper types. The influence of store environment over shopping experience is then briefly discussed, followed by online and VR shopping. The advantages, disadvantages and potentials of VR shopping are also mentioned based on literature review.

Chapter 4, *Methodology*, explains how the research sessions and post-interview were structured and conducted. The underlying user-centered research approaches including usability testing for VR are mentioned, followed next by the study protocol. Limitations of the current study are also shared in this chapter.

Chapter 5, *Data Analysis, Results and Discussion*, starts by explaining how the collected data was analyzed, forming the themes and sub-themes of the research. The found relations between the themes and sub-themes are then explained, after which a theme map showcasing the themes, sub-themes and the links between them is introduced. Each theme and sub-theme are then discussed more thoroughly with reference to the research data. The chapter is concluded with a table including the design insights which emerged as a result of this research.

Finally, Chapter 6, *Conclusion*, includes a brief overview of the thesis, answering the research questions, and indicating potential directions for future research regarding apparel shopping experiences through VR.

CHAPTER 2

LITERATURE REVIEW ON VIRTUAL REALITY

This chapter begins by giving definitions to virtuality, reality and "virtual reality" (VR). In order to better understand what reality is and what is meant by realism in a VR, topics including perception of reality, means of changing the perception of reality and the meaning of realism in the context of VR are briefly discussed. The reality virtuality continuum is shared in order to demonstrate the shift from reality to virtuality.

VR systems and different visual display methods to experience 3D VR systems, the distinction between 2D and 3D virtual environments (VEs) as well as reality and fidelity in the context of 3D VEs are discussed with references from literature. The chapter then continues with the sense of "being there", namely presence, in relation to virtual environments and the 3I's of virtual reality (i.e. immersion, interaction and imagination). Finally, use of avatars (i.e. virtual bodies or characters which represent the VR user), characteristics of shared virtual environments and design strategies that can be implemented for VR interfaces are shared with reference to existing literature.

2.1 "Virtual" vs "Reality" vs "Virtual Reality"

There are several different definitions and interpretations of virtual reality (VR). In order to better understand what this term really stands for; it is best to first look into the meanings of the two words making up this term: *virtual* and *reality*. According to Oxford Learner's Dictionaries (n.d.), "virtual" means "almost or very nearly the thing described, so that any slight difference is not important". Similarly, the Cambridge Dictionary (n.d.) describes the term as "almost a particular thing or quality". Reality, on the other hand, is a more complex word to define. To give a very brief definition to "reality", let us once again look into the dictionary meanings of this word. The same

dictionaries (Oxford Learner's Dictionaries and Cambridge Dictionary) describe the word "reality" as "a thing that is actually experienced or seen, in contrast to what people might imagine"; and "the state of things as they are, rather than as they are imagined to be", respectively.

When these two seemingly contradictory words come together (i.e. virtual reality), however, they gain a new meaning. The Academic Press Dictionary of Science and Technology defines virtual reality as "a computer simulation of a system, either real or metaphorical, that allows a user to perform operations on the simulated system and shows effects in real time" (Morris, 1992, cited in Wang, 2002, p. 232). Gigante (1993, p.3) defines virtual reality as an immersive, multi-sensory synthetic experience that "relies on three-dimensional (3D), stereoscopic, head- tracked displays, hand/body tracking and binaural sound".

Jaron Lanier, a computer scientist, visual artist and contemporary classical music composer, who is the first in history to coin the term "Virtual Reality" also gives several definitions to VR in his book *Dawn of the New Everything*. Some of these definitions include, but not limited to, "the substitution of the interface between a person and the physical environment with an interface to a simulated environment (Lanier, 2017, p. 86)"; "technology that rallies the brain to fill in the blanks and cover over the mistakes of a simulator, in order to make a simulated reality seem better than it ought to (Lanier, 2017, p. 92)"; and "entertainment products that create illusions of another place, another body, or another logic for how the world works (Lanier, 2017, p. 217)".

2.2 Perception of Reality

Before we more elaborately take the subject of virtual reality under scrutiny, let us first better understand what "reality" is. Our perception of reality is shaped mainly by two things: our minds and our senses (Stanković, 2016). We often consider sensory input as the proof of existence and realness of something (Carbon, 2014). Widely speaking, the very act of "seeing" or the ability to "feel" by touching constitute physical proof

of the existence of something (Carbon & Jakesh, 2013; Carbon, 2014). Although sensory input of any kind can be taken as proof of existence, it is also impossible to speak of an objective perception (i.e. perception that is free from our individual experiences and knowledge, or perception that is accepted by everyone) (Carbon, 2014).

Our perceptions are not merely constructed by the sensory inputs we receive from the world surrounding us, but also from our past experiences and prior knowledge (Frith & Dolan, 1997). Further, our minds have the ability to fill in the blanks and make heuristic guesses at the absence or deficiency of sensory input (Frith & Dolan, 1997; Carbon, 2014). Our sensory system is limited in that we cannot see a full spectrum of wavelengths or hear a full spectrum of frequencies.

There are several examples in the literature demonstrating the mind's ability to complete, fix, and interpret sensory information based on prior experiences. For example, Biederman (1981, cited in Carbon, 2014) exposes participants to visuals with inconsistent or inaccurate data. Instead of noticing these flaws, participants "re-arrange the setting" in the visuals based on their existing knowledge, thus mentally fixing the inaccuracies and inconsistencies.

Another example of the human mind's ability to take references from his past experiences or knowledge is mentioned by Frith and Dolan. With reference to Ramachandran (1994) they say that when one sees an impoverished or fragmented version of a black-and-white photograph (where the content is difficult to recognize), they might not be able to understand the content at first. If the viewer is shown, however, the original picture afterwards, and then the impoverished version of the same photograph one more time, they are then able to recognize the content of the picture (Ramachandran, 1994; Frith & Dolan, 1997). This shows that the human brain perceives things differently based on prior experience/knowledge.

This function of the human brain (i.e. the ability to fill in the gaps based on prior experience/knowledge) can be turned into an advantage when designing environments or experiences for Virtual Reality. Taking into account that individual differences play

a role on the perceived feeling of presence in VR (Witmer & Singer, 1998; Jicol et al., 2023), imaginative suggestibility of users can be considered a crucial factor in enhancing the feeling of presence in a VE (Jicol et al., 2023). Currently, no commercial VE can compare to the realism of real world (Jicol et al., 2023). Hence, it can be argued that imagination plays an important role in increasing the feeling of presence in VE. Through imagination, missing parts in a virtual reality system can be compensated. Further, it has been shown in literature that individuals with higher imaginative suggestibility are not only able 'fill in the gaps' but also to 'ignore the gaps' (Jicol et al., 2023). Indeed, some individuals are better able to ignore the inconsistencies or other elements that may negatively affect the feeling of presence in a VR (Jicol et al., 2023). Sheridan (2000) also touches upon this topic, stating that "some suppression of disbelief is necessary to achieve (p. 3)" immersion in the VR, very much like willingly becoming hypnotized. Considering that the human brain is also quite skilled at abstract thinking (Stanković, 2016), our abilities such as completing missing information within a scenery, accepting abstraction to a certain level and fixing some inaccuracies that may occur within a scene are concepts that can be considered by VR designers.

2.3 To Trick the Mind or to Trick the Senses?: Changing the Perception of Reality

Stanković (2016) mentions that there are two possible ways to alter one's perception of reality. First is by tricking the mind and changing the way it processes the data it receives from our senses, and the second is by tricking the senses, thus changing the data that the senses transmit to the brain (Stanković, 2016, p.3). The human mind can be more easily tricked. Use of chemical agents (e.g. psychedelic drugs, alcohol, etc.), blood glucose level or psychological techniques (e.g. hypnosis and autosuggestion) are some ways to deceive the human mind and create a misconception/alternate perception of reality (Stanković, 2016, p.3).

Tricking the senses, on the other hand, is a more complex process since our senses are capable of tracking minute differences, thereby realizing any inconsistency that may

occur (Stanković, 2016). The latter approach (i.e. tricking the senses) is exactly how virtual reality tries to work by making use of artificial computer-generated stimuli (Stanković, 2016). Indeed, our nervous system chooses one world at a time to perceive as real (Lanier, 2017, p. 95). When the artificial stimuli presented to the user of a VR system suffice to trick their nervous system, they begin to perceive the artificial world as the real external world (Lanier, 2017, p. 95). Virtual reality can be considered as a "synthetic world" where one feels "present" and where one has control over his/her surroundings (i.e. virtual environment) and objects within that virtual environment. The concepts of presence and control within an environment (i.e. interaction) will also be covered more elaborately in the coming sections.

2.4 Reality Virtuality Continuum (Virtual, Augmented and Mixed Realities)

In their "A Taxonomy of Mixed Reality Visual Displays", Milgram and Kishino (1994) introduce a "virtuality continuum" where they demonstrate on a spectrum the transition from "real environment" to "virtual environment". Figure 2.1, adapted from Milgram and Kishino (1994) demonstrates the reality-virtuality spectrum. As can also be observed in the figure, the transition from real environment to virtual environment involves Augmented Reality (AR) and Virtual Reality (VR) respectively, while the overlap of the two ends of the spectrum (i.e. when real environment and virtual environment are experienced together) is defined as Mixed Reality (MR).

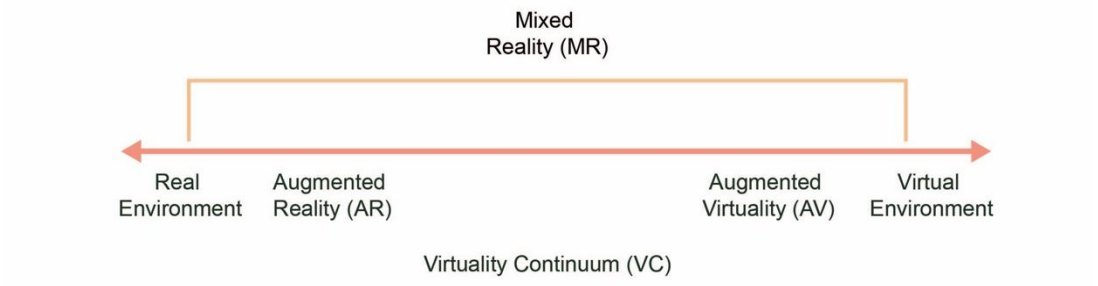


Figure 2.1. The Virtuality Continuum (redrawn from Milgram & Kishino, 1994).

Milgram and Kishino (1994) state that the main distinction between the terms “real” and “virtual” depends on “whether one is dealing with real or virtual objects, real or virtual images, and direct or non-direct viewing of these (Milgram and Kishino, 1994, p. 2)”. They distinguish between real and virtual objects by saying that “real objects are any objects that have an actual objective existence”, whereas “virtual objects are objects that exist in essence or effect (only), but not formally or actually” (Milgram & Kishino, 1994, p. 6-7). Further, a real object can be observed in a direct or non-direct manner. The direct way to observe a real object is the natural way we perceive things in the real environment (i.e. without any equipment or display screens). The non-direct way to view a real object is to sample and resynthesize it via some display device (Milgram & Kishino, 1994). A virtual object is a simulation of a non-existing entity (Milgram & Kishino, 1994). Lastly, the difference between real or virtual “image” can be explained with the contrast between the experience of viewing one's own real hand directly in front of oneself and the experience of viewing an image of the same real hand through a monitor (Milgram & Kishino, 1994).

With these distinctions in hand, they define a real environment as one which “consists solely of real objects” (Milgram & Kishino, 1994, p. 3). A Virtual Reality environment, on the other hand, is one where “the participant- observer is totally immersed in, and able to interact with, a completely synthetic world” (Milgram & Kishino, 1994, p. 2). They add that Virtual Environment (VE) can either imitate some properties of real environments, or can go beyond the limitations of our physical reality (Milgram & Kishino, 1994).

Again, in the same article, they define Augmented Reality (AR) as the “case in which (...) an otherwise real environment is ‘augmented’ by means of virtual (computer graphic) objects (Milgram & Kishino, 1994, p. 2)”. Carmigniani and Furth (2011) define Augmented Reality as “a real-time direct or indirect view of a physical real-world environment that has been enhanced/*augmented* by adding virtual computer-generated information to it” (Carmigniani & Furth, 2011, p. 3). They then continue by saying “AR enhances users’ perception of and interaction with the real world; (...) AR technology *augments* the sense of reality by superimposing virtual objects and cues

upon the real world in real time" (Carmigniani & Furth, 2011). Augmented Reality can therefore be considered as a type of Virtual Reality system where computer-generated graphics are overlaid onto the real system (Kim, 2005).

There exist many commercial applications of AR. Figure 2.2 illustrates examples from Pokémon Go, Adidas, The IKEA Place AR app and the Sephora Virtual Artist tool. The Pokémon Go uses the camera and the GPS of a digital device to hide Pokemon characters in the real world which the user of the application has to hunt. The AR feature of Adidas allows customers to virtually try shoes on their own feet by pointing the camera at their feet, while the IKEA's AR feature allows users to view furniture to scale in their own houses. Finally, the Virtual Artist tool on the Sephora application scans the customer's face for virtual product try-on with the use of face recognition technology.

Next, Milgram and Kishino describe the Augmented Virtuality (AV) as a "grey area". Unlike the Augmented Reality (AR), which adds elements, objects or cues to the real environment, thus *augmenting* the reality of the *real environment*; the Augmented Virtuality (AV) adds "*video reality*" to "completely graphic displays" (Milgram & Kishino, 1994). In the case of Augmented Virtuality, therefore, the environment that is being augmented is not the real environment of the user but rather a virtual environment that is further augmented with video display. They add, however, that with the technological developments, it might become rather difficult to distinguish "whether the primary world being experienced is in fact 'real' or predominantly 'virtual'", which may eventually close the gap between the terms AR and AV (Milgram & Kishino, 1994). We can state, thereby, that the difference between Augmented Reality (AR) and Augmented Virtuality (AV) is that the first one (i.e. Augmented Reality) overlays computer graphics onto the real world whereas the latter (i.e. Augmented Virtuality) overlays computer graphics onto video imagery (Kim, 2005).

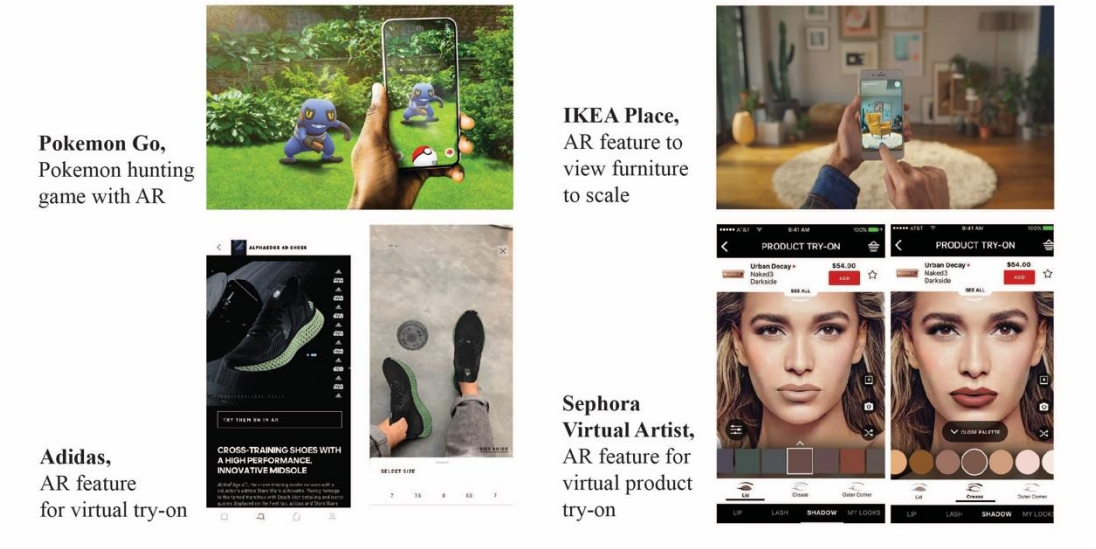


Figure 2.2. Some commercial examples of AR. Includes images from Pokémon Go, Adidas, IKEA Place and Sephora Virtual Artist. Collage prepared by the author.

This gray area on the virtuality continuum can be filled with the term Mixed Reality (MR) (Milgram & Kishino, 1994). Milgram and Kishino define Mixed Reality as when "real world and virtual world objects are presented together within a single display" (Milgram & Kishino, 1994). Lanier describes the term Mixed Reality as when "the real world is not hidden entirely by the virtual one; you see virtual stuff placed within the real world, as experienced in a HoloLens" (Lanier, 2017). Pan et al. also state that Mixed Reality (MR) is the "incorporation of virtual computer graphics objects into a real three-dimensional scene, or alternatively the inclusion of real-world elements into a virtual environment", with the "former case being generally referred to as Augmented Reality and the latter as Augmented Virtuality" (Pan et al., 2005). There are also sources in grey literature that introduce Mixed Reality as a version of Augmented Reality where the elements in the virtual layer are more interactive (Marr, 2021). Further, the term Extended Reality (XR) is also used as an umbrella term referring to MR and other combinations of virtuality and physical reality (AR, VR).

2.5 Realism in Created Media

The concept of reality in arts has long been argued. Indeed, it wasn't until the rules of perspective had been fully discovered, that the artists were able to depict environments, in addition to objects and figures, realistically (Stanković, 2016). On the other hand, it might be difficult to distinguish even the things we encounter in our physical surrounding as real or representation (Sherman & Craig, 2018). To exemplify this situation, Sherman and Craig give an example from the *The Treachery of Images* by René Magritte. Magritte depicts a realistic pipe (as seen in Figure 2.4) below which he puts the words "Ceci n'est pas une pipe. (This is not a pipe.)". Despite the realness of the pipe in the painting, it is also apparent that the depiction is indeed an art work and not a real pipe (Sherman & Craig, 2018). Still, if asked what it was, the observers of the paint would be more likely to reply by saying that it is a pipe instead of highlighting the fact that it is a painting of a pipe (Sherman & Craig, 2018). Indeed, this demonstrates the immersive quality of art, where one disregards all the physical proof that what is being depicted is not the real thing, and where one begins to be immersed in an alternate reality where the depiction becomes the reality for a while. It can be declared, thereby, that "the content conveyed by a medium is a virtual world. (Sherman & Craig, 2018, p. 64)".



Figure 2.3. The Treachery of Images, 1929 by Rene Magritte.

2.6 Virtual Reality Systems

A VR system can be considered as an intermediary between the computer and the user (Jerald, 2016). The system aims to create an illusion of immersion and presence in a virtual environment using computer-generated stimuli (Stanković, 2016). To create a sense of presence, the VR system must allow the user to interact with the virtual environment and/or objects within that environment (i.e. the user shouldn't be a mere observer during the experience). An ideal VR system allows for as smooth and transparent a communication between the computer and the user as possible, so that the user can forget he/she is in a virtual world (Jerald, 2016; Sherman & Craig, 2018). A well-designed VR system can, therefore, be considered as an "interfaceless" medium (Sherman & Craig, 2018).

In today's VR systems, the communication between the computer and the user is achieved via hardware devices. Commercially available VR headsets usually involve an HMD along with hand-held consoles which work similarly, in logic, to the mouse of a computer. In a fully immersive VR system (levels of immersion in VR systems will also be covered in detail in the coming sections of this thesis), both the head-mounted display and the hand consoles allow for interaction with the system. The HMD usually responds to head motions, simultaneously changing the graphic displays presented to the user of the system; while the hand-held consoles allow for several purposes including, but not limited to, interaction with objects, bodily gestures and movement within the virtual environment. Figure 2.4 shows a systems graphic adapted from Stanković (2016) showing the feedback loop of communication between the VR user and the VR system.

2.6.1 Visual Displays Used in Virtual and Augmented Reality Systems

There are three ways to implement a VR or AR system: head-mounted displays (HMDs), world-fixed displays and hand-held displays. A head-mounted display can be used both as a means to create a virtual and an augmented reality system.

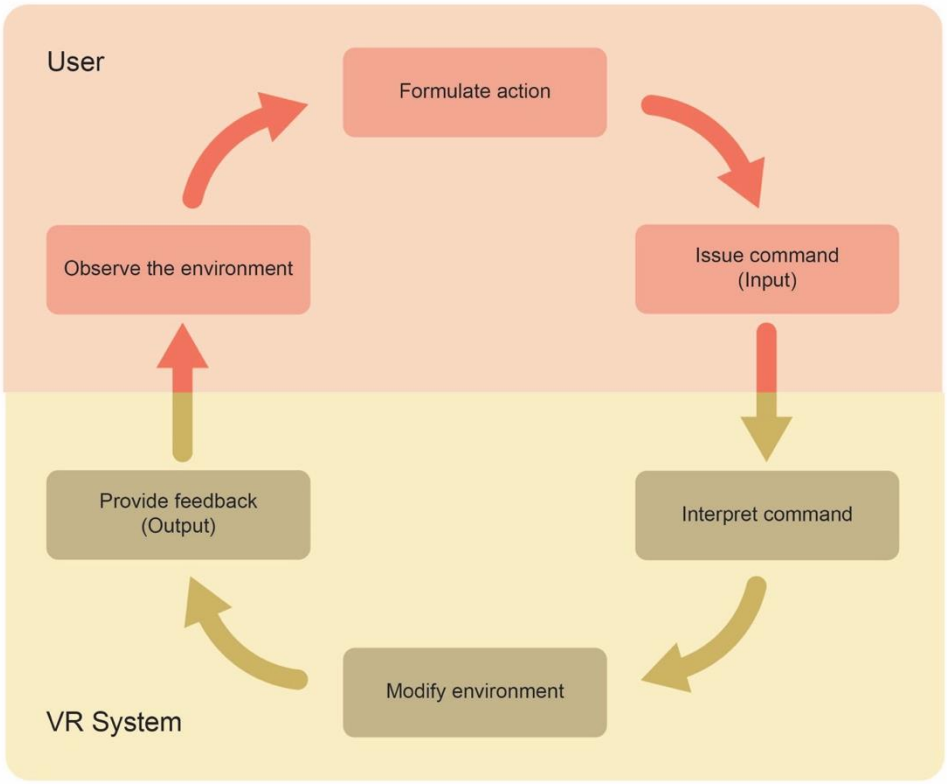


Figure 2.4. Systems graphic showing the feedback loop of communication between the VR user and the VR system (redrawn from Stanković, 2016).

2.6.1.1 Head-Mounted Displays (HMDs)

As is also suggested by its name, a head-mounted display is attached to the head. HMDs today may implement one or multiple of the following three strategies: non-see-through, optical-see-through and video-see-through (Jerald, 2016). A non-see-through HMD blocks out all the cues from the real world (Jerald, 2016) and creates immersion into an artificial environment. Ideally, the environment has to provide a 360-degree point of view so as to match the user's head orientation. The user should be provided with a different render at each point if the experience is to be fully-immersive. See-through HMDs, on the other hand are used to enhance rather than replace the real environment, thus creating an augmented reality experience (Rolland et al., 1994). There are two different see-through HMDs; optical-see-through HMDs and video-see-through HMDs.

An optical-see-through HMD superimposes computer-generated cues onto the visual field, thus creating an augmented reality experience (Rolland et al., 1994; Jerald, 2016). In optical-see-through HMDs, the real world is seen through semi-transparent mirrors, which also do the reflecting of the computer-generated content into the user's eyes (Rolland et al., 1994). Video-see-through HMDs, on the other hand, capture the real world with cameras, upon which computer-generated images are electronically overlaid (Rolland et al., 1994). Most see-through HMDs use the optical-see-through type (Rolland et al., 1994), including the Meta Quest 3 (see Figure 2.5) which was the VR headset used in the studies of this research.



Figure 2.5. A close up of the Meta Quest 3 VR headset (the HMD used for the studies of this research).

2.6.1.2 World Fixed Displays

World-fixed displays are fixed rooms/spaces where graphics are projected onto the surfaces of the display area and audio is heard through speakers. The person

experiencing the world-fixed display enters a specially designed room/space where he/she experiences rendered graphics and audio. The graphics are usually projected onto flat surfaces, although in some cases graphics may be projected on more complex shapes (Jerald, 2016).

Further, real-world objects can be placed inside the world-fixed displays (Jerald, 2016), thus making the experience an augmented reality experience and even allowing for the addition of tangible experience. Additionally, some world-fixed displays (i.e. the ones that are not restricted to a single correct viewpoint) create an allowance for social group experience (Zielinski et al., 2017).

CAVE-type virtual reality systems, exemplified in Figure 2.6, are a type of world-fixed displays. CAVE (Audio-Visual Experience Automatic Virtual Environment) is a recursive acronym. It, as a concept, is reminiscent of Plato's allegory of the cave, and is a cubical room with display screens that surround the viewer (Cruz et al., 1992).



Figure 2.6. A CAVE VR System (Taken from ST Engineering AntyCIP, 2023).

Previous research shows some advantages of CAVEs over head-mounted displays. These advantages include increased presence and lowered rates of simulator sickness (Zielinski et al., 2017). This is due to the fact that CAVEs offer a larger view field than HMDs, a better-suited distance between the projected graphics and the user's eyes, better scene continuity and increased personal awareness (Zielinski et al., 2017).

2.6.1.3 Hand held Displays

Hand-held displays are output devices that are held in hand, and which do not require precise levels of tracking or alignment with the user (Jerald, 2016). It, too, is a form of augmented reality, although in the case of hand-held displays, the experience is an indirect one (i.e. indirect augmented reality) (Jerald, 2016). Hand-held displays layer computer-generated or photo-realistic images on top of real-world images making use of a camera and an interface designed specially for this aim. Of the three types of displays mentioned (i.e. HMDs, world-fixed displays and hand-held displays) hand-held displays are the easiest to access since many smartphones and tablets can be used for this purpose (Jerald, 2016).

2.7 Virtual Environments

A virtual environment (VE) is a world simulated through computer-generated stimuli that may or may not mimic real world features. In essence, any computer-generated "place" with which a user can interact can be considered a virtual environment. Social media platforms or computer games can, therefore, be considered virtual environments where the user has the ability to interact with the environment or with the components of that environment. Figure 2.7 includes a classification of various VEs, as adapted from Stanković (2016), categorized based on their social interaction levels and visual presentation types. The environments in the figure are classed based on their level of social interaction (i.e. single vs multiple user) and type of visual presentation (i.e. text only or 2D versus realistic 3D).

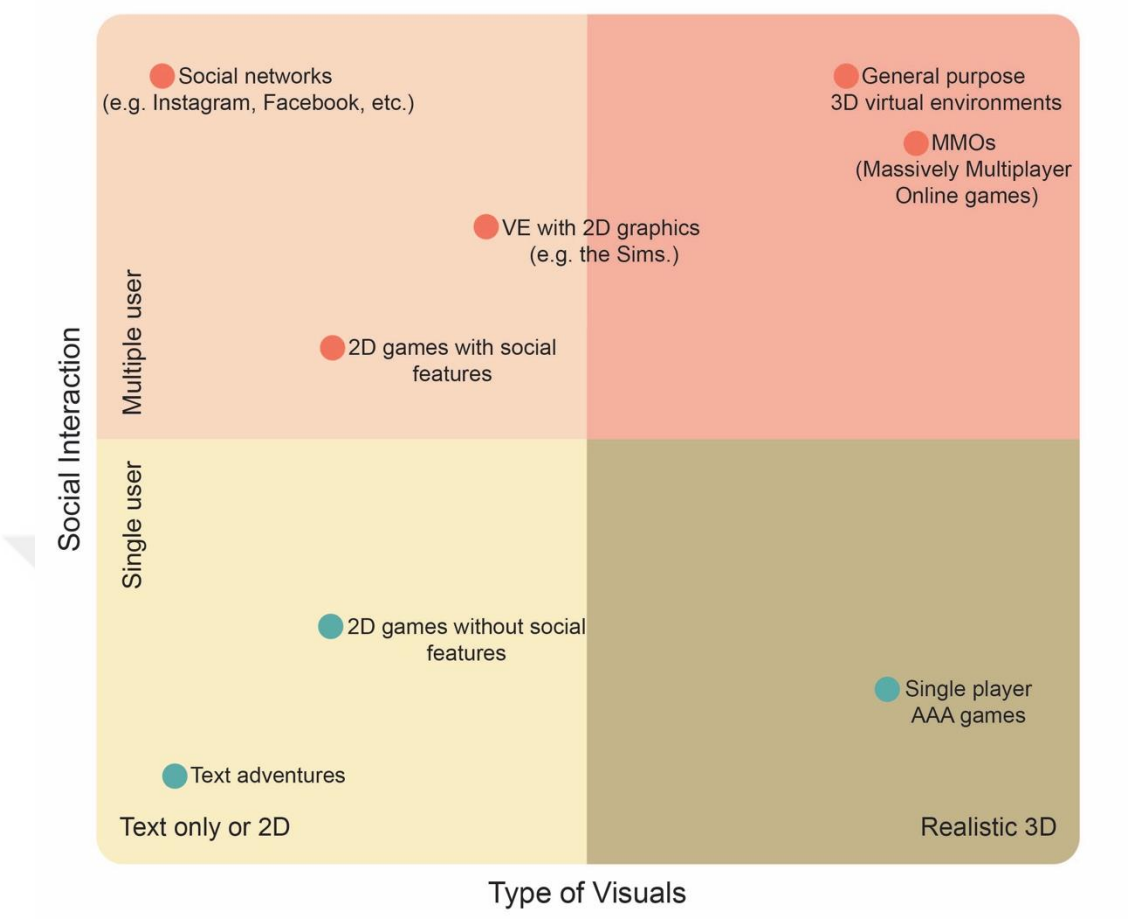


Figure 2.7. Relative classification of VE based on level of social interaction and type of visual presentation (redrawn from Stanković, 2016).

A virtual environment can be experienced either from a first person point of view, or from a third person point of view (Stanković, 2016). In the former case, the user experiences the VE as if he/she is present in that environment, whereas in the latter case, the user experiences the VE through an avatar, a virtual character representing the user (Stanković, 2016).

Grimshaw defines a "digital virtual world" as one where the user can "participate in the story, add to the content, modify the settings, and interact with other users" (2013, p. 87). The distinction between the above-mentioned VEs (e.g. social media platforms, online games, etc.) and a virtual world experienced through VR glasses is that the latter not only allows for interaction with/within the environment but also offers immersion

into the environment. Immersion, along with interaction and imagination are the three key characteristics of a virtual world. Each of these topics (i.e. immersion, interaction and imagination) will be touched upon more elaborately in the coming sections of this thesis.

It can be said that the main aim of VR is to make the user believe that he/she is "present" in a simulated world. VR has the ability to transport people to non-existent and unrealistic environments (Hale & Stanney, 2014). When reality is mentioned within the context of virtual worlds, therefore, what is really meant is not the resemblance of the virtual world to the real one, but rather the extent to which the environment makes the user feel present at the depicted scene (Toczek, 2016). The coming sections will elaborate on the meanings of realism, fidelity and "presence" in the context of virtual reality, after which some of the factors needed to create the feeling of presence in a virtual environment will be explained.

2.7.1 Reality and Fidelity in Virtual Environments

In the context of VR, as mentioned above, reality doesn't mean resemblance to the real world, but is linked, rather, to the feeling of presence in any given virtual world. Indeed, virtual worlds enable users to form a better understanding of three-dimensional shapes and spaces through perceptual phenomena (Mine, 1995). Research by Schnabel and Kvan (2003) as mentioned by Dominic & Robb (2020) shows that a 3D virtual environment helps with the readability (i.e. understanding) of the spatial qualities of an environment.

In real world, peripheral vision plays a crucial role for building spatial awareness, and for movement and navigation within an environment. Our central and peripheral visions also affect our interaction with objects (Arthur, 1996). "Visual information is provided through both peripheral and central retinal areas, each specialized for processing specific types of information (Sivak & MacKenzie, 1992, p. 234)". Sivak & MacKenzie (1992) mention that when one aims to grasp an object, his/her eyes are usually fixed at the object, thus placing the object in the central visual field; while the

hands and arms are in the peripheral visual field. During the act of reaching to an object, the hands and arms remain in the peripheral field where only towards the end of the action (i.e. when one is just about to grasp the object) do hands also fall in the central vision. Studies show that seeing both the hand and the object when making a movement leads to increased interaction accuracy compared to seeing only the hand, or only the object (Sivak & MacKenzie, 1992). When the person sees the hands, arms and object all clearly, the information is provided through both peripheral and central visual fields (Sivak & MacKenzie, 1992). Therefore, including both fields of vision (i.e. central and peripheral) when designing a VR system can help in task performance. If the user can see both the virtual object and a virtual representation of his/her hands (and arms, in certain scenarios) [i.e. hands and arms of the virtual body (VB)], the quality and resulting success of an interaction within VR may increase. Peripheral vision also helps with searching purposes (Arthur, 1996), for instance when one scans an environment to find a specific object, clue or information. A larger field of view (FOV) is also shown to increase a person's ability to navigate effectively in an environment as well as his/her ability to interact with an object in the environment though it may lead to increased simulator sickness (Arthur, 1996).

In addition to the integration of one or both fields of vision in the VR according to the requirements of the experience in hand, a designer of VR should also consider the visual reality of the graphics integrated into the system. In the context of VR, visual realism is "a spatio-temporal illusion" (Pillai et al., 2013), which is necessary in VR to better engage the user with the experience, thus increasing immersion in the VR (McMahan et al. 2012; Newman et al., 2021). However, previous research also shows that a reduced level of presence (e.g. a more abstract portray of the environment) can increase user performance in certain cases (Ellis, 1996; Schuemie et al., 2001). Therefore, there is a need to find a balance in visual realism when designing for VR. While high visual fidelity may contribute to immersion, it may also lessen user performance. In the cases where the user needs to focus on a certain task, it might be helpful to eliminate any visual details that may lead to distraction. VR designers should, therefore, consider the purpose and the context of the experience they are

aiming to create. If they aim to design an experience where the overall feeling of presence, exploration of or navigation within an environment are key, they may want to go for a higher visual fidelity in their designs. If the main purpose of the VR experience is task completion or to create a high rate of user performance, on the other hand, they might consider using lower fidelity visual displays. VR systems designed with educational purposes (except for probably ones that are aimed at training for surgery, etc.), for instance, may benefit from reduced visual fidelity.

McMahan et al. (2012) define two types of fidelity in the context of VR: (1) display fidelity (i.e. sensory realism), and (2) interaction fidelity (i.e. action realism). In their research, they compare four different VRs consisting of first-person shooter games. The four VRs have (1) high-display, high-interaction (HDHI); (2) high-display, low-interaction (HDLI); (3) low-display, high-interaction (LDHI); and (4) low-display, low-interaction (LDLI) fidelities. For high-display fidelity, they use stereoscopic graphics (i.e. graphics that give the illusion of depth by presenting two slightly different images to each eye, thus mimicking the human binocular vision) and a 360-degree field of regard (FOR). For low-display fidelity, they use non-stereoscopic graphics and a 90-degree FOR. For high-fidelity interaction, participants use a handheld controller as well as their bodies to interact with and navigate within the VR. For low-fidelity interaction, they use a mouse to interact and a keyboard to move within the environment. The results of the study show that both high-display fidelity and high-interaction fidelity positively affect the feeling of presence and user performance in the VE as well as engagement and interaction with the VR. Further, an increase in display fidelity also affects the understandability of and navigation within an environment positively (McMahan et al., 2012). Familiarity too plays a role on the interaction ability of the participants. The increased rates of task performance in LDLI and HDHI observed in the same research, as is argued by the authors, may be due to the resemblance of the LDLI to a standard desktop interaction, and the resemblance of HDHI to real world interactions.

Visual familiarity, along with interaction familiarity, can also be helpful in VR. Skeuomorphism, for instance, can be adopted as a means to increase the

understandability of environments and objects in VR. Skeuomorphic design involves mimicking of real-world details of objects or environments, such as texture or material. It makes use of familiarity to increase the understandability and to allow for more intuitive interactions (Stanković, 2016). Thus, the user can relate what he/ she sees in the depicted scene to their existing knowledge in real world, forming meaningful links. Examples of skeuomorphism in digital representations include logos/icons of digital tools or applications, graphic interfaces of games or virtual representations of real environments. Figure 2.8 shows a collage of skeuomorphic designs where real world references shape the design.

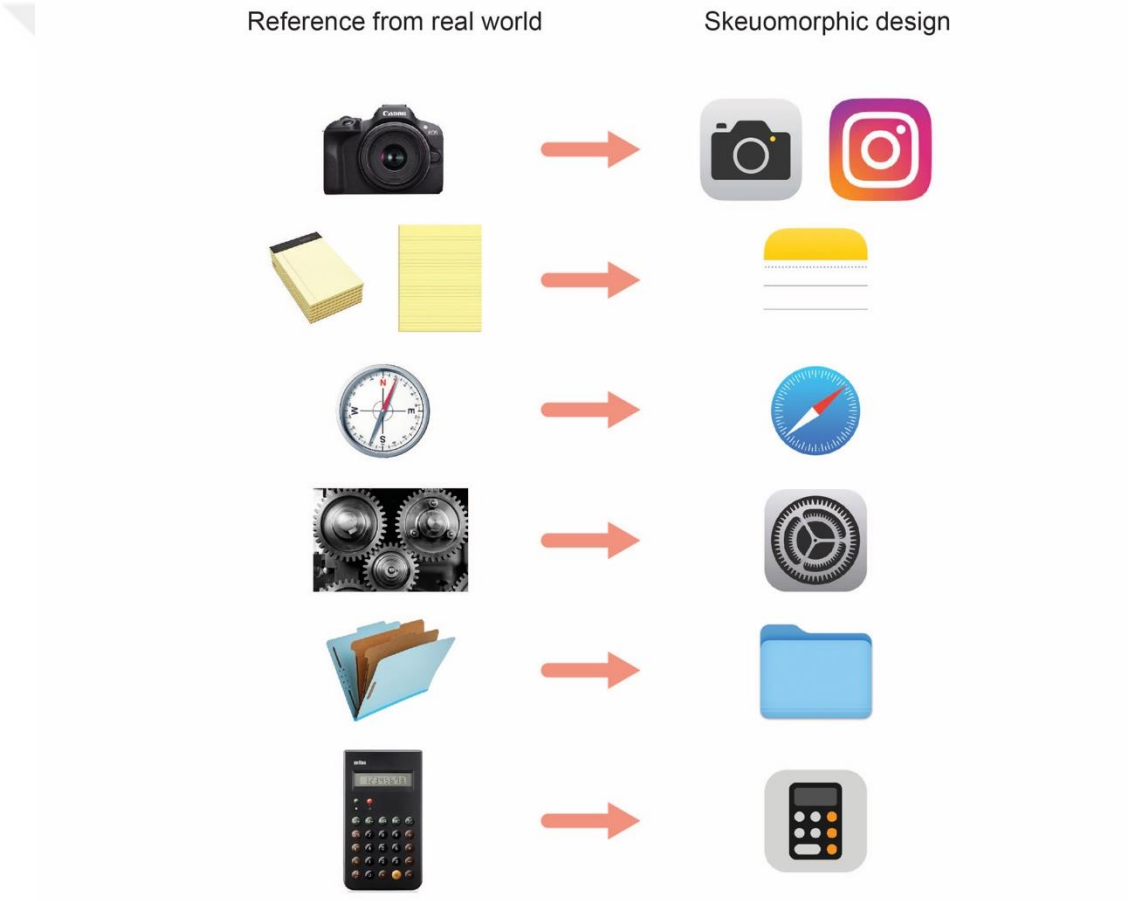


Figure 2.8. Examples of skeumorphic design (collage prepared by author).

2.8 Presence

Presence and immersion are two terms that are often used interchangeably in the field of VR (Bailenson et al. 2005; Wilkinson et al., 2021). It goes without question that the two terms are largely dependent on one another. However, there still exists different meanings for these terms. Presence, as opposed to immersion is "a state of consciousness, the (psychological) sense of being in the virtual environment" (Slater & Wilbur, 1997, p. 4). It can, therefore, be defined as a subjective rather than an objective experience (Witmer & Singer, 1998). In an ultimate VR experience, the user should experience the virtual world as more engaging an environment than his physical surrounding (Slater & Wilbur, 1997). Immersion, on the other hand, is related rather to the technical aspects (Slater & Wilbur, 1997) and technological capabilities (Oliveira et al., 2019) of a VR system. The feeling of "being there" rises from the immersive quality of a system (Slater, 2003). It can be concluded, thereby, that there lies a correlation between the immersiveness of a system and the feeling of presence induced as a result of immersion. A quadraphonic sound system (i.e. one that involves four audio channels, typically arranged in four corners of a listening space, thus enhancing spatial audio perception), for example, can create a feeling of being present in an environment different than the listener's physical one (Slater, 2003).

From a very general perspective, it can be argued that the main aim of virtual reality is to create and convey a feeling of presence to its user (Steuer, 1992; Slater, 2003). However, it should not be mistaken with the level of interest or level of involvement. Involvement is a state arising from the allocation of one's attention on a set of certain stimuli, activities or events (Schuemie et al., 2001; with reference to Witmer & Singer, 1998). Indeed, presence in VR depends largely on selective attention, i.e. tendency to focus one's attention on certain selected information or on a set of meaningful information (Witmer & Singer, 1998). Simply spoken, one might experience a virtual environment and feel very much "there" as far as presence goes, and yet might not feel intrigued or excited about the content of the experience (Slater, 2003). The same applies to real world experiences, too, where one might actually be present at a certain

location or event, but may feel uninvolved or uninterested (Slater, 2003). Obviously, the very opposite may happen, where a person might be involved in a certain activity such as watching a movie or reading a book, but may not feel present in the depicted events (Slater, 2003). Therefore, presence and the level of involvement or the level of interest are not the same (Slater, 2003).

Since the feeling of presence is rather a psychological condition, different individuals may experience different levels and types of presence in any given virtual experience (Slater et al. 1995; Chow, 2016). Different users interacting with the same virtual environment might, for instance, construct separate mental models of reality, or simply may not feel present in the VE due, for instance, to absence of sound or rejection of the virtual body (VB) presented to the user (Slater et al. 1995). Further, a user's VR experience depends on both intrinsic and extrinsic elements (Sra, 2023). Intrinsic elements are integrated into the system (i.e. the hardware and software) (Sra, 2023). Extrinsic elements, on the other hand, are related to the user's physical environment, background noise, his/ her emotions, prior knowledge, life experience, beliefs, etc. (Sra, 2023).

Presence, therefore, is both a subjective and an objective concept (Slater & Wilbur, 1997). It is subjective in that each individual may evaluate his/her degree of presence in a given VE distinctly; different users of the same VE might experience disparate levels of presence (Slater & Wilbur, 1997). It is also objective in that individuals experiencing a VE will perform observable behaviors; if the user's behaviors in VE are similar to how his/her behaviors would have been under similar circumstances in everyday reality, the level of presence in the VE can be argued to be higher (Slater & Wilbur, 1997). Schloerb (1995) also makes a distinction between a user's subjective presence and objective presence. He defines the subjective presence of a user as the degree that a user perceives the feeling of presence in a virtual environment. The objective presence, on the other hand, is the degree to which a VR user can successfully complete a given task (e.g. throwing a ball in a basket) (Schloerb, 1995). Another important component of presence is the plot line of VR (Slater & Wilbur, 1997). If the

plot line in a VR is able to present "an alternate self-contained world, the greater the chance for presence" (Slater & Wilbur, 1997, p. 5).

Chow (2016), with reference to previous research, categorizes the determinants of presence in VR into two: (1) user characteristics and (2) media characteristics.

User characteristics play a crucial role on the feeling of presence in a VE. In his work, Chow (2016) evaluates computer self-efficacy (CSE), perceived usefulness (PU), perceived is of use (PEOU) and subjective norm (SN) as determinants of user characteristics which influence the feeling of presence in VR. The results of his research show that computer self-efficacy (CSE; i.e. confidence in computer engagement) has the strongest influence on the level of presence in VR. Perceived usefulness (PU) of the VR system also largely affects the feeling of presence; when a user finds the VR experience useful for a certain task, he/she is more likely to feel present in the VE. The success of a user in task completion is also linked to the feeling of presence in VR (Schloerb, 1995). Since presence is a matter of focus, meaningful and coherent sets of stimuli will help with the feeling of presence (Chow, 2016). Perceived is of use (PEOU) is also significant in enhancing PU of a VR system (Chow, 2016). User-friendly interfaces and hiding of the complex details of the hardware and software of the system can increase the PEOU of a VR (Chow, 2016). Schloerb (1995) also mentions that the casualty of interaction with a VE helps with the feeling of presence. User's subjective norm (SN) also influences the PU of a system; when the user considers the technology important for the task in hand, he/she is more likely to connect and get involved in the virtual world (Chow, 2016).

Media characteristics, on the other hand, can be further subdivided into media form and media content (Chow, 2016). Media form is the physical properties of a display medium, that is the fidelity of sensory information presented to the user and the ability of the user to interact with the VR (Chow, 2016). Media content, on the other hand, refers to the activities, messages or story depicted in a VR (Chow, 2016). Representation of the user in the VR (i.e. involvement of a virtual body), social realism

and autonomous behaviors of the user can be listed as some of the media content which determine the feeling of presence (Chow, 2016).

Technical and technological aspects of VR also play a big role in the perceived feeling of presence. Different virtual experiences may require different technicalities based on their purposes to create a strong sense of presence. For instance, certain VR experiences might require higher qualities of auditory rendering whereas others might benefit more from the visual render quality (Slater & Wilbur, 1997). Moreover, inclusiveness of VE is also crucial. The more the events occurring in the user's physical environment are blocked out or the more they are perceived as part of the virtual experience itself by the user, the more present he/she is likely to feel in the VE (Slater & Wilbur, 1997). Next, the level of vividness of a VE also influences presence. Vividness "refers to the ability of a technology to produce a sensorially rich mediated environment" (Steuer, 1992, p. 10). The vividness of an environment depends on the depth of the sensory information presented to the user (Steuer, 1992). A study by Welck et. al (1996), as mentioned in Slater and Wilbury (1997), reports that the level of pictorial realism affects the quality of a simulated driving experience. As the pictorial realism increases so does the reported level of presence in the simulation. Thus, the vividness of a virtual environment affects the perceived sense of presence. Further, involvement of sound, whether it be spatialized or non-spatialized, increases the user's presence in the VE with the former leading to a higher level of presence (Slater & Wilbur, 1997). If the VE involves images and audio that have more depth, the user will be more likely to feel present in the depicted environment. Another key component of presence in VR is the level of feedback delay and the ability of the VR system to track and respond to the bodily gestures of the user (Slater & Wilbur, 1997). In our everyday lives, consequences of our actions are perceived rather quickly (Sra, 2023). In order for a user to fully connect with the virtual experience, the results of a user's actions in the VR, too, must be immediate, predictable and understandable. If there exists a mis-alignment with the user's interaction and the system's reaction, the user is more likely to lose his/her feeling of presence in the VR.

In order to create a feeling of presence in VR, therefore, one's bodily interactions are at least as important as what he/she sees in the environment. "Our bodies allow us to experience our (…) reality, perceive our own existence and the world around us" (Sra, 2023). We touch, pull, push, move and do several other things in addition to seeing and hearing to perceive things in real world (Sra, 2023). Multimodality, therefore, plays an important role in building a sense of presence. Although there is growing research that focuses on activating multiple senses for VR, commercially available VRs focus mostly on vision and audio. This, of course, is due to the complexities and challenges in implementing other modalities such as taste, smell and touch in today's technology (Sra, 2023). However, such shortcomings of today's technological limitations can be contemplated to a certain degree by increased fidelity of visual and auditory details and through integration of elements that already exist in the user's real-world environment (Sra, 2023).

In short, the blocking out of the real-world distractions and integration of physical cues into the VR system can help with the user's feeling of presence. The fidelity levels of visual and auditory components (e.g. realistic lighting and shadows, spatialness of audio, etc.) can maximize the user's feeling of "being there". Stimuli offered to the user of a VR can also be made to resemble real life experiences. Use of real-world sounds or integration of gestural interactions into VR can help with the feeling of presence. There also exists a need for quick and uninterrupted responses from the VR as a result of one's actions in both task-oriented and experience-oriented virtual realities. When a VR user, for instance, is taking a virtual tour of a city or a museum, he/she would expect high fidelity visuals along with in-time and smooth feedback from the VR system. The responses of the VR should well align with and correspond to the gestures, movements or actions of the user.

Another factor that affects the feeling of presence in VR is the *load of information* (Nunez, 2004). For instance, a simple paragraph depicting a scene and a photograph of it will not create equal amount of presence since the photograph likely involves more information about the depicted scene (Nunez, 2004). Similarly, context is important in creating a feeling of presence as it affects the way information is

perceived (Nunez, 2004). A user's expectations of what will occur in the given context determines how the sensory information will be interpreted (Nunez, 2004). A VR system, too, has to match the user's expectations in any given context. From the perspective of this research, it can be argued, therefore, that the amount of information presented to the user in a VR shopping experience as well as its relevance to the given context will play significant roles in the feeling of presence.

In the light of these findings, a designer can conclude that enhancing the feeling of presence in VR relies on both media characteristics and user characteristics. High-fidelity visuals, auditory realism, interactive capabilities of users within a VE, a coherent and consistent plot line in the VR as well as realistic social interactions and inclusion of a virtual body (VB) in the VR can increase the presence of users. Moreover, depicting a virtual environment from the user's perceived eye level, following the rules of perspective, using a realistic scale and allowing for social interactions (e.g. hand shaking) can add to the overall feeling of being there (Ellis, 1996).

2.9 "3 I"s of Virtual Reality

When designing a virtual reality experience, three conditions must be taken into account in order to create an increased feeling of presence: immersion, interaction and imagination. This section will elaborate on these concepts with reference to existing literature.

2.9.1 Immersion

As is also mentioned in the previous section of this thesis, immersion and presence are closely related to, yet also different from one another. Immersion, in fact, can be created through various media and without the use of technology. Watching a captivating movie, reading a book or listening to music can be considered immersive

activities. The main idea of immersion is that the experiencer gets carried away in the plot, or maybe just the activity, that he/ she disconnects from his surroundings.

Indeed, there are two types of immersion: *mental* and *physical* (Sherman & Craig, 2019). Mental immersion is "the state of being deeply engaged (Sherman & Craig, 2019, p. 10)" and can occur without the technology required for VR. Physical immersion, on the other hand, is how VR initiates immersion (Sherman & Craig, 2019). It replaces the stimuli received from the real world with synthetic ones, allowing one to bodily enter into a different medium (Sherman & Craig, 2019). It can be argued, therefore, that VR simulates a set of stimuli that block out the occurrences in the physical world, thus immersing the user into an alternate reality. Immersion can, thus, occur by two distinct approaches, i.e., "by blocking the competing signals from real world interfering in the virtual experience, and by increasing the number of sensory channels which receive information about the virtual world (Nunez, 2004, p. 83)". As far as technology and VR go, immersion can be described as "the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" (Slater & Wilbur, 1997). It can, therefore, be considered as the quality of user experience which is shaped mainly by the quality of the content presented to the user and the engagement arising from it (Stanković, 2016).

Slater and Wilbur describe immersion as "a description of a technology (1997, p. 3)" which delivers an illusion of reality that is *inclusive*, *extensive*, *surrounding* and *vivid* (Slater & Wilbur, 1997). *Inclusiveness* has to do with how much of the physical world is shut out (Slater & Wilbur, 1997). *Extensiveness* is the range of sensory modalities presented to the user (e.g., visuals, audio, haptic, etc.) (Jerald, 2016; Slater & Wilbur, 1997). *Surroundness* has to do with the view field of the VR (i.e. panoramic view field, 360-degree view field, narrow view field) (Jerald, 2016; Slater & Wilbur, 1997). Finally, *vividness* is the amount and quality of energy simulated for the displays (e.g., resolution, lighting, fidelity, frame rate) (Jerald, 2016; Slater & Wilbur, 1997).

In an ideal virtual reality experience, one would expect all these conditions (i.e. *inclusiveness, extensiveness, surroundness, vividness*) to be met efficiently. The weight of the head mounted displays (HMDs), for instance, has to be close to having no weight so that the external reality of the HMD is not perceived by the user (Slater & Wilbur, 1997). Another concept set forth by Slater and Wilbur on immersion is *plot*. For an effective level of immersion to occur, the virtual world has to present a consistent story-line, have its own dynamics and offer an alternate unfolding of the events occurring in that world, which are distinct from those in the real world (Slater & Wilbur, 1997).

Moreover, the responsiveness of a VR system to user's actions and the level of delay experienced in VR also influence immersion, thereby affecting the feeling of presence (Slater & Wilbur, 1997). In an ideal VR experience, the amount of delay between the motor actions of the user and the system's response must be minimized in order to create a "matching" VR experience (Slater & Wilbur, 1997). The term matching, in the context of VR, relates also to the perceptual and cognitive match between the actions executed by the user and the responses received from the VR (Slater & Wilbur, 1997). For instance, when a participant is walking in his/her physical environment to initiate a walking action in the VE, the optical flow perceived from the VR should match the optical flow that would normally occur when walking in real world (Slater & Wilbur, 1997).

Further, immersion is a multimodal experience (Stanković, 2016). In the case of virtual environments, multimodality can be defined as the simulation of multiple human senses (Stanković, 2016). In the real world, we experience and perceive reality with all our five senses. If, thereby, more than one of our senses are activated in the virtual world, the experience will become more immersive also. On the other hand, we rely on some of our senses more than others. Vision is the most dominant sense we rely on to perceive things, with audio being the second most dominant. This is one of the reasons why virtual reality technologies focus largely on visual and audio displays (Stanković, 2016). Figure 2.9 includes a schema adapted from Stanković (2016)

demonstrating the immersiveness of a virtual system based on the information presented to the user.

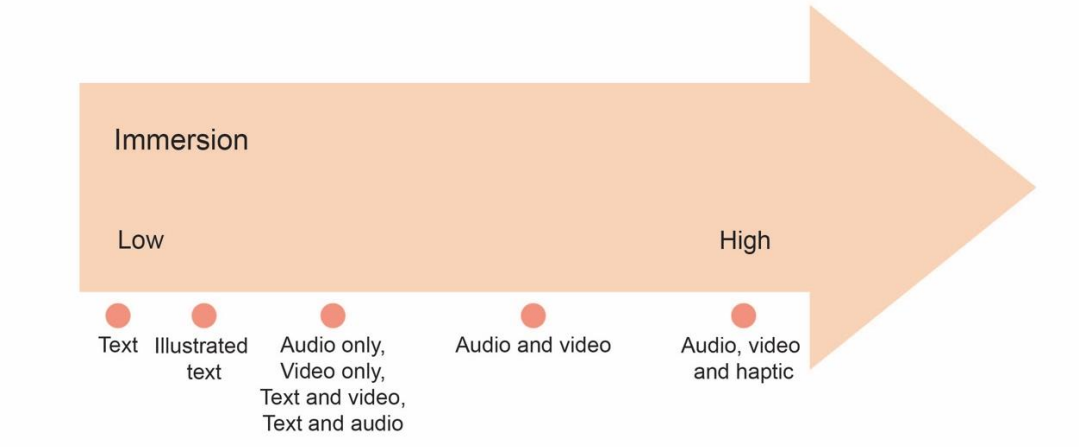


Figure 2.9. Schema illustrating the immersiveness of a virtual system, increased by multimodality (redrawn from Stanković, 2016).

2.9.1.1 Levels of Immersion

As was mentioned in the previous section, immersion doesn't always have to occur with the use of technology. Indeed, one can be mentally immersed (e.g. when reading a book, watching a play or a movie) or can be physically immersed (i.e. when the real-world stimuli are replaced with synthetic ones altogether) in a system (Sherman & Craig, 2019). In the context of VR, another categorization can be made based on the level of immersion offered by the VR system.

Virtual environments can consist of 2D or 3D images and can be experienced via screens (e.g. computer, tablet, etc.) or via VR devices (e.g. HMDs, world-fixed displays, etc.). The most typical examples of a 2D virtual environment can be listed as social networks and 2D games (See Figure 2.14). This type of VEs are experienced from behind a screen and are usually interacted with through the use of keyboards, touchpads and mouses. The physical barrier between the VE and the user (i.e. screens and gadgets used to interact with the VE) prevents from a high level of immersion. Such virtual environments are referred to as non-immersive virtual environments

(Mills & Noyes, 1999; Park et al., 2018; Kim & Choo, 2023). Immersive virtual environments, on the other hand, isolate the user utterly from the exterior world by providing realistic simulation to multiple senses of the user (Mills & Noyes, 1999; Kim & Choo, 2023). This type of VR usually requires the user to wear specialized equipment (e.g. HMDs) and use interactive devices (e.g. gloves, hand-held controllers, etc.) (Mills & Noyes, 1999; Kim & Choo, 2023). Gutiérrez et al. (2008) introduces three categories to differentiate the immersion levels of a VR system; non-immersive VEs (e.g. desktop-based VEs), semi-immersive VEs (e.g. CAVEs or other world-fixed virtual environments) and fully-immersive VEs (e.g. VEs experienced via HMDs). Other aspects affecting the level of immersion in a VE can be listed as; the field of view of the user and the size of the environment being experienced, the means to navigate and the navigation tools within the VE, responsiveness of the VR system to the user's movements and the degree of perception toward the presented world (Kim & Choo, 2023).

2.9.2 Interaction

Another key contributor of an engaging VR experience is interaction (Kim, 2005; Stanković, 2016; Sherman & Craig, 2019). There are two ways in which a user can interact with a virtual environment; (i) by causing a change within the VE or (ii) by changing his/her viewpoint in a given VE (Sherman & Craig, 2019). In that regard, some consider surround movies (i.e. spherically presented movies which permit the viewer to choose a specific region of the movie to view) as VR experiences (Sherman & Craig, 2019). VR, as is referred to in this thesis, allows for a level of immersion greater than that experienced in 2D virtual environments and some sort of manipulation with or within the VE. In that sense, interaction that occurs between the user and the VR system can be considered a feedback loop (See Figure 2.4). Although a VR system can be manipulated with input devices such as a keyboard or a mouse, the ability to interact with the VE through gestures and movements in the 3D space

adds immensely to the immersiveness of the experience, thus increasing the feeling of presence (Weise et al., 2020).

The way of interaction in a VE can either mimic the means of interaction occurring in real world, or it can provide novel, or even non-realistic, ways to interact with the virtual world (Bowman, 2002). Some examples of non-realistic interactions in a VE are when the user flies in the virtual world as a means of travel or when he/she can distort the relative proportions of the virtual objects to an unnatural level (Bowman, 2002). On the other hand, due to expected outcomes arising from familiar interaction means, VE interactions which mimic real world interactions can increase the level of immersion and presence in a virtual world, thus improving the user experience (Bowman, 2002).

Mine (1995) defines five forms of interaction in a virtual world: *movement*, *selection*, *manipulation*, *scaling*, interaction via *virtual menus and widget*. A user can perform any five of these forms of interaction (i) directly, (ii) through the use of physical controls or (iii) with virtual controls (Mine, 1995). The direct user interaction can occur in multiple ways, such as via hand tracking, gesture recognition, pointing or gaze direction (Mine, 1995). Interaction through physical controls is when the user initiates an interaction with VE via physical input devices such as buttons, joysticks, sliders, etc., whereas interaction with virtual controls is when one interacts with the VE via virtual buttons, menus and panels (Mine, 1995).

Navigation in VE

Movement, navigation or travel in a virtual environment can take several forms. In the case of world-fixed displays (e.g. CAVEs) or HMDs with see-through feature (which allow users to see the real environment while wearing the headset), the user can move in the environment in which he/she is physically situated to create movement in the VE. One downside of such interaction with the VE is that the physical surrounding of the user may not suffice to cover all areas in the VE (Nguyen et al., 2013). In such cases, the correspondence between the physical motion and virtual motion can occur at various levels (e.g. one step in the physical world can cover a much larger area of

movement in the VE) (Mine, 1995). Other interaction methods to initiate movement in the virtual environment include hand-directed interaction (i.e. using hand-held controllers), dynamic scaling (i.e. scaling down the world to choose a desired point to move to) and gaze directed interaction (e.g. moving within the VE based on the direction of gaze) (Mine, 1995). Further, physical controls (e.g. buttons, joysticks, etc.) or virtual controls (e.g. virtual buttons, steering wheels, etc.) can be used in order to move within a VE (Mine, 1995).

Navigation within a VE can either be object-driven or goal-driven. The object-driven navigation is when the user's movement in the VE is influenced by objects in the virtual world (e.g. when a user is unable to move due to an obstacle or when an autonomous vehicle such as a virtual elevator locates the user at a new place in the virtual world) (Mine, 1995). Goal-driven movement navigation is when the user can choose where to go from a list of destinations which may come in various forms such as text or icons (Mine, 1995). In some virtual worlds, the user is also able to control and alter the speed of movement in the VE (Mine, 1995).

One critical thing to consider when designing a VE is the number of degrees of freedom presented to the user of the VR (Mine, 1995). In the case of navigation within a virtual world, too few degrees of freedom will cause difficulty in reaching the desired destination whereas too many degrees of freedom can lead to disorientation and a loss of control over the system (Mine, 1995). Therefore, an optimum amount of freedom must be provided to the user of a VR to help with the ease of use and navigation within a VE. In certain use scenarios, presenting a pre-designated path on which the user can travel might come useful. In such cases, the virtual floor or the virtual environment, itself, is usually cued with navigation aids (Nguyen et al., 2013). Different forms of navigation aids can be listed as 2D or 3D maps (Chittaro & Venkataraman, 2001), landmarks (e.g. spatial cues that help with way-finding- Zhao et al., 2023), trail technique (i.e. showing the previously followed path to the user), use of compass, directional arrows and virtual sun (Darken and Peterson, 2001; Bowman et al., 2004; Bacim et al., 2012; Nguyen et al., 2012). Such means to assist with way-finding in VE are useful in order to allow the user to build a cognitive map of his/ her surroundings

in the virtual world, which increases the navigation performance of users in the VE (Elmqvist et al., 2007; Nguyen et al., 2013). Figure 2.10 includes screenshots from various virtual environments which make use of disparate virtual cues in order to help with orientation and navigation of the user inside the VE.

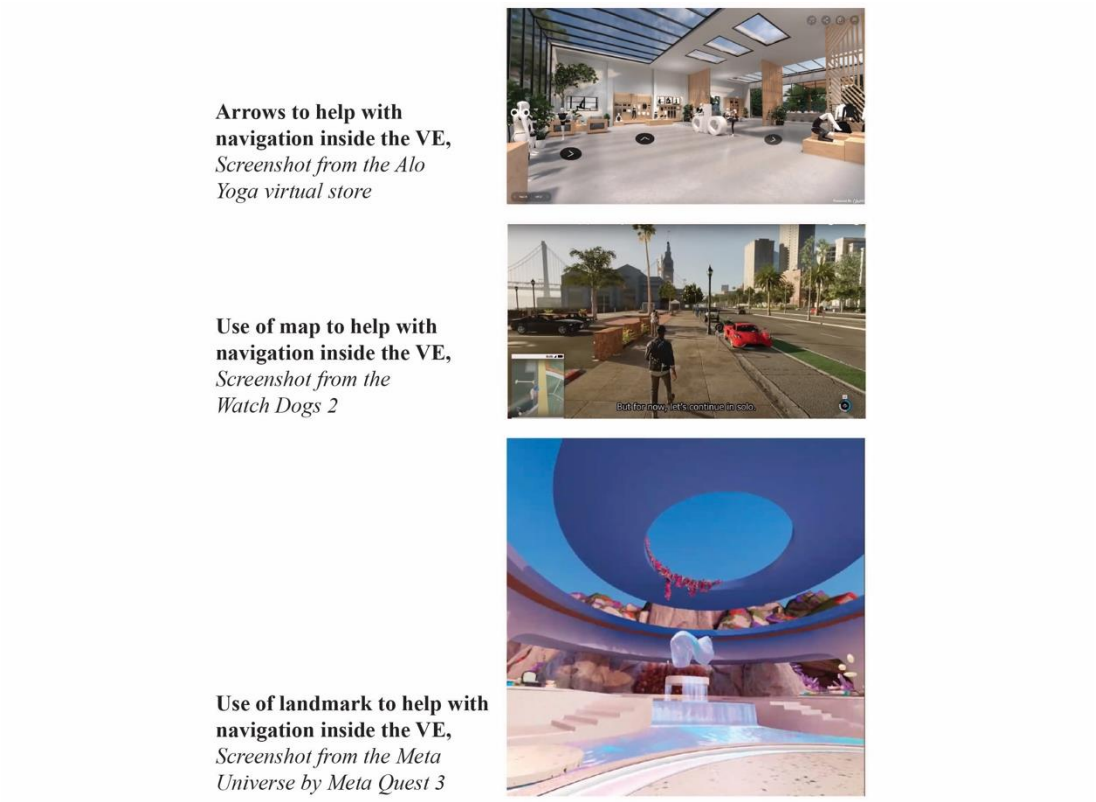


Figure 2.10. A collage of virtual cues used inside different VEs to help with the orientation and navigation of users (prepared by the author).

Making Selections in VE

Interaction with virtual objects in the VE requires some form of object selection to indicate the target object desired to interact with (Mine, 1995). Unlike the real world, a virtual environment may not only allow for interaction with close-by objects but also for distant objects in the virtual space (Mine, 1995). If the VE allows the user to interact with distant objects, virtual cues such as laser beams, spotlights or virtual cursors can be used in order to show the selection zone to the user (Mine, 1995). Gaze-

directed object selection is another way a VR user can interact with objects in the virtual world. In this case, the user gazes at an object and makes a selection via a pre-determined signal (Mine, 1995) such as blinking the eye. Voice input is an alternate way to make selections in the VE although this technique requires the user to remember the names/ IDs of all objects in the virtual world, thus increasing the cognitive load of the VR user (Mine, 1995). Finally, objects can also be presented to the user in some form of list (i.e. text or icon list) from which the user can make selections (Mine, 1995).

Manipulation of Objects and Scaling in VE

Another means to interact with a VE is to manipulate the objects present in the virtual world which, again, may or may not mimic real world interaction techniques (Mine, 1995). The VE can allow the user to grab, move and rotate an object, in which case the interaction will be analogous to physical world interaction (Mine, 1995). On the other hand, it can allow the user to zoom in and out of objects, eliminate certain objects in the virtual space or walk through objects without any manipulation (although the last one may also be a deficiency of the VE), in which case the interaction will be different from real-world interaction techniques. The user of a VR can manipulate the objects in his/ her virtual environment by using hand-specified gestures (e.g. grabbing motion, sliding motion, zoom-in motion, etc.) or via physical or virtual controls (Mine, 1995). Physical controls are external input devices (i.e. hand-held controllers), whereas virtual controls are virtual buttons, sliders, etc. that might be embedded in a virtual environment (Mine, 1995).

Scaling in VE, on the other hand, can allow a user to either (i) scale up/ down the size of the virtual world in order to help with navigation or (ii) scale the size of an object to better observe its certain features, surface details, etc. (Mine, 1995). Scaling in VE can also be done with hand-controlled interaction techniques where the movement of the hand determines the scaling, or with physical (i.e. requiring physical input devices) or virtual controls (Mine, 1995).

Use of Menus and Widgets in VE

Menus and widgets are another common interaction method with VEs. In fact, menus have been used for years to allow for regular HCI (Human-Computer Interaction) (Jacoby & Ellis, 1992). A menu is a list of items, options or commands displayed to the user to give information and initiate interaction (Jacoby & Ellis, 1992). There are several ways to construct a menu such as integrating multiple menus into a main menu bar, making use of categorization amongst the items of the menu, and hierarchically ordering the items of the menu (Jacoby & Ellis, 1992). Further, a menu can either disappear after interaction or can permanently stay on the screen/in the VE (Jacoby & Ellis, 1992; Mine 1995).

Use of menus in virtual environments differs from the use of menus in regular HCI in that, in 3D VEs, the menu doesn't appear on a screen but rather appears in a 3-dimensional virtual environment, possibly moving and changing orientation in relation to the movements of the user (Jacoby & Ellis, 1992). Since the menu in VE will move while the user himself/herself also moves within the VE, it might be problematic to locate the menu at all times (Jacoby & Ellis, 1992; Mine 1995). One way to solve this problem is by fixing the menu to a certain point in space so that its position will remain unaffected with the movements and gestures of the VR user (Mine, 1995). Another solution can be to interact with a physical button on the input device or to incorporate a bodily gesture which will pop-up the menu (Mine, 1995). The location of the menu, whether it stays fixed or moves in space as the user moves, whether it constantly remains in the VE or disappears after a selection is made, incorporation of cursor and highlights to show the selection of the user are some components that need consideration when designing menus for VR (Jacoby & Ellis, 1992).

2.9.3 Imagination

Imagination is rather a bizarre incident occurring in the human brain, which is argued in many fields including science, philosophy and art. Without delving into the very complexities of this phenomenon, this section will try to understand at a basic level

what imagination is and how it can be used (or even exploited) in the virtual reality field.

It must be noted that imagination covers all five senses with visual mental imagery being the most dominant (Pearson, 2019). When imagination is at play, the human mind takes references from the sensory content stored in the memory (Pearson, 2019). Indeed, imagination is an ability found in many humans except for people who suffer from aphantasia (i.e. a condition where an individual is unable to create mental images in his/her mind) (Pearson, 2019). Conversely, extreme levels of mental imagery also play a role in clinical problems such as anxiety disorders, depression and schizophrenia (Pearson, 2019).

The two ends of the virtuality continuum (see Figure 2.2), i.e. real environment and virtual environment, share in common that they both trigger the sensory organs (Stapleton & Davies, 2011). When we imagine something, on the other hand, the (visual) representations stored in the memory are activated, stimulating the brain in very much the same way retinal inputs do (Goodale, 1995; with reference to Kosslyn, 1994). Hence, imagination also triggers the sensory areas of the brain without any sensory input (Stapleton & Davies, 2011). Figure 2.11, adapted from Stapleton & Davies (2011) shows how reality, virtuality and imagination all stimulate the visual cortex of the brain. Reality and virtuality activate the visual cortex through sensory organs (i.e. eyes), whereas imagination triggers the same area of the brain without any sensory input.

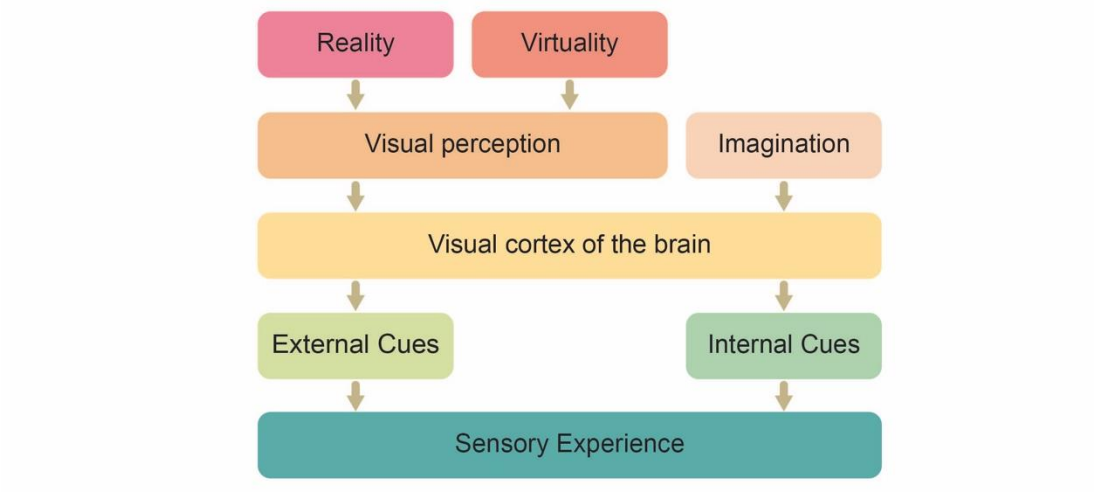


Figure 2.11. Schema of how reality, virtuality and imagination stimulate the visual cortex of the brain (redrawn from Stapleton & Davies, 2011).

As previously discussed in this chapter, immersion can happen without the use of technology, such as when reading a book or when watching a movie. What makes such experiences immersive is really the stimulation of the audience's imagination; a story is thus a combined result of both the storyteller's and the audience's imagination (Stapleton & Davies, 2011). The same strategy also applies to virtual reality experiences; the overall quality of the VR experience and the resulting feeling of presence are shaped by both the design of the VE and the imagination of the user.

VR should make users not only perceive but also believe in the reality that is being conveyed (Stapleton & Davies, 2011, with reference to Dr. Nassir Navab). This is exactly where imagination comes into play, by suppressing the disbelief (Sheridan, 2000). The suspension of disbelief is when an individual chooses to replace what they know in reality (e.g. there are no monsters) with a mental imagery, thus believing in an alternate belief system (Stapleton & Davies, 2011). In such a case, an individual chooses to believe in the internal cues coming from imagination (which are shaped largely by experience and belief) more so than the external cues (Stapleton & Davies, 2011). Indeed, until all technological challenges in VR are overcome, the suspension of disbelief will be necessary to get a full sense of presence in VR (Sheridan, 2000).

Designers can influence the perception of their audience to bridge the real and the virtual (Stapleton & Davies, 2011). Users, on the other hand, can use their imagination to fill in the gaps in a VR experience. Further, driving from the knowledge that imagination takes reference from all five senses (Pearson, 2019), addition of auditory clues (or more modalities once technology allows) can increase the triggering of imagination, making the VR experience even more immersive. Designers can also incorporate objects and scenes that are familiar to their users to trigger their imagination. A virtual living room, for instance, might feel more "real" due not only to the quality of visual renders but also to subtle clues such as a specific sound or object which will remind the user of their home. In that sense, it can also be argued that customization of certain elements in a virtual environment can help create experiences that are more meaningful and that further trigger the user's imagination to fill in the gaps. Similarly, intentional exclusion of certain details in a VR experience can also create more room for user's imagination. Familiarity, multi-modality and personalization can all be used by designers to activate the users' imagination, thus creating suspension of disbelief. It can be concluded thereby that imagination is one key element in the creation of an immersive VR experience. By understanding how imagination works, designers can create more meaningful, interesting, and realistic experiences.

2.10 Use of Avatars

As was also mentioned earlier in this chapter, a virtual environment can offer two different point of views (POV) to its user: first person or third person POV (Stanković, 2016). In the former case, the user sees the scenes as if he/ she is actually in the environment (Stanković, 2016). In the latter case, where the virtual environment is perceived from a third person POV, the user is represented by a virtual character referred to as an avatar (Stanković, 2016). The word avatar originally translates from Hindi as "the worldly incarnation of a deity" (Sherman & Craig, 2018, p. 15), and is a virtual body representing the user of a VR (Huang et al., 2023).

It has been shown that use of avatars in a VR enhances the sensed social and self-presence in VE (Huang et al., 2023) and contribute to the overall enjoyment and motivation of users' VR experience (Lee & Ji, 2024). An avatar can take various forms, such as anime, human-like, animal (Huang et al., 2023), machine-like (Lugrin et al., 2015), etc. Avatars can also be customized; users can control the bodily and facial characteristics of their avatars to create virtual bodies that are most reminiscent of themselves. Research shows that the resemblance of the user and its avatar increases the body ownership and perceived realism of users (Freeman et al. 2020; Chandra et al. 2024), as well as the emotional connection and communication between users in shared VEs (Lee & Ji, 2024).

Visual realism of avatars also has an influence on the quality of VR experience, affecting the sense of presence and immersion (Lee & Ji, 2024). However, designers must be cautious with the level of visual realism depicted on avatars since an increase in an avatar's visual realism doesn't necessarily correlate to an enhanced user acceptance and might lead to the Uncanny Valley phenomenon (Lee & Ji, 2024). The Uncanny Valley phenomenon is a term first coined by Masahiro Mori to describe the feeling of unease and discomfort when interacting with robots which look like humans but not exactly (Lee & Ji, 2024). The human mind is capable of abstract thinking and can accept unrealistic depictions or inconsistencies to a certain degree; one can even accept a big lie such as a talking teddy bear and perceive it as cute (Stanković, 2016). However, as the level of realism increases, the mind begins to perceive the depicted as real rather than imaginary (Stanković, 2016). Hence, when a character begins to resemble a human being above a certain level, the smallest discrepancies and inconsistencies lead to eeriness (Stanković, 2016; Lee & Ji, 2024). Therefore, designers must keep in mind that a more photorealistic environment or more human-like avatars won't always contribute positively to the VR experience (Stanković, 2016). Figure 2.12 includes a diagram adapted from Stanković (2016) showing the Uncanny Valley. The vertical arrow represents the acceptability of different forms of character depiction, and the horizontal arrow represents the resemblance to human.

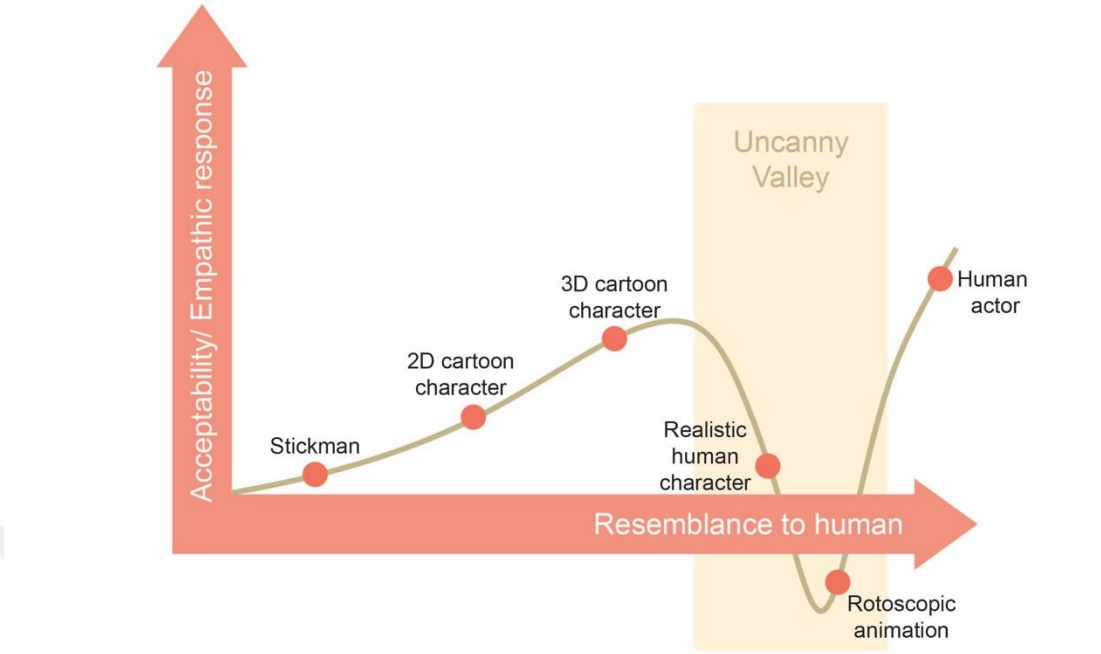


Figure 2.12. Uncanny Valley diagram (redrawn from Stanković, 2016).

Further, research shows that although visual realism (Salagean et al. 2023) of avatars are also critical, behavioral and gestural realism are more significant (Pan & Steed, 2019) in receiving a sense of ownership over an avatar. There are various ways in which avatars can appear in a VR, such as with a full body or a partial body (Pan & Steed, 2019). Research shows that when virtual clothing such as socks and gloves are used instead of a full-body avatar, users still perceive a full body between the depicted clothing (Pan & Steed, 2019, with reference to Kondo et al., 2018). It has also been shown that both a full-body avatar and a partial-body avatar which mimic its user's gestures directly (rather than with pre-defined motion animations) contribute similarly to the perceived sense of co-presence (Heidicker et al., 2017). This also shows that behavioral and gestural realism come first and foremost in accepting one's virtual body.

2.11 Shared Virtual Environments

A shared environment creates another layer of interaction in VR where multiple users share and interact within the same virtual environment (Sherman & Craig, 2018). Such environments are often referred to as CVEs (collaborative virtual environments) or social VR (van Brakel et al., 2023) and are mostly used in VR games where individuals are represented by avatars (Sherman & Craig, 2018). Indeed, the unpredictability of other avatars' next movement in shared environments can make the VR experience more challenging and more interesting (Sherman & Craig, 2018).

In such VEs, the users' actions are digitally represented on their avatars in real-time, simulating real-world behavior and experiences (van Brakel et al., 2023). In order to efficiently function, a shared VR must provide a means to perform a task as well as a means to communicate with others (Churchill et al., 2012). Communication in shared VEs can take a number of forms such as real-time conversation (i.e. one which cannot be edited later on), personal (i.e. not broadcasted), and private (i.e. by controlling who receives the message) (van Brakel et al., 2023). Further, communication in shared VRs can be verbal or non-verbal, and can also be enriched with multimodal experiences (Slater & Wilbur, 1997).

One advantage of shared virtual environments is its allowance for interaction, communication and quick response despite the geographic location of its users (van Brakel et al., 2023). Shared VEs can offer various experiences such as co-creation, socialization (e.g. hanging out with others in "public spaces") and multiplayer gaming (van Brakel et al., 2023). Whatever the content, interaction and communication are the two key factors to be considered (van Brakel et al., 2023) when designing a shared VR. Imagination can also come into play when designing a shared virtual environment. Since a shared VE can allow one to make and receive virtual gestures, such as hugging and hand-shaking (van Brakel et al., 2023), it can be used in order to create more engaging experiences through the triggering of imagination. Lastly, naturalness of social interaction and communication should also be considered in shared VEs. Research shows that natural and rich nonverbal communication (such as through

gestures) can create stronger social bonds (van Brakel et al., 2023), thus potentially increasing the perceived quality of a shared VE.

2.12 Designing Interactions and Interfaces for VR

It has been discussed earlier in this chapter that the interactions in VE can either mimic real-world interactions or be alternate novel ways. Similarly, well-known 2D interaction metaphors, as well as graphical user interfaces (GUI) and human-computer interaction (HCI) methods can be implemented in VEs (use of menus, widgets, cursors, etc.), although the properties of VE have to be taken into account when doing so (Bowman, 2002). Since the ultimate goal of VR is to immerse its user into an alternate reality, thus creating a sense of presence, interactions in VR must also be designed to meet this goal. Indeed, if the VR, or MR, technology is one day to replace the digital tools used in our everyday lives (to reduce the friction caused by screens and keyboards while interacting with digital space), its interactions and interfaces must exploit the advantages of both the digital and the real world.

When designing interactions for VE, several approaches can be taken. Firstly, the designer of a VR system can take advantage of the user's proprioceptive sense for more natural and intuitive interactions (Bowman, 2002). Proprioception is when a user intuitively locates the position of (parts of) his/her body in relation to objects of interaction (Bowman, 2002). An example of this is when a driver easily changes gears without looking due to his knowledge of hand position in relation to the gearshift (Bowman, 2002). Since head-mounted VR systems will hinder the user's ability to observe the input devices as well as their physical body (Kharoub et al., 2019), interaction with VR can benefit largely from a natural user interaction (NUI), (i.e without using the physical input devices) (Kharoub et al., 2019). Gesture-based or eye motion-based interaction methods can thus be integrated into VR systems to make interaction easier when the hands or body are invisible to the VR user (Kharoub et al., 2019). Indeed, gestural interactions were shown to positively affect the perceived naturalness and flexibility of interaction in VR as well as its enjoyment (Kharoub et

al., 2019, with reference to Saffer, 2008). It must also be remembered that each context and each VR application may require different modes and means of interaction (Kharoub et al., 2019), which will presumably be affected by the character of VR (i.e. experiential VR versus task-oriented VR). Further, VR systems may require designing a new set of gestures as well as allowing users to choose their own gestures (Kharoub et al., 2019).

The VR system can also be designed to allow for two-handed interaction, thus increasing the expressiveness and naturalness of the interaction (Bowman, 2002). Another approach that can be taken is to provide multiple ways to perform a specific interaction in the VE (Bowman, 2002). The interface of the VR can be designed in such a way that hand-directed interaction, gaze-directed interaction, interaction via virtual or physical controllers can allow for the creation of the same action in the VE, thus giving more flexibility to the user for interaction. If the VR system allows for multiple interactions to produce the same outcome, a seamless transition between these interaction modes can also help with the usability of the VR system. For instance, the user can start an action with a physical controller and continue it with gaze-directed interaction. Further, multimodal inputs and outputs for interaction (e.g. voice and gesture commands, haptic feedback on the hand-held controllers, etc.) can also help with the communication between the user and the VR system. Indeed, different modalities for input (e.g. voice commands, motion-based input, input with eye motion and gaze, etc.) as well as output (e.g. haptic, audio or visual) can create a smoother interaction between the user and the VR (Chu et al., 1998). In their work, Chu et al. demonstrate that voice commands can, in certain scenarios, feel more intuitive for tasks such as rotating an object or creating a new object in the VE (1998).

Concerning navigation inside a VE, Mills and Noyes (1998) mention that in real world, a person moves around an object to view it in 360 degrees. Conversely, in VEs, the object itself has to move in a way that will give the illusion of moving around the object to the user since he/she cannot actually move around the object (Mills & Noyes, 1998). Further, 2D virtual environments allow for four degrees of freedom in interaction mode while a 3D VE allows for six degrees of freedom (Mills & Noyes,

1998). This is especially important for 3D VEs since if adequate freedom of movement is not provided to the user, the analogy with the real world will critically decline (Mills & Noyes, 1998).

Lastly, physical problems that may lead to poor or imprecise interaction in VEs can also be considered by VE designers. Natural hand tremor of users, limited hand-eye coordination and restricted motor precision must be taken into account (Weise et al., 2020). Further, designers should keep in mind that prolonged use of VR input devices as well as gesture-based interactions might lead to fatigue in users (Weise et al., 2020). On this account, it might be useful to implement multimodal input systems and provide alternating ways to perform a specified task in VR. Simplified interaction gestures, and correction of small interaction errors by the system can also be useful to enhance the ease of use of VR systems.

One problem with VR interfaces is the depiction of textures and shadows to a degree where images look realistic enough (Mills & Noyes, 1998). In 2D VEs, user's perceptual skills can be taken advantage of in cases where textures and shadows are not super precise, whereas in 3D VEs, the images must be more lifelike so that the user gets immersed in the VE (Mills & Noyes, 1998). Use of color is yet another design dimension to consider in VR as set forth by Mills and Noyes (1998). In their work, authors discuss that 2D VEs might call for limited color palettes for quick interaction whereas in 3D VEs, lifelike color representations with abundant colors and shades might be required in order to better resemble the real world.

VR users' possible need for assistance in the virtual environment and the means to provide this help must also be designed in a way which won't feel intrusive or unnatural to the immersive experience (Mills & Noyes, 1998). Since search tools, dialogue boxes or assistance chats are not things one experiences in a real environment, inclusion of such interfaces might obstruct the perceived sense of presence in a VR (Mills & Noyes, 1998). Figure 2.13 (adapted from Sutcliffe et al., 2019) shows the effect of various modes of information presentation on perceived sense of presence, information quantity and information access in a VE. The need for user help as well

as interaction and communication with other users in shared virtual environments will also require the design of collaboration and interaction with other persons in a VE (Mills & Noyes, 1998).

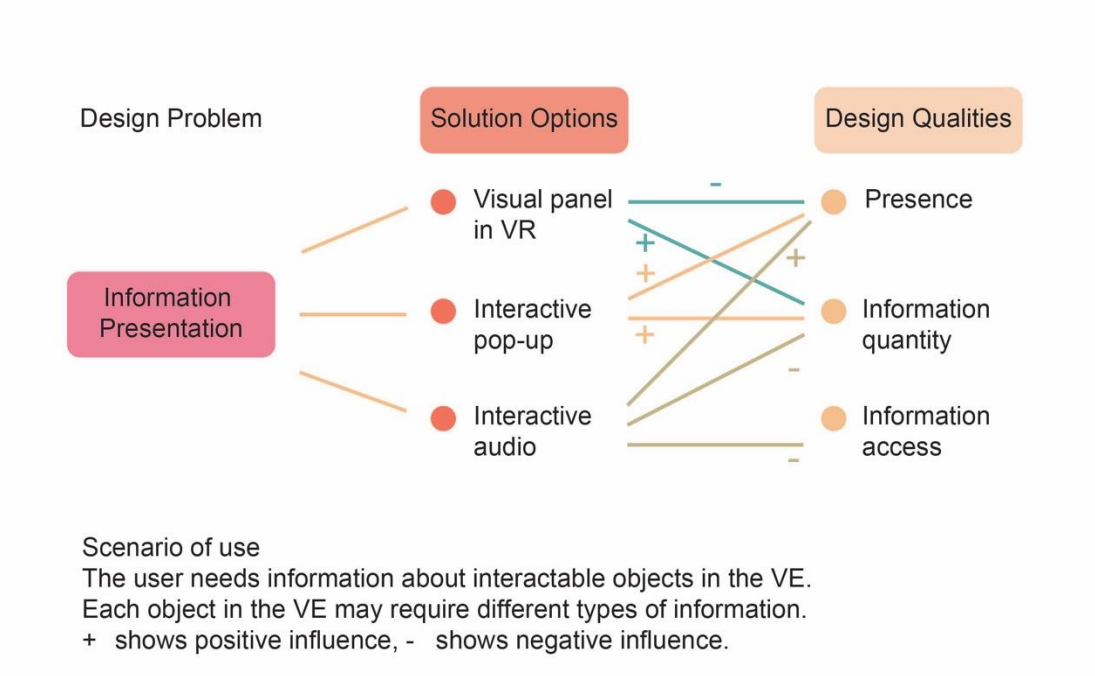


Figure 2.13. HCI trade-off chain demonstrating the effect of different forms of information presentation on perceived sense of presence, information quantity and information access in a VE (redrawn from Sutcliffe et al., 2019).

Sutcliffe et al. (2019) mention several HCI issues addressed in literature, including *interaction design for navigation and manipulation, active objects in the VE, feedback from interaction, translating domain models into VEs, cross-modal feedback, realism* and *scripting virtual actors*. They also refer to psychological constraints on user interaction such as *selective attention, working memory limitations, visual dominance* and *sensory integration* (Sutcliffe et al., 2019). With reference to Sutcliffe & Gault (2004), they present twelve HCI design heuristics for VR, which can be listed as:

- Natural engagement
- Compatibility with the user's task and domain (i.e. correspondence to user's expectations and task fulfillment)

- Natural expression of user's actions by devices, metaphors and UI (user interface) controls
- Close coordination of action, feedback and representation
- Realistic feedback using VE components rather than GUI components
- Faithful viewpoints (i.e. change in VE viewpoint in accordance to user's motion)
- Navigation and orientation support
- Clear entry and exit signs
- Consistent departures
- Support for learning
- Clear turn-taking between the user and system
- Sense of presence

Further, they argue that flow in a VR experience is related both to usability and to plausibility (Sutcliffe et al., 2019). Mohammad & Pedersen also list flow, along with embodiment (i.e. feeling of being present and interacting in a virtual body), empathy (i.e. understanding and sharing emotions in virtual scenarios), presence and immersion (2022) as important factors affecting the hedonic qualities of a VR experience. Unnatural means of control and interaction in VR may disrupt the flow of the experience, thus reducing the feeling of presence (Sutcliffe et al., 2019). Further, intuitive actions as well as affordances of objects in a VE are important parameters to consider when designing interfaces for VR (Sutcliffe & Kaur, 2000; Sutcliffe et al., 2019).

Affordances are properties of a user interface which give clues on how to interact with an object (Sutcliffe & Kaur, 2000; with reference to Norman, 1986). Both for task fulfillment and serendipitous exploration of the VE, the environment needs to afford clues about where to look or search for an object while the objects need to afford clues about how to interact with them (Sutcliffe & Kaur, 2000). If objects are not immediately visible to the user in a VE, the environment should present cues and

affordances in order to lead the user to the object (Sutcliffe & Kaur, 2000). Similarly, objects that allow for or necessitate interaction for a specific task must be highlighted or rendered in more detail to help with recognition (Sutcliffe & Kaur, 2000; with reference to Mullet & Sano, 1995). Objects within the VE must also provide affordances in order to guide the user for the right form of interaction (Sutcliffe & Kaur, 2000). More detailed renders, colors, shades and surface textures as well as multimodal information such as audio or animations (i.e. suggesting actions to user) can be helpful in guiding the user for interaction (Sutcliffe & Kaur, 2000).

CHAPTER 3

LITERATURE REVIEW ON SHOPPING EXPERIENCE

This chapter delves into the nature of shopping, briefly mentioning some factors affecting the shopping experience. First, the hedonic and utilitarian values of shopping are explained, demonstrating their effects on the perceived value of the overall shopping experience. Shopper types and shopping motivations are then explained with reference to previous research. The chapter then continues with shopping environments and factors affecting customers' cognitive and emotive responses towards a shopping environment. Online and virtual reality shopping experiences are then discussed, after which customer creativity and customer curiosity are shared as significant factors influencing the overall shopping experience.

3.1 Explaining the Shopping Experience

For many years, research regarding shopping experience was constructed through the information-processing approach, which regarded shopping as rather a logical and utilitarian activity (Fiore, 2008). According to the information-processing approach, the consumer is a logical thinker, scanning many products in a given product category to make a purchase decision (Fiore, 2008). The information-processing approach thus considers a consumer as a goal-directed problem solver who gathers information and evidence in order to make the most logical purchase decision (Fiore, 2008). However, it is difficult to fully comprehend the consumer behavior based solely on utility, function and logic. According to Hirschman and Holbrook (1982), a consumption experience involves also an experiential aspect since a shopping environment, interaction with a product, or the overall shopping experience, itself, can be satisfying intrinsically (Fiore, 2008). Therefore, evaluating

the shopping experience based merely on the discovery of a product's utilitarian potential doesn't suffice to explain the shopping experience (Fiore, 2008). Both hedonic (i.e. experiential, enjoying and pleasurable aspects) and utilitarian (i.e. practical and task-driven aspects) values of shopping need to be understood so as to better understand the shopping experience. The next section of this chapter will elaborate on both the utilitarian and experiential aspects of the shopping experience.

3.2 Utilitarian vs. Hedonic Shopping

Shopping itself involves both instrumental and experiential outcomes, evoking value both through the accomplishment of an intended goal and by providing enjoyment and fun (Babin et al., 1994). Thus, consumption can be viewed from two perspectives: utilitarian and experiential. Since this thesis focuses on apparel shopping experience in specific, the terms utilitarian shopping and hedonic shopping will be used to describe these two consumption perspectives.

Utilitarian shopping is the goal-oriented and task-driven approach to shopping where consumers focus primarily on efficiency, functionality and fulfillment of needs or a specific purpose. Customers can perceive a utilitarian value out of shopping when the purchased product is efficient, when the purchase is completed successfully or quickly, or when necessary information is collected about a certain product, even if no purchase has been made (Babin et al., 1994). A utilitarian value can be gained out of a shopping experience both through the store value and product value (Diep & Sweeney, 2008). The utilitarian store value can be described as the utility the store offers such as the range of products, ease of access, store location, opening hours, convenience and ease of navigation within a store (Diep & Sweeney, 2008). The utilitarian product value, on the other hand, can be described as the perceived quality and fulfillment of expected performance of the product (Diep & Sweeney, 2008, with reference to Sweeney & Soutar, 2001). Although utilitarian value of shopping is an important factor of the overall shopping experience, it, alone is not enough to satisfy a customer fully (Jones et al., 2006).

The hedonic value of shopping also plays a crucial role in the overall shopping experience. Hedonic shopping is the experiential and pleasure-driven aspect of shopping. Indeed, customers may perform a shopping act not only to fulfill a specific purpose or task, but simply because they love doing it (Babin et al., 1994; with reference to Triandis, 1977). Aesthetic appreciation, symbolic attributes, social interaction, sensory stimulation, involvement, fantasy fulfillment, excitement and escapism can create a hedonically valuable shopping experience (Hirschman & Holbrook, 1982; Babin et al., 1994; Davis & Hodges, 2012). Thus, it can be said that hedonic shopping relates to the multi-sensory, fantasy and emotive aspects of shopping (Hirschman & Holbrook, 1982). Similar to utilitarian value of shopping, hedonic value of shopping can also be gained through store and product value (Diep & Sweeney, 2008). The hedonic product value refers to the feelings generated through a product as well as a product's ability to enhance social self-concepts (Diep & Sweeney, 2008; with reference to Sweeney & Soutar, 2001). Hedonic store value, on the other hand, refers to the pleasure, excitement, fun and fantasy derived from the store, itself (Diep & Sweeney, 2008).

Unlike the utilitarian value of shopping, hedonic value is rather subjective and personal as it results from the perceived enjoyment and fun (Babin et al., 1994). It has been shown previously that customer emotions can override the pragmatic decision-making in shopping (Hirschman & Holbrook, 1982). Indeed, it is argued by researchers that hedonic and utilitarian values of shopping play a role in shopping motivations and shopper types (e.g. impulsive shoppers, compulsive shoppers, decisive shoppers, confident shoppers, browsers, etc.) (Babin et al., 1994; Fiore, 2008; Diep & Sweeney, 2008). Further, customer satisfaction is strongly related to the hedonic (rather than the utilitarian) value of shopping (Jones et al., 2006). While failing to fulfill utilitarian expectations can evoke anger in customers, failing to meet hedonic expectations may lead to customer dissatisfaction (Chitturi et al., 2008).

In short, shopping experience is shaped by both utilitarian and hedonic values. While utilitarian benefits of a shopping experience help customers fulfill a specific task, attain a specific purpose or gain a product-based or economic gain; hedonic values

of shopping lead to pleasure, enjoyment and fun (Fiore, 2008). Figure 3.1 includes a typology of value derived from shopping experience, adapted from Fiore & Ogle (2000). The typology organizes values derived from shopping experience based on experiential and utilitarian benefits. Formal (sensory), expressive and symbolic qualities forming the experiential and utilitarian benefits of shopping value are included in the typology.

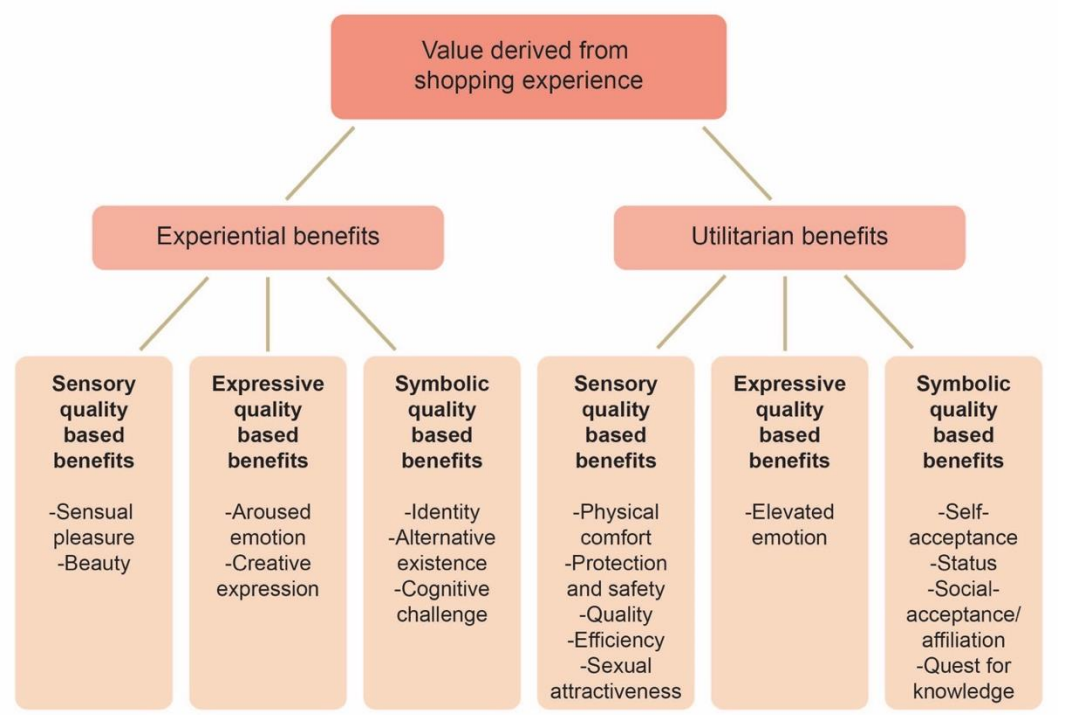


Figure 3.1. Typology of value derived from shopping experience (redrawn from Fiore & Ogle, 2000).

3.3 C-A-B (Cognition- Affect- Behavior) and C-E-V (Consciousness-Emotion- Value) Models for Explaining Shopping Experience

Based on both the utilitarian and hedonic shopping values, two models can be used to explain the shopping experience. First, based on the information-processing approach, the C-A-B model argues that thoughts and beliefs (cognition) about a product lead to product attitude (affect), which then leads to purchase decision and

brand choice (behavior) (Fiore, 2008). In the C-E-V model, introduced by Holbrook (1986), the consciousness (C) includes the C-A-B model's cognition (C) along with other mental events such as fantasies, imagery, memories, subconscious thoughts and unconscious processes that occur during the consumption experience (Fiore, 2008). The emotion (E) of the C-E-V model also expands the affect (A) of the C-A-B model, and involves feelings such as joy, delight and excitement (Fiore, 2008). Lastly, the C-E-V model doesn't focus merely on purchase decision and brand choice (B), but considers value (V) derived by the customer during the shopping experience as the final stage of the model (Fiore, 2008). Figure 3.2 includes an S-O-R (Stimulus-Organism-Response) model adapted from Fiore & Kim (2007) which brings together the C-A-B and C-E-V models of shopping experience. As was also discussed in the previous section, value derived from shopping experience includes both experiential and utilitarian benefits. Hence, it is important that both the utilitarian and hedonic values of shopping are considered when designing a shopping experience for customers.

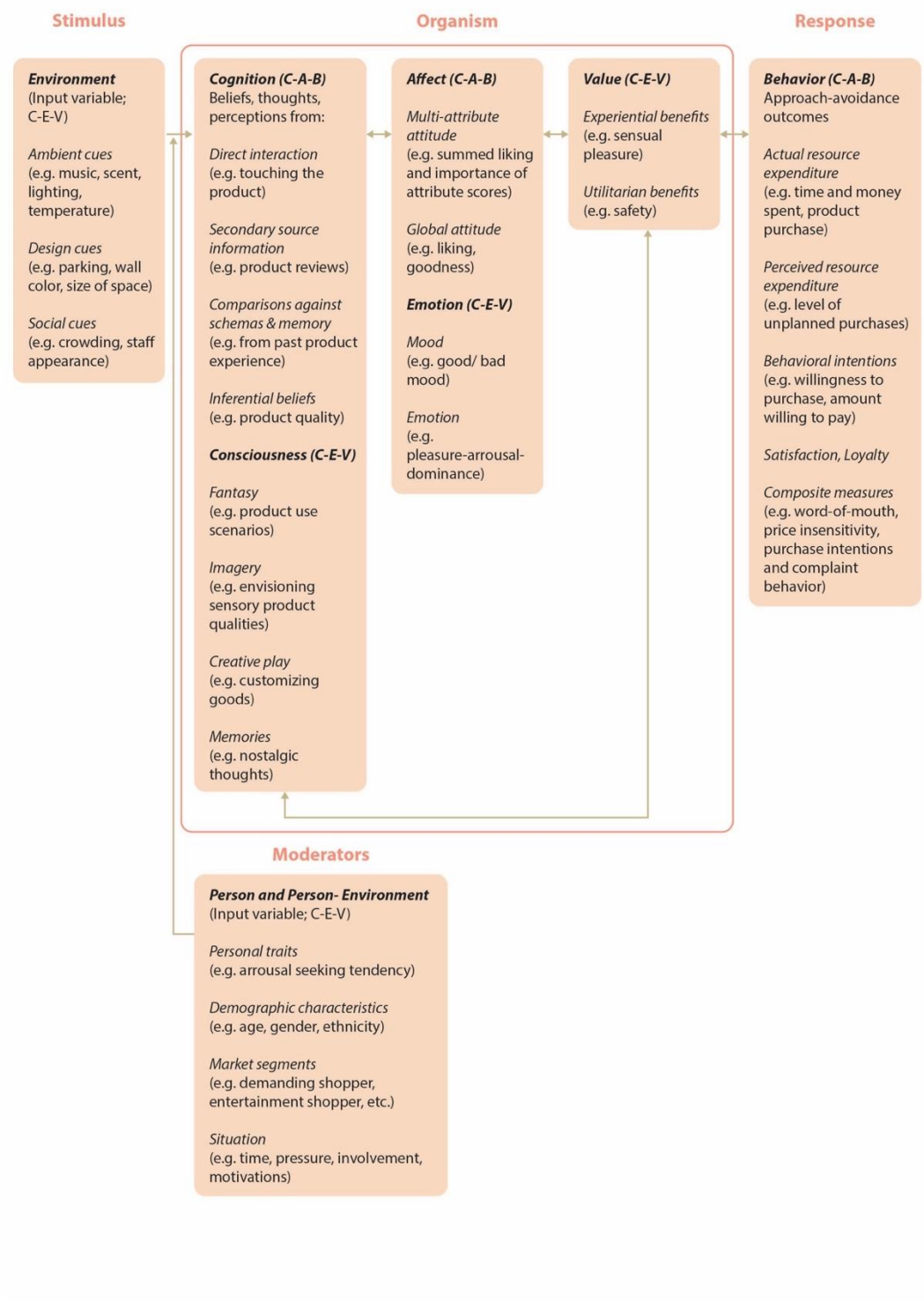


Figure 3.2. S-O-R (Stimulus-Organism-Response) model (redrawn from Fiore & Kim, 2007).

3.4 Shopper Types

It was mentioned earlier in this chapter that utilitarian and hedonic values of shopping affect the shopper types. Shopper types can be described as consumer profiles based on their shopping behaviors, preferences, motivations and attitudes. Researchers and marketers make use of such classification to better understand the needs and expectations of customers. Some of the shopper types can be listed as follows:

- Utilitarian shoppers (i.e. goal-oriented, practical shoppers) (Teller et al., 2008),
- Hedonic shoppers (i.e. shopping for pleasure, exploration and emotional satisfaction) (Teller et al., 2008),
- Bargain shoppers (i.e. shoppers motivated by discounts, sales and deals) (Babin et al., 1994; Moye & Kincade, 2002),
- Confident shoppers (Moye & Kincade, 2002),
- Decisive shoppers (Moye & Kincade, 2002),
- Impulse shoppers (Rook, 1987),
- Product enthusiasts (i.e. shoppers who buy items for hedonic responses associated with self-concept rather than for utilitarian needs) (Babin et al., 1994),
- Shopping enthusiasts (Ganesh et al., 2010),
- Trend shoppers (i.e. shoppers motivated by keeping up with trends and creating a self-image) (referred to as "destination shoppers" by Ganesh et al., 2010).

3.5 Shopping Motivations

Tauber (1995) categorizes shopping motivations into two groups: personal and social. Personal shopping motivations include *role playing*, *diversion from daily routine* (e.g. browsing products for time passing, shopping when bored, etc.), *self-*

gratification, *following the trends*, *performing physical activity* (i.e. exercising through shopping) and *sensory stimulation* (Tauber, 1995). Social shopping motivations, on the other hand, include *social experiences outside the home*, *communication with others having a similar interest*, *sense of belonging to a group*, *status*, *authority* and *pleasure of bargaining and negotiation* (Tauber, 1995). Tauber argues that a person may shop not only to fulfill a task or a need but also to get attention, spend time with people having common interests, pass leisure time, perform physical exercise, or to learn about trends and fashion (1995). Indeed, learning has been demonstrated as a significant dimension of retail shopping (Triantafillidou et al., 2017). The shopping experience can be considered an educational event during which individuals explore and learn about new products and services and obtain information on trends and innovations (Triantafillidou et al., 2017). Further, the factors listed by Tauber can act as reminders for purchase (i.e. remembering the "need to buy a product") or may lead to impulse shopping (1995). Impulse shopping results from a "need to purchase" more so than a "need for a product" (Babin et al., 1994; with reference to Rook, 1987).

Some other shopping motivations can be listed as *time-killing*, *information-gaining*, *comparing alternate products* (Buttle & Coates, 1984), *adventure shopping* (i.e. shopping for stimulation, adventure and the feeling of being in another world), *social shopping*, *gratification shopping* (i.e. shopping for escapism, relieving stress, forgetting about problems, alleviating negative moods and self-treating), *idea shopping* (i.e. keeping up with trends and fashions, seeing new products and innovations), *shopping for other people* (to make oneself feel good), *value shopping* (i.e. shopping for sales, discounts and hunting for bargains) (Arnold & Reynolds, 2003), *shopping for dreams* and *shopping as competition* (Pooler, 2003).

3.6 Shopping Environments

Environmental dimensions affect customers' purchase decisions, patronage behavior and time spent in stores (Moye & Kincade, 2002). *Store ambient conditions* (e.g.

temperature, store lighting, noise, background music and store odor), *store aesthetics* (e.g. color, style, use of materials and in-store art work), *privacy* (e.g. enclosed areas within a store), *efficiency/ convenience* (e.g. ease of finding target areas within a store, signs and cues within a store) and *social conditions* can be argued to play a role in shopping motivations (Moye & Kincade, 2002). Further, it has been previously shown that store image plays a role on how consumers perceive a firm and its capabilities, hence the significance of retail store environments (Moye & Kincade, 2002; with reference to Bitner, 1992). The in-store shopping value also affects customers' in-store shopping experiences (Davis & Hodges, 2012).

Davis and Hodges found that in-store shopping value includes the following dimensions: *product quality value, product price value, product selection value, in-store service value, shopping environment value* and *shopping efficiency value* (2012). Product quality value refers to the quality and interestingness of products offered at stores whereas product price value refers to the gain from good prices, sales and promotions (Davis & Hodges, 2012). Product selection value refers to the range of products offered within a store, in-store service value refers to the service and interaction with sales personnel, while shopping environment value refers to the pleasantness, fun and relaxation provided by the store itself (Davis & Hodges, 2012). Finally, shopping efficiency value refers to the ease of locating products within a store (Davis & Hodges, 2012). Gaining value and being satisfied both affect customers' buying behavior and post purchase behavior (El-Adly & Eid, 2016; with reference to Keng et al., 2007). Further, customers' perceived value of shopping is formed both before and after a purchase is made (El-Adly & Eid, 2016), with the former being related to in-store shopping value and the latter to the perceived product value.

Store value can be considered from two perspectives: utilitarian store value and hedonic store value (Diep & Sweeney, 2008). The utilitarian store value is the utility derived from a store such as ease of access, opening hours, convenience and range of products offered, whereas the hedonic store value is the emotive factors provided by a store such as pleasure, excitement, fun and fantasy (Diep & Sweeney, 2008).

Environmental dimensions of a retail store include attributes such as lighting, background music and scent (Moye & Kincade, 2002). For instance, it has been shown by Yalch and Spangenberg (2000) that consumers spent more time in stores when they were exposed to unfamiliar music. Milliman found that slow music helps with the sale rates of a store compared to fast music (1982). Indeed, music is an effective instrument in triggering moods, affecting consumers' behaviors and emotional responses (Sweeney & Wyber, 2002). Further, music played in stores can serve as a differentiator for a brand (i.e. differing a brand from its competitors) and contribute to the store image (Sweeney & Wyber, 2002). It has been shown by Triantafillidou et al. that music positively influences the hedonic value of shopping, the flow of shopping (i.e. heightened attention and total absorption of customers), learning and socializing during shopping (2017). Figure 3.3, adapted from Sweeney and Wyber (2002) demonstrates the relationship between music, emotional states, cognitive processing and intended approach-avoidance behaviors. Environment psychology suggests that people react to their environment in one of the two ways: approach or avoidance (Chebat & Michon, 2003; with reference to Mehrabian & Russel, 1974). The model shared in Figure 3.3 shows that in-store music positively affects the emotional states and cognitive processing of customers, thus leading to an increased likelihood of returning to a store and increased enjoyment.

Scent also has been shown to have an influence on shoppers' behaviors. Indeed, odors have the capacity to induce arousal, bring out memories and shift moods (Chebat & Michon, 2003). Further, ambient store scents contribute to the favorable perception of a store environment and, indirectly, of a product (Chebat & Michon, 2003).

Another factor that affects the consumers' perceptions of a store and their shopping behaviors is the haptics found in the shopping environment. Haptic evaluation of products (Grohmann et al., 2007) as well as haptic cues offered in a store environment (Jha et al., 2020) affect consumer decision-making. It has been shown that the ability to touch products affects customers' choice on whether to shop online or in-store (Grohmann et al., 2007). Further, in the case of physical shopping,

consumers have a greater likelihood of purchasing from retailers who allow their products to be touched (Grohmann et al., 2007). Tactiles also play a role on the perceived image of a brand (i.e. "overall picture of a company in the minds of consumers"- Jha et al., 2020, p. 592). Apart from the products offered within a store, weight and softness of brand-related tools (e.g. business cards, packaging, haptic cues in the store environment) affect customers' purchase behavior as well as their perceived brand image (Jha et al., 2020). Heavier haptic cues indicate to an increased retailer competence, while softer haptic cues communicate warmth rather than competence (Jha et al., 2020).

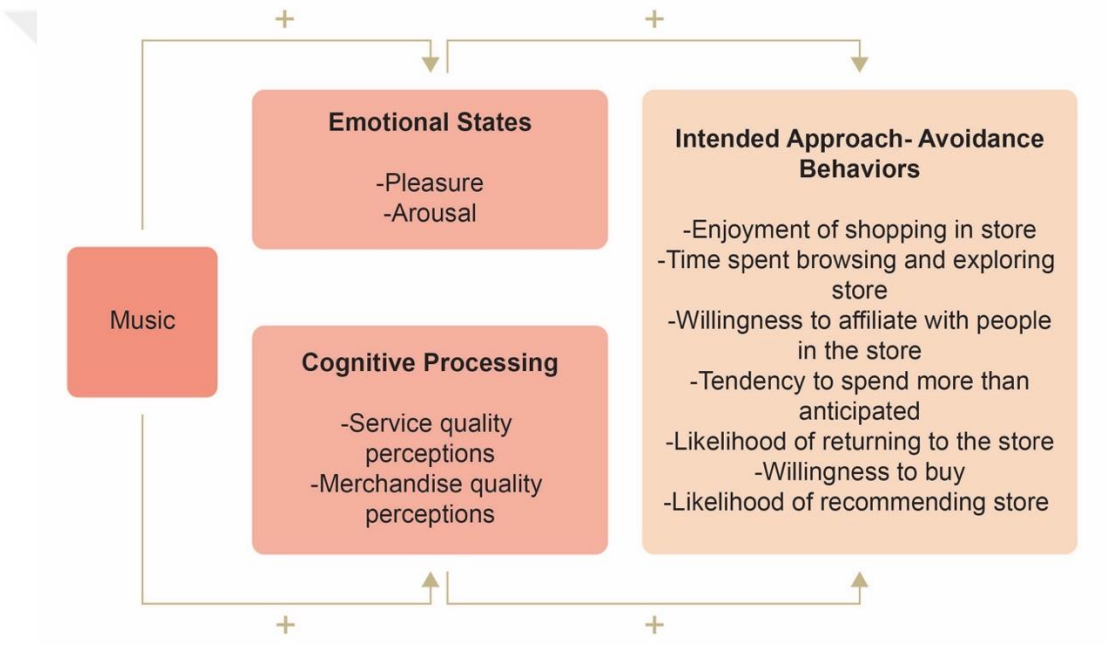


Figure 3.3. Model showing the relationship between music, emotional states, cognitive processing and approach-avoidance behaviors (redrawn from Sweeney and Wyber, 2002).

Color is another factor that has an effect on the perceived quality and characteristic of a store environment. Crowley (1993) has stated that retail environments with more extreme wavelength colors (red and blue) are perceived by customers as more active environments. Such active environments can lead to impulse buying (Crowley, 1993). Luxurious brands and stores, on the other hand may benefit more largely from

moderate wavelength colors, thus creating pleasing, rather than active, environments (Crowley, 1993). Similarly, situations where customers have to wait (e.g. in line), may benefit from more moderate wavelength colors (Crowley, 1993).

Lighting of a store in relation to the product colors has also been demonstrated to affect the behaviors of customers (Reynolds-McIlnay et al., 2017). When products are displayed in a neatly manner (i.e. organized and stacked in a neat way), sharp contrast between the brightness of the store and that of the product leads to an increased preference (Reynolds-McIlnay et al., 2017). For instance, in a brightly lit store, darker products are preferred more than lighter products if both product categories are displayed neatly since dark products visually pop out, and vice versa. However, messily displayed dark products in a bright store setting have a higher potential to create a negative aesthetic response, thus repelling customers from the display area (Reynolds-McIlnay et al., 2017).

Design elements of a store such as store layout and decoration also play role in the shopping experience (Triantafillidou et al., 2017). Store layout has an effect on the flow of shopping and socializing while interior decoration affects customer feelings (e.g. pleasure and excitement) (Triantafillidou et al., 2017). Spacious store interiors not only help with interaction within groups but also with the imagination and fantasy of customers (Triantafillidou et al., 2017). Furthermore, stores over-loaded with a multitude of products negatively affect the learning dimension within a store, thus leading to confusion in customers (Triantafillidou et al., 2017). Similarly, crowd of a store environment has also been shown to have an influence on the perceived quality of store and service quality (Chebat & Michon, 2003). While too crowded stores might negatively affect a customer's willingness to stay in the store, enhanced perceptions of personal control in crowded environments can increase pleasure (Chebat & Michon, 2003). Figure 3.4 involves a model offered by Triantafillidou et al. (2017) showing the effects of functional characteristics, ambient characteristics, design characteristics and social characteristics provided by a store on in-store shopping experiences.

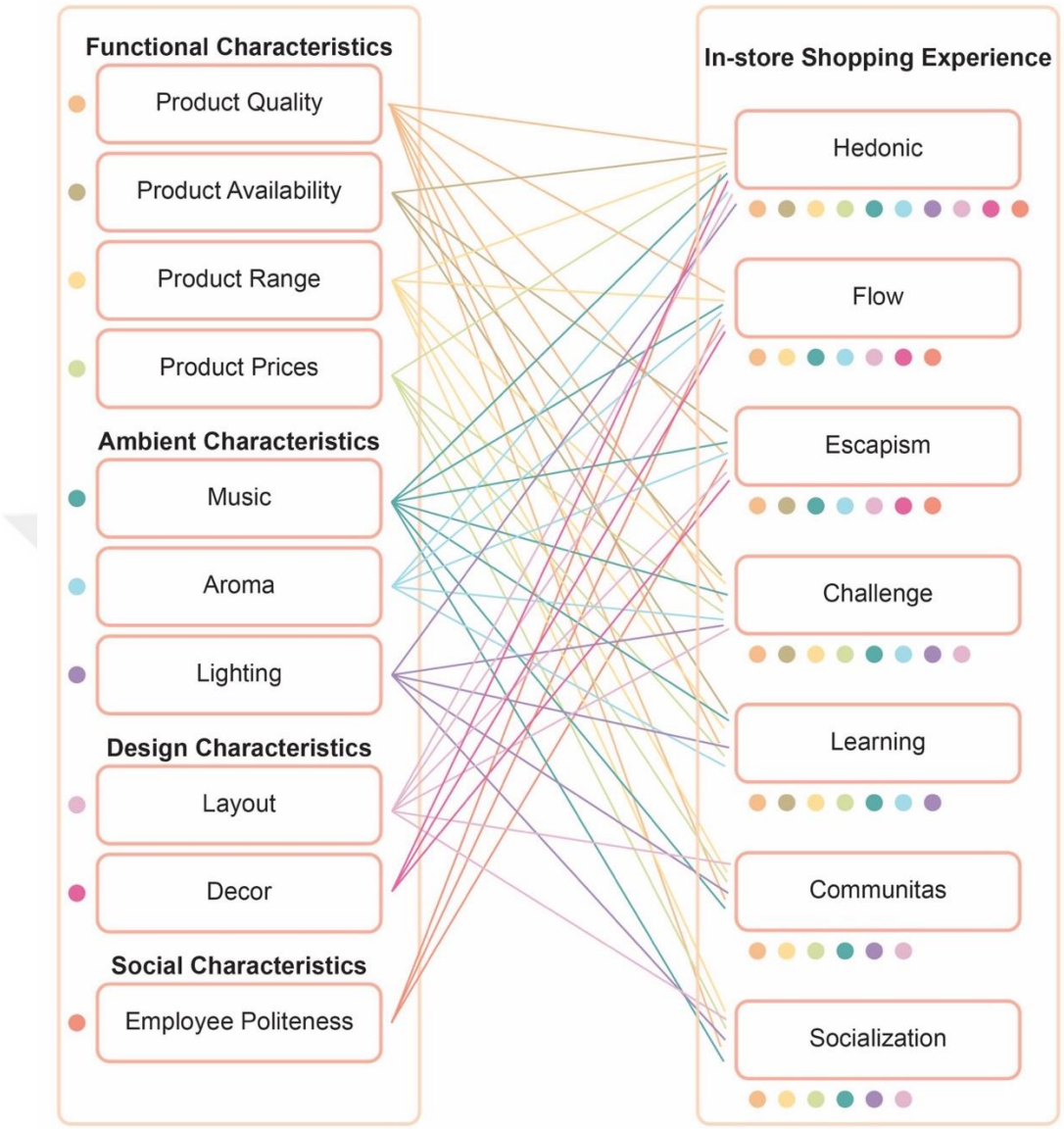


Figure 3.4. Effects of functional characteristics, ambient characteristics, design characteristics and social characteristics on Shopping Experience (redrawn from Triantafillidou et al., 2017).

3.7 Online Shopping

Online shopping is a form of digital shopping which can be done through mobile phones, tablets and computers. The shopping process covers all the steps starting with collecting product-related information and ending with a final purchase

decision (Schmid & Axhausen, 2019). Research shows that although positive attitudes towards online shopping increases the frequency of online shopping, pleasure and fun are more strongly associated with in-store rather than online shopping, although opposing arguments on this opinion also exist (Schmid & Axhausen, 2019). It is argued that online shopping is preferred mostly for search purposes (Zhai et al., 2017) since online shopping reduces the cost of search (Schmid & Axhausen, 2019). Further, customers have the tendency to prefer in-store shopping for products with higher prices, although online shopping for electronic devices surpasses this limitation with the high level of shopping convenience offered to customers (Schmid & Axhausen, 2019). Lack of trust is yet another factor which may decrease customers' tendency to shop online (Nghia et al., 2020). It can be said that customers prefer online shopping mostly due to the number of product choices and the ability to easily compare product prices (Schmid & Axhausen, 2019). Moreover, research also suggests that customers with a higher level of education may have a higher tendency to prefer online shopping (Schmid & Axhausen, 2019). Age is another factor influencing the adoption of online shopping behaviors; younger adults are more likely to exhibit online shopping behaviors (Riorini et al., 2019).

Research indicates that online shoppers may have higher demands in terms of product information, product variety and personalized/ specialized products (Ganesh et al., 2010). Online shoppers can spend as much time shopping compared to in-store shoppers due to search for product-related information (Chiu et al., 2019). Furthermore, online shopping is found to be related to both utilitarian and hedonic values of shopping (Riorini et al., 2019). While product choices and ability to compare prices can be counted among the utilitarian values provided by online shopping, following trends and exhibiting impulsive purchases during online shopping can be linked to the hedonic value of online stores (Riorini et al., 2019).

Richard & Chebat (2016) state that online emotions, flow, entertainment and informativeness in online stores influence online purchase intentions. Figure 3.5 involves a model constructed by Richard & Chebat (2016) showing the online consumer behaviors. In the model, online cognitions refers to the functional

characteristics of a website such as effectiveness of information and informativeness of an online store (Richard & Chebat, 2016). Online entertainment is related to the hedonic characteristics of an online store, whereas online emotions can be listed as pleasure, arousal and dominance (Richard & Chebat, 2016). Finally, flow refers to the online navigation while online attitudes cover website and product attitudes (Richard & Chebat, 2016).

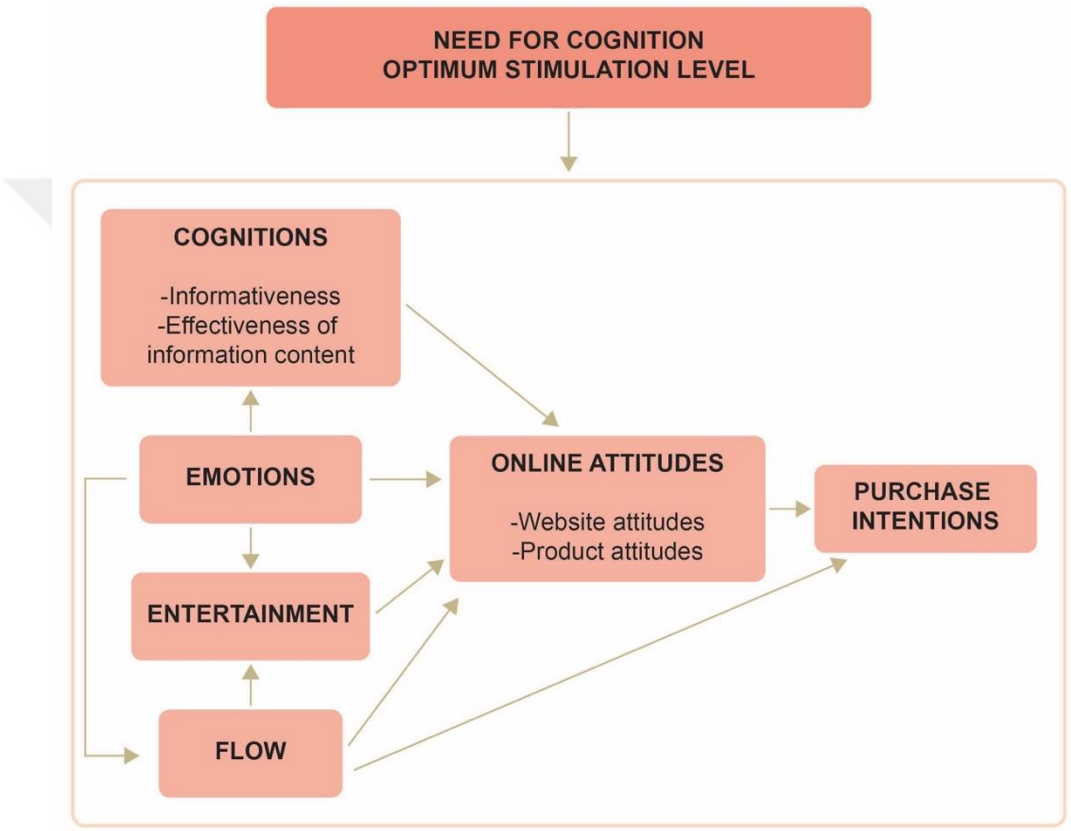


Figure 3.5. Effects of cognitions, emotions, entertainment and flow on online purchase intentions (redrawn from Richard & Chebat, 2016).

It has been shown that both usability and aesthetics are significant in the design of an online store. Understandability, usability and ease of use are amongst the key factors that influence the utilitarian values of an online store. One major concern of online shopping is that online stores don't offer customers the chance to feel, touch and try products (Porat & Tractinsky, 2012; with reference to Jiang & Benbasat,

2007). This discrepancy of online shopping can be partially compensated by providing adequate product information on store websites.

Further, store layouts which aid in easy way-finding are crucial not merely for physical but also for online stores, with the latter being more critical since exiting from an online is only one click away (Porat & Tractinsky, 2012). Hence, it is important that navigation and search features of an online store are designed so as to require minimal effort and maximum efficiency (Porat & Tractinsky, 2012). Online stores should also provide a good sense of control over interaction (Porat & Tractinsky, 2012). Figure 3.6, adapted from Hirst and Omar (2007) demonstrates a framework of shoppers' intention to buy apparel online. As can also be seen in the framework, usefulness and ease of use of an online store, along with enjoyment, influence customers' attitudes toward online shopping.



Figure 3.6. Framework showing shoppers' intention to buy apparel online (redrawn from Hirst and Omar, 2007).

Aesthetics of an online store also affect customers' attitudes towards an online store (Porat & Tractinsky, 2012). Classical aesthetics in an online store (i.e. clean and balanced visual details) can increase the understandability, learnability and usability of an online store, offering its customers visual clarity, order and legibility (Porat &

Tractinsky, 2012). Expressive aesthetics (i.e. creative and innovative online store designs), on the other hand, can act as stimulators of creativity, expressing the designers' or the brands' character, originality and creativity (Porat & Tractinsky, 2012). Hence, it can be argued that classical aesthetics help with the usability of an online store, whereas expressive aesthetics help with the immediate attractiveness of websites (Porat & Tractinsky, 2012). It can be concluded, thereby, that online stores which sell high-end and expensive products (e.g. apparel and luxury items) may benefit more largely from expressive aesthetics; while online stores offering low-end and relatively inexpensive products (e.g. books, CDs, etc.) may require a higher level of usability, thus benefiting more from classical aesthetics (Porat & Tractinsky, 2012).

3.8 Virtual Reality Shopping

It was mentioned in Chapter 2 of this thesis that the main features which set 3D virtual environments from 2D virtual environments (e.g. websites, computer games, etc.) are immersion and interaction. 3D virtual reality systems differ from 2D VR systems by interactivity, three-dimensionality and real-time response (Xi & Hamari, 2021; with reference to Whyte, 2002).

VR shopping holds the potential to construct a bridge between physical and online retail stores, making use of advantages of both shopping environments. Virtual reality shopping is believed to one day surpass the brick-and-mortar shopping as it has the potential to offer more immersive experiences than physical stores (Xi & Hamari, 2021). Many businesses have already started to explore the potentials of VR shopping in order to strengthen customer experiences, keep up with consumer expectations, sustain their current market shares and seize new marketing opportunities (Farah et al., 2019). Indeed, VR can create a similar shopping experience as a physical store while bringing more positive outcomes (Xi & Hamari, 2021). Chittaro & Ranon (2000) also mention the resemblance of VR stores to physical stores. They add that virtual stores allow for more natural shopping actions,

navigation within a store, a heightened level of immersion and interaction as well as social communication, unlike online stores (Chittaro & Ranon, 2000).

Virtual shopping can fulfill both utilitarian and hedonic expectations of customers by meeting consumer needs and enhancing the overall shopping experience (Farah et al., 2019). Research shows that a heightened level of telepresence (i.e. immersion) makes customers believe that they are better informed about a product, thus creating more positive behaviors towards it (Papagiannidis et al., 2017). Since immersive VR stores offer an increased sense of presence to customers, virtual shopping can lead to heightened emotional responses, increasing the time spent in sores (Ricci et al., 2023).

Interaction also plays a crucial role in virtual reality shopping, offering customers the opportunity to virtually interact with and examine a product (Papagiannidis et al., 2017). Unlike online stores, virtual reality stores offer customers the chance to interact with high-resolution stereoscopic images, heightened further with stereoscopic sound effects (Chittaro & Ranon, 2000). Moreover, the richness of modality in virtual stores allows for more naturalistic shopping activities than online stores (Chittaro & Ranon, 2000). Indeed, VR stores allow customers to interact with products in a more natural way compared to online stores (Xi & Hamari, 2021), thus enhancing consumer perceptions and satisfaction (Farah et al., 2019). Further, virtual stores allow for navigation within the environment, another component missing in online stores. By freely navigating inside a virtual store, customers can not only observe products similarly to physical stores but can also be tempted to spend more time inside the store. Further, advanced visual interfaces and interactivity in VR also positively affect the usability and efficiency of virtual stores (Xi & Hamari, 2021). Multisensory technologies, too, play a significant role in enhancing the virtual shopping experience, thus affecting consumers' perception, judgment and behavior in virtual environments (Xi & Hamari, 2021). Figure 3.7 is a model offered by Papagiannidis et al. (2017) demonstrating the factors affecting the simulated experience, engagement, enjoyment and satisfaction levels of shoppers along the way to purchase decision.

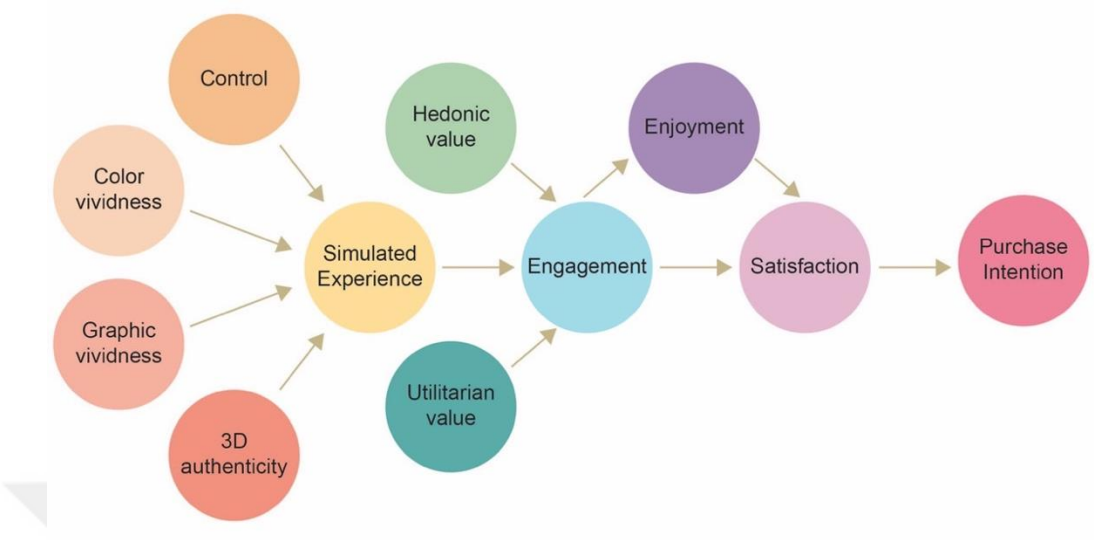


Figure 3.7. Factors affecting the engagement, enjoyment and satisfaction levels of shoppers along the way to purchase decision (redrawn from Papagiannidis et al., 2017).

The shopping journey can be divided into three main stages: "consider", "evaluate/engage" and "purchase" (Farah et al., 2019, with reference to Bousaleh & Mathew, 2011). Although many advertisements are directed towards the "consider" and "buy" phases of the shopping journey, the "evaluate/engage" phase can have a bigger influence on consumers' purchase intentions (Farah et al., 2019, with reference to Edelman, 2010). VR shops can contribute positively to the "evaluate/engage" phase of shopping through novice and creative interaction methods. Indeed, interactive marketing has a positive effect on consumers' decision-making process (Papagiannidis et al., 2017).

Research shows that there are more similarities between in-store and virtual shopping experiences than there are discrepancies. For instance, Zhao et al. show that social touch can elevate the time spent in virtual stores and the tendency to spend more money, similar to physical stores (2018). Participants who are touched by virtual assistants (i.e. avatars) in a virtual store have a higher likelihood of spending more time and money, forming positive evaluations of the overall shopping

experience (Zhao et al., 2018). The effect of social touch as well as communication with sales assistants play a crucial role in shopping experiences (Zhao et al., 2018). Since such symbiotic interactions are deficient in online stores, virtual stores can turn this into an advantage, thus offering more meaningful, hedonic and utilitarian shopping experiences. Further, presence of other customers within a virtual store also positively affects the overall virtual shopping experience, which is yet another feature missing in online stores (Xi & Hamari, 2021). Moreover, the atmosphere of a store, which cannot be replicated in online stores, can be re-created in virtual stores (Farah et al., 2019), offering a more experiential shopping to customers. In that sense, it can be argued that ambience and store layout also play significant roles in the context of virtual shopping, similar to in-store shopping (Farah et al., 2019).

Non-consequentiality is one of the features virtual reality can offer that is deficient in physical stores (Xi & Hamari, 2021). Since virtual products presented to customers in virtual stores are indestructible in the traditional sense, customers of VR shops are free from many constraints and limitations of the physical world shopping (Xi & Hamari, 2021). VR offers customers the opportunity to play, transform and experiment with the virtual products without concern for economic, social, ethical or cultural consequences (Xi & Hamari, 2021).

3.8.1 Customer Curiosity and Customer Creativity in Virtual Stores

Consumer creativity is the customers' ability to create novel and beneficial ideas in the context of consumption (Kim & Choo, 2023). Although consumer creativity can result from many various factors, VR experiences can act as stimulators of imagination, thus aiding with customer creativity (Kim & Choo, 2023). Use of metaphors and analogies as well as richness of visual information, co-presence and immersion can foster creative thinking in virtual realities (Kim & Choo, 2023). Virtual reality offers a richer set of stimuli compared to traditional communication media, thus supporting the creativity of users (Kim & Choo, 2023).

Customer curiosity, on the other hand is linked to the desire to acquire information, thus triggering interest and a need to remove ambiguity (Kim & Choo, 2023). Using mystery is a marketing strategy which is used to attract attention (Hill et al., 2016). In an experiment conducted by Van Dijk & Zeelenberg (2007), participants were asked to choose between a sealed package with unknown content and money. Participants who were given some information about the package but were told that the contents of it would remain a secret if they chose the money became more curious, becoming more likely to choose the package over the money. Similarly, consumers' purchase decisions can be affected when their purchase will be delivered with "mysterious" gifts (Laran & Tsiros, 2013).

Curiosity gets aroused when people become aware of a gap in their knowledge or when they are faced with new, inconsistent or ambiguous stimuli (Hill et al., 2016). Advertisements that withhold the identity of a brand until the end of the ad are an example of how curiosity is used to evoke customers' attention (Hill et al., 2016). Indeed, curiosity is highest when the consumer is offered a limited amount of information but understands that filling the information gap is possible with the addition of only a moderate amount of information (Hill et al., 2016). Virtual stores can convey multiple and novel sensory experiences to consumers, thus increasing their approach behavior through perceptual curiosity towards products and stores (Kim & Choo, 2023).

Curiosity and creativity both share in common the desire to learn and explore, as well as the motivation to create new and valuable things (Kim & Choo, 2023). It has been shown that curiosity positively affects the creative behaviors of individuals (Kim & Choo, 2023). With the use of rich sensory stimuli in virtual store, the vividness of the virtual experience positively affects the consumers' curiosity, thus aiding with their creativity (Kim & Choo, 2023). Further, triggering of emotions such as pleasure and arousal in VR stores can affect the perceptual curiosity and creativity of customers (Kim & Choo, 2023).

3.8.1 Virtual Reality Shopping in Fashion Industry

The fashion industry is one to follow trends and marketing transformations closely in order to meet customer demands and keep up with the technological advancements. Fashion brands embrace new technologies almost immediately to enhance their brand image and stay relevant, although luxury brands have portrayed reluctance in the past to enter e-commerce due to a fear of compromising their brand identities (Kniazeva et al., 2024).

The metaverse not only holds the potential to create more meaningful and fun experiences for customers but also to transform the business models of fashion brands through consumer interaction and co-creation (Kniazeva et al., 2024; with reference to Periyasami & Periyasamy, 2022). Studies show that entering the metaverse holds several potential advantages for fashion brands such as cost-reduction, increased customer engagement, increased brand recognition, and more sustainable brand strategies (Kniazeva et al., 2024). Virtual reality offers luxury and fashion brands the possibility to enhance their brand identities while also increasing engagement with consumers through features such as co-creation (Liu et al., 2024). Further, integration of virtual reality technologies into their business models can allow brands to expand their target markets, enabling them to reach out to younger generation consumers (Kniazeva et al., 2024). Virtual try-on features, for instance, can enhance consumer engagement particularly among younger generation consumers (Liu et al., 2024).

Virtual fitting offers customers to try and experiment with new clothing (Sarakatsanos et al., 2024) by virtually trying the garments on users' personalized avatars (e.g. avatars mimicking users' body size and visual characteristics). Avatars help relate the product with our bodies and can facilitate finding optimal fit size once the body size and characteristics are well represented in the virtual body (i.e. avatar). Further, brands can exploit this feature of virtual reality to experiment with garment creations that are otherwise difficult or even impossible to produce in physical form,

thus pushing the creative boundaries. Furthermore, the ability to try products on virtually can help reduce product returns.

One major component of apparel shopping that is missing in online stores is the ability to touch the products and understand its fabric. Research shows that the inability to touch products can influence consumers' product judgment, leading to uncertainty in purchase decision (Ruusunen et al., 2023). VR stores can partially get rid of this deficiency through heightened sensory stimuli or through, for instance the integration of simulations demonstrating the garment behavior (Sarakatsanos et al., 2024). Visually realistic, high-fidelity 3D virtual garments which mimic real-life behaviors of fabrics (Sarakatsanos et al., 2024) can aid with the decision-making process of customers, leading to heightened utilitarian and hedonic values during shopping. Further, an increase in sensory stimuli can lead to increased imagination, thus making the experience feel more real (Ruusunen et al., 2023). Similarly for virtual shoppers, an increase in sensory stimuli as well as product information can enable the mental simulation of product interaction, thus partially compensating for the need to touch (Ruusunen et al., 2023).

Seeing garments displayed in a store setting and the ability to navigate within the environment or interact with the products can also have positive contributions to the apparel shopping experience both from utilitarian and hedonic perspectives. Furthermore, virtual fittings, along with immersion and interaction within virtual stores can enhance consumer trust, leading to an increased likelihood of shopping from virtual stores (Xue et al., 2020).

CHAPTER 4

METHODOLOGY

4.1 Introduction

It is without doubt that design plays a crucial role in the smooth integration of the VR technology across various sectors including retail. Many apparel brands have already started integrating VR and AR systems into their shopping experiences, allowing customers to engage with their products in an immersive and interactive way. The integration of the VR technology into the shopping experience allows customers to explore products in a more immersive manner and at the comfort of their household, and that of AR enables customers to explore products with highly realistic renders in their real environment through a mobile device. Ralph Lauren, Dior, Lacoste, Tommy Hilfiger and Lululemon are just a few of the brands that have already started using the VR technology. New Balance, Adidas, Puma, Moncler and Nike are brands that have started using AR.

Figure 4.1 includes screenshots from the Bloomingdale's 50- Ralph Lauren virtual store, Bloomingdale's 50 virtual store and SAXX virtual store, all designed by Emperia VR. Figure 4.2 shows a series of screenshots taken by the author from the Vyking AR website, showcasing the virtual try-on feature with augmented reality technology.

The aim of this research was to explore the design intervention areas for the use of VR technology in apparel shopping. Therefore, there were two key aspects that needed scrutiny in this research. First, there was the need to observe and analyze the (virtual) shopping behaviors of the participants in the research. All the steps of a virtual shopping experience, including adding items to "basket" (but excluding the actual purchase stage) were executed by the participants of this research on the chosen platforms. As they were experiencing the shopping process, participants also

declared their impressions, thoughts and comments on the steps of the experience in a simultaneous manner.



Figure 4.1. Screenshots from the Bloomingdale's 50- Ralph Lauren virtual store, Bloomingdale's 50 virtual store and SAXX virtual store, all designed by Emperia VR (screenshots are taken by the author).

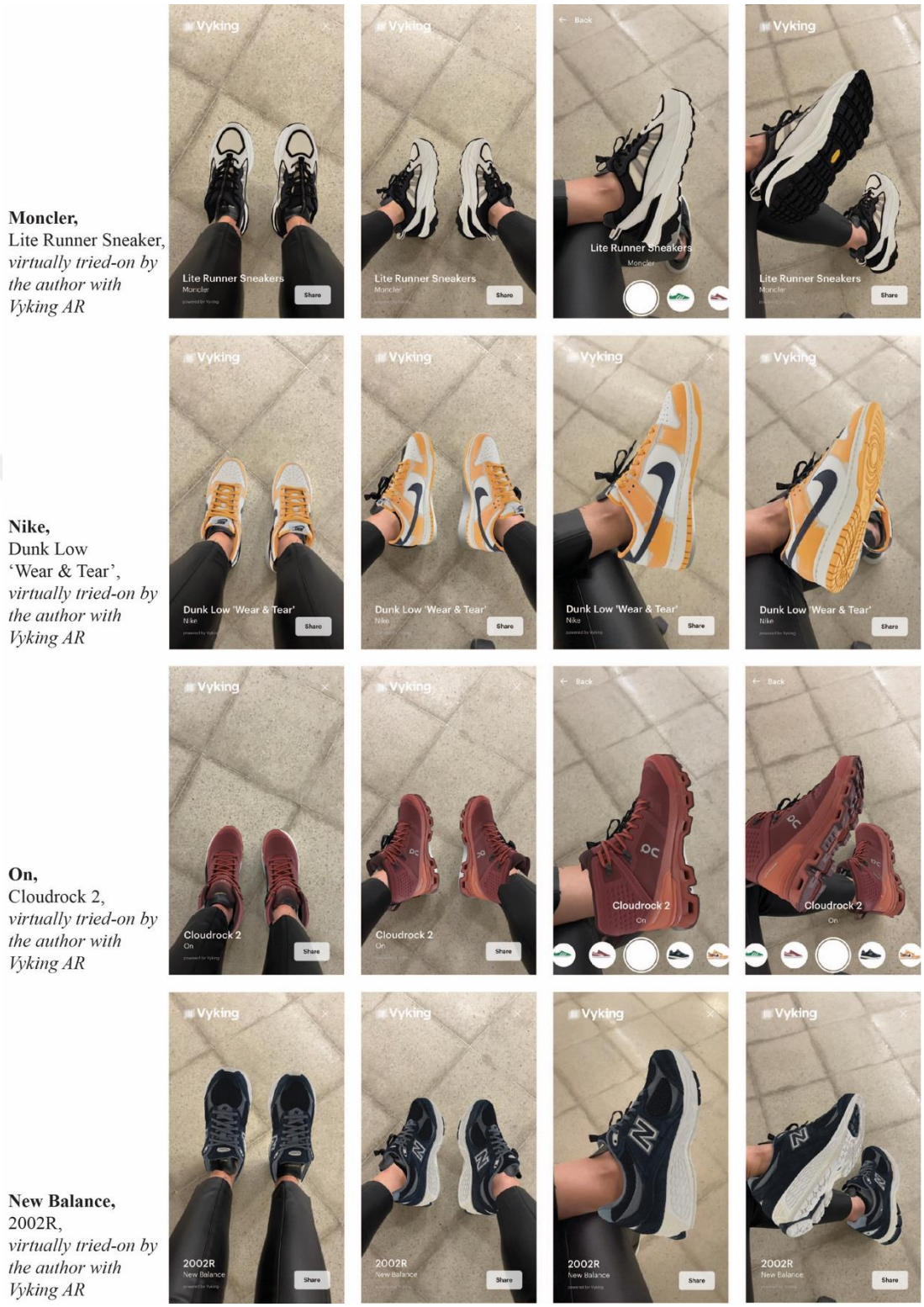


Figure 4.2. Screenshots from Vyking AR website, showcasing the virtual try-on feature with augmented reality technology (screenshots are taken by the author).

Second, there was the need to observe and understand the participants' initial reactions to, interactions with and overall responses to the usage of virtual reality during the shopping process. Since integration of VR into the shopping experience was one of the main observation points of this research, the participants were also asked to make comments on the VR aspect of the experience while they were navigating within the virtual shops.

As is discussed in Chapter 2 of this thesis, immersion and interaction are two key components of virtual reality systems which set them apart from non-immersive virtual environments such as computer games, and social network platforms. Visual reality, visual and auditory fidelity as well as familiarity play critical roles in the building of realistic and immersive VR systems. Furthermore, consistency and continuity of the plot line, perceived usefulness and perceived ease of use are also fundamental elements of a successful VR system.

Some of the key concepts relating to shopping experience are mentioned in Chapter 3 of this thesis. The chapter draws attention to the difference between utilitarian and hedonic values of shopping, highlighting their significance in the overall shopping experience. Shopper types, shopping motivations, factors of the shopping environment which affect the shopping experience are also discussed in the same chapter. Some important components of online and VR shopping are also touched upon in Chapter 3.

It is these main concepts that shaped the formulation and analysis of this research. This chapter will discuss how the research sessions were planned and conducted to find possible design intervention areas in the implementation of VR into apparel shopping experience.

4.2 Underlying Methodological Perspectives

Some methodological perspectives that helped with the formation of the study flow as well as the construction of this research are briefly mentioned in this section. The

design methodologies that helped in the overall planning and organizing of the research are thereby covered with references to literature.

4.2.1 User-Centered Research

User-centered design focuses on increasing the quality of products and services to better meet the user's needs (Sanders & Strappers, 2012). The user-centered research focuses on the needs, behaviors and goals of the users of a product in order to ensure its effectiveness, efficiency and the satisfactory quality. Product testing and the semi-structured post-interviews are two of the user-centered research methods which were used in this research. The participants of this research were first asked to spend a few minutes in a fully-immersive virtual environment, followed by 15 minutes each in two semi-immersive virtual stores. Then, they were asked post-interview questions in order to identify the strengths and weaknesses they observed during their VR shopping experience and to find the possible design intervention areas.

4.2.2 User Appraisals of the Virtual Stores

Ease of learning, ease of use, intuitiveness and fun (Barnum, 2020) as well as learning over time, speed of task completion, error rate and subjective user satisfaction (Levi & Conrad, 1997) are critical components for seamless and easy interaction with a product. Shopping experience, on the other hand, is influenced largely by the perceived value of the overall experience, consistency of the experience, service quality, usefulness and enjoyment. Research shows that ensuring a fulfilling online shopping experience depends heavily on store environment features, store image (Fiore, 2008), usefulness, ease of use and enjoyment (Hirst & Omar, 2007).

The aim of this research was to find the factors influencing the VR apparel shopping experience. In order to understand and assess the needs of VR users during VR apparel shopping, participants were asked to spend time in a fully immersive virtual

environment and two semi-immersive virtual stores. Areas that might come off as problematic in the virtual stores under examination were not decided prior to the studies. Rather, the impressions and interactions of participants with the VR shops were observed, followed by a semi-structured post-interview to find possible design intervention areas for the topic at hand. The virtual stores under examination were evaluated prior to the studies based on their allowances for specific tasks during the VR shopping experience such as ease of navigation within the VE, freedom of movement, observation of and interaction with objects, virtual try-on, etc. (which will be explained more thoroughly in the coming section of this chapter).The semi-structured post-interview, on the other hand, covered questions regarding both the VR and shopping aspects of the participants' experiences. Hence, the research in hand focuses on the user appraisals of virtual shopping experience [e.g. ease of learning, ease of use, perceived usefulness, intuitiveness and fun (Barnum, 2020)].

As was mentioned earlier, two different virtual stores were used in the studies of this research. This was done in order to present two possible approaches to virtual reality shopping experience and to demonstrate to participants various features that can be included in the design of a VR store. For instance, the Hugo Boss Bali store used in this research includes a gamification feature while the Alo Yoga virtual store offers a virtual product try-on experience. The aim of this research, however, was not to make a statement on which of the two virtual stores was designed better. Instead, it aimed to discover participants' reactions to various features that can be offered in VR shopping experience.

4.3 Virtual Stores Used in the Studies and Reasons Behind Their Selection

Prior to the research sessions, available virtual stores which could be used in the study sessions were searched. Two fully-immersive platforms were found to be available on the Meta Horizon Feed (i.e. Shop R and I Shop Meta). However, these stores had been eliminated earlier in the preparation phase of this research as they fell short on product availability and shopping features (as explained further in the

Limitations section of Chapter 6 of this thesis). Semi-immersive virtual stores which promoted products other than apparel (e.g. cosmetics, accessories, etc.) also didn't make the final list of VR shops that could be used in the study sessions since the aim of this research was to observe the effects of VR on apparel shopping specifically.

As a result, 12 semi-immersive virtual stores on apparel were examined in terms of their fitness for the research in hand. These platforms were assessed based on the features they offer to customers. A list of features (i.e. existence of a consistent plot, avatar experience, store music, virtual product trial, customization, collaborative shopping) was made with reference to existing literature on VR and shopping experience. Table 4.1, which was prepared prior to the studies of this research, shows the list of the stores examined and the features they were assessed on. As can also be observed from the table, some of the features were available or missing in all of the virtual stores examined, whereas some features were available in some and missing in others.

Table 4.1 List of the virtual stores examined prior to research studies and the features they were assessed on (prepared by the author).

Platform/ Brand	Reality of Environment and Additional Notes	Product Renders	Immersion Level	Gamification	Consistency of Plot	Avatars	Fitting Room	Virtual Product Trial	Store Music	Product Customization	Collaborative Shopping
Shop R	Cartoonish	Cartoonish	fully-immsersive	No	Yes	Yes	No	No	Yes	No	No
I Shop Meta	Cartoonish	Cartoonish	fully-immsersive	No	Yes	No	No	No	Yes	No	No
Bloomingdale's Holiday	Cartoonish- not a realistic store setting	Realistic	semi-immsersive	Yes	Yes	No	No	No	Yes	No	No
Bloomingdale's 50	Various rooms and brands, virtual elevator, realistic and cartoonish renders used together	Cartoonish, flat images	semi-immsersive	Yes	Yes	No	No	No	Yes	No	No
Lacoste	Realistic store setting inside an elegator's mouse (showroom, no shopping option)	Realistic flat images	semi-immsersive	No	Yes	No	No	No	Yes	No	No
Lacoste Summer	Cartoonish, virtual elevator, involves a members only seciton, can choose store music	Cartoonish	semi-immsersive	Yes	Yes	No	No	No	Yes	No	Yes
Lululemon	Realistic store setting, videos embedded in the VE	Realistic	semi-immsersive	Yes	Yes	No	No	No	Yes	No	No
Pinko	Realistic store setting (not apparel, just bags)	Realistic	semi-immsersive	No	Yes	No	No	No	Yes	No	No
Ralph Lauren (Bloomingdale's 50)	Realistic store setting	Realistic	semi-immsersive	No	Yes	No	No	No	Yes	No	No
Saxx	Non-real store setting, 360 product view	Realistic	semi-immsersive	Yes	Yes	No	No	No	Yes	No	No
Tommy Hilfiger	Cartoonish (showroom and store)	Cartoonish	semi-immsersive	No	Yes	No	No	No	Yes	No	No
Harrods x Burberry	Non-real store setting, 360 product view	Realistic	semi-immsersive	No	Yes	No	No	No	Yes	No	No
Hugo Boss	Realistic environment renders	Realistic	semi-immsersive	Yes	Yes	No	No	No	Yes	No	No
Alo Yoga	Realistic store setting, cartoonish renders, videos embedded in the VE	Cartoonish	semi-immsersive	No	Yes	No	Yes	No	Yes	No	No

Upon literature findings and examination of the virtual stores available for the Meta Quest 3, it was decided that two virtual stores would be used for this research; the Hugo Boss Bali virtual store by Emperia VR, and the Alo Yoga virtual store by Obsess. The Hugo Boss store was chosen for this research due to a few reasons. First, the store offers a realistic setting in Bali, owing to its realistic interior renders and its consistent plot. The store doesn't depict a regular store setting, but rather a realistic private club/house in Bali. The products within the virtual store are also categorized according to the setting (e.g. swimsuits are presented next to a pool). As was also mentioned in Chapter 2 of this thesis in further detail, the existence of a consistent story line in VR assists with immersion (Slater & Wilbur, 1997). Second, the Hugo Boss store offers realistic product renders and allows, to a certain degree, to get closer to or further away from the products. Moreover, the store music playing in the background contributes to the multimodality of the experience. As per literature review of this research, activation of multiple senses in a virtual world increases the level of immersion into a VE (Stanković, 2016). Lastly, the store involves a gamification feature (i.e. collecting the letters of the word "Boss Bali" scattered in the VE) which serves to encourage customers to visit all the areas of the store. Figure 4.3 includes screenshots taken from the Hugo Boss Bali store. The collage of images shows various areas of the virtual store, the graphic clues added on the VE (e.g. arrows on the floor to navigate, clickable icons showing the sections of the store), product display within the store and product renders.

The Alo Yoga virtual store, on the other hand, was chosen for the following reasons. First, unlike the Hugo Boss Bali store, it offers a familiar store setting. As per literature review, familiarity helps with the understanding of (Stanković, 2016) and interaction within a VE (McMahan et al., 2012). It was decided, therefore, that using a virtual store which has a setting resembling that of a physical store, alongside a virtual store that feels less familiar (i.e. depicted differently than a regular store) would be beneficial for the research in hand. Second, the products in the Alo Yoga virtual store were rendered in a more illustrative way, unlike the products in the Hugo Boss store. It was also thought of as an advantage since this difference would enable

participants to make a comparison between the two product presentation modes. Further, the Alo Yoga virtual store also allows for a virtual try-on experience making use of an avatar. It was also decided to be an important feature that could help with the findings of this research. Finally, the Alo Yoga virtual store, too, has background music and also includes YouTube videos embedded in the store which further enrich the VR experience. Figure 4.4 shows some screen images taken from the Alo Yoga virtual store. The collage of images shows various areas of the virtual store as well as the graphic clues (e.g. arrows on the floor to navigate, clickable icons leading to product information windows) added on the VE.

For these reasons, it was decided that the two virtual stores (i.e. the Hugo Boss Bali store by Emperia VR and the Alo Yoga virtual store by Obsess) would be used in the studies of this research. The participants would be asked to spend 15 minutes in each store, thus experiencing all the features offered in the two stores.

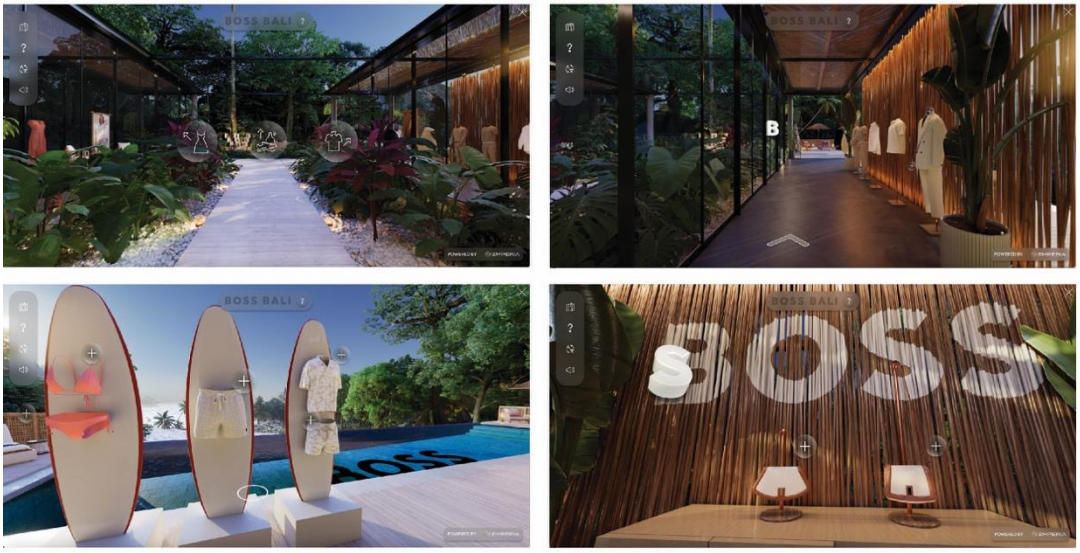


Figure 4.3. Screenshots taken from the Hugo Boss Bali virtual store designed by Emperia VR (screenshots are taken by the author).



Figure 4.4. Screenshots taken from the Alo Yoga virtual store designed by Obsess (screenshots are taken by the author).

4.4 Formation of the Semi-Structured Post-Interview Questions

The semi-structured post-interviews of this research covered two aspects. First, questions were prepared regarding topics such as the presence and immersion experienced by the participants in the virtual environments, interaction and navigation inside the VEs and consistency/predictability of the VR systems. This was necessary in order to understand the participants' overall reactions to, needs and expectations from a virtual reality (shopping) experience. Second, shopping related aspects of the virtual stores were questioned, including topics such as product selection, product combination and comparison of various shopping experiences (i.e. comparing VR shopping to online and physical shopping experiences). This was done in order to understand the expectations of participants during virtual apparel shopping and the extent to which the virtual stores allowed participants to perform their desired shopping experiences.

The questions regarding the overall VR experience were shaped with reference to literature, mainly the Presence Questionnaire by Witmer & Singer (1998) and the Heuristic Evaluation of VR by Sutcliffe & Gault (2004). The literature findings that helped with the formation of the VR-related questions of the post-interviews will be explained more thoroughly in the coming section of this chapter. Questions regarding the shopping experience, on the other hand, aimed for a reflection on the shopping flow in VR stores through a comparison with previous experiences in online and physical stores. Appendix A involves an English translation of the post-interview questions asked to each participant during the research sessions.

4.4.1 Literature References Used in the Construction of the Post-Interview Questions

VR usability tests usually take reference from Questionnaires for User Interaction Satisfaction (QUIS) and the System Usability Scale (SUS) (Fang & Lin, 2019).

The Questionnaires for User Interaction Satisfaction (QUIS) is a measurement tool designed by Chin et al. (1988) to evaluate the user's satisfaction level and subjective rating of the human-computer interface. QUIS involves questions on a likert scale on topics including, but not limited to, overall reactions to the software (e.g. difficult-easy, frustrating-satisfying, dull-stimulating, etc.), screen (e.g. readability of characters on the screen, organization of information on the screen, clarity of sequence of screens, etc.), terminology and system information (e.g. consistency of terms throughout the system, consistency of position of messages on screen, feedback from the computer on what it is doing, etc.), learning (e.g. ease of learning to operate the system, ease of exploring new features by trial and error, helpfulness of messages on the screen, etc.), and system capabilities (e.g. system speed, system reliability, undoing/ correcting mistakes, etc.).

The System Usability Scale (SUS), on the other hand, was first developed by Brooke (1996) in order to assess the subjective usability measures of users on effectiveness,

efficiency and satisfaction. The likert scale questionnaire comprises of questions such as the complexity of the system, ease of use of the system, integrity of function in the system and confidence while using the system.

In usability testing for VR, both of the models (i.e. QUIS and SUS) are frequently used. Overall response to the VR experience, satisfaction of interaction with interface tools, satisfaction of items/objects, quality of visualization, speed of interaction responses and manipulation of products in the VE were the aspects questioned, with reference to QUIS, in a research conducted by Altarteer et al. (2013) on VR shopping for luxury brands. Overall response to the VR experience, VR interface, information provided, and learnability were the factors assessed by Fang & Lin (2019), again with reference to QUIS, in their research on usability testing of VR tourism apps.

Presence Questionnaire, developed by Witmer & Singer (1998) is another tool used to measure the extent to which an individual experiences the felling of presence in a VE. “Individual differences, traits and abilities may enhance or detract from the presence experienced in a given VE (Witmer & Singer, 1998, p. 230)”. Further, the characteristics and quality of the VE also contribute to the feeling of presence in a VE (Witmer & Singer, 1998). Therefore, both the characteristics of individuals and characteristics of the VE must be taken into account when assessing the presence of a VR user in a given virtual environment. The Presence Questionnaire takes into consideration both these factors (i.e. individual characteristics and VE characteristics) in order to measure the degree of presence in a VR experience.

Sutcliffe & Gault (2004) offer a heuristic evaluation for VR applications where they focus largely on the need for intuitive interaction and the sense of immersion. They make a list of heuristics for VR including, but not limited to, *natural engagement* (i.e. virtual interactions’ fitness to user’s expectation), *compatibility with the user’s task* (i.e. correspondence of the VE and the behavior of objects within the VE to the expected behavior of the real world and real world objects), *natural expression of action* (i.e. VR’s capability to allow for actions and explorations within the VE in a

natural manner), *realistic feedback* (i.e. immediate visibility of the effects of user's actions and their conforming to the laws physics), *faithful viewpoints* (i.e. fitness of the virtual world to user's perception and undelayed renders to user's head movements), *navigation and orientation support*, *clear entry and exit points*, *support for learning* (i.e. self-explaining quality of active objects in the VE) and *sense of presence* (Sutcliffe & Gault, 2004).

Upon literature review made as part of this research, several topics were noted that deserved scrutiny during the study sessions of this research. These topics include:

- Immersion into the VR and the feeling of presence
- Interaction with the VE and objects inside the VE, responsiveness of the VR
- Perceived usefulness and perceived ease of use of the VR
- User interface of the VR
- Navigation and orientation within the VE
- Consistency of the plot in the VR experience
- Visual realism, visual, auditory and interaction fidelity of the VR
- Multimodality of the VR
- Utilitarian and hedonic aspects of shopping
- Product observation, product informativeness and understandability of products in the virtual stores
- Product selection, product comparison and product combination
- Virtual try-on and avatar experience

The questions of the post-interview were structured based on literature review findings. For the questions regarding the VR aspect of the participants' shopping experience, reference was taken from existing literature, mainly from the Presence Questionnaire by Witmer & Singer (1998) and the heuristic evaluation method by Sutcliffe & Gault (2004). The shopping related questions, on the other hand, were built as a retrospective of the shopping experience, focusing on topics such as

product understandability, product comparisons and shopping flow. Table 4.2 shows the correspondence between the post-interview questions of the studies of this research and their references from literature. Further, Appendix A involves the English translation of the post-interview questions.

Table 4.2 Correspondence between the post-interview questions and their references from the Presence Questionnaire (Witmer & Singer, 1998) and the heuristic evaluation method (Sutcliffe & Gault, 2004) (prepared by the author).

Number of Question in the Post- Interview of this Research	*Reference from the Presence Questionnaire*	*Reference from the VR Heuristic Evaluation Method*
1	SF 4, SF 5, SF 6, RF 11, RF 23, DF 30	Sense of presence
2	CF3, CF 7, RF-CF 12, CF 25, RF-SF 15, RF-SF 16	Natural engagement, Natural expression of action
3	-	Sense of presence
4	CF1, CF 2, DF 24, CF 26, CF 27, DF-CF 29	Natural expression of action,
5	CF 3, RF-CF 12, CF 13	Compatibility with the user's task and domain, Close coordination of action and representation, Realistic feedback
6	SF 10, SF 19	
7	SF 20, SF 21	
8	-	
9	-	
10	-	
11	RF-CF-SF 14	Faithful viewpoints,
12	SF 18, RF 22	Navigation and orientation support, Clear entry and exit points
13	-	Compatibility with the user's task and domain
14	-	
15	-	
16	-	

CF= Control Factors, SF= Sensory Factors, DF= Distraction Factors, RF= Realism Factors

4.5 The Study

The aim of this study was to observe the effects of using VR for apparel shopping, thus finding possible design intervention areas for virtual apparel shopping experiences. For this aim, literature reviews on virtual reality, shopping experience and shopping with VR were made prior to the preparation for the research studies. After the literature review, multiple platforms for VR shopping and VR apparel shopping were examined in order to find the virtual stores that would best fit the aim

of this study. This step was a crucial part of this research in order to construct an efficient and goal-oriented flow for the studies of research.

The scope of this research involves observing the effects of immersion into VR, interaction with the VR and their resulting effects on the virtual shopping experience. Therefore, it was imperative that the participants of this research were immersed into the VR, could interact with the VE and/or objects within the VE, and go through all the steps of virtual shopping experience with the use of VR headset. The virtual stores chosen for the study sessions of this research and the reasons behind their selection were mentioned in the previous sections of this chapter. The coming sections of this chapter will explain the venue and equipment used for the study sessions of this research and the flow of sessions.

4.5.1 Venue and Equipment

Before the research studies started to take place, an application was made to the Applied Ethics Research Center of Middle East Technical University. This research was approved by the committee with a protocol number of 0465-ODTUİAEK-2024.

The venues arranged for this research were a study room in TED University and BILTIR-UTEST (Product Usability Testing Unit) at METU Faculty of Architecture. Both of the venues chosen for the studies were large enough for participants to feel at ease during the study, providing sufficient space for safe movement and comfortable sitting. The study venues were ventilated prior to participants' arrival in order to decrease the possible side effects of the VR headset use. Additionally, both of the study venues were quiet environments and most of the studies were conducted during the weekends in order to minimize external noise which may have distracted participants during research. Furthermore, both of the venues of this research were equipped with stable and high-speed internet connection to allow for fast and seamless operation of VR systems. Participants were also provided with sweet and

savory snacks as well as natural eye tears during the research in case of possible side effects of VR such as simulator sickness and eye irritation.

The VR headset used in this research was Meta Quest 3 by Reality Labs, a division of Meta Platforms, released on 10 October 2024. Since the Meta Quest 3 VR headsets used in this research, like other VR headsets, may cause simulator sickness with side effects such as dizziness, headache or nausea, the venues of this research were chosen specifically to accommodate the comfort of participants.

The participants were asked for permission prior to study to take screen video records and voice records throughout the session. The screen videos of participants during the VR use were projected on a laptop screen through the "casting" feature offered by the VR headset used in the research. Thus, participants' actions and navigation within the virtual stores could be tracked and their questions be answered when they needed help or information during the VR use. The screen video records were recorded and saved with the laptop used during the research. The voice records were taken with an i-Phone 13 Pro.

4.5.2 Participant Sampling

Although VR is not a technology meant to be used solely by designers, this study was conducted amongst a group of designers and design students. There are a few reasons why the participants involved in this research were chosen specifically from amongst designers and design students.

First, the virtual stores used in this research were semi-immersive rather than fully-immersive (as was explained in the previous sections of this chapter in further detail). The main limitation of this research (i.e. the virtual stores being semi-immersive) called for a group of participants who could see the full potentials of the VR experience by imagining that the experience was fully-immersive. Therefore, it was decided prior to the research sessions that designers and design students would bem

better able to imagine and foresee the potentials of VR shopping experience given the virtual stores were fully-immersive.

Second, the research called for participants to make comments not only on the shopping experience and the overall impression over the use of VR technology during the shopping experience, but also on topics such as navigation within the VE, representation of products, interaction with products and product-environment relation. Hence, it was decided, also prior to research, that participants with design knowledge or design background would provide more insight into the research with their comments during the use of VR and their answers to the interview questions.

Another factor that was considered while choosing participants was age. People above the age of 50, as showcased by Park et al. (2006), and people above the age of 70, as showcased by Classen et al. (2011) are more susceptible to simulator sickness (SS). Hence, in order to eliminate the possibility of SS that could occur with the use of VR, the participants of this research were chosen from amongst individuals younger than the age of 50. Participants' ages were known prior to research since the application for the studies were made through a Google Form which included a question asking the age of the participants.

The call for studies were made through the Instagram account of the author with previously designed story templates as shown in Figure 4.5. A Google Form link was attached in the story for volunteer participants to apply for the study. Applicants' ages, occupations (having a design background or not) and their year of study in college (only for students) were considered while choosing the participants for this research. Only junior and senior year students were accepted for the research in order to ensure that their experience in the field of design exceeded a certain level.

The studies were conducted with 9 Industrial Design students and 9 professionals. 4 of the professionals are industrial designers currently working in an industrial design firm, 3 of the professionals are industrial designers working in academics, 1 of the professionals is an architect, and 1 of the professionals is an interior designer.

Figure 4.6 shows two pictures taken during the study sessions of this research. The left image was captured during one of the studies conducted at TED University with a junior industrial design student and the image on the right was captured during one of the studies at UTEST in METU Department of Architecture with a professional industrial designer.



Figure 4.5. Story templates used for call to studies of this research (both prepared by the author).

4.5.3 Study Protocol

The participants of the study were contacted to arrange one-hour appointments prior to studies. They were invited to the METU or TED University campus according to their convenience. The venues were ventilated before each study and were prepared in a way that would allow for comfortable seating and comfortable movement while using the VR headset.

At the beginning of each study, participants were told about the possible side effects of VR use and were told that they were free to take breaks or stop altogether the research should they experience overwhelming discomfort due to the use of VR headset. They were also asked for permission to take screen video records and voice records throughout the study. A consent form was signed by each participant which also included the risks and asked for permission to take the screen video and voice records during the study.

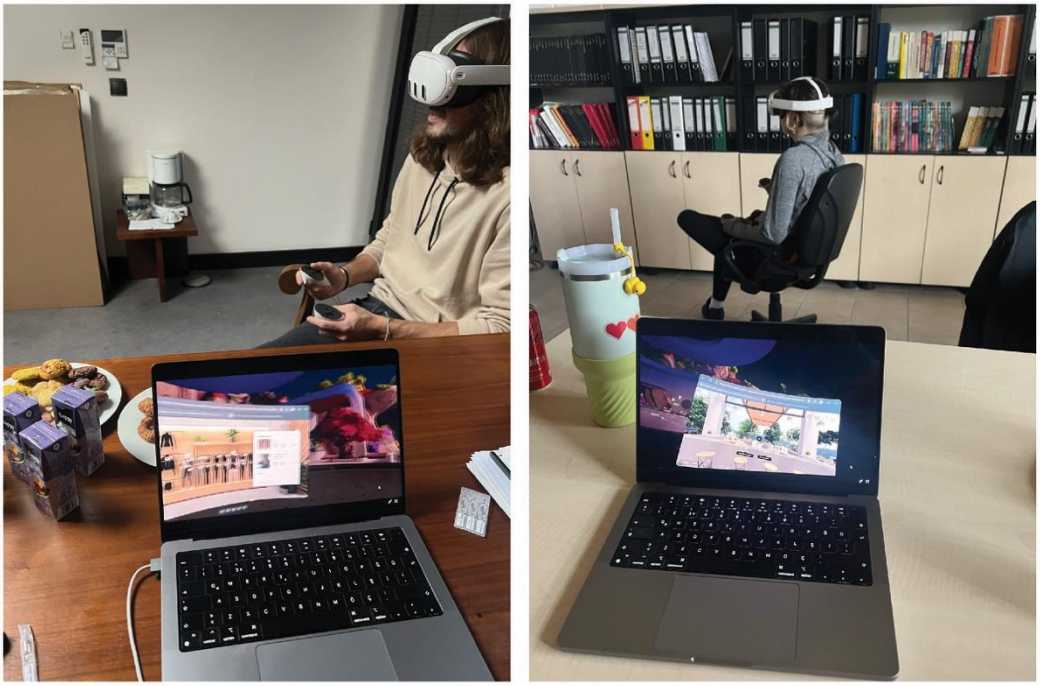


Figure 4.6. Picture taken during one of the studies conducted at TED University with a junior industrial design student (on the left), and picture taken during one of the studies at UTEST in METU Faculty of Architecture with a professional industrial designer (on the right).

After the consent forms were signed, a short presentation was made to the participants covering the aim of the research, the flow of the study, a basic guide on how to use the VR headset and hand controllers. Basic information about the virtual stores that would be experienced (such as how to navigate within each environment and how to get information on the products within each store) were also given with

explanations and screen shots from each store. Figure 4.7 includes some of the slides of the introductory presentation made to the participants at the beginning of each study session. Figure 4.8 shows the flow of the studies, which was also included in the same introductory presentation.

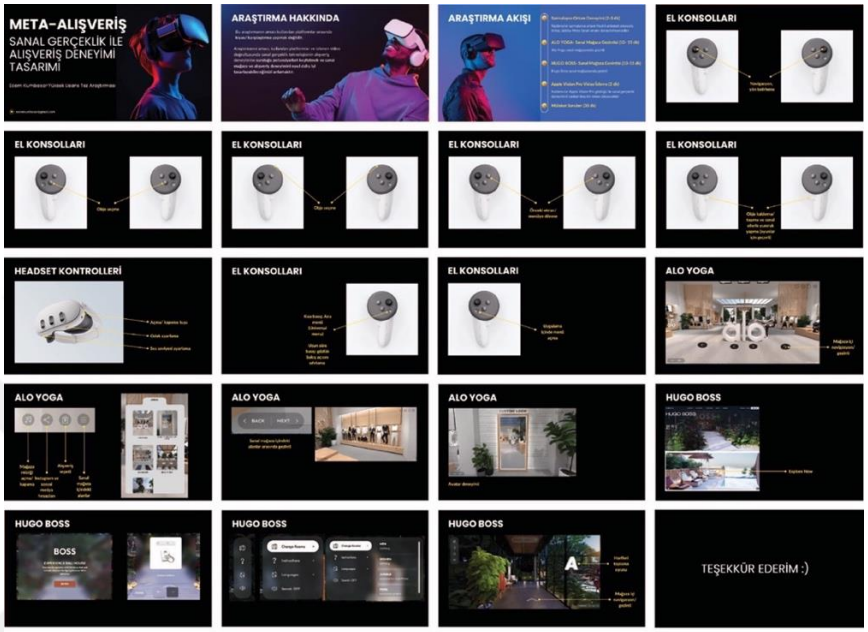


Figure 4.7. Some of the slides presented to the participants at the beginning of study sessions (prepared by the author).



Figure 4.8. Slide demonstrating the flow of the studies, which was included in the introductory presentation made to the participants at the beginning of study sessions (prepared by the author).

After the aim of the research and the steps of the study were explained, participants were asked to put on the VR headset. It was adjusted for each participant by ensuring a comfortable fit on their heads and adjusting the focal point of the VR glasses. Once the VR headset was worn, the participants were guided step-by-step on what to do in the VR. First, participants were guided on how to create their boundaries in order to adjust the VR according to their eye level and set their interaction boundaries inside their physical environment. Then, they were asked to give screen share allowance from the Meta Quest Camera app so that their experience in the VR could be viewed and recorded on the laptop used by the author of this thesis. Once the personal settings (i.e. boundary creation) and screen share allowance were made by participants, they were asked to open the fully-immersive Meta Universe. Figure 4.9 includes screenshots from the Meta Universe. As can also be seen in this collage of screen images, the Meta Universe includes an avatar whose overall appearance and clothes can be changed once clicked on the avatar in the mirror. The participants were asked to play with the avatar, changing its clothes and overall appearance if they wished, and to stroll within the virtual environment, thus getting the feeling of immersion and presence in a VE. The changing of the clothes of the avatar was specifically asked since the experience also involves textiles and resembles a virtual try-on experience in a virtual store.

After the participants stated that they understood what it was like to get fully immersed into a virtual environment, they were asked to continue their experience with the Alo Yoga virtual store. Since the virtual stores were only available through a browser and were similar, in appearance to computer browsers, the window of the browser was enlarged to the largest size available and made into a curved screen (in order to give a more immersive feeling compared to viewing a browser on a regular computer screen). Once participants entered the semi-immersive Alo Yoga virtual store, they started strolling and observing the products within the store. The store



Figure 4.9. Screenshots taken from the fully-immersive Meta Universe in Meta Quest 3 (screenshots are taken by the author).

interface allowed users to click on the products to get more information and add them to their basket if they wanted. The participants were asked specifically to visit all the areas of the virtual store, add at least a few items to their baskets, and interact with the virtual-try on mirror where they could see some of the products in the store on an avatar. Once the participants visited all the areas of the Alo Yoga virtual store and used the avatar feature of the store, they were instructed to switch to the next tab in the browser, which led them to the Hugo Boss Bali virtual store.

Again, the participants were asked to visit all the areas within the store, observe the products and click on them to get further product information. The Hugo Boss Bali virtual store doesn't allow for adding items to basket within the same window. Instead, it directs the user to the online store (i.e. website) of the brand on a separate tab in the browser. Still, the participants were asked to also experience this in order to observe the two different approaches to product selection designed in the two stores. Once all the areas in the Hugo Boss Bali store were visited and products within the store observed, participants were told the take off the VR headset.

They were then shown the video promoting the Emperia VR app for Apple Vision Pro in order to see the potentials of VR shopping. Once all these steps were completed (within a time frame of 30-35 minutes), participants were asked the post interview questions. As they were being interviewed, the same virtual stores (i.e. the Alo Yoga store and Hugo Boss Bali store) were opened on the browser of a laptop. Participants were told that they could go through the virtual stores as they answered the interview questions if they wanted. Some of the participants preferred to stroll within the stores as they answered the interview questions. During their strolling on the computer, the screen video records were still on in order to capture the details they pointed out as they answered the questions.

4.5.4 Interviews

The post-interview of the research studies lasted approximately 30-40 minutes for each participant. The interview consisted of 16 questions in total covering the topics of:

- VR experience, immersion and the feeling of presence
- User Interface
- Product information, product selection, product comparison and product combination
- Navigation and way-finding within the VE
- Overall impressions on VR and comparison of VR shopping experience to physical and online shopping experiences (see Appendix A).

CHAPTER 5

DATA ANALYSIS, RESULTS AND DISCUSSION

This chapter will first present how the collected data was analyzed and categorized into themes and sub-themes, after which the found relations between these themes and sub-themes will be explained. A heat map based on the analyzed data will then be presented, demonstrating which themes and sub-themes appeared more often in the collected data, thus portraying which aspects of VR apparel shopping caught the most attention from the participants of the research.

Then, with references to the participant comments, each theme and sub-theme will be touched upon more elaborately, thus explaining more clearly the relationships between them. For each theme, design insights and possible design solutions will be shared based on the analyzed data. A table including the summary of design insights based on the analyzed data will be shared at the end of the chapter.

5.1 Analysis of Data

The data analysis of this research began after the voice records of participants were transcribed. Since participants made occasional comments during their VR experiences, screen video records taken during the sessions were revisited to match the transcribed texts when necessary. After the transcription, participants' key comments during VR sessions as well as their answers to post-interview questions were listed on a Microsoft Excel spreadsheet. This data was then gone through multiple times to find relations, patterns and themes. Based on both the findings from literature review of this research and the data listed on the Excel spreadsheet, themes and sub-themes began to appear. Figure 5.1 shows the initial map of themes created by author with post-its. Color coding was used in order to make the categories and the relations between the categories more visible.



Figure 5.1. Initial map of themes and sub-themes based on literature review and data from transcribed voice records, prepared by author.

Next, the Excel spreadsheet was updated in relation to the themes and sub-themes. A total of 410 comments were categorized under these themes. In the cases where a comment or answer to post-interview questions matched multiple categories, the overlap was shown by adding the categories side-by-side. The same color coding as the one used in initial map of themes was used. Thus, the relations between different themes also became more visible. Figure 5.2 includes some exemplary data from the updated Excel spreadsheet. The first column in the data spreadsheet corresponds to the number of participant and number of comment (e.g. P1, C1: Participant 1, Comment 1, etc.). The second column includes quotations from the participants, the third column shows during which part of the study sessions the comments were made by participants (i.e. during the VR experience of Alo Yoga virtual store, Hugo Boss virtual store, or as an answer to post-interview questions). The fourth and fifth

columns in the spreadsheet include the themes and sub-themes that merged during the analysis of data.

P7, C9	I would want to rotate the garments 360 degrees. I would also want to get close-up images to understand the fabric by zooming into the product.	Post-Interview	Use and Usability	Interaction	product informativeness
P13, C16	I felt more in contol in Alo Yoga. In Boss, I couldn't click on the arrows, it gets stuck and suddenly moves you to the ceiling or the floor. It should work in synchrony to my moves.	Post-Interview	Use and Usability	Interaction *(ease of use, ease of interaction)*	
P16, C9	When I discovered the Zoom feature, I felt happy because it is a gesture/interaction I am familiar with from my previous digital experiences. I intuitively did the same gesture and the system responded to it, which was nice.	Post-Interview	Use and Usability	Interaction *(intuitive, heuristic interaction)*	
P14, C8	If it doesn't resond too quickly to my gestures, I could adapt th this more easily.	Post-Interview	Use and Usability	Interaction *(resposiveness and speed)*	
P12, C9	Navigation wasn't good in either of the stores. That puts a barrier.	Post-Interview	Use and Usability	Navigation and Movement	
P12, C27	I would like to see the store but then jump into the shopping phase. My aim is to buy things. I should ve able to quickly discover the products inside the store.	Post-Interview	Utilitarian Shopping	Fitness to Purpose, Task Fulfillment and Speed	
P11, C46	Every individual has different shopping habits. For instance, some people try clothes in physical stores but purhcase from online to avoid waiting in long lines. Maybe this could be used as a pre-exploration of products before visiting an actual physical store.	Post-Interview	Utilitarian Shopping	Task Fulfillment and Speed	
P2, C7	I would want to try on the products that I chose in front of the virtual fitting mirror. Maybe see them on a separate window inside the VE and drag them on my avatar... Also I would love to see the products more organized, or grouped... Maybe demonstrated in combinations similar to physical stores.	Post-Interview	Utilitarian Shopping	Product Variation	
P7, C17	In inline sopping, it helps when they give the height/weight of the model. I would also want to see it here, instead of virtually trying them on an avatar. Or maybe I can customize the avatar based on my body measurements so that I can at least imagine how the product will look on my body.	Post-Interview	Product Size	Avatars	
P3, C7	When you are getting a realistic render, some things shouldn't appear this much organized. For example, the stools over here are perfectly aligned, everything is so perfectly organized. It reminds me that this is a fictional setting.	Alo Yoga	Store Layout	Realistic vs. fantasy store designs	

Figure 5.2. Some of the data from the Excel spreadsheet matching the comments of participants with themes and sub-themes.

Next, the data were grouped based on the themes to better observe the relationships between themes and sub-themes. Based on the corresponding findings, the map showing the themes and sub-themes was updated into its final version. Figure 5.3 shows the final map of themes and sub-themes which emerged from the analysis of the data.

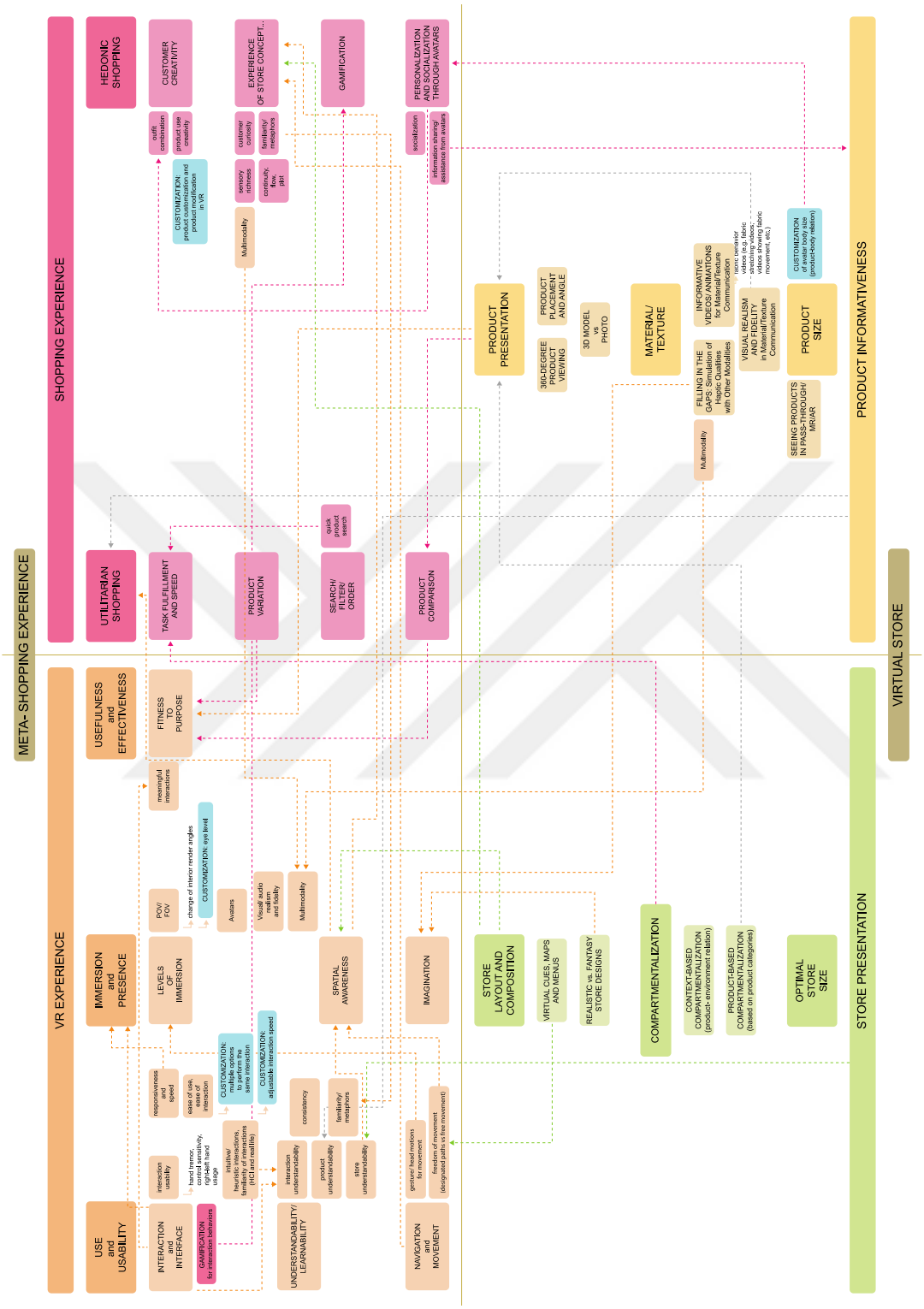


Figure 5.3. Final map of themes and sub-themes, prepared by author.

5.2 Themes and Sub-themes Summarized

As a result of the analysis of data, two main categories emerged under which four main titles were listed. The two main categories are “Meta-Shopping Experience” and “Virtual Store”. The first main category “Meta-Shopping Experience” includes comments and post-interview answers related to the VR and shopping experience. The second main category “Virtual Store” includes themes and sub-themes related to store presentation and product informativeness. Thus, the first main category (i.e. Meta-Shopping Experience) contains VR Experience and Shopping Experience as its main titles, and the second main category (i.e. Virtual Store) includes Store Presentation and Product Informativeness as its main titles. Figure 5.4 demonstrates more clearly the four main titles with overlaps among them.

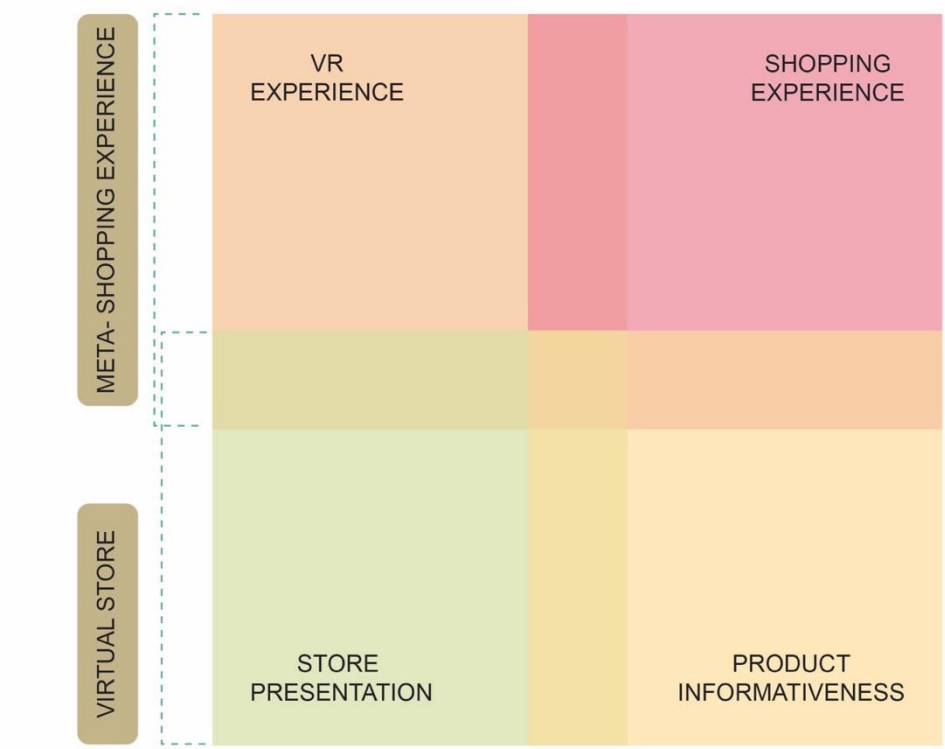


Figure 5.4. The two main categories and four main titles of the theme map, prepared by author.

5.3 Found Relationships between Themes and Sub-themes

This section will briefly mention what each theme and sub-theme under the four main titles stands for in the context of this research, as well as the links between them.

The first of the four main titles, VR Experience, includes (a) **Use and Usability**, (b) **Immersion and Presence**, and (c) **Usefulness and Effectiveness** as its themes. Figure 5.5 includes the upper-left hand side of the theme map introduced earlier in this chapter, in order to more clearly demonstrate the themes and sub-themes under the first main title, VR Experience.

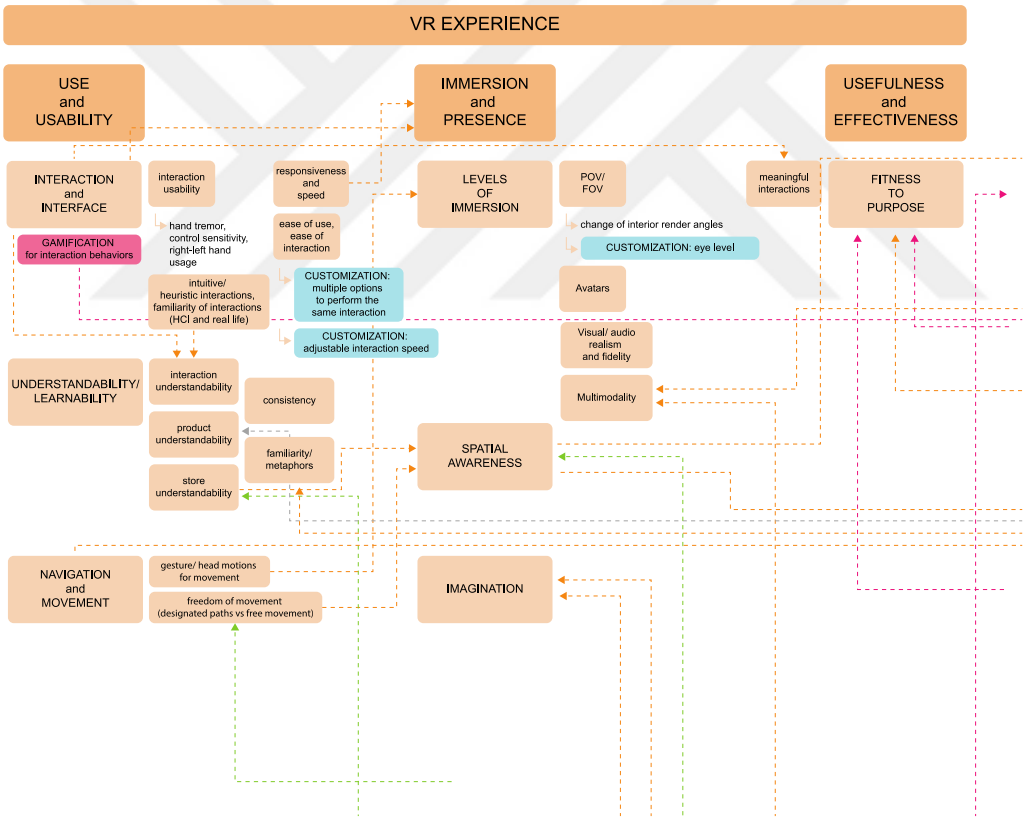


Figure 5.5. Upper-left hand side of the theme map demonstrating the themes and sub-themes under the VR Experience main title, prepared by author.

In the context of this research, (a) "**Use and Usability**" refers to the overall usability of the VR stores visited by participants. The sub-themes below this theme are (i) *Interaction and Interface*, (ii) *Understandability/Learnability*, and (iii) *Navigation and Movement*. Comments made by participants related to topics such as interaction usability, intuitiveness of interactions, responsiveness and speed, ease of use and ease of interaction were listed under the *Interaction and Interface* sub-theme of **Use and Usability** theme. The *Interaction and Interface* sub-theme was found to have links with the *meaningful interaction*s under the **Usefulness and Effectiveness** theme, the interaction understandability (under *Understandability/Learnability*) and the **Immersion and Presence** theme (all indicated with arrows on the map).

Comments related to interaction understandability/learnability, product understandability, store understandability, consistency and familiarity/metaphors were linked to the *Understandability/Learnability* sub-theme under the **Use and Usability** theme. Product understandability was found to be linked with Product Informativeness (the fourth main title) while store understandability was found to have relations with Store Presentation (the third main title) and the *Spatial Awareness* sub-theme of **Immersion and Presence**. Comments related to familiarity/metaphors were found to be linked with the *Experience of the Store Concept and Ambience* sub-theme of **Hedonic Shopping**. The interaction understandability topic was also found to be linked to the intuitive interactions topic under the *Interaction and Interface* sub-theme of **Use and Usability**.

Finally, comments related to navigation and movement within the virtual stores, including comments made on freedom of movement vs. designated paths and gestural movements were listed under the *Navigation and Movement* sub-theme of **Use and Usability**. This sub-theme was found to have links with the **Store Layout and Composition** theme under the third main title (Store Presentation), the *Levels of Immersion* and *Spatial Awareness* sub-themes of **Immersion and Presence**, and the *Experience of the Store Concept and Ambience* sub-theme of **Hedonic Shopping**.

Next, the second theme of VR Experience, (b) "**Immersion and Presence**" refers to the telepresence experienced during the VR experience. This theme includes (i) *Levels of Immersion*, (ii) *Spatial Awareness*, and (iii) *Imagination* as its sub-themes. Links were found between the **Immersion and Presence** theme and *Interaction and Interface* sub-theme, between *Levels of Immersion* and *Navigation and Movement*, between *Levels of Immersion* and *Experience of the Store Concept and Ambience* (under **Hedonic Shopping**), and between *Levels of Immersion* and *Multimodality* (under **Material/ Texture**). Further, the *Spatial Awareness* sub-theme was found to have links with the store understandability topic of *Understandability/Learnability*, *Navigation and Movement*, **Store Layout and Composition**, **Utilitarian Shopping** and *Experience of the Store Concept and Ambience* (under **Hedonic Shopping**). The *Imagination* sub-theme was also found to have links with *Realistic vs. Fantasy Store Designs* under **Store Layout and Composition**, and with *Filling in the Gaps: Simulation of Haptic Qualities with other Modalities* under **Material/ Texture**.

The third theme under the VR Experience, (c) "**Usefulness and Effectiveness**", encompasses the relevance of content presented by the platforms as well as the platforms' ability to fulfill customers' intended purposes (through elements such as meaningful interactions). This theme includes the sub-theme of (i) *Fitness to Purpose*. Links were found between *Fitness to Purpose* and *Product Comparison* under **Utilitarian Shopping**, *Fitness to Purpose* and *Product Variation* under **Utilitarian Shopping**, and *Fitness to Purpose* and **Product Presentation**. The topic of meaningful interactions under the *Interaction and Interface* sub-theme was also found to have relations with the *Fitness to Purpose* sub-theme.

Next, the second main title, Shopping Experience, includes (a) **Utilitarian Shopping** and (b) **Hedonic Shopping** as its themes. Figure 5.6 includes the upper-right hand side of the theme map to demonstrate the themes and sub-themes under the Shopping Experience.

As was also mentioned in the literature review of this thesis, utilitarian shopping refers to the goal-oriented and task-driven aspects of shopping. It is related to the

efficiency and functionality aspects of the shopping experience as well as the achievement of a specific need or purpose while shopping. In the context of this research, four sub-themes emerged under the theme of **Utilitarian Shopping**: (i) *Task Fulfillment and Speed*, (ii) *Product Variation*, (iii) *Search/Filter/Order* for products, and (iv) *Product Comparison*. Hedonic Shopping, on the other hand, is related to the pleasure, enjoyment and emotional fulfillment during the shopping experience. The sub-themes under **Hedonic Shopping** are (i) *Customer Creativity*, (ii) *Experience of the Store Concept and Ambience*, (iii) *Gamification* and (iv) *Personalization and Social Interactions through Avatars*.

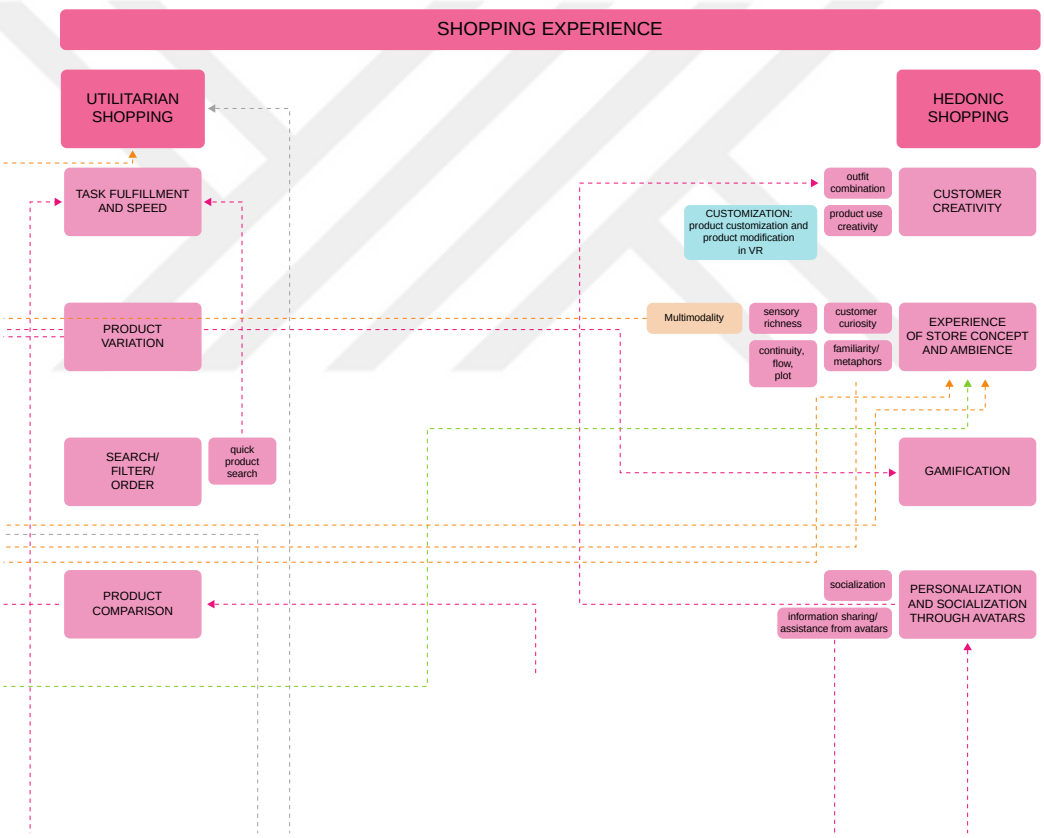


Figure 5.6. Upper-right hand side of the theme map demonstrating the themes and sub-themes under the Shopping Experience main title, prepared by author.

Based on the data analysis of this research, links were found between **Utilitarian Shopping** and Product Informativeness (the fourth main title in the theme map),

between **Utilitarian Shopping** and *Spatial Awareness*, between *Task Fulfillment and Speed* and **Compartmentalization** (under the Store Presentation title), between *Task Fulfillment and Speed* and *Search/Filter/Order*, between *Product Variation* and *Fitness to Purpose,* between *Product Comparison* and **Product Presentation**, and between *Product Comparison* and *Fitness to Purpose*. The sub-themes under the theme of **Hedonic Shopping**, on the other hand, were found to have the following links: *Customer Creativity* and *Personalization and Social Interactions through Avatars*, *Experience of the Store Concept and Ambience* and **Store Layout and Composition**, *Experience of the Store Concept and Ambience* and *Spatial Awareness***,** *Experience of the Store Concept and Ambience* and *Navigation and Movement, Experience of the Store Concept and Ambience* and *Understandability/Learnability*, *Experience of the Store Concept and Ambience* and *Levels of Immersion*, *Gamification* and *Interaction and Interface*, *Personalization and Social Interactions through Avatars* and *Customer Creativity*, *Personalization and Social Interactions through Avatars* and **Product Size**, and *Personalization and Social Interactions through Avatars* and Product Informativeness (the fourth main title- through information sharing/ assistance from avatars).

The third main title, Store Presentation, includes three themes: (a) **Store Layout and Composition**, (b) **Compartmentalization** and (c) **Optimal Store Size**. Figure 5.7 includes the lower-left hand side of the theme map to demonstrate the themes and sub-themes under the Store Presentation title.

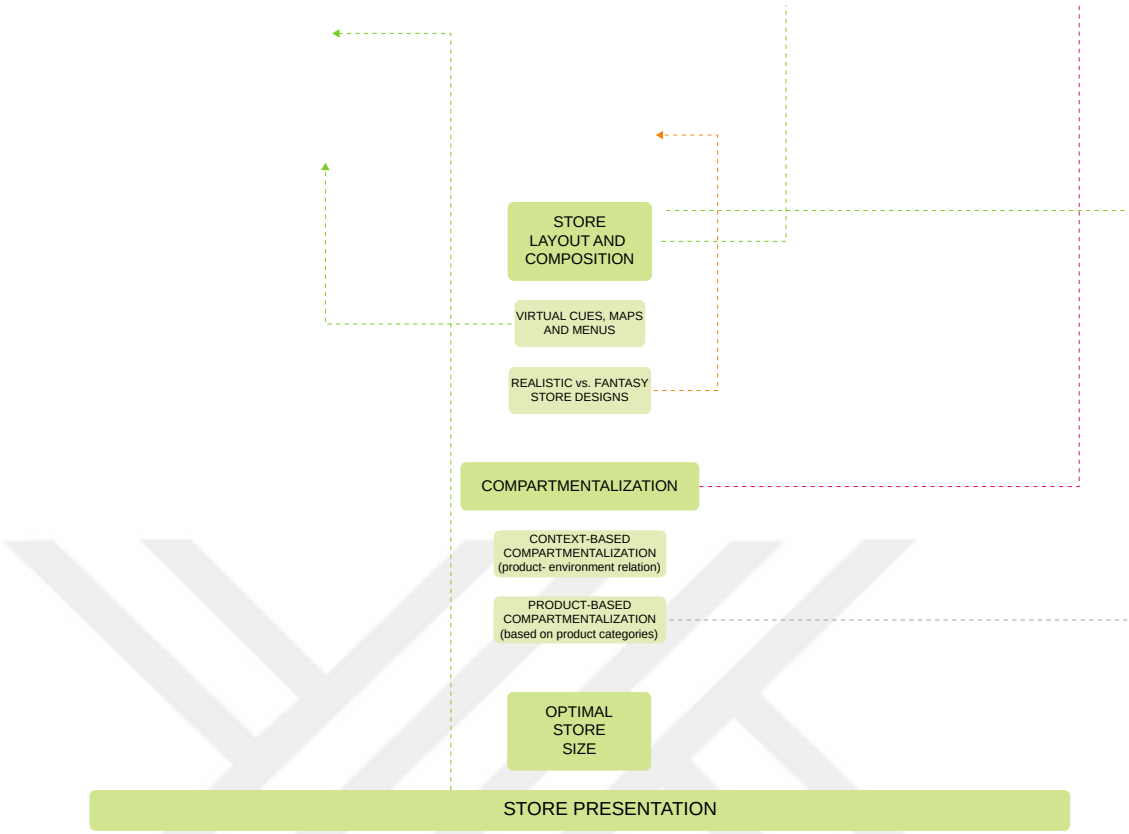


Figure 5.7. Lower-left hand side of the theme map demonstrating the themes and sub-themes under the Store Presentation main title, prepared by author.

The (a) **Store Layout and Composition** theme contains the sub-themes of (i) *Virtual Cues, Maps and Menus*, and (ii) *Realistic vs. Fantasy Store Designs*. Links were found between **Store Layout and Composition** and *Experience of the Store Concept and Ambience* (under **Hedonic Shopping**), between **Store Layout and Composition** and *Spatial Awareness*, between *Virtual Cues, Maps and Menus* and *Navigation and Movement* (under **Use and Usability**), and between *Realistic vs. Fantasy Store Designs* and *Imagination* (under **Immersion and Presence**).

The theme (b) **Compartmentalization** includes (i) *Context-Based Compartmentalization* (product-environment relation) and (ii) *Product-Based Compartmentalization* (based on product categories) as its sub-themes. Links were found between **Compartmentalization** and *Task Fulfillment and Speed* (under **Utilitarian Shopping**), and between *Product-Based Compartmentalization* and

Product Presentation. The third theme, (c) **Optimal Store Size** wasn't found to be linked to other themes or sub-themes, although the overall Store Presentation title was found to have a link with the *Understandability/Learnability* sub-theme of **Use and Usability**.

Finally, the fourth main title, Product Informativeness, has three themes: (a) **Product Presentation**, (b) **Material/ Texture** and (c) **Product Size**. Figure 5.8 includes the lower-right hand side of the theme map to demonstrate the themes and sub-themes under the Product Informativeness title.

The theme (a) **Product Presentation** deals with how the products appear and how they are interacted with inside the VR store and includes (i) *360-degree Product Viewing*, (ii) *Product Placement and Angle* and (iii) *3D Model vs Photo* as its sub-themes. Based on the data of this research, the **Product Presentation** theme was found to be linked with *Product Comparison* (under **Utilitarian Shopping**), *Fitness to Purpose* (under **Usefulness and Effectiveness**), *Product-Based Compartmentalization* (under **Compartmentalization**), and *Visual Realism and Fidelity* (under **Material/ Texture**).

The theme (b) **Material/ Texture** has (i) *Filling in the Gaps* (sound/ video/ etc. instead of haptics), (ii) *Informative Videos/ Animation* and (iii) *Visual Realism and Fidelity in Material/Texture Communication* as its sub-themes. *Filling in the Gaps*: *Simulation of Haptic Qualities with Other Modalities* was found to be linked with *Imagination* and *Levels of Immersion* (both under **Immersion and Presence**). *Visual Realism and Fidelity in Material/Texture Communication*, on the other hand, was found to be linked with **Product Presentation**.

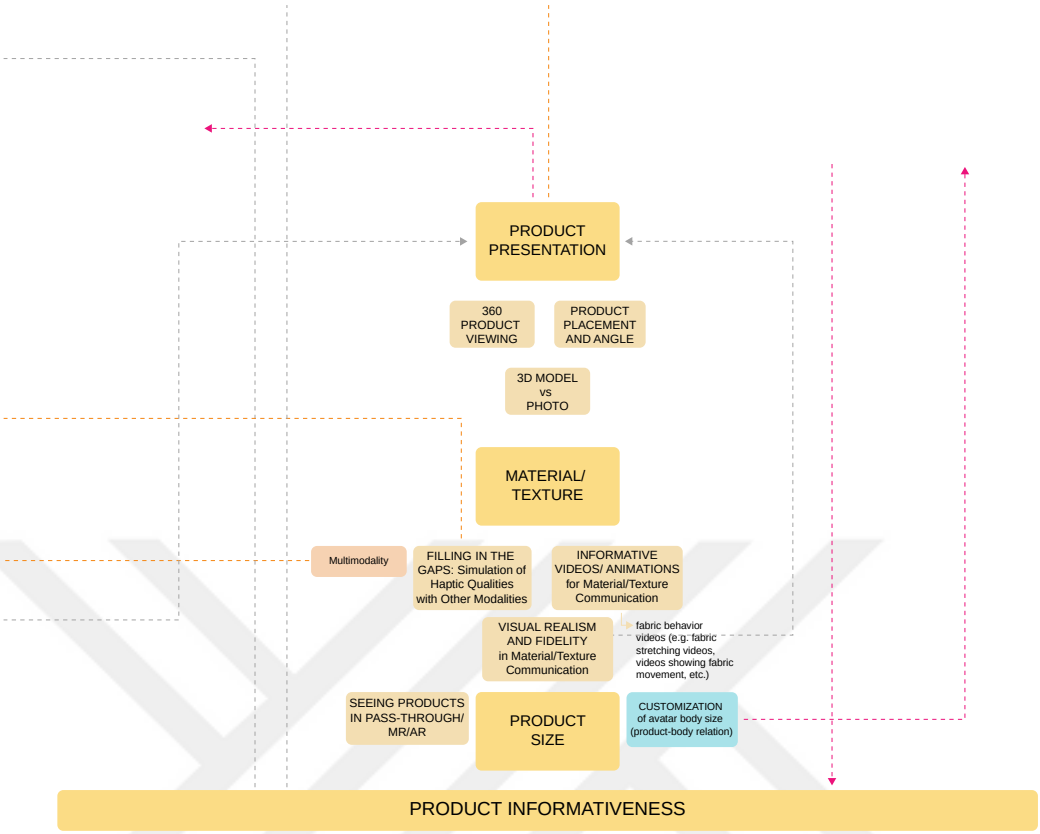


Figure 5.8. Lower-right hand side of the theme map demonstrating the themes and sub-themes under the Product Informativeness main title, prepared by author.

The theme (c) **Product Size** includes the sub-theme of (i) *Seeing Products in Pass-through/MR/AR* and was found to be linked with *Personalization and Social Interactions through Avatars* (under **Hedonic Shopping**). Lastly, the main title Product Informativeness was found to be linked with product understandability under the *Understandability/Learnability* sub-theme of **Use and Usability**, and with **Utilitarian Shopping**. The information sharing/assistance from avatars topic under the *Personalization and Social Interactions through Avatars* sub-theme (under **Hedonic Shopping**) was also found to be linked with the main title Product Informativeness.

5.4 Heat Map

After the relations between the themes and sub-themes were set on the map (as indicated with arrows), the data was filtered one more time to find patterns and see how often each theme and sub-theme occurred in the data. Figure 5.9 includes a map with numbers of comments made by participants on each theme and sub-theme. Since some comments were found to be related to more than one theme/sub-theme, there are variations between the total sums of sub-theme comments and theme comments. A heat map was also prepared in relation to the data map offered in Figure 5.9 in order to better visualize which themes appeared most and least in the collected data. Figure 5.10 includes this heat map, with the red areas representing more than 41 comments by participants, orange areas representing a number of comments between 21 and 40, and yellow areas representing 20 or less comments.

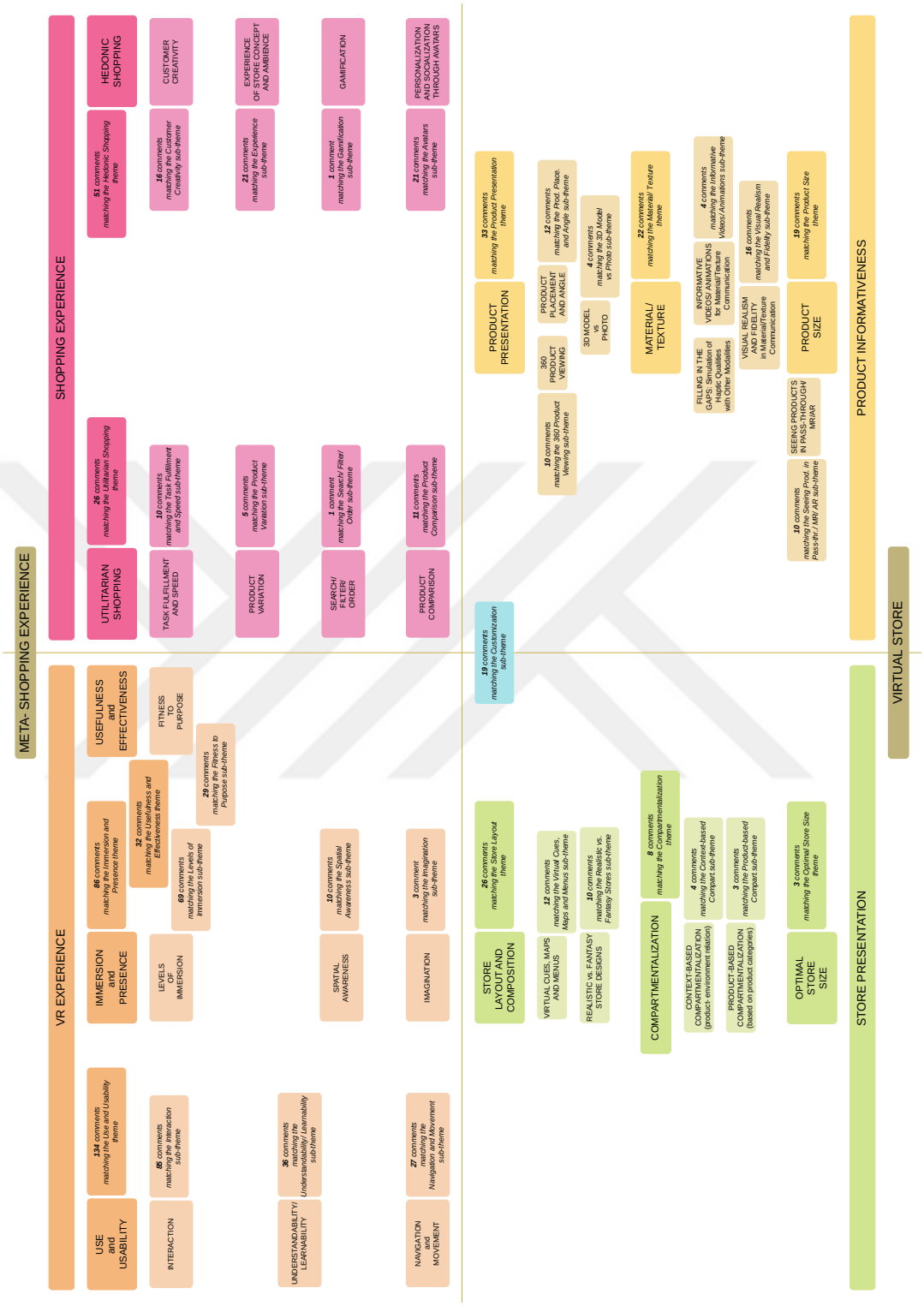


Figure 5.9. Number of comments made by participants on each theme and sub-theme, prepared by author.

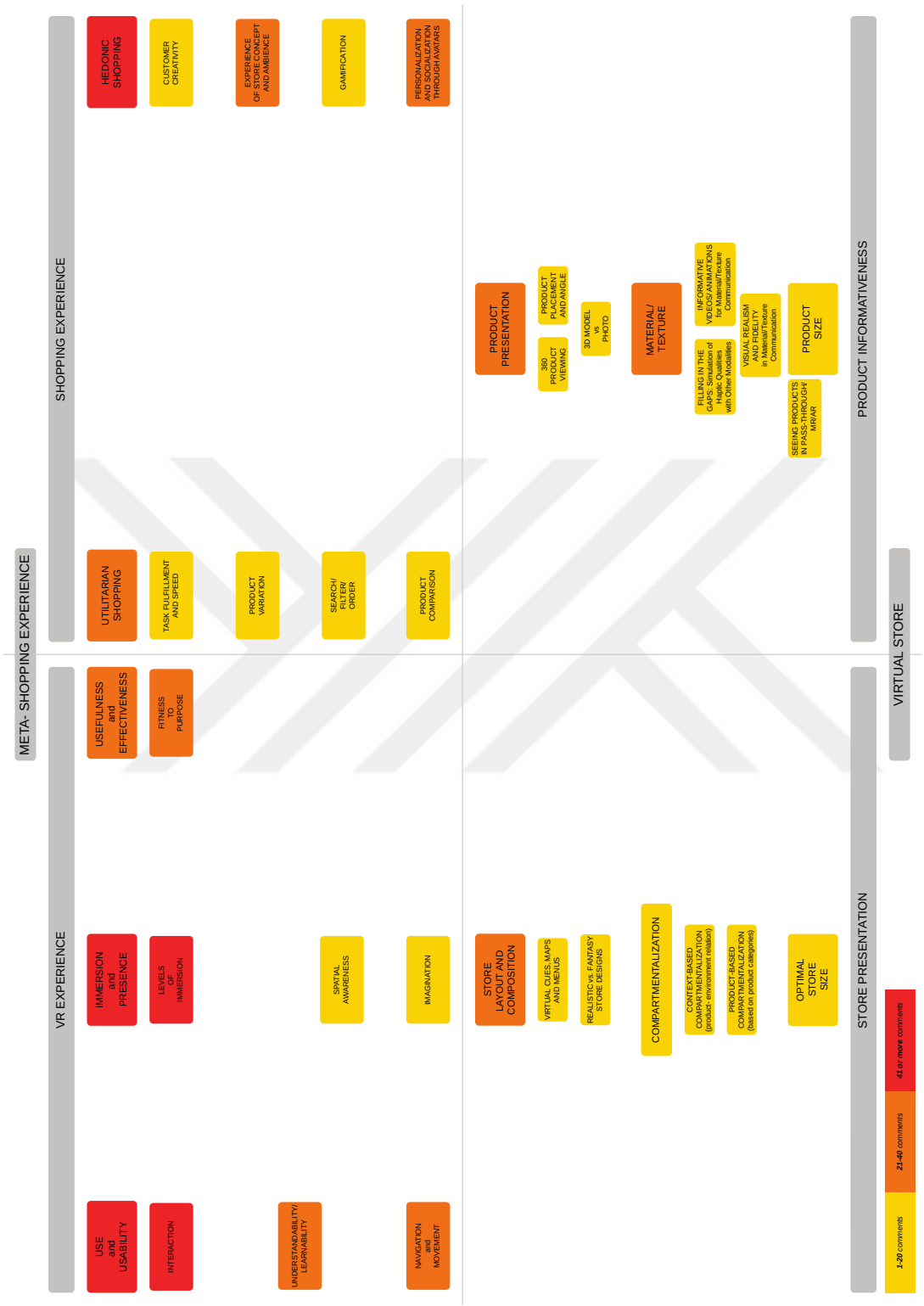


Figure 5.10. Heat map based on the number of comments made by participants on each theme and sub-theme, prepared by author.

5.5 Results and Discussion

5.5.1 Results and Discussion of the Themes and Sub-themes of VR Experience

As mentioned in Chapter 2 of this thesis, virtual reality offers three main attributes which set it apart from 2D virtual environments: immersion, interaction and imagination. Based on the data collected in this research, the "3I"s of virtual reality turned into themes and sub-themes in the analysis of research. While **Immersion and Presence** became a theme on its own, comments made on imagination were found to be linked largely to immersion. Hence *Imagination* became a sub-theme of **Immersion and Presence**. Interaction, on the other hand, was found to be linked largely to the interface and usability of VR, thus merging with interface (i.e *Interaction and Interface*) and becoming a sub-theme of **Use and Usability**. Further, *Understandability/Learnability*, *Navigation and Movement* (in virtual environments), *Spatial Awareness*, *Levels of Immersion* and *Fitness to Purpose* stood out as important sub-themes. As a result, the first main title in the theme map, VR Experience, ended up gathering comments made by participants regarding the themes (a) **Use and Usability**, (b) **Immersion and Presence,** and (c) **Usefulness and Effectiveness** with each theme having several sub-themes. The themes and sub-themes regarding the VR Experience will be shared in the following sections.

5.5.1.1 Use and Usability Theme

In the context of virtual reality, communication between the user and VR system occurs as a feedback loop (Stanković, 2016). The user observes the environment, formulates an action, and issues command (input), which is then interpreted by the VR system, making modifications in the environment, to provide feedback (output) to the user- see Figure 2.4 (Stanković, 2016). Further, in a well-designed digital world, users must be able to participate in a story or plotline, add to or modify the

contents of the world, and interact with the environment and others in the environment (Grimshaw, 2013). In order for a continuous VR experience to occur, usability thus becomes a key factor in the design of VR experiences. 134 out of 410 comments analyzed in this research were found to be linked to the **Use and Usability** theme, which makes this theme the mostly commented on theme amongst all others. This demonstrates the significance of the theme **Use and Usability** as well as its sub-themes (*Interaction and Interface*, *Understandability/ Learnability*, *Navigation and Movement*) for designing smooth, continuous and understandable VR experiences.

Interaction and Interface

The first sub-theme of **Use and Usability** is *Interaction and Interface*. Users of VR can interact with the virtual environment by either modifying and causing a change in the VE, or by changing their viewpoint in the VE (Sherman & Craig, 2019). The first virtual environment experienced in the research studies of this thesis (the fully-immersive Meta Universe) allowed for a change of viewpoint in synchrony with the head motions of users while also allowing for navigation and avatar-related interactions (i.e. personalizing and dressing up the avatar) through hand-held controllers. The two virtual stores (i.e. Alo Yoga and Hugo Boss) allowed for interaction with products, although in a limited manner. Neither of the two virtual stores allowed for object manipulations such as rotating or virtually holding the garments, but offered clickable icons on products to get product-related information. The virtual stores used in this research didn't allow for interaction through gestures or head motions. Navigation inside the stores were also limiting in certain aspects, which will be discussed more elaborately in the coming sections.

A total of 85 comments made by participants were found to be linked with the *Interaction and Interface* sub-theme. When the data regarding *Interaction and Interface* was analyzed one more time to see patterns and related topics, several needs, expectations and issues regarding interaction in VE were revealed.

Active involvement: First, the data reveals that *active involvement* (i.e. interacting more freely and extensively with the products or objects inside a VE) emerges as an

important expectation of users of a virtual environment. Some of the comments made by participants regarding active involvement are listed below.

- *P2: "…very limited in terms of interactions. I don't want to just click an icon to get product's information. Maybe I could grab the objects, go to another place inside the store and try them on…"*
- *P7: "At first I thought I could hold and rotate the objects. I would have wanted to turn garments 360 degrees, get closer to them to better observe their fabrics. It felt more like walking around a showroom than shopping."*
- *P10: "I had expected these to be more interactive. The environments didn't really allow me to do much. I could only click on the products. It was also difficult for me to move around."*
- *P16: "The only means of interaction I have is walking towards the entrance doors, moving around and looking around, observing static objects and try to identify the icons in the environment through which I can interact. The only modification I can make in the environment is to click on icons so that pop-up windows can appear. But I can never directly interact with or rotate, for instance, the objects."*

These comments made by participants reflect on the desire to more actively engage with the objects/products offered in a virtual reality environment. This may also indicate that when users can interact with the virtual objects only in similar ways to 2D virtual environments (i.e. merely moving inside the store and clicking on icons to get pop-up information windows), they might lose sense of being inside a virtual world. The analyzed data shows that interaction also affects the sense of presence and immersion experienced by users of a VR. Hence, it is important that immersive virtual stores are designed in such a way to allow for heightened means of interaction compared to computer or mobile VEs.

Ease of interaction: Ease of interaction was found to affect the level of immersion and enjoyment of participants. Below are some of the comments regarding this issue.

- *P1*: *"Since I cannot move as I wish, this doesn't feel enjoying. The previous store was more easier to handle. I had more fun there."*
- *P5*: *"It was a bit easier to use the hand controllers in Alo and I got immediate responses from the environment. I felt more present in Alo. In Hugo, I couldn't click on the icons easily, I didn't really feel involved there."*
- *P15*: *"It was very difficult to click on the icons in Hugo Boss. When I couldn't easily interact, I felt more distanced from the environment. I kept remembering I was inside a VE. My actions felt more natural in Alo Yoga."*
- *P16*: *"I don't know if it's because of my hand tremor but when I used the hand controller, it was hard to align my hand motion with icons inside the environment. Then I clicked on them, but it didn't respond well."*

These comments show the significance of ease of interaction in a VE. When users feel their actions are not understood by the system (i.e. when the system doesn't respond well), their sense of presence and immersion get decreased, also affecting their enjoyment in the VR.

Realness of interactions: Participant comments reflect also on another important aspect; the *realness of interactions*. On that account *P11* made the following comment, expressing that zooming in to products, or more generally speaking, making an interaction that is otherwise impossible to do in the real world, negatively affects the feeling of reality.

> *"Zooming in to products kills the realness of it. In real life, I cannot suddenly zoom in to certain details of the environment or product."*

Although zooming in and out of products to see fabric details, in the case of apparel shopping, can come useful in certain scenarios, it must also be kept in mind that such interactions can lessen the realness of the experience. However, interactions which cannot be performed in real life, such as zooming in and out, can be integrated into the VEs for utilitarian needs. For instance, the VE can be designed in such a way that the users can use the zoom in feature on products but not in the environment, itself.

Regarding the topic of *realness of interactions*, *P15* also made the following comment:

> *"If we consider the visuals a means of interaction, it offers something richer. But in terms of interaction, nothing feels realistic or similar to real world."*

This shows the expectation of VR users to interact with virtual environment in ways that feel real, natural and similar to their real-world interactions.

Natural vs. novice interaction means: Participant comments indicate the significance of *naturalness of interactions*. For example, *P18* said they spent a better time in Alo Yoga because both the store environment and the interactions felt more natural there. A contradictory comment was made by *P1* saying that if they were to experience a virtual shopping experience, they would expect novice and unexpected ways to interact with the VR. These comments show that VEs can benefit from interaction means which feel natural but don't directly mimic the interaction means offered in 2D.

Responsiveness and speed: Responsiveness and speed rises as another key topic under the *Interaction* theme. Several participants made comments regarding this topic, some of which are listed below:

- *P9*: *"When I am trying to change my point of view, I swipe with the hand controller very gently but my POV suddenly changes immensely."*
- *P11*: *"It is good that this works smoothly. It responds well to my interactions."*
- *P13*: *"I felt more in control in Alo Yoga, not so much in Boss. It is difficult to click on the arrows. It doesn't align well with my motions. I found myself suddenly staring at the ceiling or the floor multiple times. It should work in synchrony to my interactions."*
- *P14*: *"It was a bit too fast when I tried to move by using the trigger* (of the hand-held controller)*. If it didn't move so fast, I could have adapted more easily. At the times I moved around too fast in the environment, I mostly found*

myself looking at the floor. When that happened, I intuitively looked up with my head as a reflex, but the environment doesn't respond to my head gestures, either."

- *P16*: *"I think the responsiveness can decrease a bit. There is this huge environment with a small arrow. I try to catch the arrow to move around. If the area near the arrow is empty and I touch that area, it could also understand that I want to press the arrow since there are no other clickable icons around it. Why all this drama?"*

These comments indicate that the speed of response of the VR system and the speed of user interactions need be aligned for a smooth VR experience. When the users perform a small amount of interaction and receive an unpredictable or dramatic outcome, they lose sense of their control in the VE. It can also be argued that such instances also affect the sense of immersion during the VR experience.

Further, *P6* pointed out to another important factor for the *temporal aspects* of the VR interactions, by saying *"The menu disappears before I can make a selection from it."*. During their VR experience inside the Hugo Boss store, the participant tried to make selections from the menu on the left-hand side. However, the menu kept disappearing before the participant could make a selection. This indicates that the disappearing menus have to either remain on the screen for an optimum amount of time (i.e. enough to allow users to go through all the items in the menu and make a selection), or allow the user to choose when the menu will be closed (e.g. the user can click on the menu icon a second time to close the menu). It must be remembered that clicking icons with hand-held controllers rather than with traditional touchpads, keyboards, etc. can be more difficult especially for novice users of VR. When the users' interaction speed is reflected in the VE in an increased manner, making selections from disappearing menus or icons can become a difficult task, hence the necessity to find an optimum duration for the disappearing menus/ icons to remain in the screen, or give the users the option to close them when they want (e.g. by clicking).

The comment made by *P16* (given above) indicates to another design insight, as well. The participant expressed the difficulty they had to align the hand-held controllers with the icons inside the environment. Indeed, the VE can be designed in such a way that in the cases where two clickable icons are not too close to each other (i.e. when there is only one clickable icon in a certain area), the system can still respond by "guessing" the intended interaction.

*Navigational interactions**:*** Next, there were found links between the *Interaction and Interface* and *Navigation and Movement* sub-themes of **Use and Usability**. Both of the stores visited during the research sessions allowed users to navigate inside the VE in two ways: (i) by clicking on the arrows on the floor to walk, and (ii) by making hand-gestures with the hand-controllers to change the POV and to walk, although participants declared that walking with hand-gestures (i.e. by pushing the triggers on the controller) didn't always respond well. *P11* said that it was more difficult to move around when zoomed in. *P6* and *P7* said that they would prefer to walk using the thumbsticks on the hand-controller rather than by clicking on the arrows on the floor. The thumbsticks on the hand-controllers were matched with the zoom in and zoom out features in the virtual stores, but didn't allow for walking inside the VE. Some participants also mentioned the difficulty of navigation due to the *responsiveness and speed* of VR.

Further, the navigation arrows in the Hugo Boss store were moving very slightly. *P9* reflected on this by saying *"Here navigation is difficult. It is hard to interact with the arrows since they are also moving."*. *P1* also reflected on the same issue also by saying that their hand tremor made it even more difficult to align the hand-controllers with the moving arrows. While motions embedded in virtual cues can come useful in certain cases (e.g. to indicate or encourage interaction), they can also make it more difficult to perform the intended interaction. A well balance between ease of interaction and motions of virtual cues needs to be sustained for smooth VR experiences.

Meaningfulness of interactions: Concerning both interaction and navigation, another topic that was mentioned by several participants was the *meaningfulness of interactions*. For example, *P13* said *"You move similarly to Google Maps, one step at a time. But clicking some of the arrows only changes your POV."*, while *P6* said during their visit to the Hugo Boss virtual store *"This was very meaningless. I clicked on this arrow and it brought me here. There's nothing new I can observe here."*. While virtual cues in the VE can be helpful for certain interactions and navigation, it must be kept in mind that if the outcome of interaction can be perceived as "meaningless" by the users, it can lead to confusion or frustration. This problem can be tackled by either giving the user more freedom and alternate ways to perform an action or by getting rid of the virtual cues that lead to useless outcomes depending on the context.

Intuitive interactions: Finally, *intuitive interactions* was another major topic which appeared under the *Interaction* sub-theme. *P10* said *"I thought I would be able to walk with the thumbsticks* (on the hand-controller) *but turns out they are only for zooming in and out."*. On the other hand, *P16* expressed a different opinion regarding the same interaction by saying *"It felt good when I figured out the zoom gesture. Because it was a form of interaction I knew from previous experiences and realizing that it also works in this environment felt nice."* Similarly, *P11* and *P16* said they felt good when the system responded to swipe motions made with hand-controllers to change the POV inside the VE. *P11* said *"In the mirror* (in Alo Yoga), *I intuitively made the swipe gesture to change the outfit rather than clicking on the arrows next to them, and it worked. It felt good."* Figure 5.11 shows a screenshot from the avatar experience in the Alo Yoga store which allows users to make outfit combinations. The user can change the outfits both by clicking on the arrows and through swipe motion with hand-controllers. Based on these comments, it can be argued that integrating interaction forms that users are familiar with based on their previous knowledge (i.e. interaction forms users are familiar with from 2D digital environments and real-life) can help with the intuitiveness and ease of interaction inside a VE.

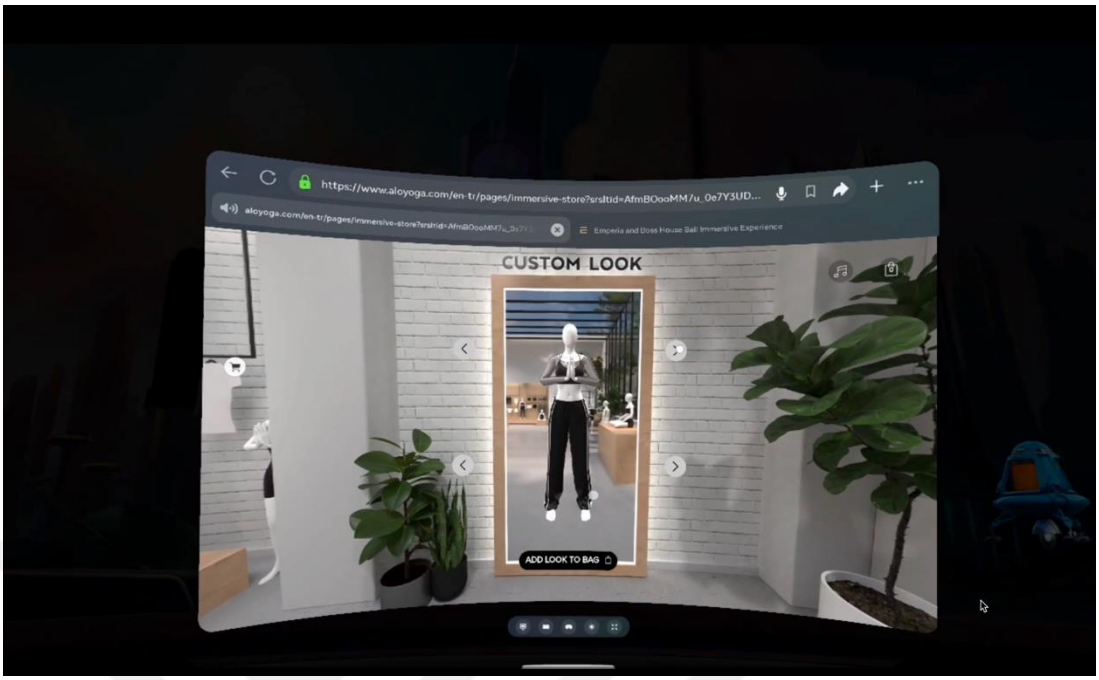


Figure 5.11. Screenshot taken from the screen video record of P11's Alo Yoga virtual store experience.

Novice Interfaces for VR: Participant comments indicate that they expect to experience something different from online stores if they are wearing VR glasses to shop. Several participants questioned the similarity of interfaces (as well as interaction means) to those of computers, indicating that novice interaction means as well as interfaces unique to the VR environments can be designed to differentiate the experience altogether. Some of the participant comments regarding this topic are listed below.

- *P1*: *"Should the interfaces look like this, I'm not sure. Right now, I can do everything I do here on a computer. Even mobile and desktop interfaces are different. VR can have an interface belonging to its own." "They added videos inside the VE. But these are things I can also do on a computer or tablet…""…or for example this avatar* (refers to the avatar in the virtual fitting mirror- see Figure 6.1) *could at least work in synchrony to my gestures. Right now, this doesn't offer anything that a computer cannot offer."*

- *P12*: "*The product information windows that appear when you click on the items are 2D, offering the exact same interface of online stores. If they aren't offering me a new interface, then why would I bother wearing these glasses in the first place?"*

Product information windows inside the virtual stores: Some participants also made comments on how product information was shared in the screens. *P1* questioned the size of the information window saying,

> *"Why am I seeing the product information on a small are on the right of the screen? I have this huge rectangular screen which they can use. When I'm done looking at the product info, I will close this window to continue shopping anyways."*

whereas several participants favored the smaller preview windows which appeared in the Alo Yoga store by hovering over the products (before the user clicks on the product to open a larger product information window). On that account, P11 made the following comment:

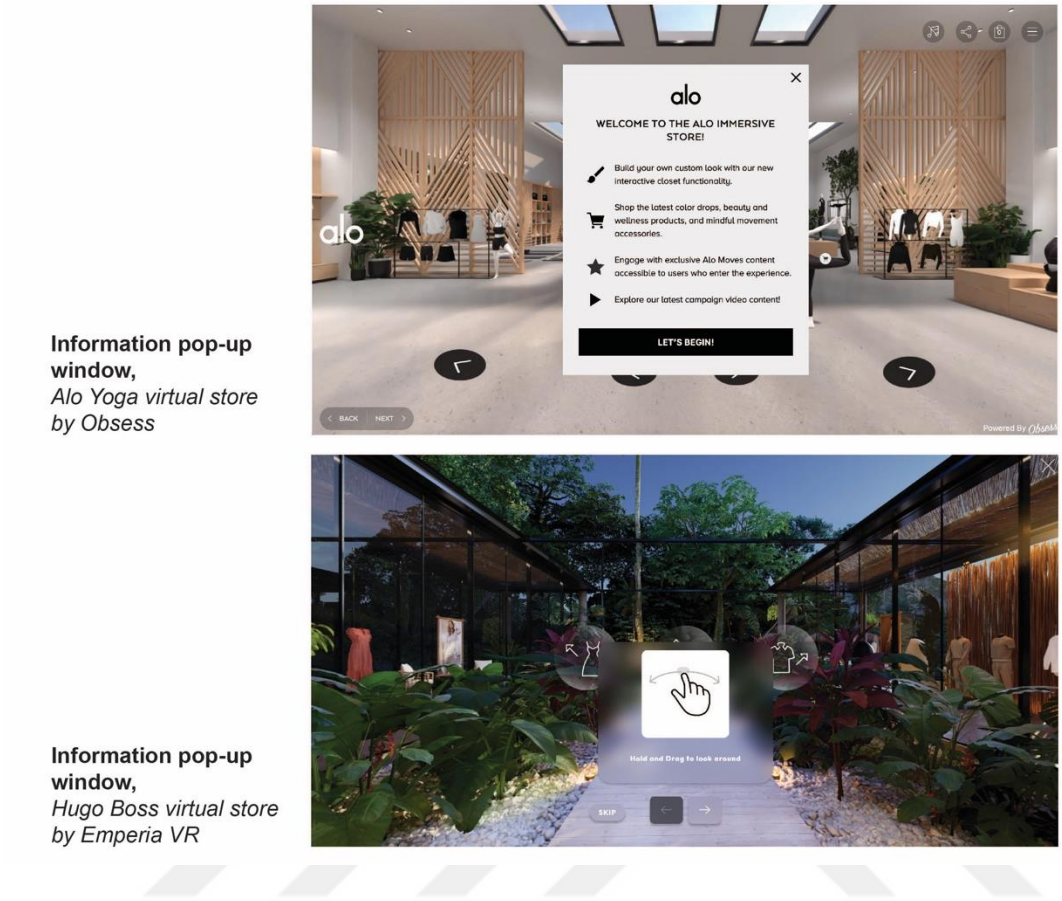
> *"I think it was nice that Alo offered a smaller product-info window when you hover over a product. If you click it, the window gets larger, it helps…"*

Similarly, *P14* said that the smaller preview windows in Alo Yoga made them feel better guided in terms of how to interact with the system.

Understandability/Learnability

The second sub-theme of **Use and Usability** is *Understandability/Learnability*. In order for users to effectively engage with the VE during a shopping experience, it is crucial that the means of interaction, product-related information and store-related aspects such as the layout of the store are understood clearly by users. A total of 36 comments were made by participants which fell under the *Understandability/Learnability* sub-theme. These comments reveal the needs, expectations and issues encountered by users during their VR shopping experience.

Directions on how to use the system: Firstly, the collected data hints that understandability and learnability of interactions of a VR are important for quick adaptation of users. On that account, *P18* said that adaptation to a VE must occur quickly in order to meet the utilitarian shopping needs. Both of the stores explored by participants offer pop-up windows at the very beginning of VR experience, containing tips about the interface and usability of virtual stores. Figure 5.12 involves screenshots of the information pop-up windows of both stores. *P1* made a comment regarding this feature saying that *"I will skip these if it's okay. I prefer to explore these as I use the system."*. This indicates that while some users may find the onboarding instructions for the usage useful, some may prefer to discover features of VR on their own. The guidance can be provided with a more direct and hands-on approach, whenever necessary throughout the VR experience, rather than giving all instructions while onboarding. It is also important that the entity of the VE is designed clearly in order to allow for easy understanding and quick adaptation to the system. *P14* made a comment regarding the learnability of interactions saying that *gamification* can be used to teach the interaction of a VR. (*"At the beginning of the VR experience, users can start with a game where they learn tips on how to interact with a VE."*) Indeed, a training area can also be provided for VEs where the user can practice different modes of interaction before stepping into the actual virtual environment. Another feature that might come useful is to allow for the undo option; that is if the user is not happy with the produced outcome of his interaction, he/she can undo the interaction. In such a case, a simple gesture or a physical/virtual controller easy to locate might be added into the VR in order to undo a wrong/undesired interaction. Feedback provided by the VE are also important when ensuring the interaction quality. With each interaction, the user must be provided with sufficient and clear feedback as to whether his/her interaction with the VE succeeded the desired task. Integration of multimodal feedback into the VE can increase the quality of interaction feedback.



Information pop-up window,
Alo Yoga virtual store by Obsess

Information pop-up window,
Hugo Boss virtual store by Emperia VR

Figure 5.12. Screenshots taken from Alo Yoga and Hugo Boss virtual stores, showing the information pop-up windows at the beginning of virtual experience.

Predictability of interaction outcomes: Participant comments show that predictability of interaction outcomes plays a role on the understandability/learnability of a VR system. On that account, P14 said,

> *"I felt nervous during the Hugo Boss experience. The results of my actions were hard to predict. I always kept asking myself if I did something wrong. In Alo Yoga, everything was more predictable."*.

Similarly, P13 said,

> *"In Hugo, I hover over a product* but *I don't what will happen. I hover over the plus icon* (to open the product information window), *I don't know what will happen. I couldn't foresee anything there."*

These comments demonstrate that predicting the outcomes of interactions is important in order to make users feel safe and guided during the VR experience, thus offering them a more immersive and continuous VR shopping experience.

Communication of virtual cues: Another topic that appeared often in the data is the *communication of virtual cues*, regarding the navigation arrows in Hugo Boss. The arrows on the floor in the Hugo Boss virtual store had a slow motion, moving ever so slightly. Some participants said that this led to a confusion and that they had a hard time trying to understand how to interact with the navigation arrows. On this account, *P14* said *"Since the arrows move and light up, I kept thinking I pressed them. I didn't really understand the feedback, because I click on the arrows. The arrows light up and move, but I remain in the same place."*. The VE must give users clear feedback on whether their interactions have been achieved and must refrain from using motions, color changes or light-up effects in the virtual cues if they have a risk of misleading the user. The feedforward and feedback should be easily differentiated from each other.

Product understandability: Product understandability also stood out as an important sub-topic of the *Understandability/Learnability* sub-theme. Some of the comments made by participants regarding product understandability are as follows:

- *P3*: *"I see three leggings here. They're all black and they all appear the same. I need to click on each of them separately to see what they actually look like."*
- *P7*: *"There are differences between the 3D model of the product in the store and the picture that pops up in the information window. I wouldn't have thought that this is how this dress looks like in real life* (comparing the 3D model to the picture)*."*
- *P13*: *"Products appear more realistic in Boss. In Alo, they look cartoonish. White products are also hard to see, there are no shadows on product renders."*

- *P18*: *"The products are displayed under artificial virtual lighting. I also cannot make sure of the actual color of the products."*

These comments indicate that users expect to see a consistency between the 3D models of products (i.e. virtual products) inside a VE and the real-life pictures that appear when products are clicked on. Indeed, customer trust is an important factor in online (and virtual) shopping. Virtual products inside the VR stores must be as realistic as possible, depicting a high visual fidelity and realism in order for users to understand products. Textures and fabric qualities of garments should also be reflected clearly on the 3D models to help users quickly understand and differentiate between products inside the store.

Familiarity: Participant comments also pointed to the topic of familiarity. For instance, P18 said,

> *"The product displays are very realistic, similar to physical stores. And you can see them from a similar distance and angle as you would in a real store. That helps with the understandability and realness."*

This also shows that when users of a virtual store are presented with details that they are familiar with from their previous knowledge (i.e. real-world experiences), they have a higher likelihood of understanding the context, thus perceiving the experience as more realistic. Indeed, familiarity and skeuomorphism (in VR) help with the understandability and flow of the overall experience (Stanković, 2016).

Visibility and understandability of icons: The topic of *visibility and understandability of icons* was found strongly related to the *Interaction and Interface* sub-theme of **Usefulness and Effectiveness**. Regarding the visibility of the Change Rooms icon offered in one of the virtual stores, *P7* said,

> *"I hadn't seen this Change Rooms menu before you told me. I didn't understand I could click on these."*

Similarly, some participants had trouble finding the icons to turn off the music or virtual maps during their VR experiences in both stores.

Further, another very outstanding issue that all 18 participants encountered during the research sessions was that they all failed to close the product information windows in the Hugo Boss store in their first trial. The Hugo Boss store, like the Alo Yoga store, allows users to click on products to get product-related information. When they are done reading the information, they need to close the pop-up window in order to continue with the virtual tour. However, none of the 18 participants realized at the beginning that there was a white cross on the upper right-hand side of the screen in Hugo Boss throughout the entire VR experience. When the information window popped up, another smaller white cross appeared at exactly the same place. The product pictures also had white background, making it twice harder to see either of the two crosses. Hence, when the users tried to close the information window, they ended up closing the entire app. Some users did this mistake multiple times during their visit to the Hugo Boss store. The correct way to close the information windows was to click on another part of the screen, or the virtual product itself. Figure 5.13 involves screenshots from the virtual store showing both of the white crosses; one to close the information pop-up window, and the other to close the entire app.

These findings indicate to several design insights. First, the icons and menus can be visible to users at all times, falling inside the users' field of view while also not distracting them from the VR experience. Second, users can be offered the chance to customize their icons, deciding which icons will be visible at all times and which will pop up upon a certain gesture, etc. They can also decide on the size and placement of icons, thus creating their own icon layouts inside a VE. Context-aware icons which appear only when relevant to the users' intended actions can also be implemented. For example, when the user is observing a product more carefully, icons such as store map can be muted. When the user gets back to the virtual store area (i.e. by closing the information window), icons can be highlighted with a subtle motion to remind users where to find the icons. Audio commands can also be another way to help with the usability of interfaces.

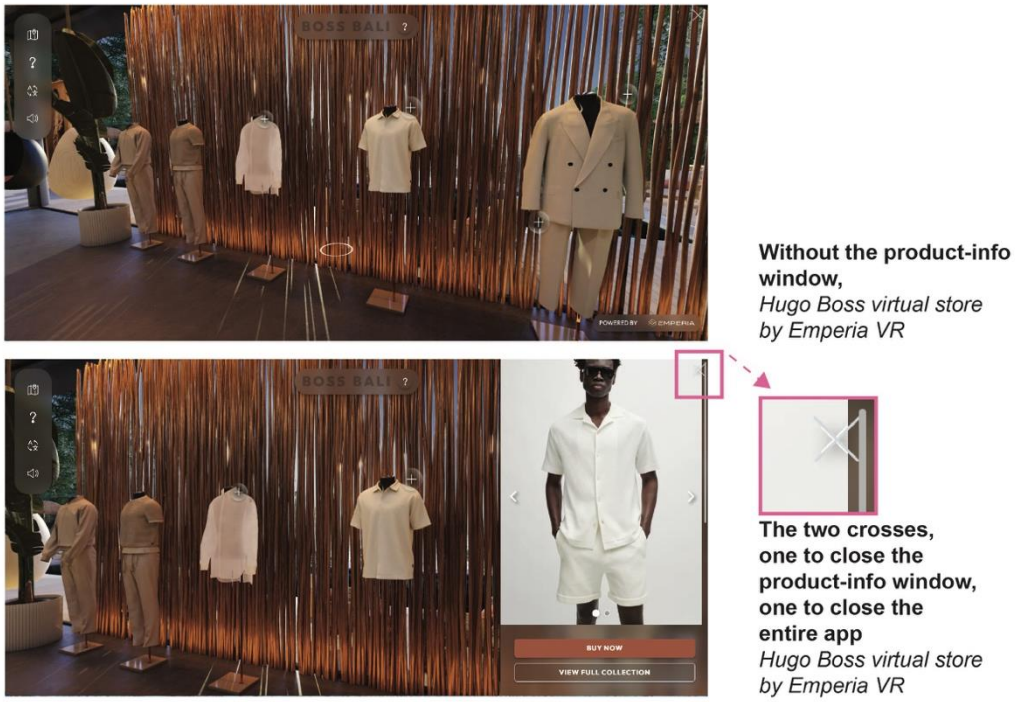


Figure 5.13. Screenshots taken from the Hugo Boss virtual store, showing the two white crosses.

Navigation and Movement

The third sub-theme of **Use and Usability** is *Navigation and Movement*. Navigation is one of the attributes that can enhance the hedonic shopping experience in VR compared to online shopping. It is paramount that the navigation and movement inside a VE feels natural and intuitive, allowing a certain amount of freedom to the users. There are several forms in which navigation can occur in a VE, such as moving freely inside the virtual world, and using navigation aids [e.g. virtual cues, 2D or 3D maps (Chittaro & Venkataraman, 2001), landmarks (Zhao et al., 2023) and trail technique (i.e. showing the previously followed path to the user)]. A total of 27 comments were made by participants under the *Navigation and Movement* sub-theme.

Participant comments reveal some important aspects regarding navigation in a VE.

Naturalness of navigation and travel motions: The study shows that *naturalness of navigation and travel motions* affects the sense of presence of users. On that account, *P1* said,

> *"In Hugo, my movements were similar to Google Map Street View. It just slightly dragged me forward when I clicked on the arrows. I couldn't get immersed in the VE as much."*

This shows that when users feel as if they are "dragged" or moved to a certain point in store that they didn't choose to go on their own, their immersion in the environment decreases.

Interactions with virtual navigation cues: Interactions with visual navigation cues was another main topic mentioned under *Navigation and Movement*. Most of the participants stated that they would prefer to move more freely inside the VE rather than being restricted to the arrows on the floor. Some of the participant comments regarding the navigation cues inside the stores are listed below.

- *P3*: *"The arrows are helpful but at the same time I keep thinking if I enter a world where I can do anything, do I really have to be restricted with arrows? Also I don't know how much distance I will cover when I click an arrow. I just click on them to see how much I will move."*
- *P6*: *"It's as if I'm not moving but they take me to wherever they want."*
- *P7*: *"In Alo Yoga, the Next button was quite helpful. It's missing here in Hugo, I wish they also had it."*
- *P12*: *"In such an immersive environment, it feels weird to be restricted with arrows. It would be much better if I could move freely in the VE."*
- *P17*: *"In Alo Yoga there were arrows that took you to a lot of different places. In Hugo Boss, there are too few arrows and you can barely click them. I would prefer to have more paths. I would want to go to wherever I want instead of following the path they gave me."*

Several participants questioned the using of arrows to navigate inside the VEs suggesting that they would expect more freedom in terms of navigation in VR. However, many participants also expressed that they favored the number of arrows the Alo Yoga store offered. This shows that if users of VR are restricted to navigation cues such as arrows to walk around, the number of navigation cues can be increased so as to allow more navigation paths to the users. One participant also stressed that it was also unknown how much distance would be covered when the arrows were clicked. In the light of this comment, it can be argued that consistency and predictability of interaction outcome are also crucial in the design of navigation means inside a VR. Figure 5.14 involves screenshots from both of the stores, showing the navigation arrows.

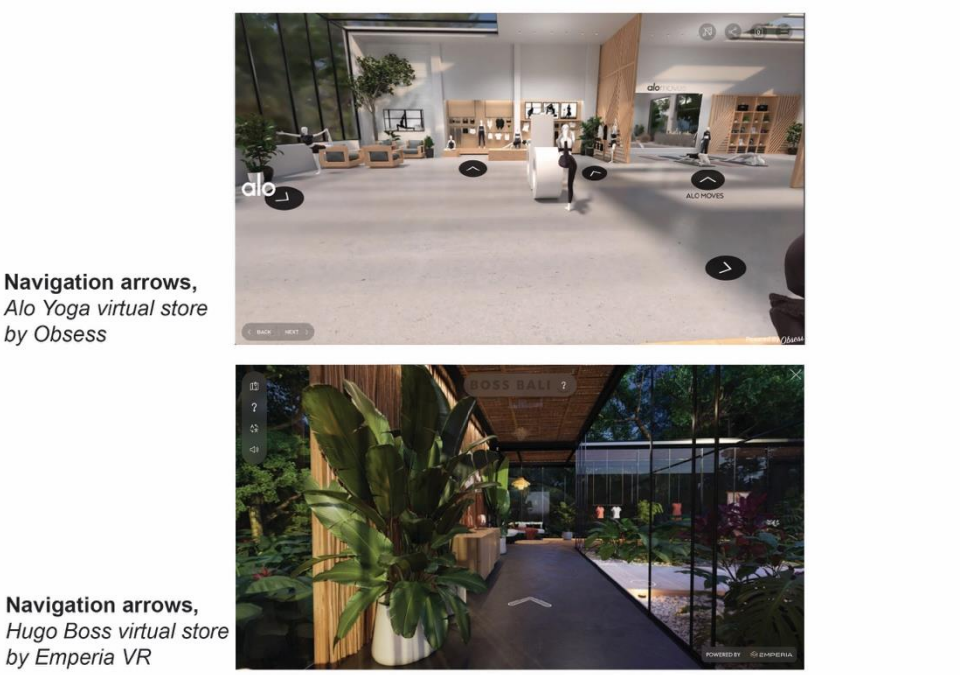


Figure 5.14. Screenshots from Alo Yoga and Hugo Boss virtual stores, showing the navigation arrows on the floor.

Several comments demonstrate that the ease or difficulty of navigation also affects the understandability of the store layout:

- *P9: "In Alo Yoga, you can understand where you are by looking around. In Hugo, the navigation is very difficult, and it makes it hard to understand the store layout. I still didn't get lost but only because they had too few products in the store. If they had more products, I think I would have got lost in Hugo."*
- *P11*: *"I think I would prefer to use the navigation menu only when I want to go to a far-away place. But to know which parts of the store are far away from each other, I first need to travel in the store and understand its layout. Also, I would prefer to walk instead of using a menu if I am in such an environment."*
- *P:12"It was difficult to understand the store layouts. It takes too long to reach one place from another, I lost track of the interior layout."*

These comments show that if traveling between two distant places inside a virtual store takes too long, or if users find it difficult to navigate inside the virtual stores due to interaction usability, they can lose sense of their surroundings. This also indicates to a link between *Navigation and Movement* and *Spatial Awareness*, one of the sub-themes of **Immersion and Presence**. Hence, it can be argued that navigation is one of the interaction means that must be designed with care. Indeed, users must be able to easily move and change their POVs inside a VE, thus building a better sense of spatial awareness.

5.5.1.2 Immersion and Presence Theme

Immersion, along with interaction and imagination, is considered one of the most significant components of VR. It was mentioned in Chapter 2 of this thesis that immersion and presence are two concepts closely related to each other. In essence, a VR must block out the real world and offer its user immersion into a different environment. Since the virtual stores used in this research were semi-immersive (i.e. not 360-degree immersive worlds), the presence and immersion felt by participants gained increased significance. A total of 86 comments were made by participants

regarding the **Immersion and Presence** theme. There are three sub-themes below this theme: *Levels of Immersion*, *Spatial Awareness* and *Imagination*.

Levels of Immersion

The first sub-theme of **Immersion and Presence** is *Levels of Immersion*. A total of 69 comments were found to be linked with this sub-theme. It was mentioned in Chapter 2 of this thesis that different users of the same VE can experience different levels of presence. Hence, it is important to understand which factors affect users' immersion into a virtual environment. Typically, VEs can be non-immersive, semi-immersive or fully-immersive (Gutiérrez et al., 2008). Furthermore, the level of delay experienced in VR (Slater & Wilbur, 1997), multimodality (Stanković, 2016), use of avatars, POV and FOV affect the level of immersion of users in a VE.

The two virtual stores used in the research sessions were semi-immersive, meaning that they allowed for a heightened level of interaction and change of view compared to 2D virtual environments. However, the stores weren't 360-degree immersive environments which worked in full synchrony with the head motions and bodily gestures of users. A lot of participants expressed a felt barrier between the VE and themselves due to the semi-immersive nature of the store. *P15* made a comment regarding this issue: *"If it cannot immerse me 360, at least the tabs on the screen can be hidden from my sight."*. Similarly, *P1* said *"I didn't feel present in either of the stores since I was aware that I was on a website."*. *P13* also said *"When I was inside a sphere in the Meta Universe, I felt very present. Also, the environment moved in synchrony to my motions. When I see the screen, I feel a barrier."*. These were expected outcomes before the research since the existence of a screen during the VR experience is very likely to decrease the feeling of being in a virtual environment.

Layers of immersion: However, participants started their VR experience by first spending a few minutes inside the fully-immersive Meta Universe. They were then asked to open the virtual stores from the browser. When the participants clicked on the browser, the screen appeared inside the immersive Meta Universe. Figure 5.15

includes screenshots taken from one the research sessions showing the browser screen inside the immersive VE.

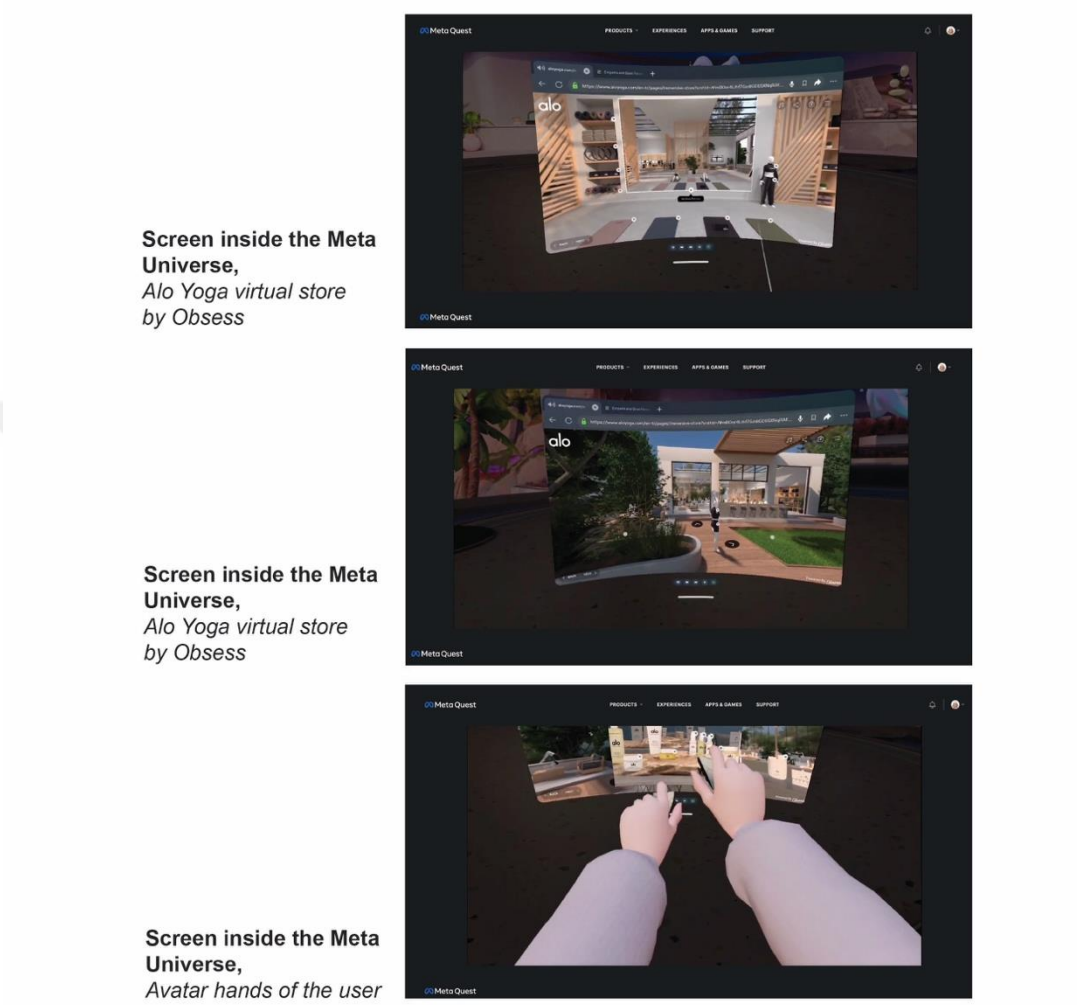


Figure 5.15. Screenshots taken from one of the research sessions showing the browser screen inside the immersive VE.

Some participants made the following comments regarding the screen opening inside an immersive environment, thus creating different *layers of immersion*:

- *P3*: *"I like that the screen is inside the Meta Universe. It's as if we're creating an immersive experience inside another immersive experience. I think this really helps with immersion."*

- *P3*: *"Once I took the VR glasses off, I realized I had gotten used to that environment."*
- *P11*: *"I just realized I was still inside the Meta Universe and the screen is inside it. I guess this means I got immersed into the store."*

These comments show that even if the immediate virtual environment being experienced is not fully-immersive, placing it as an additional layer inside another VE that surrounds the user 360 degrees can help with the immersion of users.

Use of avatars: The *use of avatars* can also help with immersion. Following comments were made regarding avatars during the VR experience:

- *P1*: *"Seeing my avatar hands helped with the feeling of presence and 3 dimensionality."*
- *P7*: *"I think it would help with the feeling of presence if I could see myself as an avatar inside the store. Even a black silhouette would do."*
- *P10*: *"In Alo Yoga, virtually trying products in front of the mirror made me feel I was inside a store. This is not something we can experience in online."*
- *P8*: *"The virtual fitting was good. Only the pose of the avatar killed the realness of it."*

These comments are in line with literature suggesting that inclusion of avatars increases the sense of presence inside a VE.

Navigation and immersion in virtual stores: A multitude of the comments made by participants regarding the level of immersion show that *navigation and interaction in virtual stores* has an influence on the *Level of Immersion* experienced by users. Some of these comments are listed below:

- *P4*: *"If I could feel as if I was walking in the environment and observe the products around myself as I walked in the store, I would feel more present in the store. Also when the VE responds late to my actions I felt distanced from the VE."*

- *P6*: *"When I use the arrows to navigate, it kills the sense of presence." "...It suddenly teleports me to another place inside the store when I click on an arrow. That kills the realness of it because in real world, we walk slowly and not teleport."*
- *P9*: *"Since I cannot hold and pull closer the garments, rotate them or observe them interactively, I didn't feel present in the stores."*
- *P12*: *"The browser took away the feeling of presence. But the flexibility of movement and navigation still helped with the feeling of presence."*
- *P15*: *"I felt very immersed into the Meta Universe. If the stores could also respond to my head gestures, it would help with the feeling of presence."*

These comments demonstrate the effects of interaction and navigation on the perceived sense of presence and immersion in a VE. Also, the responsiveness and speed of VR influences the feeling of presence. Therefore, if the users of a VR are allowed more flexibility in terms of navigation and interaction with instant feedback from the VR, and if the system responds, even if partially, to the head and bodily gestures of users, they can experience an increased level of immersion. Moreover, naturalness of the interaction outcomes and navigation also affects the sense of presence. The comment made by *P6* suggests that the outcomes of users' interactions inside a VE must resemble the outcomes of interactions in real world for an increased sense of immersion and realness inside a VE.

POV and FOV: The *POV and FOV* of users also play a significant role in the level of immersion. Regarding this, several comments were made by participants:

- *P12*: *"When I press this arrow it suddenly changes my POV. If I could continue to explore the store from the same POV, it could give an increased sense of navigation and presence. Or maybe it can respect the angle of my gaze…"* "*…The spatial arrangement, I mean the perspective, felt real. For example, the relative sizes of products based on their*

distance to me…" "…Also I don't normally see the world from this height. It took me a while to look at the world from this angle."

- *P13"When you move inside the environment it changes the angle. Do you see?" "…I think I felt more present when the angle was similar to how I see the real world. I think it has to do with the POV."*

Based on these comments, it can be argued that the point of view and angle from which the VE and the products are observed influence users' immersion. Several participants also said that the VE would feel more immersive if the height from which they observe the environment would match their real-world experience. Giving users the ability to adjust their height at the beginning of a VR experience and arranging the POV based on the customized height can help get rid of this problem.

Visual realism and fidelity: Visual realism and fidelity also stood out as important factors affecting the participants' immersion. Some of the comments made by participants regarding this topic are as follows:

- *P8*: *"In Hugo Boss, I felt as if I was there due to the render quality."*
- *P10*: *"The cartoonish product renders of Alo Yoga killed the feeling of realness. Also the visual quality of products decrease when you zoom in. That was also not very realistic."*
- *P11*: *"The environments felt real, the products not so much. The render of the environment, its lighting and shadows felt real."*
- *P12*: *"The products look 3-dimensional. It is different than observing them from a picture."*
- *P13*: *"The visuals in Boss are more realistic but it felt as if I was moving inside a panoramic picture there."*
- *P16*: *"Maybe it's because I'm a designer but the entire thing felt very 'modeled'. That kept reminding me that this is a project and not a real world."*

Several insights can be drawn based on these comments. First, visual realism and high quality of renders can help with the level of immersion. Second, the 3-dimensionality of products and the VE also contribute to the realness of the environment. However, when users can understand that the VE or the products are 3D computer models, their sense of presence can get diminished. Third, realistic lighting, shadows and high-fidelity visual details can increase the *realness of VEs*, thus helping to increase users' immersion.

Store layout and environment: Some participants also made comments regarding *the store layout and environment* affecting their sense of presence. For example, *P2* said *"The views in the VE really helps with the feeling of presence."*, and *P17* said,

> *"The mannequins and the décor of the Alo Yoga store made me feel that I was really there. The only thing that reminded me it was not a real world was the 2-dimensionality of some of the products."*

Based on these comments, it can also be argued that décor and views in the environment can help with the felt presence, thus helping with immersion into a VE.

Multimodality and realness of sounds: Another topic that appeared often regarding *Levels of Immersion* was *multimodality*. On that account, several participants noted that the music helped with immersion, with *P18* also highlighting that addition of music helps with the feeling of being in a store not only because it helps block out the physical world but also because we are used to hearing music in physical retail stores. Two participants also commented on the *realness of sounds* and added that integration of voices one would normally hear in real world such as footstep sounds or sounds to represent fabric materials can also help with the immersion and the overall shopping experience. These comments also hint to a link between the multimodality topic of *Levels of Immersion* and **Material/ Texture** theme of Product Informativeness.

Spatial Awareness

The second sub-theme of **Immersion and Presence** is *Spatial Awareness*. A total of 10 comments were found linked to this sub-theme. Spatial awareness in VR has an influence on users' immersion and felt presence. Further, it also affects the utilitarian and hedonic aspects of shopping. Indeed, it is important for users of a virtual store to understand the space they are immersed into so that they can quickly locate the products they are looking for in the VR store. Further, the hedonic experience felt during shopping is increased through an uninterrupted flow. Understanding one's whereabouts in a virtual space therefore also helps with the hedonic shopping experience. Based on the comments made by participants, the *Spatial Awareness* sub-theme was found to be linked to store understandability, task fulfillment and speed, hedonic shopping experience, store layout, store size, product variation and navigation inside a store.

Exploring the surroundings in 360 degrees: The comments made by participants of this research reveal some insights regarding users' spatial awareness inside a store. *P8* said that they were always aware where they were in the Alo Yoga store since they could look around 360 degrees inside the store although through a browser. Users' being able to explore their surroundings inside a VR helps with their spatial awareness.

Store interiors: Several important comments were made regarding the *interiors of stores* and spatial awareness. For example, *P2* said *"In Hugo, it felt as if all places were the same. They could have differentiated the spaces with color or décor. I always kept asking myself 'Have I been here before?'"*. Similarly, *P6* said *"In Alo Yoga, I understood the store layout more easily. In Hugo I kept thinking there were more rooms to discover where, in fact, I had already been to all areas of the store."*. The Alo Yoga store, which was found more understandable in terms of store layout by most participants, offered a large area similar to a typical retail store. The main factor helping with the spatial awareness of users inside that store, however, was that users could see most of the areas of the store from where they were standing by just

spinning the environment. In the Hugo Boss store, on the other hand, the store layout was *"defined by corridors and a garden"*, as also indicated by one of the participants. The fact that users could experience the virtual space by walking between the corridors might have diminished their spatial awareness. Figure 5.16 involves screenshots from both of the stores to show the different interior approaches preferred by the two stores.



Figure 5.16. Screenshots taken from the Alo Yoga and Hugo Boss virtual stores.

Continuity of store interiors: *Continuity of store interiors* also helps with users' spatial awareness. On that account, *P12* said (during their visit to the Alo Yoga store) *"I realize only now that the whole space is made up of smaller sections that continue each other."*. If a virtual store offers a clear continuation between different compartments of the store, users' spatial awareness can improve.

Store size and number of products inside the store: Participants' comments also indicate that spatial awareness is linked to the *store size*, *number of products*

displayed inside the store and *navigation*. For example *P6* said that they didn't get lost inside the stores because they were not *"too large spaces"*, and that they were always aware where they were due to the constrained size of the stores. *P9* made a comment regarding the number of products and navigation affecting their spatial awareness inside the stores;

> *"In Alo Yoga, you could understand where everything was by looking around. In Hugo, the navigation was hard and it made it difficult to understand the place. The only reason I didn't get lost in Hugo is because there were too little products."*

This comment indicates that ease of navigation and being able to explore areas of a virtual store can help with the understandability of store, thus helping with spatial awareness. Although the Alo Yoga virtual store involved more products than the Hugo Boss store, the participant indicated that the Hugo Boss store would become more complex to follow had there been more products. It can be argued, therefore, that the ease of navigation and store understandability gain further importance in virtual stores which offer more products. This not only helps with the spatial awareness of customers but also affects the utilitarian and hedonic aspects of shopping.

Imagination

The third sub-theme of **Immersion and Presence** is *Imagination*. Although a total of 3 comments were found linked to this sub-theme, imagination is one of the three key components of virtual reality. As also mentioned in Chapter 2, immersion can happen without the use of technology. The human mind's ability to imagine can help with immersion and the perceived sense of presence inside a VE. When the suspension of disbelief happens (i.e. when the user chooses to believe in the cues coming from imagination more so than the cues coming from his/ her physical environment) (Stapleton & Davies, 2011), an increased feeling of "being there" can be experienced by VR users. Imagination can also help VR users to "fill in the gaps",

thus helping to turn the overall VR experience into a continuous, believable flow. For example, P3 said during the post-interview session,

> *"I think scent is also important when shopping. In VR, I imagined that the Alo Yoga store would have a powder-like odor whereas the Hugo Boss store would probably smell of an exclusive perfume."*

Indeed, humans experience the real world with all five senses. Since today's commercially available VR technologies cannot trigger all 5 senses, users' imagination can come into play to fill in the gaps make believe in the reality of virtual environments.

5.5.1.3 Usefulness and Effectiveness Theme

Comments made by participants regarding the interface and meaningfulness of the overall system design were evaluated under the **Usefulness and Effectiveness** theme. A total of 32 out of 410 comments analyzed in this research were found to be linked to the **Usefulness and Effectiveness** theme. Of these, 29 were evaluated under the *Fitness to Purpose* sub-theme, whereas the remaining of the comments fell directly under the **Usefulness and Effectiveness** theme.

Fitness to Purpose

Comments made by participants questioning the reason or appreciating the inclusion of certain features into the VEs were evaluated under the *Fitness to Purpose* sub-theme. A total of 29 comments were made by participants regarding this sub-theme. Some of the main topics that emerged under the *Fitness to Purpose* sub-theme are shared below.

Isolating or integrating purchase-related tasks: Isolating or integrating purchase-related tasks emerged as an important decision for the design of VR stores. The Alo Yoga store gave the option to add items to basket inside the VR, whereas in the Hugo Boss store, users were taken to the brand website to make a purchase. Several

participants commented on this reflecting on the fitness to purpose of the VR store. Participants expressed that if they are inside a virtual store, they would expect to perform the entire shopping experience "inside" the store. Some of the participant comments regarding this issue are given below.

- *P11*: *"In Alo Yoga, I could at least add items to my basket. In Hugo, I had to go to the website to add items to my basket. That doesn't fit the purpose. Then why am I here?"*
- *P17*: *"I think Alo offered me something different than online shopping. But Hugo took me to its website to make the purchase. The difference is gone."*

Visibility of the products inside a virtual store: Multiple comments were made by participants suggesting a *higher visibility of the products inside a virtual store*, since the main purpose is to do shopping. Several participants declared that both of the stores' interiors and décor were more attention-catching than the displayed products. On that account, P3 made the following comment:

> *"I think the environments were more attention catching than the products in both stores. But if I'm here to shop, products must also be more visible."*

This shows a need to find a balance between designing capturing environments to immerse users and clearly showcasing the products to shop. A few participants also questioned the sitting units inside the stores saying that it led to a confusion as to whether they could interact with them. On that account, *P4* made the following comment:

> *"I would want to also sit on the couches in the store. That's why I clicked on them a few times to see if anything would happen. Especially in Hugo, you walk a bit and then see a sitting unit, then walk a bit more, another couch. But I can't do anything with it…"*

If users of a VR store are offered avatars through which they can perform virtual product fittings or socialize with other shoppers' avatars, the sitting units can turn

into places for observing the products or getting product-related opinion from other users.

Quick exploration in VE and responsiveness of VR: Several participants also commented on the *explorativeness of VE and responsiveness of VR* in regard to how quickly they could meet their shopping goals inside the virtual stores:

- *P9*: *"In terms of shopping experience, I think Alo is more meaningful. At least I can get immediate response from the system there. Alo was also better in terms of product interaction, seeing alternative colors, etc.… Also, in terms of navigation…"*
- *P12*: *"If I wanted this type of experience, I would go to a physical store. I don't think they have to replicate the actual shopping experience here. This offers me the chance to see products at the comfort of my house and I can actually see things in 3D without even standing up. I would have wanted to go through product options more quickly, change their colors…"*

These comments also suggest links to the utilitarian aspect of shopping. Getting immediate response from the system, interacting with products by changing their colors, being able to quickly scan alternative products are expected interactions by VR shoppers.

Presentation of the rooms: Another topic that emerged under the *Fitness to Purpose* theme, pointing out also to the utilitarian aspect of shopping is the *presentation of the rooms*. *P12* made a comment with reference to the "Change Rooms" menu offered in both stores, saying,

> *"I think the Change Rooms menu was helpful on both stores. Maybe instead of giving me the names of the rooms, they could give the product categories in the menu. In the real world, too, you enter a store, look around maybe once or twice to get the vibe of the brand, but then decide where to go based on what product category you want to see."*

This participant comment suggests that the items of the teleportation menu can be arranged based on product names, rather than room names to fit the purpose of shopping.

POV adjustment for observing products from the best angle: P4 made a comment on the *POV adjustment for observing products from the best angle* inside one of the stores by saying,

> *"In Hugo, I click on an arrow but it moves me to a weird angle. So then I change my POV by using the controllers. If I am limited to arrows for navigation, at least bring me to an angle from which I can observe the products."*

The participant indicated that if they are limited to arrows in terms of navigation, the arrows must teleport the user to a *perfect angle to observe the intended product*.

Customization: P17 commented on the *customization* offered in stores by saying,

> *"I think being able to turn on and off the music is also good. Because I can turn the music on when I'm walking around, but when I want to focus more attentively before making the purchase, I can turn it off."*

In both of the stores, users had the option to turn on and off the music anytime in both of the stores. The participant found it helpful, indicating that during the more experiential process of shopping (i.e. walking around the store to discover products), music can help with the flow and the overall experience. However, when one wants to make a purchase, the music can be turned down or completely off so that users can more attentively make purchase decisions. Another customization means can also be integrated into VR stores to allow users to choose their own music. Since VR shoppers will not be limited by real-world problems such as "disturbing others" during shopping, they can be offered the option to play their desired music when shopping. Customization can be extended to other areas of the interface to help with the usability as well as the created experience of virtual shopping.

5.5.2 Results and Discussion of the Themes and Sub-themes of Shopping Experience

The second main title appearing in the theme map is Shopping Experience. This topic involves two themes, (a) **Utilitarian Shopping** and (b) **Hedonic Shopping**. As mentioned in Chapter 3 of this thesis, the shopping experience involves both instrumental and experiential outcomes (Babin et al., 1994). While the utilitarian aspect of shopping is paramount to meet the goals of shoppers, it is the hedonic and experiential part of the overall shopping experience that leads to a full customer satisfaction (Jones et al., 2006).

Based on the comments made by participants, *Task Fulfillment and Speed*, *Product Variation*, *Search/ Filter/ Order* and *Product Comparison* became the sub-themes of **Utilitarian Shopping**. The **Hedonic Shopping** theme, on the other hand involves the sub-themes of *Customer Creativity*, *Experience of the Store Concept and Ambience, Gamification* and *Personalization and Social Interactions through Avatars*.

5.5.2.1 Utilitarian Shopping Theme

Utilitarian shopping can be defined as the goal-oriented, task-driven and practical aspects of shopping. Utilitarian shopping comes into play when primary focus of customers is on efficiency, functionality and fulfillment of needs. A total of 26 comments were made by participants regarding the **Utilitarian Shopping** theme.

Task Fulfillment and Speed

The first sub-theme of **Utilitarian Shopping** is *Task Fulfillment and Speed*. A total of 10 comments were made by participants relating to this sub-theme.

Explorative shopping: Regarding the explorative shopping topic, *P11* said,

"Everybody has different shopping habits. For example, some people go to physical stores to see the products but purcahse them online to avoid waiting in line. Maybe this can be an alternative for pre-product discovery."

It can be said that VR stores can be beneficial for pre-discovery of product alternatives, thus eliminating the time spent to travel to physical stores. If visual realism and fidelity of products are informative enough, VR stores can one day be preferred by customers to both observe products and get a sense of being inside a store.

Quick product scanning and task fulfillment inside a virtual store: Another important topic which appeared under the *Task Fulfillment and Speed* sub-theme is *quick product scanning and task fulfillment inside a virtual store*. On that account *P12* made the following comment:

"I would have wanted to see the virtual store, maybe walk in it a bit, but then skip to the shopping part. My aim is to buy something. Now I want to look at products quickly. I'm not here to just walk in the store." "In physical stores I can walk by maybe 20 products in 2 minutes, touching and looking. Here, it takes at least double that time to observe less products. Time is important when shopping."

Similarly, *P13* made the following comment:

"I think this has a huge disadvantage compared to online shopping. In online shopping, I can quickly scan maybe 100 products in a few minutes."

P16 also said,

"I would have wanted to see more product options, but quickly, that's very important and make the purchase also inside the VR store. It shouldn't open a new tab to direct me to the online store."

In the light of these comments, it can be argued that participants felt a disadvantage compared to both physical and online stores during their virtual shopping experience.

The main utilitarian concern of shoppers appears to be speed and time spent inside the stores. Although shopping for task-fulfillment alone doesn't suffice to bring customer satisfaction, it must also be kept in mind that scanning products and getting product-related information must happen quickly inside a virtual store.

Product Variation

The second sub-theme of **Utilitarian Shopping** is *Product Variation*. A total of 5 comments were made by participants relating to this sub-theme. Some of the comments made by participants regarding *Product Variation* are listed below:

- *P10*: *"I think Hugo had too few porducts and they weren't realistic. When I clicked on the products to see their pictures, I said 'Oh is it really how this product looks?' a few times."*
- *P17*: *"Hugo has better renders but I wanted to spend more time in Alo Yoga. Because I could see the product options, they offered a wider variety of products."*
- *P17*: *"Since Alo has more products displayed on the wall it also helps with product combination. They already hung clothes with tops and bottoms creating combinations like a physical store. I think that contributes a lot to the experience too, really differs it from online shopping."*

In the light of these comments, it can be argued that product variation inside a virtual store plays a significant role on the perceived value of shopping. The comment made by *P10* also highlights the importance of product renders' resemblance to their real-life pictures. Since many comments were also made on the importance of speed while shopping, *product renders* should accurately represent the products, thus eliminating the need to click on each and every product inside a virtual store to understand "what they really look like". *P17* also made an important comment about the *product displays and combinations*, relating also to **Product Presentation** theme, which will be discussed in further detail in the coming sections. The participant indicated that seeing products displayed in combination, similar to how they are displayed in physical stores, can aid with mental product combination as well as with the speed

of product scanning. Users can observe a multitude of products in one look, making selections from the display area. Figure 5.17 includes screenshots from both stores showcasing how products are displayed in the virtual spaces.

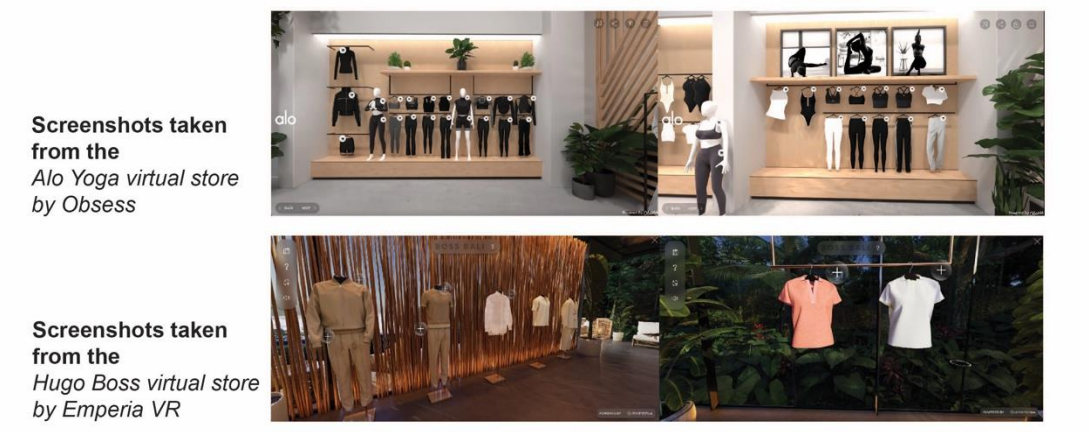


Figure 5.17. Screenshots taken from the Alo Yoga and Hugo Boss virtual stores, showing product variation and displays in both stores.

Search/Filter/Order

The third sub-theme of **Utilitarian Shopping** is *Search/Filter/Order* option. The participant comments show that the visited virtual stores were compared by users to both online and physical stores. A lot of participants commented on the importance of quickness and easy task fulfillment during shopping. On that account, it can be argued that including a search/filter/order option into the VR stores can help with the speed of shopping. Although this is a common feature available in a lot of online stores, the virtual stores visited during the research sessions were lacking the options to search products, put filters or order products based on certain features. *P11* also made a comment regarding this issue, saying that they prefer online shopping over in-store shopping due to the search, filter and order options. Indeed, integration of these features can aid with the utilitarian shopping for VR users. It must be remembered, however, that a novel interface can be applied to virtual stores' search/filter/order feature rather than replicating the traditional online interface.

Product Comparison

The fourth sub-theme of **Utilitarian Shopping** is *Product Comparison.* A total of 11 comments were found linked to this sub-theme. Participant comments regarding *Product Comparison* point to a few insights. First, neither of the virtual stores visited by participants allowed for product comparisons or combinations. Alo Yoga store had a virtual fitting mirror where users could make combinations from a few products. However, most participants said that they would prefer to see on the avatar the products which they chose while shopping, rather than choosing from a pool containing only some of the products displayed in the store. On that account, *P11* said *"The virtual fitting in Alo didn't make sense to me. In a real store, I would want to try the products I chose to make a comparison or decision. Instead, they allow you to combine just a few of the products offered in the store."*. Similarly, *P4* suggested that the "add to basket" icon can add the selected garments in a separate section of the basket, from which the users can then choose the final products they wish to purchase.

Another comment made by *P12* is *"In Alo, you change the avatar's clothes by clicking on the arrows or swiping. But once I change it, I forget the previous outfit. I cannot make comparisons if I keep forgetting the previous item."*. This comment brings out another important insight. Indeed, when users of a VR store want to make product comparisons, the compared products must be visible to customers until they make a decision. Similarly, *P7* suggested seeing two avatars side by side to make product combinations and comparisons would help. In fact, virtual stores can give customers the option to multiply their avatars as many times as they wish to make several outfit combinations and compare them side by side.

5.5.2.2 Hedonic Shopping

Hedonic shopping refers to the experiential aspects of shopping, such as enjoyment, pleasure and excitement perceived by consumers during shopping. A total of 51 comments were made by participants regarding the **Hedonic Shopping** theme.

Customer Creativity

The first sub-theme of **Hedonic Shopping** is *Customer Creativity*. Based on the comments made by participants, the topics of outfit combination and product use creativity emerged under this sub-theme. A total of 16 comments were made by participants relating to *Customer Creativity*.

Virtual fitting on customized avatars: Most of the participants favored the *virtual fitting* feature offered in Alo Yoga store. However, they all expressed a desire to try the products on their personalized avatars. Participants said that they would prefer if they could customize the avatars based on their individual appearances and body measurement, outfit combinations could become more meaningful and fun. On that account, *P11* said,

> *"We are opening this browser inside the Meta Universe and I can customize my avatar in the Meta Universe. Maybe the two systems can work in integrity, and I can try the products on the avatar which I had created in the Meta Universe."*

Indeed, virtual stores can allow users to adjust their avatars by entering their bodily measurements and selecting their physical features so as to better decide whether an outfit will fit them or not. This feature would not only replace one of the missing features of online shopping but can also allow customers to make outfit combinations in a much easier and quicker manner compared to physical stores. The users, for instance, can choose from a pool of products, quickly making selections or dragging garments onto their avatars to make outfit combinations. *P13* made another comment

regarding this topic saying that they would prefer to make outfit combinations in the store whenever they wanted. They said,

> *"In physical stores, the easiest way to shop is to first collect the products you want to try on and then go to the fitting room. Here, I don't have to follow the same process."*

Instead of one designated area for virtual fitting, shoppers of VR can be offered the chance to try their selected items whenever and wherever they want. An icon or gesture, for instance, can pop up a virtual fitting screen allowing customers to make outfit combinations whenever they want.

Similarly, the same participant (*P13*) also said dressing avatars inside the store and watching them walk by inside the store can be another way to perform outfit combinations. To take it a step further from the participant's suggestions, virtual stores can even allow customers to create their own runway shows with the products offered in the store. This can also be turned into a competition, where different users' runway shows can be voted. The winner, as a result, can receive a small gift or a discount which they can later use. Indeed, such means of gamification can draw more customers to virtual stores, increase the time spent inside virtual stores and strengthen the customer-brand relations, while also enhancing brand identities.

Further, one of the participants said that seeing products reflected on their own bodies (by using AR) can also be an exciting feature which can be offered by VR. Product combinations can therefore be made not merely on the digital avatars of customers but also on their own bodies through augmented reality.

Virtual fitting and virtual teleportation: An interesting comment made by one of the participants (*P5*) regarding *Customer Creativity* is as follows:

> *"When buying a garment, you think about where and on which occasions you can wear it. Maybe the VR can allow to make combinations on my own avatar and then take them to other places such as a beach party or night club to see whether the outfit fits the selected occasion."*

This comment can give inspiration to VR store designers in understanding the possibilities of VR shopping that are impossible or difficult to do in physical or online stores. The quick outfit combinations as well as seeing outfits in different environments can help with the hedonic aspect of VR shopping, thus encouraging customers to spend more time in virtual stores.

Product modifications and product customizations inside the virtual store: Another intriguing comment was made by *P16*:

> *"I would want to be able to do things here that I would feel guilty doing in a physical store. For example, I would want to stretch the fabric however much I want, cut the garments and make product modifications."*

Indeed, non-consequentiality is one of the features virtual stores can offer which physical stores cannot (Xi & Hamari, 2021). Customers inside a virtual store can be allowed the flexibility to make product modifications or even customizations. Such features can help not merely with the experiential aspect of shopping but also with brand attachment. *P14* also made a comment regarding customization, saying that such creative experiences during shopping really excite them.

Experience of the Store Concept and Ambience

The second sub-theme of **Hedonic Shopping** is *Experience of the Store Concept and Ambience*. Based on the comments made by participants, several topics emerged under the sub-theme of *Experience of the Store Concept and Ambience*. A total of 21 comments were made by participants relating to *Experience of the Store Concept and Ambience*.

Sensory richness: First, several comments were made by participants regarding the *sensory richness* of virtual environments affecting the experience of the ambience. For example, *P2* stated that they felt "trapped" inside the Hugo Boss store due to the "overwhelming décor and dark colors" preferred in the store. Similarly, the same participant favored the integration of views in both Alo Yoga and Hugo Boss store saying that even just observing a serene scene can help elevate the shopping

experience. *P17* made a comment saying that although the render quality was better in the Hugo Boss store, the emptiness of the store and the number of displayed products led to boredom. *P3* said the stillness of the environments created a dull feeling in both of the stores. They suggested that if subtle motions were layered on the still images, giving the environment a more "alive" appearance, the overall store experience could be elevated positively. Similarly, *P2* suggested that the mannequins inside the Alo Yoga store can move ever so slowly, making yoga movements, or a few avatars can sub-bathe or swim in the Hugo Boss pool. *P9* said that they enjoyed the virtual store tours more than they normally enjoy online stores, and *P13* said, *"At least you can walk around or interact more here. I think this is a strength against online shopping."*

These comments show that interior design of stores must feel relaxing rather than overwhelming, alive rather than dull and filled with an optimum number of products and an optimum amount of motion and interactivity. It is paramount that the VR stores offer an increased level of fun, enjoyment and excitement to users in order to encourage them to spend time in virtual stores.

Flow and continuity of the shopping experience: The *flow and continuity of the shopping experience* was also mentioned by several participants. For example, *P13* said it is important that the experience is smooth and uninterrupted. They also said that they felt more immersed in Alo Yoga due to the overall flow of the experience. 2 participants also made comments regarding the videos embedded in the Alo Yoga store. On that account, *P13* said,

> *"The videos in Alo are a fun way to keep customers interested. They also help with immersion. You realize you are inside a 3D environment when you open another screen inside it."*

Integration of product or brand-related animations and videos can help with product informativeness as well as the overall enjoyment perceived by customers. Brands can also benefit from this to strengthen bonds with existing customers or to get attention of novice customers.

Participant comments also indicated the importance of relaxing VR experiences independent from time and space restrictions of the physical stores. For instance, *P14* made a comment comparing their virtual experience to in-store experiences by saying,

> *"Physical stores are too crowded and the products are usually damaged. I think this is a more relaxing experience. You don't have to rush to observe the products, you don't have to wait for other people to move aside to look at garments…"*

On a similar account, *P3* made another comment saying,

> *"I wish I could sit in the couches, observe the views in silence, maybe go through products from where I'm sitting and have that exclusive shopping experience."*

These comments show that creating relaxing and exclusive shopping experiences where customers don't feel under pressure or limited by time constraints can help with the overall shopping experience.

Gamification

The third sub-theme of **Hedonic Shopping** is *Gamification*. Of the two stores visited by the participants of this research, the Hugo Boss store had a gaming feature integrated. The virtual store is filled with flying letters to make up the word "BOSS BALI". Upon successful completion of the phrase (i.e. collecting all the letters inside the store), customers are gifted with a discount on their purchase. Figure 5.18 involves a screenshot from the Hugo Boss virtual store showing the letters to be collected.

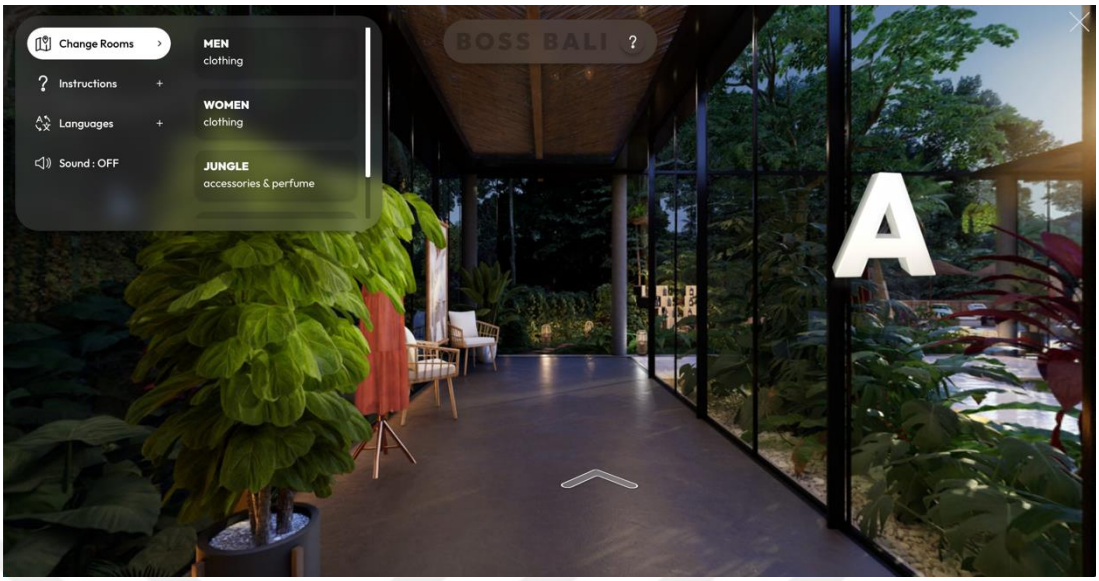


Figure 5.18. Screenshot from the Hugo Boss virtual store, showing the letter-collecting game.

P12 made a comment regarding this feature by saying,

> *"The way to motivate me to spend more time here is definitely not collecting letters. They should make the shopping experience itself fun."*

This comment indicates that more interactive and engaging activities can help motivate users to spend more time in a virtual store. In the context of apparel shopping, customers can be offered with more interactive games such as making collaborative outfit combinations with other users, product modification competitions where customers re-create the existing products offered in a store, runway show competitions, etc. Avatar makeovers where customers can re-create their own or other customers' avatars, socialization through shopping such as giving and receiving comments from other customers on outfit combinations, creating and sharing with other customers virtual lookbooks to keep a collection of favorite outfits, product customization or quick brand-related quizzes, for instance, can help create more interactive and fun shopping experiences to VR shoppers.

Personalization and Social Interactions through Avatars

The fourth sub-theme of **Hedonic Shopping** is *Personalization and Social Interactions through Avatars*. Based on a total of 21 comments made by participants, the topics of personalization, socialization and information sharing/assistance from avatars emerged under this sub-theme. Several participants made comments indicating that they would prefer to virtually try products on their personalized avatars. On that account, *P15* said,

> *"In the Meta Universe, it could locate my hands and arms and respond to my bodily gestures. I can see an avatar in the mirror* (referring to the virtual fitting in Alo Yoga) *but it doesn't look like me, nor does it correspond to my movements."*

Similarly, *P2* said that they had expected a more interactive shopping experience enriched with avatars before they entered the virtual stores. Further, P3 said shopping for their avatar could also be a fun and social experience. If, in the future, VR allows people to virtually come together and "socialize", shopping for avatars can become a meaningful interaction which can motivate VR shoppers. Indeed, *socialization* appeared as another topic under the *Avatars* sub-theme based on the comments made by participants. For example, P11 said *"I would want to see other people's avatars, too. Maybe a shopping buddy that I can also socialize with…"*

Similarly, *information sharing and getting assistance from avatars* "working" in the VR store can help elevate the shopping experience, while also helping with the utilitarian aspect of shopping. Customers can ask where to find a certain product inside the store, get outfit inspirations or ask for product-related information or outfit suggestions to the assistant avatars. This could also help get rid of the "dullness" of virtual stores, giving them a more alive feeling, which was a comment made by several participants regarding the virtual stores they experienced (see under the *Experience* sub-theme). On that account, P3 said,

"It would be nice to see an avatar to help me inside the store. Maybe I can go ask where a product is or learn which physical stores I can visit in real life to actually try the product on."

Indeed, some online stores do offer information regarding which physical stores have a specific item. This feature can well be integrated into VR stores where customers can learn which store they have to go to try on a product and make a purchase in real life.

Another comment made by P11 regarding avatars indicates to another useful tip. The participant said,

"When I stand here, I cannot understand the sizes of the products. Maybe if I had an avatar, I could at least try to figure out the sizes of products in relation to the avatar's body."

Product informativeness is one important topic regarding virtual apparel shopping. Understanding the product size through comparing it to the size of avatars inside the VE can help with product understandability as well, a topic which will be discussed again under the **Product Size** theme of Product Informativeness title.

Another comment made by P5 is as follows:

"It was good that there were mannequins inside the Alo Yoga store. You can see various outfit combinations displayed on the mannequins as you go around in the store."

This comment highlights one more time the users' desire to see product combinations during apparel shopping. Indeed, integration of avatars into VR stores can help with this need of customers in various ways. The VR store can offer customers multiple avatars on which they can make outfit combinations. Users can choose items from the store, drag them onto avatars or mannequins inside the store and make various combinations which can help them with their purchase decisions and increase their overall enjoyment during the shopping experience.

5.5.3 Results and Discussion of the Themes and Sub-themes of Store Presentation

The third main title of the theme map based on the analyzed data is Store Presentation. This topic contains the themes of (a) **Store Layout and Composition** with the sub-themes of *Virtual Cues, Maps and Menus*, and *Realistic vs Fantasy Store Designs*, (b) **Compartmentalization** with the sub-themes of *Context-Based Compartmentalization* (product-environment relation) and *Product-Based Compartmentalization* (based on product categories), and (c) **Optimal Store Size**. A total of 38 comments were made by participants regarding the Store Presentation title. The dimensions relating to Store Presentation will be discussed in relation to the above-mentioned VR and shopping experience dimensions.

5.5.3.1 Store Layout and Composition Theme

Store layout presents itself as an important theme to aid with store understandability, spatial awareness and imagination of users in a virtual store. A total of 26 comments were found to have links to the **Store Layout and Composition** theme, with 4 of these comments originally falling under other themes but relating also to the layout of virtual stores.

Virtual Cues, Maps and Menus

The first sub-theme of **Store Layout and Composition** is *Virtual Cues, Maps and Menus*. Virtual cues help with navigation and way-finding of users inside a virtual environment. These cues can come in various forms such as virtual maps, virtual menus, landmarks to help with way-finding and navigation arrows. A total of 12 comments were found related to the *Virtual Cues, Maps and Menus* sub-theme.

As was mentioned before, both of the virtual stores visited for this research allowed users to navigate by clicking on virtual arrows. Multiple participants made comments saying that they would prefer to move more freely inside the store rather than

following designated paths. However, a lot of comments were also received by participants saying that the virtual arrows on the floors were helpful in way-finding. One participant (*P11*) also said,

> *"In Alo Yoga, some arrows also contained information about where the arrow will take you to. That was also helpful."*

Further, two participants (*P3* and *P17*) said the "alo" letters (which can be considered to work in a similar way to a virtual landmark) were also helpful in way-finding. Figure 5.19 involves a screenshot from the Alo Yoga virtual store, showing the "alo" letters located at the very entrance of the store.

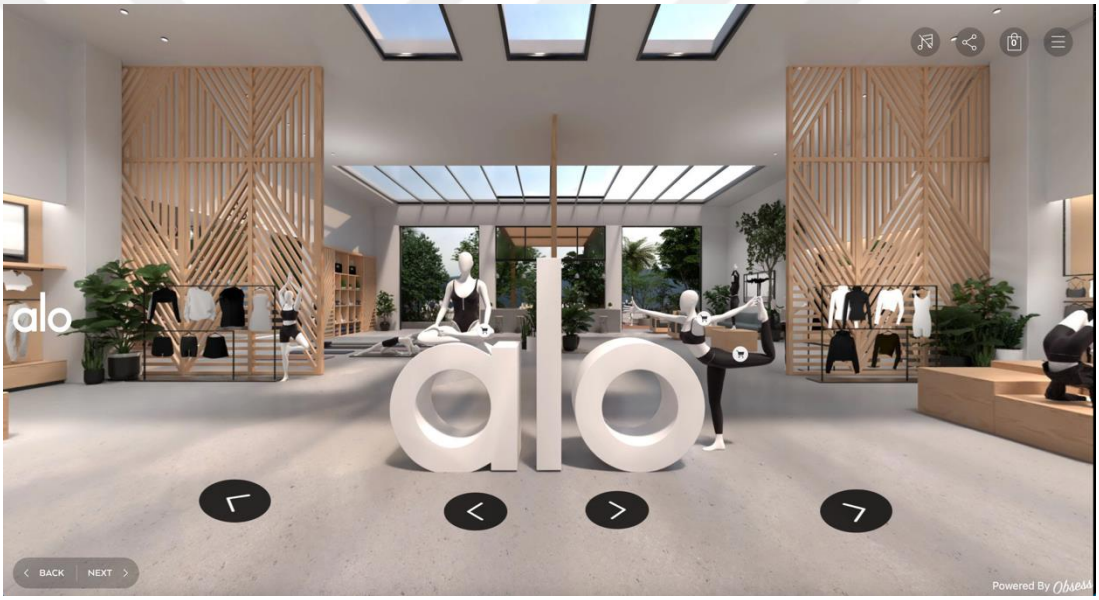


Figure 5.19. Screenshot from the Alo Yoga virtual store, showing the "landmark" to help with way-finding.

Several participants also mentioned that the "Change Rooms" menus offered in both of the stores were also helpful, both to understand the store layout and to navigate inside a store. On that account, *P4* said,

> *"There were instances where I got stuck staring at the ceiling or the floor in Hugo Boss. The Change Rooms menu came most helpful to me during those instances."*

Similarly, *P7* said,

> *"It was difficult to click on the arrows in Hugo Boss. The menu was really helpful for that."*

It can be argued based on these comments that integration of virtual cues such as maps, arrows and landmarks help with the understandability of store layout and navigation inside a virtual store. When a landmark similar to the one in Alo Yoga store is used, its visibility must also be taken into consideration. If users can see the landmark from multiple points inside the store, they can build a better sense of spatial awareness. Further, including text information on some of the arrows to indicate which way they will take the user to also helps with store layout and store understandability.

3 participants (*P3, P9, P13*) made comments relating to the virtual cues saying virtual signs that resemble the ones in physical stores can also help with the realism of stores. Instead of using virtual signs which would normally not be observed in real-life, more realistic signage system can be preferred. Regarding this, *P13* said,

> *"It was difficult to always keep track of which part of the store I was at. In physical stores, they have huge signs on the walls showing product categories or women's/ men's compartments. Let's say I want to buy shoes. Where do I have to go to see the shoes? I think a signage system similar to real stores can be helpful. You can add signs inside a 3-dimensional world."*

This comment made by *P13* also highlights another need of customers. Instead of knowing the name of the room where they are being led to, they can be provided with product categories on the signs of the VR store. This way, shoppers can more easily find their way to the product category they want to explore.

Another interesting comment by *P8* was *"In Alo Yoga, everything was scattered everywhere. That made it more difficult to understand the store layout."*. This indicates that an organized store interior which doesn't overwhelm its users with too

crowded décor and product displays can also help with the understandability of store layout. On that account *P16* also said,

> *"In real-life they may put too many products in smaller display areas due to space limitations. Here, they can create as large a store as they wish. The products don't have to be so jammed."*

Lastly, *P18* suggested that starting the VR experience by first taking a bird eye view of the store and seeing the entire layout of the store before-hand could also be helpful. Indeed, showing the entire store area to users can help with store understandability as well as spatial awareness during the shopping experience. A few participants made comments on how they lost track of their whereabouts inside the Hugo Boss store due to the store layout made up of narrow corridors (see under *Spatial Awareness* sub-theme). Taking a bird eye view of the store before entering it could come helpful in such cases. Stores which have rather complicated layouts can benefit largely from this feature.

Realistic vs Fantasy Store Designs

The second sub-theme of **Store Layout and Composition** is *Realistic vs Fantasy Store Designs*. A total of 10 comments by participants were listed under this sub-theme.

The data reveals that participants either favor or question the resemblance of virtual stores to physical stores. 3 comments made by participants questioning the resemblance of virtual stores and experiences to real-life stores and experiences are shared below:

- *P1*: *"I didn't like that it presented to me an experience that I'm already familiar with. If I'm wearing these glasses, it could take me to, I don't know, the space. I can walk around and shop in the space."*
- *P1*: *"Why do I have to move by walking? I could, for instance, fly."*
- *P16*: *"Going to a complete opposite direction and presenting a store layout we are unfamiliar would be something I would prefer in VR."*

Contrasting comments made by participants include:

- *P3*: *"I think it should resemble real stores. Because what this is compared to is real-world shopping.."*
- *P8*: *"I would expect this to resemble a real store because I come here to experience a realistic shopping experience."*
- *P18*: *"I think the virtual stores resembling real-life stores integrates the user better into the experience. It's not mandatory but it's nice."*

In the light of these comments, it can be argued that different users can have different expectations in terms of resemblance to real-life cases when shopping in VR. An alternative solution can be to offer customers both options, allowing them to shop in both realistic and fantasy stores depending on their preference.

Further, two comments were made by participants questioning the very neat décor and the ceiling of the stores. *P1* and *P3* made the following comments,

- *P1*: *"For instance, why is there a ceiling? What is the use of it in a virtual store? To protect us from the cold or from the rain?"*
- *P3*: *"I think when rendering environments, objects shouldn't be so orderly and organized inside the space. It kills the realness of it."*

The comment made by *P3* can also be linked to the "dullness" of environments mentioned by several users. Users of VR might expect to see environments as if they are being lived in. Although presenting neat stores can help with brand images, VR customers can maybe interact with the décor of stores in addition to the products. Adding into the stores avatars of other users can also help with this.

It can be argued that whether the virtual stores are designed as realistic or fantastic environments, brands must make sure that their image and brand identity are reflected through their VR stores.

5.5.3.2 Compartmentalization Theme

In-store compartmentalization is a feature commonly offered in physical worlds. Compartmentalization in stores helps customers to easily locate products inside a store, thus aiding with way-finding, store understandability, spatial awareness and utilitarian needs of customers (i.e. task fulfillment and speed). Of the analyzed data, a total of 8 comments were found to have links to the **Compartmentalization** theme, with 1 comment originally falling under another theme but relating also to store compartmentalization.

Context-Based Compartmentalization

The first sub-theme of **Compartmentalization** is *Context-Based Compartmentalization* (product-environment relation). A total of 4 comments were made by participants relating to this sub-theme. *P4* made a comment regarding the pool area portrayed in the Hugo Boss saying,

> *"I think it's nice they created a pool side to display swimsuits. In normal* (physical) *stores, they categorize garments such as sportswear, night wear."*

Based on this comment, it can be argued that creating defined environments inside a virtual store designed specifically to match the content of the displayed products can add to the overall flow of shopping experience. Similarly, it was argued under the *Customer Creativity* sub-theme of **Hedonic Shopping** (based on a comment made by *P5*) that users can be teleported to various virtual environments to see whether a specific garment or outfit matches a specific occasion or event. Indeed, context-based décors inside a virtual store can help customers to better visualize how a product will appear in a related occasion or place in real life (such as visualizing swimsuits on the beach or on a poolside). This feature can also be used to accentuate the flow and the narrative of VR shopping, contributing again to the hedonic shopping experience.

Similarly, *P16* made a comment regarding the compartmentalization in Alo Yoga store by saying,

> *"They portrayed different environments inside the store, but they all contain similar products. I think it would be nice to see product-related environments. For example, if the product wants to convey a sense of freshness, fresh looking environments can be added to the background. Or in the garden, for example, they can display winter clothes."*

This comment links to two insights. First, the interior décor or the environment itself can help convey product-related information. By matching the context of the environment with that of the product, customers can be better informed about the displayed products. For instance, winter clothes which protect from extreme weather conditions can be displayed in a snowy environment both to contribute to the narrative and to give further insights into the composition of fabric. Second, the imagination of VR users can be triggered through the depicted narratives, helping them "fill in the gaps" by contextualizing the product use scenarios.

Product-Based Compartmentalization

The second sub-theme of **Compartmentalization** is *Product-Based Compartmentalization* (based on product categories). A total of 3 comments were made by participants relating to this sub-theme, which are shared below:

- *P5*: *"They can write the names of product categories on the walls to help with way-finding, just like they do in physical stores."*
- *P7*: *"It was nice that products belonging to the same collection were displayed together."*
- *P15*: *"I think they should categorize not like balcony, terrace but based on the product type. It was meaningful to find swimsuits next to the pool in Hugo. Maybe other beach-related products can also be displayed there."*

Compartmentalizing virtual stores based on product categories can help customers locate the products inside a store. It can thus contribute to the *Task Fulfillment and*

Speed (under **Utilitarian Shopping**) of customers. Next, seeing products belonging to the same collection displayed together can aid with mental outfit combination, one feature of VR which can be turned into an advantage compared to online shopping. Although products can also be categorized based on collections in online stores, being able to see them hung on the walls, creating alternate matches, can help customers to visualize outfit combinations, contributing to *Customer Creativity*. Lastly, it can be argued based on the comment made by *P15* that customers mostly expect to find products related to the depicted environment or products relating to a certain group category (such as summer clothes, sportwear, etc.) displayed together inside a virtual store, aiding again with the utilitarian shopping experience.

5.5.3.3 Optimal Store Size Theme

Optimal Store Size is the third theme of Store Presentation title. A total of 3 comments were made by participants relating to this theme.

One of the participants (*P17*) said,

> *"Alo Yoga had a more spacious interior and a large garden. I think it was nice. In Hugo, the environment was too limited, it didn't offer a large area to walk. The products were also limited there."*

P18, who is an architect, made another comment, saying,

> *"It's similar to shopping malls. If they create a vast interior, you will feel threatened by its relative size to yourself. Areas which you cannot understand or devour quickly can lead to a felling of getting lost and smallness. The environment shouldn't be too large to damage one's feeling of self-control."*

Based on these comments, it can be argued that finding a right balance in store sizes can be crucial to aid with the overall virtual shopping experience. Although VR doesn't come with limitations such as limited store size or increased rent rates depending on square inch, it must be remembered that the store size should be

optimized. While too small environments filled with garments can create a crowded and overwhelming interior, too large spaces can become intimidating to customers. Also, traveling between two distant spaces inside a store must be done quickly so that customers can quickly complete their intended shopping tasks. Adding virtual menus or providing shortcut arrows into the environment which quickly teleport customers to distant areas of the stores can become useful in larger VR stores.

5.5.4 Results and Discussion of the Themes and Sub-themes of Product Informativeness

The fourth main title of the theme map is Product Informativeness. This topic contains three themes, (a) **Product Presentation**, (b) **Material/ Texture**, and (c) **Product Size**. Apparel shopping calls for an increased need and expectancy to gather product-related information such as its true color, size, fitting, fabric, texture, etc. Research indicates that online shoppers have higher demands on product information, product variety and specialized products (Ganesh et al., 2010). Since virtual shopping, similar to online shopping, cannot offer its customers the ability to touch products, at least with today's technology, it is of great importance that VR customers are provided with sufficient information and clues regarding the products inside a VR store.

A total of 83 comments were placed under the Product Informativeness title. Based on the comments made by participants, *360-degree Product Viewing*, *Product Placement and Angle*, and *3D Model vs Photo* became the sub-themes of **Product Presentation**. The **Material/ Texture** theme involves the sub-themes of *Informative Videos/Animations for Material/Texture Communication*, *Visual Realism and Fidelity in Material/Texture Communication* and *Filling in the Gaps: Simulation of Haptic Qualities with Other Modalities.* This sub-theme was also found to be largely linked to multimodality, a topic under the *Levels of Immersi*on sub-theme of **Immersion and Presence**. Lastly, the **Product Size** theme contains the *Seeing Products in Pass-through/MR/AR* as its sub-theme. This theme was also found

largely linked to the *Personalization and Social Interactions through Avatars* sub-theme of **Hedonic Shopping**.

5.5.4.1 Product Presentation Theme

The flexibility VR offers in terms of in-store product presentation can be considered an advantage of virtual stores. Indeed, VR can allow brands to display their products in unlimited options, even surpassing the physical boundaries of the real world. VR stores can be designed similarly to physical retail stores or can offer fantastical concepts and store interiors that are otherwise difficult to create in real life (see *Realistic vs Fantasy Store Designs* under the **Store Layout and Composition** theme). Although the environments in which products are displayed can also help with product presentation and brand image, it is also important that products are understood well by customers inside a virtual store if VR shopping aims to one day become an equivalent of, or even exceed, in-store shopping experience. Regarding the **Product Presentation** theme, a total of 33 comments were made by participants.

360-degree Product Viewing

Being able to view a garment from various angles became one of the hot topics under the **Product Presentation** theme. Several participants expressed a desire to view the apparels inside the virtual stores in 360 degrees, although neither of the two stores gave such an allowance. Some of the comments made by participants regarding this sub-theme are as follows:

- *P1*: *"In normal* (physical) *stores, you can hold a product, turn it around, see it from the back… Sometimes the back of a garment has a detail that you wouldn't like and you have to see it. When I click on it, I can only see pictures taken from a few angles…"*
- *P5*: *"I would have wanted to see the product from 360 degrees. Right now, I have to click on the plus icon to get product information but it doesn't have*

to be like so. I could rotate things even if I cannot "hold" them… I can turn clothes 360 degrees anywhere in the screen."

- *P12*: *"Can't I turn it?* (refers to the avatar in the virtual fitting mirror) *It would be nice if I could turn this."*
- *P15*: *"It would be nice if I could at least turn the avatar in the Alo Yoga store. Maybe I could use one of the hand-controllers for the swipe motion and change the clothes, and with the other hand-controller I could rotate the avatar."*

These comments show participants' expectation to view garments from various angles during virtual shopping. Indeed, being able to freely rotate a product 360 degrees inside a VR store can partially make up for the missing components of online and VR shopping compared to in-store shopping. Given that high-quality 360-degree product renders are achievable in today's technology, integration of this feature into virtual stores can help with both the utilitarian and hedonic aspects of VR shopping.

Product Placement and Angle

Product placement and modes of product display inside a store are also significant factors that need consideration while designing virtual stores. A total of 12 comments were made regarding the *Product Placement and Angle* sub-theme. The comments made by participants point to several topics related to or resulting from product placement and angle inside virtual stores.

Firstly, several participants commented on the mannequins depicted in yoga postures inside the Alo Yoga virtual store. While some participants commented by saying it helped with the perceived realism of the stores since they are also accustomed to seeing products displayed as such in physical stores, some participants made comments that the "absurd poses" were disturbing and unnatural. Similarly, 1 participant (*P3*) also made a comment regarding the virtual fitting mirror inside the Alo Yoga store by saying *"I think it was nice to make combinations in front of a mirror although the t-pose was most unnatural."*

Figure 5.20 involves screenshots taken from the Alo Yoga virtual store demonstrating the mannequins scattered inside the store with several yoga poses and the “unnatural” pose of the avatar in the virtual fitting mirror.



Screenshots taken from the *Alo Yoga virtual store by Obsess*

Figure 5.20. Screenshots taken from the Alo Yoga virtual store, showing the mannequins and avatar in the virtual fitting mirror.

The comments made by participants reveal that participants can favor natural-appearing poses, or even scenes, in virtual stores despite the limitless display options VR can offer. This can be explained through the Uncanny Valley phenomenon, which is explained more elaborately in Chapter 2 of this thesis. Further, several participants made comments in favor of the mannequins inside the Alo Yoga virtual store. They said that the fact that real-world stores also use mannequins to display products helped with the reality of VR stores. This can be explained with familiarity and skeuomorphism.

Further, comments were made by participants regarding display and location of products inside a store. *P2* made a comment saying,

> *“Alo Yoga felt more like a store. Maybe because of the way they hung clothes in the display areas. I could also partially see products from several angles*

inside the store. In Hugo, I couldn't see the back sides of any of the products because of their placement and angles."

Similarly, *P3* said,

"In Hugo Boss, I realized there were bags behind the glasses only after several tours. It is important that all products can be found easily inside a store."

These comments show the importance of product location and placement inside the virtual stores. Placing 3D renders of products inside the store in places which VR users can approach from various angles can help them explore the product from various angles. It is also crucial that all products inside a store are placed at visible and easy to find places so that customers do not miss any of the products when walking inside the VR store.

P15 made a comment saying, *"The products inside Alo Yoga were too small. In Hugo, there were too few products."*. *P17* made another comment regarding the Hugo Boss virtual store; *"It's as if they randomly scattered products inside a house."*. These comments show that the distance of product displays must be well balanced in relation to the POV of users. Further, product displays which showcase multiple products in an organized manner inside a store can also positively influence the VR shopping experience.

3D Model vs Photo

Regarding the product presentation (3D model vs photo), 4 comments were made by participants, some of which are shared below:

- *P13*: *"In fact, Boss has better visual fidelity, but they look like high-quality pictures. In Alo Yoga, the products and the décor objects are 3D modeled. I think it helps, I think they should be modeled."*
- *P13*: *"In Alo Yoga, the products look like papers. The environment looks more 3D, but not the products…"*

- *P17*: *"In Alo Yoga, some products were 3D, and some were 2D. I think they all should be the same."*

Based on these comments, it can be argued that 3D models can help with the perceived realism of virtual stores as well as products, aiding, thus, with store and product understandability. Consistency between different products' presentations is also expected by customers; all products inside a VR store must be modeled in same quality, appearing 3D rather than 2D. Further, a comment made by P8, which is placed under the theme **Product Presentation**, and found to be linked to the product understandability, suggests that seeing products in volume can help with the understandability of the garments.

5.5.4.2 Material/Texture Theme

It is important that the VR store conveys the material and texture of apparels inside a VR store to customers in one way or another. Indeed, if VR stores can manage to clearly represent the fabric and material of garments, they can hold a tremendous advantage compared to online, maybe even physical, shopping. A total of 22 comments made by participants were found to be linked to the **Material/ Texture** theme.

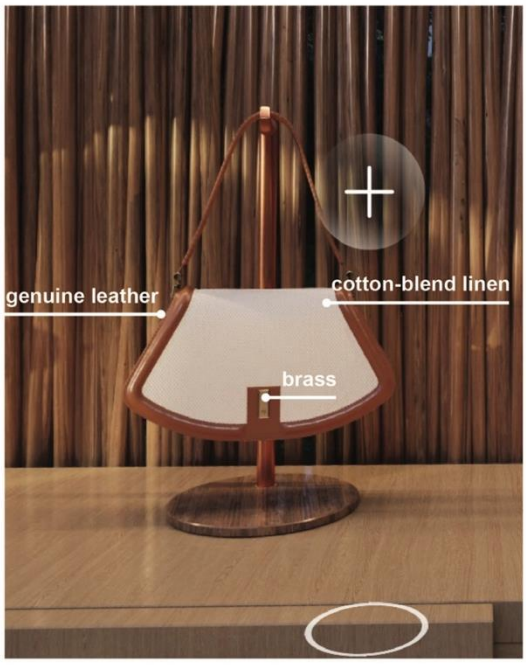
Informative Videos/Animations for Material/Texture Communication

Informative videos and animations can help with product informativeness in general, as well as materials and fabrics. Several participants made comments on the videos embedded inside the Alo Yoga virtual store, saying that watching 2D videos inside a virtual environment helped with immersion into the VR. Indeed, such videos can be taken advantage of both to increase immersion and to inform customers about product qualities without embedding complex information to the virtual environment itself. *P16* made a comment saying fabric stretching videos or GIFs showing fabric's motion could help with the understandability of fabric qualities. *P7*, on the other hand, said material information could appear when products are clicked on. Indeed,

apparels and accessories inside a virtual store can be modeled in 3D. When users of VR click on the products, the materials of the product can appear in the 3D environment, thus quickly conveying the product information to customers. Further, a customization option can be integrated through which customers can click on a specific material on a given product, scrolling down from a menu to choose which material they would want to replace the chosen part with. Figure 5.21 involves a screenshot taken from the Hugo Boss store, edited by the author in Adobe Illustrator, to help visualize how material information can be shared on the product itself inside a virtual environment.



Screenshot taken from the *Hugo Boss virtual store by Emperia VR*



Screenshot taken from the Hugo Boss virtual store, *edited by author*

Figure 5.21. Screenshot from the Hugo Boss virtual store, edited by the author.

Visual Realism and Fidelity in Material/Texture Communication

It is without doubt that the visual quality of products placed inside a virtual store plays a crucial role in the communication of product-related information to customers. Several participants mentioned the importance of visual realism and fidelity of the depicted products inside a virtual store. *P1*, for instance, made a comment on the significance of material understandability in an apparel shopping experience. They said that they especially observed both the products and the environment itself in terms of texture and found that the floor, walls and products didn't have bump maps or textures incorporated into them. Further, the same participant also made a comment on the perfume bottles displayed in the Hugo Boss store saying that the bottles appeared to be made of "cheap plastic". Indeed, it can be argued that especially for VR stores and brands which aim to create a rather exclusive experience for their customers must care for the quality of materials being conveyed accurately to the customers. Figure 5.22 involves a screenshot taken from the Hugo Boss store's product display area filled with the perfume bottles mentioned by *P1*.

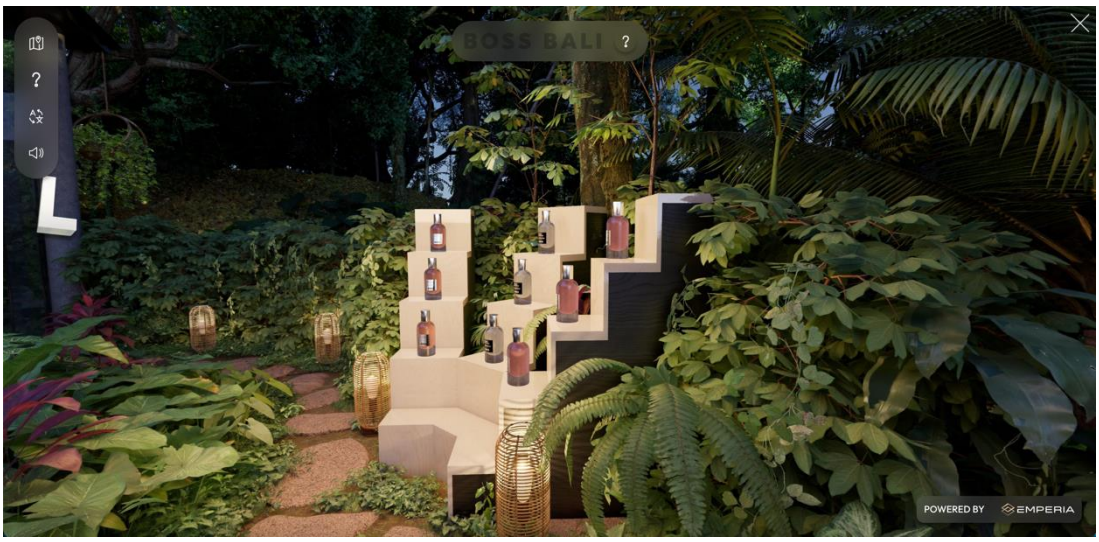
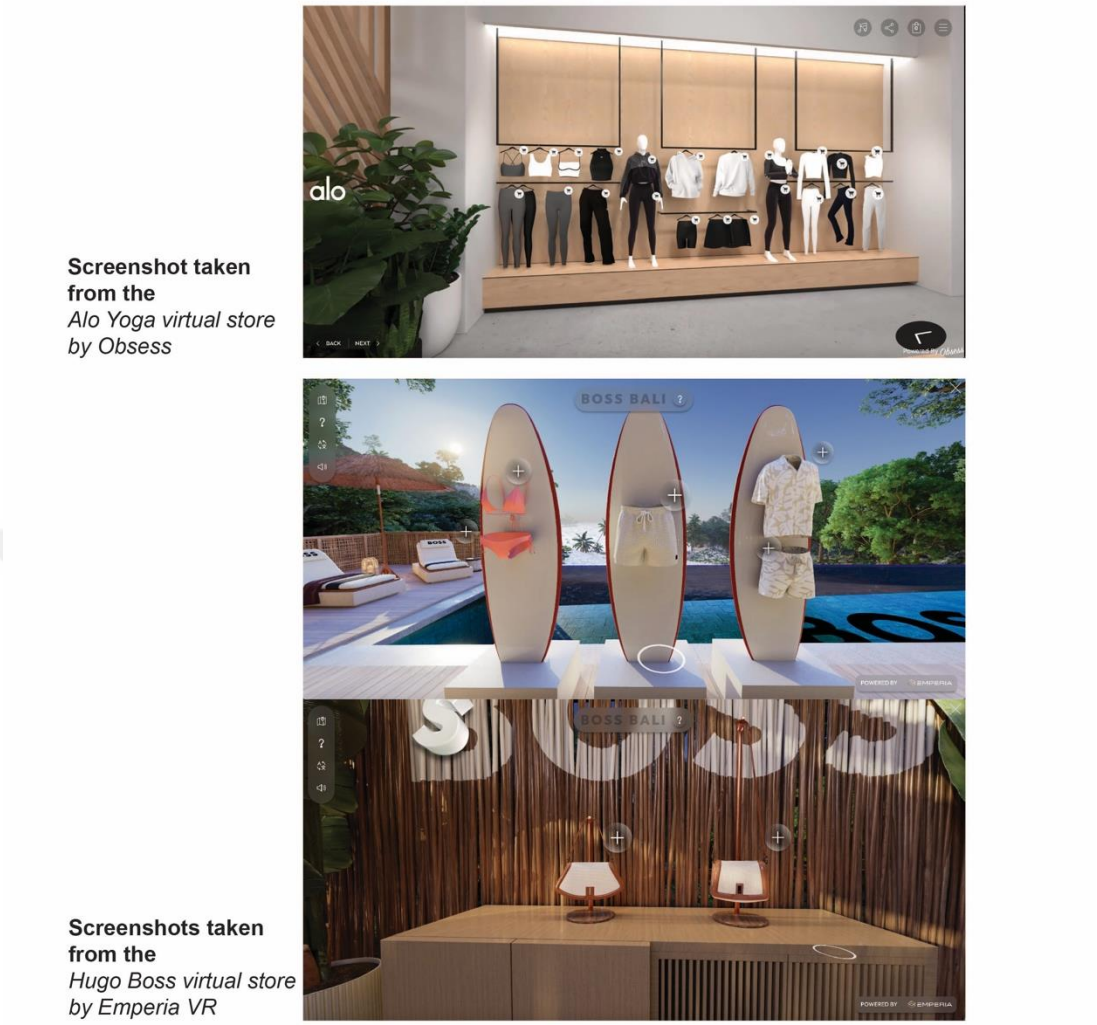


Figure 5.22. Screenshot taken from the Hugo Boss virtual store, showing the perfume display area.

P4 also said that if graphics of VR store can be enhanced to convey the "feeling" of apparels' materials, the deficiency of touching garments can be compensated for to a certain degree. *P6* mentioned that the textures of all garments inside the Alo Yoga store looked the same, making it difficult to understand fabric qualities and make comparisons between different products. Similarly, the same participant said that the same thing held true for the Hugo Boss store, where the swimsuits and the handbags placed inside the store appeared as if they were made of the same material. *P16* made a comment saying that, as it is, VR stores appear to have "taken a step back" compared to online stores in terms of material understandability. This suggests that 3D models of garments must efficiently present the material and texture of apparels, thus better aiding with product understandability. Figure 5.23 involves screenshots from both of the virtual stores, demonstrating the products displayed inside the VEs.

One comment made by *P10* was that being able to see product information regarding its material is something they favor in online shopping since they don't take the time to read the fabric details written on product labels when shopping in physical stores. They said they liked that Alo Yoga store also presented clearly the material information of each product in the information pop-up windows.

Several participants also commented by saying the zoom-in feature in VR could be used to show the fabric details in close-up. Indeed, various means of including close-up details of garments can be adopted in virtual reality systems to help customers understand the material and texture of products.



Screenshot taken from the *Alo Yoga virtual store by Obsess*

Screenshots taken from the *Hugo Boss virtual store by Emperia VR*

Figure 5.23. Screenshots from Alo Yoga and Hugo Boss virtual stores, showing product displays.

Filling in the Gaps: Simulation of Haptic Qualities with Other Modalities

The human imagination can be used to fill in the gaps inside a VR experience. Further, humans are capable of abstract thinking and taking references from past experience and previous knowledge to match a given context to make sense of it. Indeed, subtle clues offered in VR stores can help customers mentally simulate the haptic qualities of garments. For instance, visual details demonstrating fabric movement such as animations or motion videos, realistic renders and shadowing on products, sounds embedded inside a VR to give a sense of fabric material, or close-

up pictures of garments can help convey to customers the material and texture of apparels offered inside the store. Avatars dressed up with the apparels offered inside a VR store can also walk around inside the store to demonstrate fabric behaviors. This can help not only with product informativeness but also with the hedonic shopping experience in VR. Further, a comment made by P16 under *Customer Creativity*, regarding the non-consequentiality of VR mentioned their wish to be able to stretch the garments inside a virtual store to understand its fabric qualities. Similarly, P7 said it would help if they could "virtually touch" the garments, and the garments made a movement in return. The motion of the movement could help understand whether the fabric is a heavy or light material, etc. Indeed, such interaction with clothes in VR can also help customers "fill in the gaps" and understand the fabric qualities when shopping for apparels.

5.5.4.3 Product Size Theme

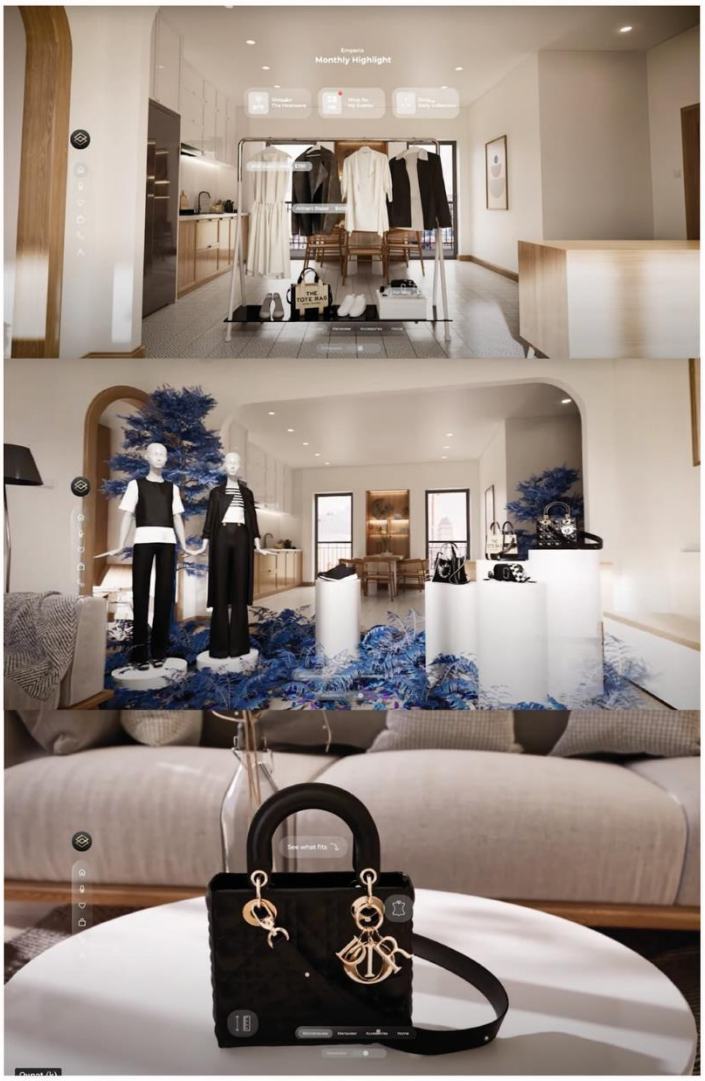
Understanding the product size and fit is important in apparel shopping. Although customers can not physically try on product in a virtual store, personalized avatars and seeing products in see-through, MR or AR can help customers make guesses about the sizes of garments. A total of 29 comment were made by participants regarding the **Product Size** theme, showing the high expectation of customers to understand the sizes of products when shopping.

Seeing Products in Pass-through/MR/AR

As was mentioned in Chapter 4 (Methodology) of this thesis, the participants of this research were presented with a video provided by Emperia VR showcasing how virtual reality can work for apparel shopping. Upon spending 15 minutes each in the VR stores of Alo Yoga and Hugo Boss, and then watching the video provided by Emperia VR, several participants made comments regarding the pass-through, augmented and mixed reality features in the context of VR apparel shopping. Figure 5.24 involves screenshots from the mentioned video.

Many of the participants made comments based on the mentioned video, saying that seeing products in pass-through can help with understanding the relative size of products compared to their physical environment, thus aiding with product understandability. Further, one participant made a comment saying that they try garments on in physical stores before making a purchase to see whether the color of the fabric will match their skin tone. They added that seeing products reflected on their body with augmented reality could be useful to make up for this deficiency in VR, creating an advantage over online shopping.

Further, a lot of comments were made by participants regarding the use of avatars to understand the product size. Participants made comments on the understandability of product sizes in relation to décor objects and avatars/ mannequins inside a store. For example, *P11* said, *"They placed this mannequin on the yoga mat, which gives clues to the user regarding its size."*. Indeed, inclusion of details that users are familiar with (based on their real-world experiences) can help them understand relative sizes of products inside a virtual store. If the VR store cannot give its users the ability to see products in pass-through, try them on with AR or virtually hold them with their avatar hands inside the VR, using representative bodies inside the store to help compare product proportions can come useful. Moreover, many participants made comments regarding personalized avatars, suggesting that customizing the avatars based on their bodily measurements can help understand the product size and fit.



Screenshots taken from the video provided by Emperia VR, *showcasing MR where products can be viewed in see-through feature*

Figure 5.24. Screenshots taken from the video provided by the Emperia VR company, showcasing a mixed reality where products can be viewed in see-through mode of VR glasses.

Lastly, some participants made general comments regarding the Product Informativeness title. Based on these comments, it can be said that

- Adding customer comments and videos/animations showing production methods of products can be integrated into VR to help with utilitarian and hedonic needs of shoppers.

- Some participants also stressed the importance they give to sustainability in apparel shopping. They said that information regarding the sustainability of products can also be added for brands who follow sustainable production methods.
- When making product combinations on an avatar inside a VR store, the background can compete with the visuals of garments. Participants can be taken to a different place or the background can be muted when customers want to make outfit combinations or product comparisons.

5.6 Summary of Design Insights

Table 5.1 includes a table showing the design insights regarding each theme and sub-theme based on the analysis of data.

Table 5.1 Summary of Design Insights

THEME	SUB-THEME	DESIGN STRATEGY
Use and Usability	*Interaction and Interface*	• *Active involvement:* Holding garments, rotating products 360 degrees, interacting with gestures rather than clickable icons. • *Ease of interaction:* Gesture/voice-commands for certain tasks, virtual cues that are easy to click, making the areas near virtual cues senstive to user selections. • *Realness of interactions:* Using unrealistic interactions such as zooming into products or instant teleportation inside the VE only for utilitarian tasks to avoid killing the "realness" of the VR experience. • *Natural vs novice interaction means/ Intuitive interactions:* Natural interaction means that users are familiar with from real-life and 2D digital world experiences (e.g. scrolling, zoom in gestures, etc.). • Novel interfaces that don't directly duplicate desktop/mobile interfaces (e.g. Product-related information can be given inside the 3D VE, without using 2D information windows similar to mobile interfaces). • *Responsiveness and speed:* Predictable, non-dramatic feedback and responses that are in synchrony with user's interaction. • *Temporal aspects:* Giving users enough time to make selections inside a disappearing menu. Opening disappearing menus/icons with multimodal inputs such as voice commands and gestures. • *Interaction for navigation:* Using thumbsticks of hand-held controllers to walk rather than restricting users to virtual arrows for navigation.
	Understandability/ Learnability	• All shopping-related activities including the purchase must be done inside the VE (without taking users to brand's website). • *Visibility of products inside a store:* Crowded interiors and bold decor which overshadow the products must be avoided. • Giving users the ability to quickly scan/go through products, explore alternative colors of garments, etc. • The "Change Rooms" menu can offer the names of the products rather than names of the rooms to help customers find what they are looking for. • *POV adjustment for observing products from the best angle:* When products or navigation arrows are clicked on, users must be taken to an optimum angle and distance to help them observe the intended product. • *Customization:* Giving users customization options such as turning on/off store music.
	Navigation and Movement	• *Naturalness of travel motions:* Avoiding navigation motions such as "being dragged" to different places or being instantly teleported to different spots inside the VE. (Teleportation to distant places inside a VE for quick navigation can be done with a different input from the user) • *Interactions with virtual navigation cues:* Increased number of arrows and paths to travel if a total freedom of movement inside the VE cannot be given to users. • Getting rid of virtual cues/navigation arrows that produce "meaningless" results for users. • Respecting the POV of users after navigation to avoid a loss of sense of surroundings.

Table 5.2 Summary of Design Insights (Continued)

THEME	SUB-THEME	DESIGN STRATEGY
Utilitarian Shopping	*Task Fulfillment and Speed*	• High-fidelity and realistic product renders that accurately represent the details of products. • Interactable products (e.g. rotation, fabric stretching, etc.). • *Quick product scanning:* Product displays must contain adequate number of products side by side to allow for instant product exploration and comparison. • Product-related information must be given inside the VE (without taking users to brand websites).
	Product Variation	• The virtual store must present an adequate number of products to users.
	Search/Filter/Order	• Integrating search/filter/order features into virtual stores (the interfaces of these features can be novice to VR rather than duplicating mobile/desktop interfaces).
	Product Comparison	• Users can dress multiple avatars side by side to try different combinations and compare different products. • Users can drag/carry garments to a different/specialized location inside the store and observe them together/side by side to help with product comparison and outfit combination.
Hedonic Shopping	*Customer Creativity*	• Making outfit combinations in pop-up windows, on avatars or mannequins inside a store any time during the shopping. • Muting the background during virtual fitting in order to avoid distraction. • *Virtual fitting and virtual teleportation:* Users can teleport their avatars to different VEs (such as a beach party or night club) to see whether an outfit will "fit" a certain occasion. • Product displays inside the store can show garments in combination. • *Product modifications and product customizations inside the virtual store:* Making modifications/customizations on virtual products such as cutting/adding initials/etc.
	Experience of the Store Concept and Ambience	• *Sensory richness:* Relaxing and lively virtual stores. Avoiding dark color palettes and crowded interiors. Adding motions to the still images and objects inside the virtual store. Avatars can move inside the virtual store to create alive environments. • *Flow and continuity of the shopping experience:* Product or brand-related animations/videos can be embedded into virtual stores to keep customers intrigued.
	Gamification	• Collaborative outfit combinations, virtual runway shows, product modification competitions, avatar make-overs, sharing outfit tips with other customers, product customization, brand-related quizzes, etc.
	Personalization and Social Interactions through Avatars	• *Virtual fitting on customized avatars:* Customizing avatars based on body measurements and physical attributes of users. • Virtual fitting mirrors/avatars that correspond the bodily gestures of users (when standing in front of the mirror). • *Information sharing and getting assistance from avatars inside a virtual store:* VR customers can get outfit suggestions or product-related information from the assistant avatars inside a store. They can be given information on which physical stores they can find a certain product. • Specialized compartments inside virtual stores for customers to socialize (through avatars).

Table 5.3 Summary of Design Insights (Continued)

THEME	SUB-THEME	DESIGN STRATEGY
Store Layout and Composition	*Virtual Cues, Maps and Menus*	• *Bird eye view of stores:* Users can see the store layout with a bird eye view when they want. They can also make selections from the bird eye view layout to virtually teleport inside the VE. • Virtual cues, maps and menus to help with way-finding, product-finding and fast transportation inside a virtual store. • Using virtual landmarks that are visible from all areas of the virtual store (e.g. brand's name/a clear entrance door/etc) to help with way-finding. • Using virtual signs that are similar to signs used in physical stores (e.g. on the walls of a virtual store) to help users locate a specific product category.
	Realistic vs Fantasy Store Designs	• Customers can choose the store setting (e.g. realistic store setting vs. fantastical store setting- shopping underwater/ on a different planet/ etc.).
Compartmentalization	*Contex-based Compartment.*	• Reflecting the context of product inside the stores (e.g. winter clothes can be displayed with a winter-theme, sportswear garments can be displayed with a sports context, etc.).
	Product-based Compartment.	• Displaying the products that belong to the same category/collection together. • Compartmentalizing virtual stores based on product categories.
Optimal Store Size	N/A	• Avoiding the feeling of being trapped inside a store and offering users a large enough space to walk in and explore products. Avoiding large interiors so that users don't get lost inside the store.

Table 5.4 Summary of Design Insights (Continued)

THEME	SUB-THEME	DESIGN STRATEGY
Product Presentation	*360-degree Product Viewing*	• 3D models of garments for users to rotate 360-degrees. • Turning avatars around 360 degrees during virtual fitting to observe outfits from multiple angles.
	Product Placement and Angle	• Placing products in angles that allow for adequate product understandability by just looking. • Allowing customers to approach products from multiple directions/ angles. • Natural-appearing mannequins and avatars to avoid the Uncanny Valley phenomenon. • Placing product displays at visible parts of a virtual store. • Placing products display areas at an optimum distance from the VR user and in an optimum size.
	3D Model vs Photo	• All products placed inside a VE must be presented similary (i.e. all 2D pictures or all 3D models). • The 3D renders of products and real-life pictures of the product (which appear when a product is clicked on) must be consistent to ensure customer trust.
Material/ Texture	*Informative Videos/ Animations for Material/Texture Communication*	• Informative videos/animations to share product features. • Adding motions that show the fabric behavior. • Fabric stretching videos/ allowing customers to virtually stretch the garment/fabric. • Material information appearing on a 3D product render(see Figure 5.21).
	Visual Realism and Fidelity in Material/Texture Communication	• High-fidelity 3D models that reflect the material/texture of garments (users must be able to recognize different materials/textures from a distance inside the VE). • Zooming in to products to see high-fidelity close-up pictures/texture of garments.
	Filling in the Gaps: Simulation of Haptic Qualities with Other Modalities	• Adding fabric sounds. • Avatars dressed up in stores can walk inside a virtual store to demonstrate fabric behaviors.
Product Size	Seeing Products in Pass-through/MR/AR	• Observing the products of a virtual store in pass-through/AR mode to compare their sizes to the objects in the physical environment. • Users can try products of a virtual store with AR mode of virtual glasses. • Avatars and decor objects can be used in virtual stores to help customers compare the relative sizes of products in relation to the sizes of objects they are familiar with from real life.

CHAPTER 6

CONCLUSION

The aim of this thesis was to explore the potentials of VR to design immersive and engaging apparel shopping experiences. For this aim, the research questions were constructed in a way that would allow to define the dimensions and design strategies that can be taken to create immersive and engaging shopping experiences through VR, based on the hedonic and utilitarian needs of apparel shoppers. To form a better understanding of the dimensions and challenges regarding VR apparel shopping, a literature review on VR and shopping experience was made, based on which the methodology of the research studies and the data analysis of the research were structured.

In this chapter, an overview of the thesis will be given, offering a short summary of the literature review, and summarizing the methodology and data analysis of the research. A list of themes and sub-themes will then be shared, after which the research questions which inspired and initiated this research will be re-visited. Answers will be given to the research questions grounded on the collected data and the gathered results. Limitations of the current study and potential directions for future studies regarding apparel shopping experiences through virtual reality will also be shared in this chapter.

6.1 Overview of the Thesis

6.1.1 Main Insights Gathered from the Literature Review on Virtual Reality

This section will present a brief summary of the Chapter 2 of this thesis, mentioning some of the noteworthy insights gathered based on literature review regarding VR. First and foremost, virtual reality offers its users a digitally constructed world, simulating environments and experiences different than users' physical surroundings

and current physical activities. It aims to immerse people into alternate realities, blocking out the elements occurring in their physical environments.

Our perception of reality is constructed both by the sensory inputs we receive from the world surrounding us (be it a physical or digital surrounding), and based on our previous knowledge and past experiences (Frith & Dolan, 1997). Moreover, our minds are capable of abstract thinking (Stanković, 2016) and filling in the gaps, thus making heuristic guesses when sensory input is missing or insufficient (Frith & Dolan, 1997).

There are two ways in which one's perception of reality can be altered; by tricking the mind (e.g. through psychedelic drugs, alcohol, hypnosis, etc.) or by tricking the senses (Stanković, 2016). VR aims to alter users' perception of reality through senses, offering them digitally simulated environments to make believe they are present in the digitally depicted environment.

Presence and immersion in VR are closely linked to each other, with the former relating to a rather psychological state, described as the feeling of "being there" (Slater & Wilbur, 1997), and the latter depending largely on technological capabilities and restrictions. Since humans perceive reality with all their five senses, multimodality, along with surroundness, vividness, inclusiveness and extensiveness (Slater & Wilbur, 1997) are factors that affect users' immersion into a virtual environment. Virtual environments can be non-immersive (e.g. desktop-based VEs), semi-immersive (e.g. CAVEs or other world-fixed virtual environments), or fully-immersive (e.g. VEs experienced via HMDs) (Gutiérrez et al., 2008).

Interaction is another key feature of VR (Kim, 2005; Stanković, 2016; Sherman & Craig, 2019). Users of a virtual reality can interact with a VE by creating a change in their environment, or by changing their POV inside the environment (Sherman & Craig, 2019). Navigation, making selections and manipulating objects inside a VE can be listed as some of the means of interaction users can perform inside a VE.

Imagination is another key contributor of VR. A virtual reality should aim to make its users both perceive and believe in the alternate reality being depicted (Stapleton & Davies, 2011). The suspension of disbelief (i.e. when the user of VR chooses to replace what they know to be real, and believe, instead, in an alternate belief system)

plays a crucial role in the effectiveness of a VR system (Stapleton & Davies, 2011). This is exactly where imagination in VR comes into play, allowing its users to fill in the gaps which may occur in a virtual environment, thus believing in the digitally presented reality.

6.1.2 Main Insights Gathered from the Literature Review on Shopping Experience

This section will provide a summary of the Chapter 3 of this thesis, touching upon some of the findings of the literature review regarding shopping experience.

As was mentioned more elaborately in Chapter 3, the shopping experience has both a utilitarian and a hedonic value embedded into it. The utilitarian value of shopping deals with the instrumental outcomes of shopping, focusing extensively on the goal-oriented and purpose-driven aspects of shopping. It focuses on efficiency, functionality and fulfillment of customers' needs when shopping. A utilitarian value in shopping can be gained both through store and product value (Diep & Sweeney, 2008). The utilitarian store value can be increased through an adequate range of products, easy access to products and convenient opening hours (Diep & Sweeney, 2008). Similarly, the utilitarian product value can be improved if the purchased product fulfills the performance and quality expectancy of customers (Diep & Sweeney, 2008).

The hedonic value of shopping, on the other hand, deals rather with the experiential and pleasure-driven sides of shopping, such as the flow of experience, fun and enjoyment received by customers during the shopping experience. Aesthetic appreciation, social interaction, involvement, fantasy fulfillment and escapism can be counted amongst some of the factors which can elevate the hedonic aspect of shopping (Hirschman & Holbrook, 1982; Babin et al., 1994; Davis & Hodges, 2012).

Research shows that failing to fulfill the utilitarian needs of customers can lead to anger, while failing to meet their hedonic expectations can lead to customer dissatisfaction (Chitturi et al., 2008). Hence, both utilitarian and hedonic aspects of shopping need be considered when designing shopping experiences for customers.

The shopping environment plays a crucial role on the perceived utilitarian and hedonic values of shopping. Store ambient colors, store lighting, music, scent, efficiency/convenience and social conditions can be counted amongst the factors which affect customers' purchase decisions, patronage behavior and time spent inside the store (Moye & Kincade, 2002).

Further, there can be listed a variety of factors which motivate people to shop. Diversion from daily routine, performing physical activity, following and learning about trends, sense of belonging to a group, gaining status, authority, and pleasure of bargaining can be listed as some of the personal and social shopping motivations (Tauber, 1995).

In the case of online and VR shopping, utilitarian and hedonic aspects of shopping also play significant roles. Research shows that online shopping is preferred mostly for search purposes (Zhai et al., 2017), while the frequency and time spent in online stores can be increased by integrating hedonic values into online stores. Interface, usability, enjoyment and customer trust play important roles in customers' attitudes towards online shopping (Hirst and Omar, 2007).

Virtual reality shopping, on the other hand, holds the potential to one day bridge the in-store and online shopping experiences. Indeed, VR shopping is believed to one day extend beyond physical shopping stores (Xi & Hamari, 2021) since it has the potential to offer more utilitarian and hedonic shopping experiences to customers. Research indicates that a heightened level of presence inside a virtual store can make customers believe they are better informed about products (Papagiannidis et al., 2017). Further, immersive VR stores can enhance the emotional responses of customers, thus fulfilling their hedonic expectations, leading to an increase in the time spent in stores (Ricci et al., 2023). An heightened feeling of presence inside the VR store, interaction and customer creativity can be exploited to turn virtual shopping experiences into an advantage over online (and maybe one day physical) shopping.

In the context of apparel shopping, VR can be used to make up for some of the deficiencies of online stores. First, VR can help brands create more meaningful and fun shopping experiences for their customers (Kniazeva et al., 2024), potentially

triggering curiosity and customer creativity, thus strengthening the relationship between brands and customers. It can also help brands to reach out to younger generation customers, helping them expand their target markets (Kniazeva et al., 2024). Virtual product fittings, socializing with others through avatars, product co-creation can be listed as some of the features that can elevate the shopping experience in VR. Further, integration of virtual reality technologies and multimodality can help customers to "fill in the gaps", aiding them to imagine the haptic qualities of garments, thus compensating partially for the inability to touch products during online shopping.

6.1.3 Research Sessions

This section briefly summarizes the methodology of research sessions conducted as part of this thesis, which was mentioned elaborately in the Chapter 4 of this thesis. The research was conducted with 18 participants, 9 of whom were students studying a field of design, and 9 of whom were professional designers currently working in various sectors. The venues used for the study sessions were the BILTIR-UTEST (Product Usability Testing Unit) at METU Faculty of Architecture, and a study room in TED University. The Meta Quest 3 VR headsets by Reality Labs were used for the research sessions of this thesis.

The research sessions included 5 activities. First, the users were introduced to a fully-immersive virtual environment created by Meta and were asked to spend a few minutes there to get a better understanding of immersion. Participants also interacted with the fitting mirror inside the Meta Universe, customizing their avatars. Then, users were asked to spend around 15 minutes each in the virtual stores of Alo Yoga and Hugo Boss. As was mentioned earlier, the virtual stores that could be explored with the Meta Quest 3 were semi-immersive, meaning that the environments didn't surround the user in 360 and didn't allow for unlimited means of interaction. After the stores were discovered by participants, they were shown a video provided by the Emperia VR company, showing full potentials of virtual reality for apparel shopping. After these 4 activities, participants were asked several post-interview questions regarding their shopping experience in VR. The post-interview questions had been constructed based mostly on literature review, with reference to the Presence

Questionnaire by Witmer & Singer (1998) and the heuristic evaluation method for VR by Sutcliffe & Gault (2004).

The participants were asked for permission beforehand to take voice and screen video records throughout the research sessions, which were later transcribed and analyzed by the author to discover design insights relating to apparel virtual reality shopping.

6.1.4 Data Analysis and Findings

The transcribed voice records of participants were analyzed meticulously to find relations, patterns and themes which appeared in the data. In order to make better sense of the relations between different themes and topics which emerged from data analysis, a theme map was prepared to group the themes and sub-themes, and to show the links and relations between them. After going through the data multiple times, links were revealed between several themes and sub-themes. As a result, it was decided that the themes and sub-themes could be categorized under four main titles: VR Experience, Shopping Experience, Store Presentation and Product Informativeness. While the first two main titles concentrate on the key dimensions of shopping experience in VR, the latter two reveal the key aspects of the VR store with a specific eye on the spatial design and features of the products presented. The themes and sub-themes which emerged under these four main titles based on data analysis are listed below.

Themes and Sub-themes of the VR Experience Title

- **Use and Usability:** *Interaction and Interface, Understandability/Learnability, Navigation and Movement*
- **Immersion and Presence:** *Levels of Immersion, Spatial Awareness, Imagination*
- **Usefulness and Effectiveness:** *Fitness to Purpose*

Themes and Sub-themes of the Shopping Experience Title

- **Utilitarian Shopping:** *Task Fulfillment and Speed, Product Variation, Search/Filter/Order, Product Comparison*
- **Hedonic Shopping:** *Customer Creativity, Experience of the Store Concept and Ambience, Gamification, Personalization and Social Interactions through Avatars*

Themes and Sub-themes of the Store Presentation Title

- **Store Layout and Composition:** *Virtual Cues, Maps and Menus, Realistic vs Fantasy Store Designs*
- **Compartmentalization:** *Context-based Compartmentalization, Product-based Compartmentalization*
- **Optimal Store Size**

Themes and Sub-themes of the Product Informativeness Title

- **Product Presentation:** *360-degree Product Viewing, Product Placement and Angle, 3D Model vs Photo*
- **Material/ Texture:** *Informative Videos/Animations for Material/Texture Communication, Visual Realism and Fidelity in Material/Texture Communication, Filling in the Gaps: Simulation of Haptic Qualities with Other Modalities*
- **Product Size:** *Seeing Products in Pass-through/MR/AR*

6.2 Revisiting the Research Questions

The main objectives of this study were to (i) discover the design potentials to create more engaging and simulating VR experiences, (ii) discover how design can be used to create more immersive, engaging and experiential apparel shopping experiences, and (iii) discover how the need for touch during apparel shopping can be partially contemplated for through VR apparel shopping. The research questions which arose based on the main objectives listed, which were also mentioned in the Chapter 1 of this thesis, will be answered in this section in relation to the findings of this research.

In that regard, the two research questions which initiated this research are shared one more time below.

1) What are the dimensions to consider when creating immersive and engaging (apparel) shopping experiences through VR?
2) What design strategies can be followed to meet the hedonic and utilitarian needs of apparel shoppers by using the potentials of VR?

What are the dimensions to consider when creating immersive and engaging (apparel) shopping experiences through VR?

The first research question found its answers in the Chapters 2,3 and 5 of this thesis. To be able to respond the first research question, the dimensions and heuristics related to VR were first explored in Chapter 2, which demonstrates that immersion, interaction and imagination are the three key components of a VR experience. For a full immersion to occur in VR, users must be presented with a continuous flow of plot or activity, disconnecting from their physical surroundings. *Inclusiveness* (i.e. the extent to which the physical world of VR users is blocked out), *extensiveness* (i.e. range of modalities presented to the user such as visuals, audio and haptic), *surroundness* (i.e. the field of view presented to the user such as panoramic or 360 degree view), and *vividness* (e.g. resolution, fidelity, frame rate, etc.) affect the level of immersion experienced in VR. Further, for an escalated feeling of presence to be experienced in VR, users must be able to interact with and get un-delayed response from the system. It was also mentioned in Chapter 2 that interaction in VR can occur in various forms, including *movement*, *selection*, *manipulation*, *scaling*, and *interaction via virtual menus and widget* (Mine, 1995). The means of interaction in VR can either mimic the interaction means users are familiar with from their real-world (or 2D digital) experiences, or can happen in novel, even non-realistic forms (Bowman, 2002).

Findings of the current research (see Chapter 5) are also in line with literature findings. Results of this research show that users of VR expect to more actively engage with the environment or products offered within the environment. A majority of the participants expressed their desire to interact with the garments placed inside the

virtual stores in ways that will feel more “realistic, natural and 3-dimensional”. Instead of following traditional computer or mobile interaction means such as clicking on products, users expressed an expectation to see novel and real-life like interaction modes, such as virtually holding the garments, rotating them 360 degrees and walking inside the stores (rather than being instantly teleported to different locations inside the store). Intuitiveness of interactions also appeared as an important topic based on participant comments. Indeed, participants expressed a feeling of “happiness” when they discovered how to interact with the objects in the VE or the interface of the VR on their own.

Further, a majority of participants mentioned that reaching the virtual stores through a browser, thereby viewing them on a “screen” inside the VR decreased their sense of presence. However, they also mentioned that opening the browser inside the fully-immersive Meta Universe, alongside the videos embedded in the Alo Yoga store helped with immersion into the virtual stores. Participants said that watching videos inside a virtual store escalated the feeling of being inside a digitally constructed world, thus helping with immersion. Moreover, comments were made on the graphic qualities of the virtual stores. Participant comments show that 3D models, compared to 2D images of products and panoramic pictures to depict the store, can help with the perceived realism of stores. However, participants also declared that understanding that the environment is a digitally modeled one can keep reminding them that “it is a just project”. Hence, there exists a need to realistically depict both the virtual store and the products inside the store with high-fidelity and realistic 3D models. An increased visual realism and increased fidelity of the virtual stores and of the products can help escalate the feeling of presence inside the VR. Furthermore, multimodality was also found to affect immersion, falling in line, again, with literature findings. Participants mentioned that the background music and brand-related videos embedded in the virtual store helped them get carried away in the VR. Further, participant comments revealed that integration of features such as fabric sounds, videos showcasing fabric behavior, and means to virtually interact with the garments (e.g. virtually stretching the fabric of a garment) can help users imagine the fabric of products, thus compensating, to a certain extent, the need to touch the product, which is also missing in online shopping.

Next, chapter 3 of this thesis highlighted some of the pivotal factors affecting the shopping experience. First, it was mentioned that both utilitarian (i.e. goal-oriented) and hedonic (i.e. experience oriented) aspects of the shopping experience need to be considered in order to fully satisfy a customer (Chitturi et al., 2008). Literature findings demonstrate that the range of products offered in a store, ease of access and ease of navigation within a store can affect the perceived utilitarian value of shopping (Diep & Sweeney, 2008). Further, store aesthetics, social interaction, sensory stimulation, and excitement are some of the factors which affect the hedonic value of shopping (Hirschman & Holbrook, 1982; Babin et al., 1994; Davis & Hodges, 2012). Customer creativity, ambient cues (e.g. music, scent, lighting, etc.), store décor (Fiore & Kim, 2007), and multimodality of the shopping experience (e.g. haptic cues inside the store, ambient music, store odor, etc.) (Moye & Kincade, 2002) are also critical factors affecting the hedonic value of shopping.

The findings of the current study demonstrate that the perceived value of shopping in VR is also governed by similar principles to in-store shopping. First, participants of this research stressed the importance of quickness during VR shopping. Multiple participants compared the ease of searching for products and the quickness of online shopping to their VR shopping experience, demonstrating the importance of easy task fulfillment and speed of shopping for customers. Further, multiple participants commented on the product variation inside the VR stores, suggesting that a VR store must present an adequate range of products in order to make the shopping experience meaningful and time-worthy. Ease of locating products inside the store, ease of navigation and way-finding were also topics participants made multiple comments on. Participants expressed that the difficulty they encountered when navigating inside the VR stores interrupted the flow of their VR shopping experience, thus also decreasing the experiential side of VR shopping. Further, multiple participants commented on the compartments offered in the VR stores they visited, showing that while product-based compartmentalization affects the utilitarian shopping, context-based compartmentalization influences both the utilitarian (i.e. understandability of product qualities) and the hedonic (i.e. narrative and flow) aspects of shopping.

Next, participants made noteworthy comments on the aesthetics, layout and décor of the virtual stores visited in the research sessions. The results of the research indicate that virtual shoppers expect to see more "alive", relaxing and understandable environments. Indeed, participant comments demonstrate that understandability of the store layout, size of the store, colors used inside the virtual stores and décor have significant influence on the perceived value of VR shopping. Social interaction, product customization and a more interactive shopping experience were also amongst the expressed expectations of participants during VR shopping.

What design strategies can be followed to meet the hedonic and utilitarian needs of apparel shoppers by using the potentials of VR?

The second research question found answers in Chapters 3 and 5 of this thesis. It was mentioned in Chapter 3 that consumers have an increased likelihood of purchasing from retailers who allow their products to be touched (Grohmann et al., 2007). Indeed, haptic evaluation of products (Grohmann et al., 2007) and tactiles inside a store environment (Jha et al., 2020) affect the decision-making of customers. One tremendous advantage of physical apparel stores compared to both online and virtual stores is the ability to touch the garments, thus getting a better understanding of the fabric quality. This shows the importance of not necessarily the activity of touching the products, but more importantly the significance of understandability of products when shopping for apparels. Indeed, understanding the material and texture of garments is an important expectation of apparel shoppers. Participants of this research also made several comments on this issue, saying that the integration of fabric sounds to communicate its material, animations demonstrating the fabric behaviors and high-fidelity close-up pictures showing product details can help with the understanding of product materials.

Further, several participants mentioned their typical in-store apparel shopping behaviors during the post-interview questions, stressing mostly the significance of rotating garments and observing products from various angles. Multiple participants expressed a desire to see the "back" of a garment when shopping for apparels.

Similarly, participants highlighted the importance of observing products from various angles, the ability to rotate them 360 degrees and understanding the sizes of products when shopping in VR. On that account, participants made comments indicating that seeing products in pass-through or AR mode as well as comparing the sizes of virtual garments to the objects, décor and avatars inside a VR store can help to understand the product size. Participants also stressed the importance of "fitting", not merely to make outfit combinations but also to understand how the garment will fit their bodies. They mentioned that customization of avatars inside a VR store based on the physical attributes of VR users can help better visualize how a garment will fit their body.

Other important topics mentioned by participants regarding their in-store apparel shopping behaviors include the ability to locate products inside the store, the ability to scan multiple products quickly and the ability to make outfit combinations. Several participants said that instead of context-based compartmentalization, product-based compartmentalization can be adopted in VR stores, thus aiding with locating of products. Further, they favored the display of products inside the Alo Yoga store, which showcased multiple products side by side, thus making it easier to observe a multitude of products quickly. Participants also said that the displaying of tops and bottoms together, as well as the mannequins dressed with matching clothes inside the Alo Yoga store, helped with mental outfit combinations.

Lastly, several participants made comments indicating that the experiential side of VR shopping can be used as a tremendous advantage over online shopping, if the overall flow, continuity, visual realism, ease of interaction and navigation, as well as product understandability in VR can be implemented sufficiently. Several participants made comments indicating that if they could observe and interact with the garments inside a VR store more 3-dimensionally, virtual shopping could extend beyond online shopping. Indeed, an increased immersion, a continuous flow of shopping, a heightened understandability of products, socialization through avatars, games, contests and workshop classes integrated into VR stores, product fittings and outfit combinations can encourage customers to spend an increased amount of time in virtual stores compared to online (or even physical) stores.

6.3 Limitations

The studies of the research required a pre-examination of the existing VR shops and VR apparel shops in order to find the virtual store(s) that could be used for this research. First, the Meta Quest application store (i.e. Meta Horizon Feed) was searched in order to find a fully-immersive virtual store that could be used for the studies of this research. Two apps were discovered during this search:

- Shop R
- I Shop Meta

Although the two stores are fully-immersive (i.e. offering a 360 degree field of view) shopping malls that allow for navigation within the VE and respond to the bodily gestures of the users to a certain degree, there were certain factors that prevented the use of these stores for this research. First, the Shop R application doesn't offer any apparel products, thus making this application irrelevant to the aim and scope of the research in hand. Second, during the pilot study made prior to the research studies, the participant (as well as other people who were informally asked to try this app with the VR headset) reported simulator sickness (SS) during and after the use of the Shop R application. The Shop R application was thereby decided to not be used in the studies of this research. The second fully-immersive shopping mall found on the Meta Horizon Feed (i.e. I Shop Meta), on the other hand, offers no products to observe or interact with other than one sneaker located in one of the virtual stores. The sneaker doesn't allow for user interaction but is solely for observation. Since all the stores within this mall are mere virtual spaces with no products to observe or shop, this application was also eliminated from the list of virtual stores that could be used for this research. Figure 6.1 shows screen shots of some of the stores in the Shop R application taken with the VR headset, and Figure 6.2 includes screen shots from the I Shop Meta virtual store. Since the main aim of this research was to observe the VR shopping experience specifically in apparel, these two stores couldn't be used in the studies of this research.

All other virtual stores found for this research which offer apparel products, unfortunately, were semi-immersive. Therefore, the virtual environments in these

stores didn’t offer a 360-degree field of view and the environments were not responsive to the bodily gestures of the VR users (i.e. hand and head movements). One of the leading companies designing fully-immersive VR stores, the Emperia VR, was contacted prior to the studies of this research. Unfortunately, their stores are fully-immersive only for the Apple Vision Pro, which, during the time of this research, was not (and is still not) available in the Turkish market. Hence, their stores could only be experienced in a semi-immersive manner with the Meta Quest 3 VR headset which was used in the studies of this research. However, the company shared a link which showcased how the platforms behave on Vision Pro. This video was also played to the participants of the research at the end of each study in order to more comprehensively demonstrate the potentials of VR shopping experience. The limitations arising from the semi-immersive quality of the stores used in this research were compensated partially by using the Meta Universe, a fully-immersive virtual environment offered in the Meta Quest 3. The participants of this study first spent a few minutes in the Meta Universe to get the feeling of presence and immersion into the VR. Then they continued with the semi-immersive virtual apparel shops.

The studies conducted with participants of this research, therefore, had to be made in semi-immersive virtual stores. This, at first, appeared as a limitation to the research in hand. However, the results of the studies indicated a hidden advantage underlying this limitation. Since the participants of the studies got the chance to spend time in the Meta Universe (a fully-immersive environment), they understood the potential of VR to fully immerse its user into an environment at the beginning of the study. Then, they entered the virtual apparel stores, thus observing the apparel shop experience with VR, though in a semi-immersive manner. The video provided by the company Emperia VR was also presented to the participants, thus further demonstrating the potentials of VR apparel shopping.

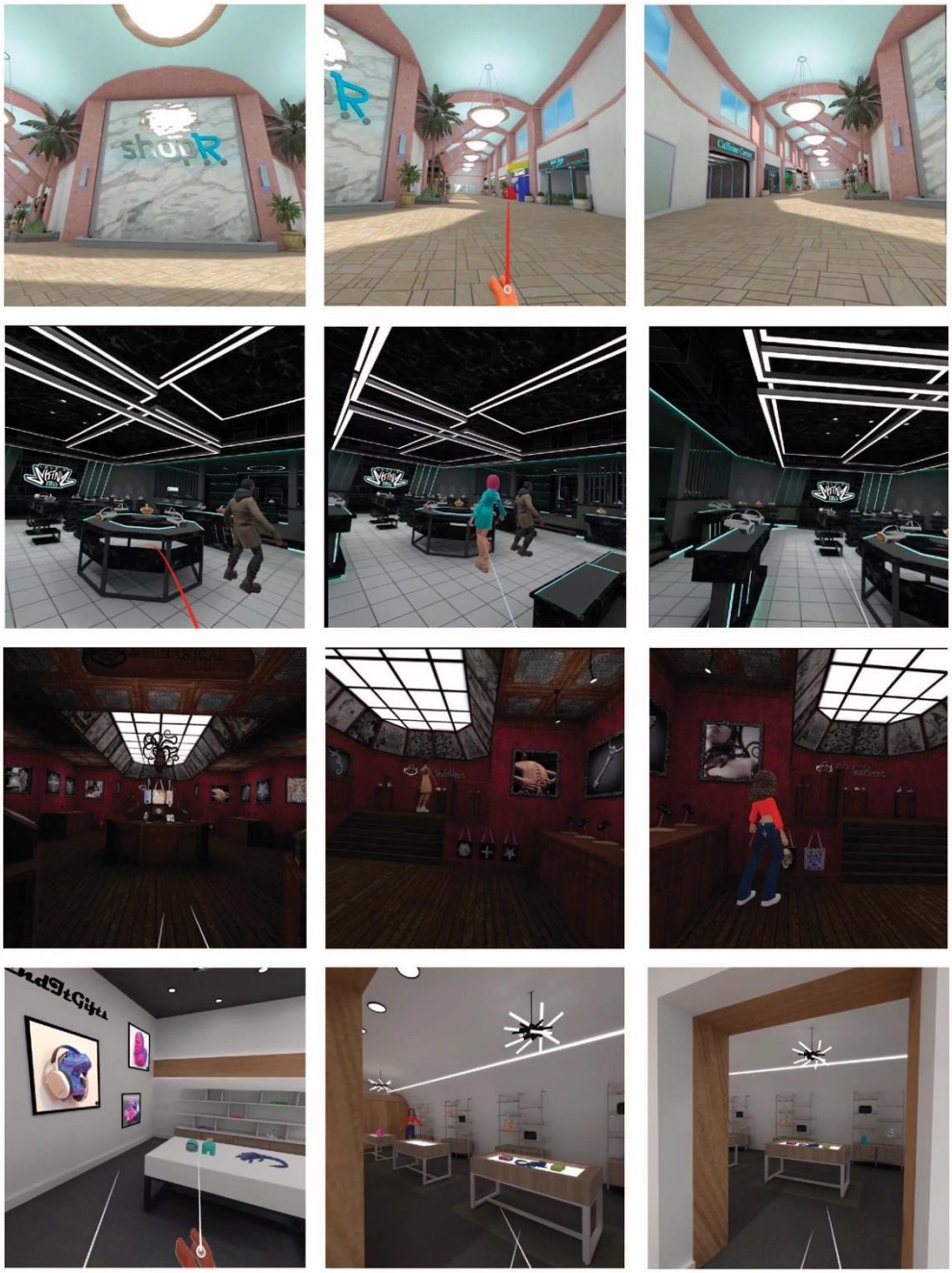


Figure 6.1. Screenshots from the Shop R application (screenshots were taken with the screen capturing option of Meta Quest 3 VR glasses by the author).



Figure 6.2. Screenshots from the I Shop Meta application (screenshots were taken with the screen capturing option of Meta Quest 3 VR glasses by the author).

As is cited by Zenasni et al. (2008), "creative people tolerate ambiguity well" (Sanders & Stappers, 2012, p. 44). Since the main limitation of this research was that the accessed virtual apparel stores were not fully-immersive, it was decided prior to studies of the research to conduct the sessions with designers. This would decidedly be helpful in envisioning the full potential of virtual apparel shopping experience, thus providing more insightful data for the research in hand. Hence, the studies were conducted on 18 participants in total, with 9 of them being professionals with design background and 9 being junior or senior year industrial design students (See section *4.5.2 Participant Sampling* of this thesis for further detail). The comments made by participants during their experience with the VR as well as their answers to the follow-up interview questions indicate that "incompleteness (compelled them) to fill in" (Sanders & Stappers, 2012, p. 45; Şen & Şener, 2022). The semi-immersive quality of the two virtual stores used in this research, thus led the participants to make valuable comments on what features could be added to and how these features could be executed in a VR shop. They came up with a number of direct and a number of indirect suggestions on how to improve the virtual apparel stores they experienced.

Another factor that might be counted as a limitation to this research is that the participants of this research all volunteered to take part in the studies of the research. They were, therefore, curious to discover the VR headset use in the context of apparel

shopping. Their voluntarily participation as well as willingness and curiosity to explore the potentials of VR apparel shopping might have had an influence on their subjective norm (SN), perceived usefulness (PU) and perceived ease of use (PEOU) of the technology, as is also mentioned in the literature review of this thesis with reference to Chow (2016).

6.4 Final Notes and Future Studies

This research began with a desire to discover the potentials of virtual reality in apparel shopping. Based on the literature findings and results of this research, it can be argued that virtual shopping is more similar to, rather than different from, in-store shopping. Apparel shoppers expect to first and foremost understand the product attributes, make outfit combinations and quick product scans inside an apparel store. VR users, on the other hand, expect a larger FOV, a familiar POV (one that respects their height), ease of interaction and an easy-to-use interface to get a higher level of immersion into the VR. Indeed, if virtual stores are designed more immersively, allowing for smooth and easy interaction, offering customers a valid level of product variation, an increased understandability of products and a heightened level of hedonic shopping, it can one day form a bridge between online and physical shopping, possibly even replace them altogether once the technology suffices.

Although the current research was conducted with semi-immersive virtual stores, the results of it pointed to several pivotal findings regarding virtual apparel shopping experience. Still, there remains a need to observe and understand the virtual apparel shopping behaviors in fully-immersive VEs. Moreover, the scope of this research can be expanded to observe the virtual shopping behaviors occurring in other product categories. Similarly, the steps and components of virtual apparel shopping experience can be observed more elaborately, thus aiding with an increased comprehension of VR shoppers' expectations when shopping for apparels.

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APPENDIX

A. Post-interview questions translated to English

Regarding the VR Experience and Immersion

1. During which phases of the VR experience did you or did you not feel immersed (present) in the virtual environment? What details or factors contributed to this? Which of your sense(s) do you think played the most significant role? Why?
2. In what ways did your interactions with the virtual environment and its stimuli felt natural and consistent with the real world, or not? Why?
3. What other elements/factors do you think could contribute to the feeling of presence and to feel like a part of the virtual reality experience?

Regarding Usability and Interface

4. During your experience, did you feel competent in moving and interacting within the virtual environment? Were there any aspects that made it difficult for you to adapt to the system or that hindered your sense of control over the system? If so, what were these aspects? What can be done, in your opinion, to shorten this adaptation process?
5. Did you find the environments' responses to your movements consistent and predictable? Why or why not?

Regarding Receiving Product Information, Product Selection, Product Comparison and Product Combination

6. What factors contributed to/hindered your perception of products inside the virtual stores as realistic and understandable (e.g. color, pattern, fabric, etc.)? Do you have any suggestions/ideas that you think would contribute to the realness and understandability of products inside the virtual stores?
7. During your virtual store experience, at which stages did you feel the need to zoom in or out on products, move them, or observe them from different angles? To what extent did the virtual environment allowed you to accommodate this need or not?
8. During your virtual store experience, what factors made it easier or harder for you to observe and combine different products together? If you had the chance to make outfit combinations during virtual shopping, how and what stages of the shopping flow would you prefer to do so?
9. If you had the chance to compare different products during your virtual shopping experience, how would you prefer to do it and why?
10. What additional features or information about the products would you have liked to access during your virtual shopping experience? Why?

Regarding Navigation and Orientation

11. What factors made it easier or harder for you to navigate inside the virtual store and observe the store and products to get a general impression?
12. What factors made it easier or harder for you to find your way while navigating inside the virtual environment? What would you suggest be done to make wayfinding easier while navigating inside a virtual store?
13. What factors contributed to the realness/consistency of the relationship between the products and the setting of the virtual environment? Why? Would you expect a realistic/consistent relationship between the environment and the products in a virtual store experience?

Overall reactions to virtual shopping experience, comparing virtual shopping experience to previous shopping experiences

14. When you compare your virtual store experience with your experience in physical stores, what similarities/differences did you observe? During your virtual store experience, what advantages/disadvantages did you feel you had compared to shopping in a physical store? Why?
15. When you compare your virtual store experience with your online shopping experience, what similarities/differences did you observe? During your virtual store experience, what advantages/disadvantages did you feel you had compared to online shopping? Why?
16. What factors do you think could make the shopping experience in virtual reality more enjoyable and motivating?