Investigating User Experience in Virtual Goods Shopping through a VR Diegetic In-Game Store

Yiming Sun*
ysun60@dcl.cs.waseda.ac.jp
Waseda University
Tokyo, Japan

Yang Zhan*
yang.zhan@dcl.cs.waseda.ac.jp
Waseda University
Tokyo, Japan

Tatsuo Nakajima
tatsuo@dcl.cs.waseda.ac.jp
Waseda University
Tokyo, Japan

ABSTRACT

Virtual Reality (VR) shopping allows users to closely browse goods like the physical store, contributing to a novel shopping experience. Yet, it is still unknown the shopping experiences and the optimal store design for virtual goods that are merely used in virtual environments. We believe the shopping of virtual goods should be further studied, given its inherent distinctions from physical goods in terms of contextual information, complex motivation, and goods properties. In this work, we explore the user experience during virtual goods shopping by comparing diegetic and non-diegetic stores in a VR shooting game. The quantitative and qualitative results from our within-subject study (N=14) confirmed that the diegetic store enhanced the hedonic experiences. A mediation analysis further unveiled the contribution of social interaction to enjoyment and immersion in the diegetic store. Our study furnishes valuable implications for the future design of VR stores and the study of social VR.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; **Virtual reality**; **User interface design**.

KEYWORDS

Virtual reality and games, VR shopping experience, diegetic interface, virtual goods

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1 INTRODUCTION

Virtual Reality (VR) shopping leverages the merits of secluded and immersive VR environments, allowing users to purchase in an online virtual store while replicating a shopping experience akin to the physical retail setting [27]. Extensive research endeavors have been undertaken to enhance user experiences in VR shopping, focusing on aspects such as immersion [20, 25], shopping motivation [21], and interaction [1]. A noteworthy fact is the predominant focus on physical goods as commodities in these studies, treating VR shopping as an innovative tool for online retail. However, it is also common for users to make consumption of virtual goods in the virtual world because of their self-presentation needs [32] and ambition [8]. In the context of the evolving VR environment, particularly with the emergence of the metaverse, we contend that virtual goods shopping assumes a more pivotal role in consumption relative to traditional virtual worlds.

Figure 1: Screenshots of game stores. A) A diegetic store shows goods on shelves and is integrated into the virtual world. From Starfield [29]. B) A non-diegetic store shows goods in a 2D interface, which is merely interacted with by users. From World of Warcraft [12].

Virtual goods refer to items exclusively utilized within gaming or virtual environments and can be integral to the revenue streams of free-to-play games or software [7]. Examples encompass character clothes, potent weapons, and equipment. A salient challenge in the marketing of virtual goods lies in store design, where an optimal design necessitates a utilitarian function while concurrently upholding hedonic experiences congruent with virtual worlds. Despite numerous research guiding the design of stores for physical goods [24, 25, 28], we believe that the transference of such design principles to virtual goods stores is not straightforward due to intrinsic factors unique to virtual goods shopping. These factors include *contextual information*, wherein virtual goods exhibit a robust contextual connection with virtual worlds, necessitating purchase decisions based on contextual cognition; *complex motivation*, as the acquisition of virtual goods is driven not solely by the desire for goods but also by self-satisfaction [9]; and *goods properties*, as virtual goods manifest diverse forms and functions often unrelated to one another, demanding users to possess more prior knowledge and information to purchase.

In this work, we aim to explore shopping experiences within virtual goods stores and furnish insights into store design. A VR shooting game was designed to provide contextual information

*Both authors contributed equally to this research.

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preceding shopping and partial shopping motivations. As an exploratory study, two primary store designs [19] shown in Figure 2 were selected and embedded within the game: a non-diegetic store showcasing goods in a 2D list interface and a diegetic store simulating realistic 3D retail environments. These distinct store designs offer different utilitarian and hedonic features. The significance of this study lies in 1) our exploration of the utilitarian and hedonic differences between two types of stores and 2) identifying social experience as a notable factor that impacts the joyfulness and immersion experienced in VR shopping. These insights are crucial for enhancing user engagement in virtual shopping environments.

2 RELATED WORK

2.1 Shopping experiences in virtual worlds

Since VR shopping stands out as a novel purchasing mechanism in recent years, its utilitarian functions are the basic expectation to ensure comfortable shopping experiences. The imperative for users is to locate merchandise swiftly and complete purchases seamlessly. While VR stores build immersive experiences by replicating physical stores, they inevitably inherit certain drawbacks associated with traditional retail spaces. For instance, physical stores often lack filter and search functions, which are fundamental aspects of online shopping. In response to this, Speicher et al. [27] proposed a VR store incorporating speech-searching functionality to harness the advantages of online stores. Further, an apartment was designed as a VR store, enabling users to quickly locate products based on their daily experiences [28]. Beyond mere efficiency, product diagnosticity is also important because users need to evaluate the merchandise quality [4]. Existing research has delved into its influence on purchase decisions [5, 13], cognitive workload [31], and reuse intention [20], offering insights for enhancing VR retail experiences.

Arnold et al. [2] revealed that users engage in shopping not solely to acquire merchandise but also to fulfill various psychological needs, such as exploring novel items, socializing, and emotional adjustment. Consequently, the hedonic functions of VR stores emerge as the other crucial perspective influencing shopping experiences [14]. An optimal shopping system, therefore, should adeptly support both utilitarian and hedonic experiences concurrently. Peukert et al. [20] compared the VR stores on desktop and headset platforms and concluded that immersion enhances hedonic experiences while diminishing utilitarian aspects. Furthermore, while user satisfaction is positively impacted by both utilitarian and hedonic experiences, utilitarian perspectives appear to wield a greater influence [21]. It is noteworthy, however, that much of this existing research is grounded in physical retail contexts, potentially failing to encapsulate the nuances inherent in virtual goods shopping. For example, studies in physical retail often introduce time constraints [27, 33] or merely assign a purchase goal [16, 20], thereby simplifying shopping motivations. In the realm of virtual goods shopping, the motivations are diverse and rooted in hedonistic considerations [9], impacting users' evaluations of shopping experiences. Therefore, we designed a VR game with embedded stores to simulate the shopping process within virtual worlds, diverging from a mere comparative assessment of experiences using stores.

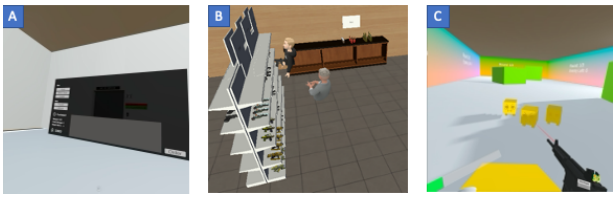

Figure 2: Screenshots of our VR stores and game. A) Non-diegetic 2D store. B) Diegetic 3D store. C) Game scene.

2.2 Interface designs

Diegetic design refers to the design that is isomorphic with the narrative contents and has been widely studied in film and games [6]. In the gaming context, diegetic designs are congruent with and integrated into the game world, while non-diegetic designs exist independently and are observable solely by players [22]. Figure 1 shows examples of (non-)diegetic in-game stores. Prior research has concentrated on the impact of diegetic User Interface (UI) design on gameplay, demonstrating its capacity to enhance immersion [11, 15, 22] and player performance [18]. Nonetheless, the non-diegetic design also garners advantages from its familiarity and clarity [15, 17]. Ogier et al. [19] assumed that the diegetic in-game store confers similar advantages in terms of immersion and proposed an algorithm to convert the non-diegetic store UI to a diegetic format. They also suggested that it is appropriate to compare the diegetic and non-diegetic designs within the same game. However, their emphasis lay on the algorithm itself, with limited exploration into the shopping experiences. In summation, both diegetic and non-diegetic designs exhibit distinctive merits, and thus we believe it is worth investigating their respective impacts on the shopping experiences.

3 EXPERIMENTAL DESIGN

To establish a contextual background, we developed a VR shooter game, incorporating the stores into the game theme. The primary objective of the game is to defeat all enemies in a specified room across three rounds, each featuring the random spawn of six enemies. The enemies display three behaviors—resting, targeting the user, and attacking—depending on their distance from the user. Users can teleport within the room for attack or evasion and are armed with guns to engage the enemies. The guns and a health indicator are integrated into the controllers and all actions are executed through controllers. Should the user's health fall to zero, they are repositioned to the starting point for a restart. Additionally, the game incorporates sound effects to signal enemy spawn and when the user is under attack.

Our game features two distinct store formats. A non-diegetic 2D store (Fig. 2A) presents a user-friendly panel that displays products detailed by images and text information. UI bottoms on the panel can be highlighted by a laser beam shot from the dominant controller and activated by the trigger on the controller. The alternative is a diegetic 3D store (Fig. 2B), which replicates a physical shopping environment, granting users the freedom to navigate and engage with the merchandise on shelves. As long as the user grabs the merchandise touched by the dominant controller, merchandise

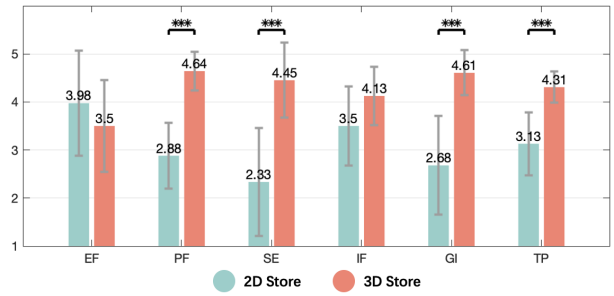

Figure 3: The results of our post-experimental questionnaire, encompassing means and standard deviations across six sub-scales. Each question is answered on a 5-point Likert scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. Statistical significance levels are denoted by $***$ ($p < 0.001$).

information will be displayed on a floating window anchored to the secondary controller. Acknowledging the significance of socializing in hedonic shopping [2, 9], a facet overlooked in prior studies, we explored the social dimension by implementing a multi-user shopping component that allows users to communicate while shopping. In the 2D store environment, communication is facilitated through voice chat, whereas in the 3D store, users can observe one another's avatars[1] as they perform shopping-related activities. In line with the shooting theme of the game, the available merchandise includes weaponry and potions, as well as items that enhance attributes, such as increasing a user's attack strength.

3.1 Procedure and Measures

A within-subjects study was executed to assess both utilitarian and hedonic shopping experiences within virtual goods stores. In the study, 14 participants ($M = 24.3$, $SD = 2.63$) were recruited from the campus, including 13 males and 1 female. Of these, six had never used a VR headset before, six used VR less than monthly, and two used VR headsets weekly. The procedure was as follows: In each study, two participants were invited as a pair to attend. After informing participants of our research goals and acquiring consent, a tutorial was conducted to familiarize participants with in-game control. After the tutorial, participants started to play the game using a basic weapon, leading to challenging gaming experiences. The study round began after 3 minutes. Participants were encouraged to purchase merchandise together in the same type of store without time limitation. When the shopping ended, they finished the round by challenging the game with purchased equipment. They filled out the questionnaires at the end of each round. There were totally two rounds with different stores implemented and a post-study interview. To minimize the impact of the order on the results, the two stores were presented in alternate sequences.

The evaluation utilizes two distinct questionnaires. The first one is the abridged User Experience Questionnaire (UEQ-S), which, despite its fewer items, evaluates product qualities similarly to the UEQ's comprehensive version[26]. The second questionnaire, crafted by our team, includes six distinct sub-scales: Efficiency (EF) and Informativeness (IF) for assessing utilitarian aspects, and Playfulness (PF), Social Experience (SE), Game Integration (GI), and Telepresence (TP) for the hedonic aspects. As noted in section 2.1, EF and IF primarily gauge utilitarian features. PF, derived from Chen et al. [5], evaluates the ability to provide enjoyable experiences linked to emotional reactions during shopping. SE is included for probing the social effect on shopping experiences via mediation analysis. Adapted from Schild et al. [23], GI evaluates the narrative coherence of stores. TP was sourced from the Presence Questionnaire [30], which measures the immersive quality aimed for in VR shopping.

[1]https://developer.oculus.com/documentation/unity/meta-avatars-overview/ (accessed on 27 November 2023)

4 RESULTS

4.1 Questionnaires

We used the Wilcoxon Signed-rank test to analyze statistical significance since all the data was ordinal. The UEQ-S questionnaire presents the general evaluation of user experiences, including pragmatic quality (PQ) and hedonic quality (HQ). Scores for these attributes range from -3 to 3, with 'overall' representing the average score for these attributes. Significant differences ($p < 0.001$) were found on overall scores between the 2D ($M = 0.152$) and 3D ($M = 1.75$) store. In detail, the 3D store ($M = 2.375$) outperformed the 2D store ($M = -0.875$) in HQ scores significantly ($p < 0.001$), whereas no differences were found in PQ scores (2D: $M = 1.179$, 3D: $M = 1.125$). Figure 3 illustrates the results from our questionnaire. This figure highlights that the 3D store received significantly higher ratings than the 2D store in four hedonic sub-scales, namely the PF, SE, GI, and TP. No significant difference was found in EF and IF, while the 2D store had the better average score in EF and the 3D store outperformed in IF.

4.2 Mediating Effect

Figure 4 presents the results of our analysis on the mediating effect, focusing on the influence of the type of store on shopping experiences. After checking the assumption of mediation, we used PROCESS model 4 [10] in R with the bootstrapping option to conduct the analysis. The type of store serves as the independent variable and the SE is positioned as the mediator variable, while the other five sub-scales are treated as dependent variables. Our findings reveal a partial mediation effect of SE on the relationship between the store types and two specific sub-scales: PF and TP. This nuanced understanding underscores the importance of the social experience in enhancing playfulness and telepresence in virtual goods shopping.

4.3 Interview

A semi-structured interview was conducted to understand participants' opinions on the store designs and experiences. Three themes were generated from the recordings based on thematic analysis [3].

Demands for intuitiveness and convenience. About 40% participants liked the 2D store. Moreover, most participants agreed that the 2D store listed the goods clearly, contributing to efficient browsing and shopping. Key concerns about the 3D store were the effort needed to retrieve goods information and the increased operational demands, such as grabbing and teleportation. There was a suggestion for long-distance grabbing and information obtaining to improve convenience. However, many participants favored the

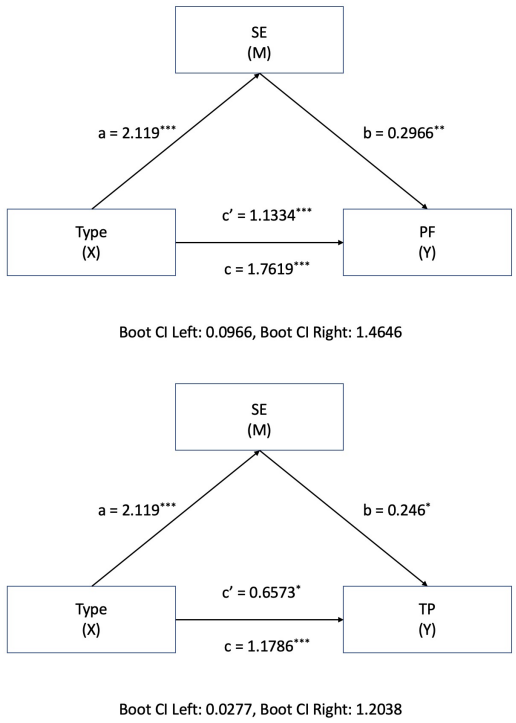

Figure 4: A mediation analysis diagram showing the influence of store type (X) on PF (Y) and TP (Y), with social experience (SE) as the mediator (M). Path coefficients (a, b, c, c') and their significance levels are indicated, with 95% bootstrapped confidence intervals for the indirect effect at the bottom.

more vivid appearance of goods and better interactivity in the 3D store.

Beyond shopping in 3D store. Around 60% participants preferred the 3D store for its joyfulness and immersive experience. They believed that the 3D store fit the virtual world and provided a natural transition, making it a better choice for VR games. Some participants also mentioned the rich interactivity and freedom, which allows them to enjoy unusual shopping, like throwing the goods everywhere.

Challenges for social interaction in 3D store. Several participants described the advantages brought by the social interaction, including deeper immersion and aroused curiosity about goods picked by another participant. However, many participants complained that avatars lacked facial expression, sense of touch, and precise gestures. A few participants mentioned their attention to social distance, which prevents them from browsing the same shelf with others.

5 DISCUSSION

Our study revealed that the 3D store delivers a better user experience, mainly due to its hedonic qualities. Both the UEQ-S and our questionnaire highlighted that while the 2D store is slightly more efficient, the 3D store offers more detailed information about products. This is because users can understand the properties of virtual goods through text, but their appearance is more engaging in 3D.

The mediation analysis yielded a significant insight: SE, acting as a partial mediation, significantly influences both PF and TP. Insights from interview responses further illuminated that the integration of simulated physics within the 3D store, when synchronized server-side, facilitated playful interactions such as item-throwing between partners, thereby enhancing PF. Additionally, many participants noted that shopping in the 3D store mirrored the experience of real-life shopping with friends, which in turn augmented TP. These findings from both the mediation analysis and the interviews suggest that a robust social experience can significantly elevate enjoyment and the sense of immersion during VR shopping experiences. These outcomes point to the social experience as one of the crucial factors, meriting deeper investigation within the realm of VR shopping to fully understand its impact on consumer behavior and satisfaction.

Our interviews further revealed a preference among some participants for a more efficient shopping experience. This indicates a segment of users willing to trade immersive experiences for efficiency. One participant emphasized his focus on finding powerful gear to complete the game, suggesting that a hedonic shopping experience was less important to him. This diversity in user preferences underscores the importance of balancing immersion and efficiency in virtual shopping environments, which largely depends on the application context. For instance, in games that emphasize narrative, a hedonic store can greatly enhance the experience by adding to the story and environment. On the other hand, in more competitive games or for players motivated primarily by game completion, prioritizing efficiency over immersion becomes crucial. This balance is not only relevant within games but also extends to the design of VR stores beyond gaming contexts. Understanding the users' objectives and the intended use of the VR environment is key to designing an experience that aligns with their expectations and enhances their overall interaction with the virtual space.

We further identified several limitations in our research. The UI of our 2D store wasn't as attractive as those found in commercial games, which could have impacted the user experience to some extent. A similar limitation was present in the 3D store; the quality of the 3D models for store items was not very high, as most of them were free assets sourced from the internet. This aspect could also have influenced the user's shopping experience.

6 CONCLUSION

In our comparative study of 2D user interfaces and 3D diegetic stores in games, we found that although the 2D store is slightly more efficient, the 3D store excels in joyfulness and immersion. The 3D store's seamless integration into the game's environment and its enhanced social experience make it a promising candidate for in-game VR store designs. Furthermore, its rich social interaction and immersive, interactive qualities could significantly improve VR shopping environments, offering users a dynamic, lifelike shopping experience that enhances the appeal and usability of virtual shopping platforms for those seeking engaging and socially interactive experiences. Finally, distinct motivations can lead to diverse demands, making it necessary to balance utilitarian and hedonic qualities in future VR store designs.

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