

Assessing the impact of immersive versus desktop virtual reality shopping experiences in the fashion industry metaverse

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Abstract

The digital transition towards the Metaverse deeply permeated by digital technologies is the core of current debates. In this shift, fashion emerges as a relevant context for analyzing the implications of the Metaverse, with fashion companies being among the first industries to implement projects in this persistent virtual space. Today, with fashion being such a relevant global business, but one of the most polluting industries, its transition towards "hybrid" experience modes can produce significant impacts in terms of more efficient and sustainable modes of production.

Also, in the existing spectrum of digital technologies, Virtual Reality (VR) represents an opportunity and a tool from which the fashion industry can benefit. However, although VR has proven its effectiveness in fashion retail, the scientific literature still presents limited studies; yet there is plenty of scope for its potential use in the fashion industry. Also, there is a lack of studies comparing Immersive VR (IVR) to non-immersive shopping experiences, such as Desktop Virtual Reality (DVR). Therefore, researchers must identify the differences between IVR and DVR systems since they may affect users during their evaluation. For this reason, further research is needed to assess how VR technology can improve the shopping experience towards the Metaverse.

The aim of the research is to compare the experience of buying an accessory (i.e., a luxury handbag) on a desktop computer, DVR, with that in IVR, assessing the impact in terms of system usability. To test the differences in terms of usability, we developed two versions of the application. The first is developed as a traditional desktop application and the second is developed for the IVR Head-Mounted Display (Oculus Quest 2).

We hypothesized that IVR modes can be more easily used and accessed by the user. To this aim, we conducted a within-subject experiment with 60 participants by administering the System Usability Scale (SUS) questionnaire to compare the DVR and IVR applications.

Thus, the paper shows that display, interaction, and locomotion in the design of shopping experiences can generate different feedback on the system usability, and therefore IVR could be a more suitable tool for novel shopping modes in the fashion industry towards the Metaverse.

Author keywords

Virtual Reality; Fashion Industry; Shopping Experience; Metaverse; Sustainability

Introduction

In recent years, the retail industry has witnessed an unprecedented acceleration of digitization, where Covid-19 has been the main driver (McKinsey, 2020; Shankar et al., 2021). In this transition scenario, companies have been looking for fast and alternative ways to innovate while adapting to government-issued restrictions (i.e., the isolation and closure of physical shops).

Therefore, companies have started to make exponential use of the new technologies available to make production systems more responsive, flexible, sustainable, and efficient, and to improve sales processes (Bisson et al., 2021; Fiorentino et al., 2022).

Due to this digital transition, the physical reality made of "things" has gradually started to evolve towards a less tangible dimension, characterized by relations between people and immaterial, digital, and "metaphysical" objects.

Among the rising technologies, we focus on Mixed Reality (MR) as the continuum of Virtual and Augmented Reality (VR, AR), (Milgram & Kishino, 1994), which contributes to the development and diffusion of the Metaverse, a persistent virtual space that users can use for work, entertainment and for other activities, such as shopping experiences. Within this emerging space, a new form of 'immersive' interaction between users and services is shaping (M. Park et al., 2018; S. M. Park & Kim, 2022), especially using VR and Head-Mounted Displays (HMDs).

Although the Metaverse does not necessarily require the use of VR technology, recent studies state that it will be an open challenge from a future-oriented perspective (Babu & Mohan, 2022; S. M. Park & Kim, 2022)

But while the general frameworks describing the Metaverse are becoming increasingly accessible, the implementation strategies and their implications on specific industrial systems are largely unexplored.

In this regard, our paper focuses on the fashion industry, one of the industries that can certainly benefit from this ongoing transition towards the Metaverse (Bertola & Teunissen,



2018; Cappellieri et al., 2021; McKinsey, 2023), for several reasons.

First, the fashion industry, traditionally based on physical and material interactions, had to face the consequences of the Covid-19 pandemic, one of the major challenges so far. Since 2020, many companies – both luxury and fast fashion – have closed their manufacturing factories and physical shops, laid off employees, and canceled fashion shows and events due to the severe restrictions in place. The natural consequence of this was a sudden decrease in sales.

Moreover, after the first lockdown, companies had to adapt to the rapid change in consumer behavior caused by social distancing and isolation. Therefore, consumers – especially Generation Z – developed a new approach to fashion shopping experiences. This is because the lockdown has shown how it is possible to replicate our daily lives in the digital world. In fact, almost all the activities we do daily, from study to work, from sports to socialization, can now be accomplished digitally. This is very relevant because it has given digital spaces a whole new meaning for consumers, changing their purchasing behavior and expectations.

Meanwhile, Covid-19 raised a new level of awareness with respect to the planet. Sustainability became a priority in the minds of consumers, who demand different production processes, especially avoiding waste that is difficult to dispose of in the environment.

The fashion industry is widely recognized as one of the most polluting, with a long history of established wasteful practices that increased with the rise of fast fashion. The need to speed up time-to-market and reduce market costs resulted in the use of toxic textile dyes that made fashion second only to the oil industry in terms of global pollution damage (Dhir, 2021).

As a result, the fashion industry is surprisingly one of the keenest to adopt digitization strategies using digital technologies such as VR to transform its business model, motivated by the apparent plethora of options and benefits it offers (Bertola & Teunissen, 2018; Boardman et al., 2020; Ricci, 2022). Indeed, considering the importance of fashion as a global business today, the transition to 'hybrid' modes of experience can have a huge impact also in terms of more efficient and sustainable modes of production (Bulovic & Covic, 2020).

One of the biggest benefits that digital fashion is bound to bring is the promotion of sustainability, helping brands target environmentally conscious consumers. Virtual fashion prototyping allows a company to have a series of products visualized and configured in real-time before the physical product is made. Digital and virtual clothing can save 3,300 liters of water per garment and emit 97% fewer carbon emissions (DressX, 2021).

However, the literature concerning the fashion industry and the use of VR is scarce (Xi & Hamari, 2021) and, therefore, also about its implications in the emerging Metaverse. Thus, although VR has proven its effectiveness in the field of fashion retail, there are only limited experimental studies (Xi & Hamari, 2021). On this basis, this paper aims to provide insights into the use of digital VR technology to improve the shopping experience in the fashion industry towards the Metaverse, by expanding the previous study of Ricci (2022), and by presenting the results of an experimental design.

The objective of the research is to compare the shopping experience of an accessory (i.e., a luxury handbag) on a desk-

top computer – Desktop Virtual Reality (DVR) – with that in Immersive VR (IVR), evaluating the impact from the point of view of system usability. To test the differences in terms of usability, we developed two versions of the application. The first was developed as a traditional desktop application, while the second was developed for Oculus Quest 2.

To this end, we conducted an in-subject experiment with 60 participants, administering the System Usability Scale (SUS) questionnaire to compare DVR and IVR applications.

The research question is: "Can an IVR shopping application be more usable than a DVR application?"

Background

When investigating the use of VR in the fashion industry, two rather different approaches can be identified (Morotti et al., 2020). The first originates in the fashion industry and the second in the academic field. We will focus on the contributions from academia, as they present the results of experimental studies.

Namely, the Metaverse can be enjoyed with both non-immersive and immersive virtual technologies (Dwivedi et al., 2022). Yet, there are no studies in the field of fashion that clarify the differences between immersive and non-immersive VR experiences. In fact, such comparative studies only exist in one other product area (i.e., groceries) (Lombart et al., 2020; Peukert et al., 2019; Schnack et al., 2019).

In the area of fashion, the present studies are rather concerned with analyzing the implications of VR for enhancing the shopping experience through specific metrics.

For example, Lau et al. (2014) researched how interactivity can enhance consumers' shopping experiences. To do this, they designed an IVR shop in which participants were instructed to look around and explore fashion products within the virtual environment. Subsequent interviews revealed that participants engaged with and enjoyed the experience, demonstrating how interactive design can enhance consumers' shopping experiences (Lau et al., 2014).

Similarly, Jang et al. (2019) studied the role of interactivity along with vividness in consumers' intentions to approach an IVR shop. The results showed that participants who perceived greater interactivity and vividness also tended to show stronger purchase intentions. Furthermore, these positive influences were mediated by perceived telepresence and the value of experiential shopping (Jang et al., 2019). In contrast, Lau and Lee (2019) validated that VR could improve interactive shopping, consumer purchase intention, and hedonic user experience within consumer shopping experiences (Lau et al., 2019).

However, designing an IVR shop may also be useful to measure the dimensions of the user experience within virtual shops and how it affects the shopping results. In this regard, Park et al. (2018) designed an IVR shop, addressing a female target group. During a one-hour individual session, all participants were asked to enter the shop and freely explore it as much as they wanted. Preliminary results showed that the immersive VR experience is positively correlated with pleasure, attitude towards virtual shops, and purchase intention. Therefore, the researchers concluded that IVR could be used as a new shopping tool to improve consumer experience and engagement (M. Park et al., 2018).

Moes and Van Vliet (2017) analyzed to what extent a shopping experience can take place using online material (e.g., a normal shop photo, a 360-degree photo, or a VR photo) and to

what extent these different materials create different effects in an online or physical shop. The main result is that presenting the experience of a physical shop on an online platform is more effective with the help of VR than with a normal or 360-degree photo. In addition, the use of VR seemed very suitable to achieve other positive effects, such as increasing the consumer's intention to visit the physical shop. Therefore, in a society where online shopping is on the rise and physical shops are under pressure, "the use of VR seems a logical step" (Moes & Vliet, 2017).

In terms of interactivity in relation to the hearing sense within the virtual shopping experience, Morotti et al. (2020) discussed the potential of using voice commands in an IVR fashion shop, exploring the benefits of speaking and interacting verbally with a VR assistant embodying a salesperson. Preliminary results suggested that VR could provide effective experiences, and the integration of the voice assistant could help make the virtual experience more natural and easier (Morotti et al., 2020).

In summary, the results of this research provide a strong initial statement on the positive effects of VR for retailers, with respect to the metrics investigated (Moes & Vliet, 2017). However, further research in the fashion industry is still needed to establish the effects of different experience modes. Furthermore, although all contributions address the improvement of the shopping experience in the fashion context, there are no studies comparing IVR and non-immersive VR experiences.

Only Ricci (2022) presented a future agenda about the design and development of VR and haptic applications with the aim of improving the fashion shopping experience.

Therefore, we aim to extend this work by presenting an experimental design, conducting a comparative study, and formulating the following hypothesis:

H1: Users perceive the IVR shopping application as more usable and accessible than the DVR.

Methods

We conducted a within-subjects experiment with two conditions: IVR mode and DVR mode. Both conditions provided the same shopping experience but differ in terms of display and interaction systems within the applications. To balance the treatment orders, a Latin square was used.

Participants

At the Polytechnic University of Bari, sixty volunteers (35 male and 24 female) aged 22 to 58 ($M=30,5$, $SD=10,23$) were recruited for this study. Nobody had ever used VR for a shopping experience, although most of them ($n=41$) had previous experience with VR before the experiment, with a level of familiarity with this technology equal to 4 on a 7-Points Likert scale.

Task

We designed a virtual fashion showroom using the Unity 3D engine. The case study is a luxury handbag, as accessories compared to clothes (such as t-shirts, shirts, etc.) have simpler physics and are much easier to render in the 3D engine. Subsequently, the task of the experiment assigned to the users was to find a luxury handbag in the virtual shop and explore its features freely until they were ready to buy it. The features of the handbag user interface included:

- » Zoom in or out of the product.

- » Display detailed information about the handbag (e.g., brand, history, production process, size guide, washing method, and reviews).
- » Call up an attributes window to change the color and finishings.
- » When finished, click on the handbag to add it to the shopping cart.

Setup

This experiment was carried out in a university laboratory that included a workstation with a seat, a Zotac ZBOX MAGNUS ONE i7-10400, an Oculus Quest 2 HMD, and two wireless controllers. We designed two versions of the applications: DVR and IVR. The first was a traditional desktop application, while the second was designed for Oculus Quest 2 (See Figure 1).



Figure 1. User testing the IVR shopping application.

Both versions presented the same functionalities but differed in terms of interaction and display devices. The keyboard and mouse were used to interact within the DVR application, and the display was on the computer monitor. However, interaction occurred with the controllers in the IVR application, and the scene was seen through the HMD. In this case, we implemented the standard metaphor of raycasting (Lee et al., 2003), a group of interactive techniques used in IVR for selecting distant targets. We implemented a raycasting-based virtual pointer as a laser pointer that, when intersecting a target object, selects it (See Figure 2).

Furthermore, the locomotion technique also differed between the two versions. Whereas in DVR, locomotion took place using arrows on the keyboard, in IVR we implemented a natural navigation metaphor, i.e., teleportation (Bozgeyikli et al., 2016). Specifically, point & teleport is a locomotion technique that overcomes the problem of limited tracking areas by allowing users to teleport to selected target positions using either controller. Furthermore, teleportation was the most suitable

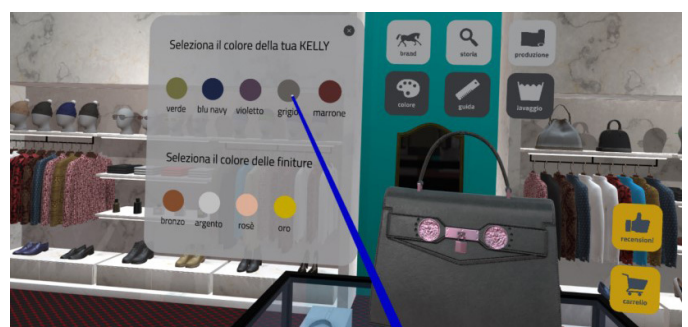


Figure 2. Raycasting technique for the interaction mode in the IVR application.

technique for our application, as the designed virtual shop was very large in terms of spatial extension.

Procedure

We welcomed the participants when they arrived and asked them to sit in a designated position and to provide informed consent. First, we described the purpose and tasks of the experiment to all 60 participants through a PowerPoint presentation. Afterward, we showed the participants how to interact and move in both DVR and IVR modes. We administered the pre-experience questionnaire to the subjects when they were ready to start. Next, participants had to go through the DVR and IVR training sequences, performing tasks like the real experiment, in a cube training environment. Then, once they were ready, they tested the experimental scenario to complete the task.

Measures

Finally, we invited participants to complete a questionnaire at the end of the experiment, both for DVR and immersive VR modes. To test our hypothesis, we assessed the subjective measurement of system usability. As a result, we requested that participants fill out the System Usability Scale questionnaire (SUS). The SUS is a ten-item standardized questionnaire used to assess perceived usability (Lewis, 2018) (See Table 1). To interpret the SUS results, we used the curved rating scale (Lewis & Sauro, 2016) ranging from rating A (Best Imaginable) to rating F (Worst Imaginable).

Table 1. SUS assessment method

Questionnaire	Number of items	Type of rating scale	Time of the administration	Application(s)
System Usability Scale (SUS)	10	5-point Likert Scale	Assessment of the perceived usability at the end of a study	Subjective assessments of perceived usability of products

Results and Discussion

All participants completed the task and answered the questionnaire, returning valid results without outliers. The score returned by the SUS questionnaire for the IVR mode is 81 (Excellent), corresponding to an A rating, on Lewis and Sauro curved rating scale, while the score returned for the DVR mode is 54.50 (Poor), corresponding to a D rating. Confirming our hypothesis, the IVR application results in being easier to use than the DVR.

The perceived usability may depend on how the IVR system is implemented compared to the DVR system. Thus, we can suppose that the explanation for this is in the display, interaction, and locomotion systems. The effects of IVR versus DVR display modalities on usability have been investigated by numerous studies but not for retail and, particularly, for the fashion industry.

For instance, in the case of the DVR application, the display system was on a 2D screen and returned flat images with a low degree of immersiveness. In the case of the IVR, instead, users could be fully immersed in a virtual environment that surrounds them at 360°.

Recent literature reports that IVR displays have been shown to positively affect performance in a visual search task

(Pallavicini & Pepe, 2019), such as finding the handbag in our experiment. Also, users feel more naturally immersed in the IVR scenario, showing a more intense emotional response in IVR versus after DVR (Othman et al., 2022). Additionally, users commented to feel a greater sense of presence in IVR as opposed to DVR condition, probably due to the higher degree of immersiveness. Interaction could also be a contributing factor. Indeed, interaction in the DVR took place with the mouse, which, regardless of how familiar users were with this tool, was probably not suited to the visual search task compared to the raycasting technique (Pallavicini & Pepe, 2019). The same is true for locomotion, which in the DVR was accomplished using the arrow keys on the keyboard and was limited in comparison to the ability for users to project themselves anywhere via teleportation in IVR. These results regarding the usability of the IVR compared to the DVR are encouraging for further applications in the fashion industry.

Conclusion

We are currently living in an ever-expanding digital reality, which has affected every part of our lives, including the way we experience shopping. Indeed, the Covid-19 pandemic has accelerated digitization through the spread of technologies such as VR, assumed as one of the elected tools for experiencing the Metaverse. In this transition, the fashion industry can take advantage of this technology to become more sustainable, by reducing its pollution impact.

Nonetheless, the literature concerning VR adoption within the fashion industry is very limited. And, clearly, there is a lack of studies comparing IVR versus non-immersive shopping experiences, i.e., DVR. Indeed, researchers should acknowledge the differences between IVR and DVR applications because this could affect the users during the evaluation. As a result, more experimental research is needed to determine how VR technology may improve the fashion shopping experience in the Metaverse.

We, therefore, extended the work of Ricci (2022) by performing a comparative study between an IVR and a DVR shopping experience and assuming a luxury handbag as a case study. The aim was to test the usability of the applications to assess which of the two was the more usable.

To this aim, we conducted a within-subject experiment with 60 participants, administering the SUS questionnaire to compare the DVR and IVR applications. As a result, the study demonstrated that higher immersion in the design of shopping experiences can provide different feedback on system usability, showing that the IVR application (A rating) is more usable than the DVR (D rating). The explanations for this may be found in the implementation of IVR and DVR systems and their differences in display, interaction, and locomotion systems.

One of the main outcomes of this study is that IVR has the potential to create new shopping modalities for the fashion industry. Indeed, as users find IVR applications more usable than DVR, it is possible to think that in the emerging Metaverse applications, IVR could play a fundamental role among all the technologies involved, being potentially accepted among users.

Also, further research is needed in order to assess other measures such as user experience, customer engagement, and purchase intention, and analyze their implications in the Metaverse.

To conclude, this research may also have potential implications regarding sustainability. In fact, it would also be interesting to analyze in depth what benefits it could bring from a sustainable perspective, quantifying the reduction of waste and product returns.

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