Avatar Design in Virtual Retail Environments: A Scoping Review and Proposed Framework

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Abstract

The effective use of avatars in 3D virtual stores is a critical component of the success of virtual retail. However, there is a lack of established guidelines on avatar design, an overview of its impact, and its limitations. This work aims to fill these gaps with a scoping review of avatar usage in immersive virtual retail in the last 8 years. Starting with an initial 243 publications, we selected and analysed nine studies to propose the original Virtual Retail Avatar Design (VRAD) framework, as well as investigate the impact avatars have on user's perceptions, experiences, and behaviors in immersive virtual retail environment. The VRAD framework revealed the key elements of the avatar design to achieve more engaging and effective virtual shopping experiences. We also summarized the avatar's impact on shopper behaviour, perception, and experience in the iVR retail environment and the future research agenda of avatars in iVR retail. We believe our work can be extended from retail to related areas where avatars play a key role in their further evolution.

CCS Concepts

• **Human-centered computing** → **HCI theory, concepts and models**; **Interaction techniques**; **Virtual reality**; • **Computing methodologies** → *Virtual reality*; • **Applied computing** → **Online shopping**.

Keywords

Avatar Design, Immersive Virtual Reality, Shopping Experience, Virtual Retail, Scoping Review

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1 Introduction

Avatars, also broadly known as virtual characters, can be defined as "interactable digital entities controlled by either software or a human, that can perform certain behaviours" [25]. The theory of social response states that people tend to treat computers as social entities, whether the computer is represented by a screen, a voice, or an agent [27]. Such a tendency is more likely to occur when computer technology exhibits humanlike behaviours such as language generation, conversation production, and reciprocal interaction [45]. Thus, computer technology can be personified in the form of avatars, which are gradually considered the most important elements of online service in various fields such as education, banking, gaming, and especially in retail [16].

Social cues and interactions with other individuals are a natural part of any shopping experience in a retail store. It has been emphasized that one of the most important factors of a satisfying shopping experience is the interaction between the buyer and the shopping environment [21]. Thanks to the advancements in computer technology, the popularity of avatars has gained an important social role in improving Human-Computer Interaction (HCI) and user experiences. According to Emergent Research, the global digital human avatar market size is expected to reach USD 527.58 Billion in 2030 and register a revenue Compound Annual Growth Rate of 46.4% during the forecast period [6].

Even though avatar adoption in online shopping continues to rise, the multisensory interaction between customers and the shopping environment cannot be entirely replicated by online retailing, as it provides limited opportunity for face-to-face communication as well as the interaction between customers [10, 35]. Moreover, previous studies have not addressed the design of avatars to represent other shoppers in online retail, as they found it complex to replicate the rich experiences and interactions found in physical stores[1]. Alternatively, immersive Virtual Reality (iVR) provides users with a richer and more realistic interaction of the avatars than a desktop computer for which user interaction only relies on mouse and keyboard [32]. Also, it has been found that the presence of other avatars in virtual retail stores has an impact on shoppers' behaviour perception, behaviour, and user experience in virtual retail environments [8, 30, 50]. Users can also embody an avatar that has the same appearance and body shape as them to try on clothes in a virtual fashion store (Virtual Try-On System) [24].

However, existing literature provides limited knowledge about the adoption of different forms of avatars and their impact on user's behaviour and experience. It is critical to understand how avatars have been used and designed in virtual simulated stores and how they affect shoppers' perceptions, behaviour, and experiences. To fill the gap, we conducted a scoping review and proposed the Virtual Retail Avatar Design (VRAD) framework to guide researchers for better understanding and designing virtual avatars in virtual environments. We also investigated shoppers' behavioural changes by exploring how avatars have been adopted in virtual retail stores and proposed the future research agenda in the field of iVR retailing. Our work provided valuable insights on creating an immersive and engaging shopping experience and paved the way for the future virtual retail business. The following Research Questions (RQs) are formulated:

- RQ1: How can avatars be designed in virtual retail environments?
- RQ2: How do avatars impact shopper behaviour, perception, and experiences?
- RQ3: What are the limitations of current avatar research in IVR retail?

The remaining paper is structured in five sections. Section 2 provides the methodology of the scoping literature review and section 3 outlines the VRAD framework for avatars in VR retail environments and provides an in-depth analysis of each design element. Following with a discussion, we discussed the VRAD framework, the avatars' impact on user experience and shopping behaviour in existing literature, and future research agenda. Lastly, we report our conclusions.

2 Method

The literature review was carried out by following the guidelines proposed by Petticrew and Roberts [13]. We adapted and combined the proposed literature review steps to our research goals and proceeded according to the following stages:

(1) Identification of the relevant keywords and definition of search terms.
(2) Input of queries into multiple electronic databases.
(3) Literature identification and screening with verified eligibility criteria.
(4) Data synthesis and extraction.
(5) Framework generation and report of results.

We conducted the review according to the methodology described by Paré et al. [34] based on empirical studies to understand a concept from a theoretical perspective and highlight gaps in knowledge. In addition, our research team discussed each stage's results to ensure the research's transparency.

2.1 Search Term

We selected the IEEE, Scopus, and Web of Science databases. Search terms were defined and tested through multiple search rounds in Stage 1 and Stage 2 and refined until the final database showed sufficient validity (e.g., the key literature could be yielded with the search terms).

Table 1: Search string used in all three databases.

Search String
Scopus (ABS = Abstract)
ABS((vr OR virtual) AND (avatar* OR assistant*) AND(retail* OR market* OR store* OR supermarket* OR shop* OR mall*) AND (customer* OR consumer* OR shopper* OR experience OR behaviour*))
Web of Science (AB = abstract)
((AB=(avatar*)) OR AB=(shop assistant*)) AND (AB=(virtual) OR AB=(VR)) AND (AB=(retail*) OR AB=(market*) OR AB=(store*) OR AB=(supermarket*) OR AB=(mall*) OR AB=(shop*)) AND (AB=(customer*) OR AB=(consumer*) OR AB= (shopper*) OR AB=(experience) OR AB=(behavio*))
IEEE
("Abstract":VR OR "Abstract":virtual) AND ("Abstract":avatar OR "Abstract":assistant*) AND ("Abstract":retail* OR "Abstract":market* OR "Abstract":store OR "Abstract":supermarket OR "Abstract":shop OR "Abstract":mall) AND ("Abstract":customer* OR "Abstract":consumer* OR "Abstract":shopper* OR "Abstract":experience OR "Abstract":behavio*)

For the keyword formulation, we first started with "virtual OR VR", to include all possible forms of the word "Virtual Reality". To include sufficient literature related to the retail environment, the keywords "retail", "market", "store", "supermarket", "mall", and "shop" were considered. Also, the keywords "customer", "consumer", "shopper", "experience", and "behaviour" were selected to include literature related to individuals' shopping experience and their behavioural changes. Also, "avatar OR shop assistant" were selected to include literature related to different forms of avatars.

The search queries used for the three databases are shown in Table 1. We searched only for peer-reviewed literature written in English from 2015 since, the first use of immersive VR interfaces in the retail sector that was attested in the same year [1], until the latest available date in 2023. The search yielded a total of 359 results, including 199 results on Scopus, 35 results on IEEE, and 125 results on Web of Science.

2.2 Eligibility Criteria and Study Selection

The study selection process was conducted and evaluated in multiple screening stages after removing duplicates. Eligibility criteria were first applied to the titles and abstracts to define the relevance of the article. If the title and /or abstract met the inclusion criteria, the article was registered in the database. After filtering all articles through title and abstract, the remaining articles went to the second stage of full content evaluation. A total of 246 results were filtered in the study selection process, resulting in the final inclusion of 9 articles. The flowchart and screening process of the article followed the PRISMA guidelines for systematic review [33] and are illustrated in Figure 1.

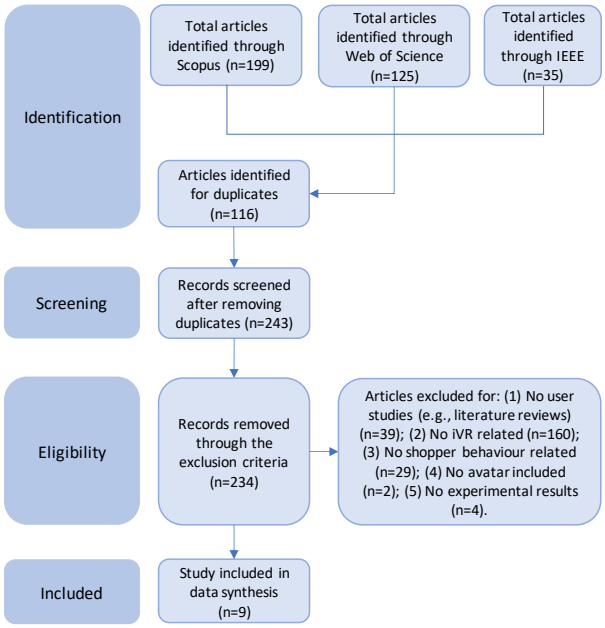

Figure 1: Scoping review selection phase flow chart.

We defined eligibility criteria to filter the literature search. First, the papers must be research articles and not reviews (e.g., systematic, literature, etc.) written in English and without any writing issue (i.e., not presenting full content). Papers must be related to iVR technology with HMDs and/or motion-tracking controllers, rather than semi-immersive VR such as CAVE [46] or Desktop VR. The measurements involved in the studies must be related to consumer behaviour or VR experience. Examples of these measurements are user experience, product choices, total shopping time, shopping experience perception, attitudes, and emotions. Studies must include avatars in a specific retailing context, such as a supermarket, a store, or a mall. At least one form of avatar (i.e., virtual embodiment or NPAs) must be used in the study with anthropomorphic appearance and/or behaviour. Studies must include an experimental design and results from the design and development of user studies. After applying the eligibility criteria, nine papers were included after the study selection process.

3 VRAD Framework

We analyzed the 9 papers and proposed an original framework - VRAD (See Figure 2) to guide future researchers in better designing and developing avatars with iVR. This framework provides guidance for researchers to make decisions on designing and implementing avatars in iVR retail stores and allows academics to locate specific design elements to make avatars more effective for various research goals.

Avatars can vary in their appearance and behaviour when interacting with people due to different design elements. The design choices are influenced by whether avatars are used for virtual embodiment or as non-player characters. When introducing avatars into a VR store, it is important to consider the type of adoption they fall into. There are two main adoption types: (1) virtual embodiment, where users see themselves as avatars and interact through them, and (2) NPC virtual avatars, where users can see and interact with other avatars in the virtual environment.

3.1 Virtual Embodiment Avatar

The virtual embodiment describes the "physical process of employing VR hardware and software to replace users' human body with a virtual body when they enter the virtual world" [41]. It elicits the Sense of Embodiment (SoE) into an avatar when users are self-located, having the corresponding feelings of actions and treating their virtual body as the source of sensation [43]. The SoE comprises three "sensations" or components: self-location, agency, and body ownership [20]. Thus, in describing the design of embodiment avatars, we further classified the design typology into four design elements: user perspective, sensory feedback, characteristics, and behaviour. In the selected studies, five out of nine papers included the virtual embodiment and the avatar design. Thus, while proposing the VRAD framework, we will also discuss the avatar design elements that have been mentioned in our selected papers for Virtual Embodiment Avatar (VEA) studies within the iVR retail context (See table 2).

3.1.1 User perspective. The perspective of the user's virtual body has been achieved by using two different viewpoints, the **first-person** perspective and the **third-person** perspective. In the iVR environment, the first-person perspective allows users to see themselves by looking down at their extremities and own bodies or perceiving it by the reflection object in the virtual environment, such as a mirror or window glasses [31, 43]. The third-person perspective enabled users to have a holistic view of their virtual body [20]. In this case, users will not only perceive their virtual body as themselves but also consider the avatar as a separate entity in the virtual space [3]. Both first- and third-person perspectives of virtual embodiment have been proven to be compatible with achieving the body ownership perception in the iVR environment and have been widely used in various studies [2]. The effect of different perspectives on the sense of embodiment in VR environment has been investigated in previous studies. Specifically, participants who embodied in a virtual avatar with a first-person perspective have been confirmed to have a more accurate interaction, a stronger sense of presence, and perform better in navigation tasks, while the third-person perspective provides better space awareness, visual search ability and spatial memory accuracy [4]. Thus, based on different research aims, the viewpoint of virtual embodiment needs to be considered wisely for researchers when designing self-avatars in iVR environments.

In the iVR retail context, four out of five studies used the first-person point of view when the user is embodied in a virtual avatar, while only one study adopted the third-person perspective in a virtual retail context. Specifically, users were allowed to explore and interact with the virtual retail environment from a first-person point of view in several studies [12, 29, 30, 43]. Users were able to see themselves either through the mirror and window reflection [12, 29, 43] or see their extremities when looking down as a first-person viewpoint in the virtual environment [30]. One study used the third-person point of view in a 3D Virtual Try-On (VTO) where

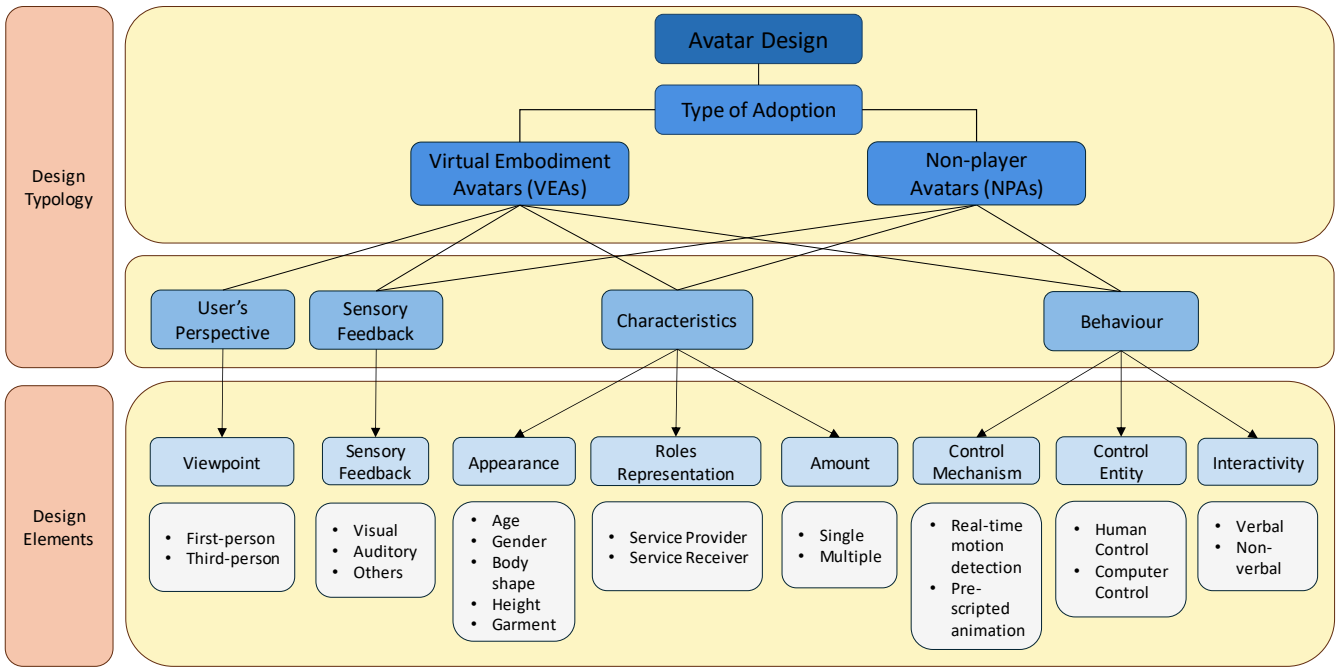

Figure 2: VRAD Framework

users could view their avatar models in a third-person point of view and personalize their avatars with different virtual garments [24]. Nevertheless, whether the first or third-person point of view, different methods for avatars' visual feedback were used to increase the sense of embodiment and body ownership in the VR settings.

3.1.2 Sensory Feedback. In the context of multisensory technology, iVR delivers a range of environmental stimuli to trigger user responses that they may have in real-life. To achieve a strong sense of embodiment, various sensory feedback mechanisms are utilized in VR systems, including visual, auditory, and other feedback.

Visual feedback. Visual feedback includes a realistic rendering of the virtual environment presented to the user, including the spatial layout, virtual objects, and other entities. When applied to the embodiment avatar design, it specifically refers to the display of a virtual body or avatar that users can perceive through their vision. The virtual body should be rendered and displayed realistically in real-time, consistent with the user's motion and location in the virtual world. This can be achieved by providing the avatars' extremities or reflections to assist users in better perceiving the location and understanding the spatial relationship of their avatars in virtual space.

Regarding the visual feedback design in a virtual retail environment, virtual objects such as mirrors and windows were adopted in three studies [12, 29, 43] to provide visual cues and a self-referential experience, allowing users to perceive themselves through the reflections of their avatars. Specifically, Verhulst et al. [43] integrated a large window in a virtual grocery store, affording participants views of the store's exterior and their virtual body reflections. They also utilized mirrors during the completion of the questionnaire in VR. In contrast, Nasser et al. [30] enabled users to observe their extremities in a first-person perspective within a virtual supermarket. In diverse retail settings, mirrors were primarily employed in virtual fashion stores to allow users to assess their appearance while trying on clothing [12] and enable the real-time observation of head, hand, and arm movements [29]. In another VR-based try-on system proposed by Liu et al. [24], users were able to see their avatars face to face in a third-person viewpoint on the user interface and personalized their avatars with virtual garments.

These visual cues the virtual environment provides help immerse the user in a coherent and visually consistent world, enhancing the overall sense of presence and embodiment. More visual cues, such as the avatar's characteristics, will be discussed further in section 4.1.3.

Auditory feedback Different designs, such as sounds that match the attributes of the avatar and/or correspond to the avatar's body movements and interactions, have been used in previous iVR studies. For instance, sounds can be designed and selected to match the avatar's attributes such as gender [46], age [42], weight[40] and any unique qualities it possesses. Considering the avatar's body movements and interactions, synchronized footsteps, breathing, gestures, and vocalization can also be included in the sound feedback design to enhance the presence and sense of embodiment.

In the iVR retail context, only 2 studies from our selection have included this type of feedback in their avatar design. In Dzardanova et al. [12], users could hear the footsteps of their avatars, along with an ambient sound resembling a silent room. In Verhulst et al.[43], audio feedback was used to facilitate user's interaction within the iVR store.

Other feedbacks While visual and auditory feedback have played critical roles in the design of embodied avatars, additional

Table 2: Virtual Embodiment Studies.

	User Perspective	Sensory Feedback		Characteristics		Behaviour		Scenario
		Visual	Auditory	Appearance	Representation	Control Mechanism	Interactivity	
[12]	First person	A mirror to see themselves	Footsteps and ambient sound resembling a silent room	Appearance transformed from avatar with clothes to a nacked avatar	Shopper	Pre-scripted idle, walking pick-up and squat animation	Text-based interaction panel	Clothing store
[24]	Third person	See their avatars face to face in third-person perspective	None	Personalized avatars with a representation of users' own face and body feature	Shopper	None	Non-verbal interaction through a 2D graphic menu	Virtual Dressing Room
[29]	First person	See their idle avatars from the mirror when exploring outfits	None	Pre-modelled male avatar, appearance transformed from barely dressed to one with selected outfit	Shopper	Real-time hands, arms, and head movement	Non-verbal interaction through a 3D graphic interface	Virtual Dressing Room
[30]	First person	Vision: See their avatars extremities when looking down	None	Visible hands and legs with a shopping cart that can teleport with the users	Shopper	Real-time head and body movement control through HMD and motion capture suit	non-verbal interaction with controllers	Grocery store
[43]	First person	See their avatars reflection in a window	User interaction audio feedback	Pre-modelled obese avatars with user interaction avatar's height, body shape adjusted through BMI	Shopper	Real time navigation through motion-tracked controller	A gaze-based metaphor and text-based interaction panel	Grocery store

feedback such as haptic feedback, olfactory feedback and proprioceptive feedback remain relevant elements for creating a truly iVR experience when embodied in an avatar.

Haptic feedback in iVR includes tactile cues that simulate interactions with virtual objects and other entities. Previous research [5] showed that the lack of haptic feedback in the virtual world could cause slower actions as users might not know exactly when the collision has occurred. Basic haptic sensations when touching a virtual object or a collision occurs can be simulated using standard VR controllers and handheld devices by triggering the vibration motors. Furthermore, users can also feel a sense of resistance when pressing or pulling the buttons from the controller when they control their avatars interacting with virtual objects or performing actions in the VR environment. However, these types of hardware may not provide a high level of immersion and realism compared to specific professional haptic hardware in terms of object perception and tactile sensitivity. Thus, the integration of haptic feedback mechanisms in VEA design is inevitably linked to wearable devices such as haptic gloves, exoskeletons, or force-feedback devices.

Similarly, when discussing olfactory feedback, various olfactory display technologies have been explored to deliver scent feedback in iVR [17]. These technologies include scent diffusers, vaporizers, or microencapsulation systems that can be integrated into headsets, wearable devices, or the surrounding environment, such as shops, to deliver scents to the user. Ross. [37] considered the possibilities of integrating multiple sensory feedback to provide a wider embodiment experience in VR environments; however, with the limitations of current technology, it remains a challenge to simulate separate sensory interactions and join up into a full sensory in VR compared to reality. In the meantime, these feedback designs for embodied avatars were not found in our selected literature for iVR retail, which remained a challenging and interesting topic in iVR development.

3.1.3 Characteristics. In the context of iVR, the avatars that closely resemble the user's appearance had a positive impact on the sense of embodiment. Previous research showed that personalizing avatars to match users' real appearances further intensifies the feeling of ownership within virtual environments [44].

From the selected papers, all five studies mentioned the **Appearance** design of the embodied avatars with a main focus on their facial appearance, body shape and virtual garment. In fashion retailing, studies mainly focused on the VTO experience when users put on and take off their clothes. In this case, it is critical to create a visually convincing and realistic avatar with a resemblance to the user's physical characteristics (e.g., gender, height, body shape and proportions) to facilitate a strong sense of embodiment. Existing studies have proposed various methods to accurately represent diverse body sizes and shapes for creating a unique VTO experience for each user in the iVR fashion retail environment. For instance, Liu et al. [24] proposed a VTO to personalize avatars based on each user's sex, height, body figures and facial attributes to generate a more immersive shopping experience. Moreover, users were also allowed to see their avatars wearing virtual clothes in different conditions that were simulated in the iVR environment, such as supermarkets, streets, and offices. In Morotti et al.[29] users were embodied in a barely dressed pre-modelled male avatar, and the goal is to dress him up by selecting virtual shirts, pants, and accessories. In another study proposed by Dzardanova et al. [12], participants were embodied in a virtual body and transformed into naked female and male avatars while trying the virtual cloth. In two other studies on the iVR grocery stores, embodied avatars were designed to present only limbs [30] or pre-modelled obesity virtual body with the body shape adjusted through BMI [43].

In the studies examined, it is noteworthy that the avatars were designed to ensure basic consistency, such as age and gender representation, that aligned with the real participants' attributes. For example, when studying the effect of an avatar's body shape on shopper perception and behaviour [43], the avatar was designed with an East Asian pre-set and national Japanese height to match the physical recruited participants' attributes in general. In Dzardanova et al. [12], participants were embodied in a virtual body with the same gender better to elicit a sense of presence and body ownership. This practice highlights the importance of considering the appearance of embodied avatars based on the specific research goals when designing avatars in the iVR retail context. Researchers can mitigate the risk of eliciting stereotypes or biases that may negatively impact user experiences and social interactions in virtual environments.

Roles Representation refers to the different identities that the avatar represents in the iVR scenario. In different iVR contexts, avatar roles are designed to fulfil specific functions and serve purposes. In our selected literature, users were embodied in avatars representing the service receiver - peer-shopper across all studies, either in fashion or grocery store scenarios. As a shopper or a customer, users could interact with virtual products, browse through virtual stores, and make purchasing decisions just like a shopper does in real life. The accurate role representation in iVR retailing facilitates an immersive and personalized shopping experience.

3.1.4 Behaviour. The behaviour design of embodied avatars focuses on giving users a sense of agency and control over the avatar's actions. In this case, the behaviour design elements should help researchers to determine to what extent users can control their avatars to perform actions in the virtual scenario. Thus, we classified these design elements into two main aspects: control mechanism and interactivity.

Control Mechanism The avatar's motion should be mapped in a way that is consistent with the user's input and allows users to control the avatar's movements within the virtual environment. This can involve walking, running, hand gestures or body expressions, depending on the context of the VR experience. For example, when the user intends to walk in the virtual environment, corresponding locomotion techniques such as instant teleportation or motion-tracked walking could be applied to achieve the avatar's movement in the iVR scenario [38]. Moreover, when the user moves their body or performs gestures in real life, the avatar could mirror that motion to facilitate a more immersive VR experience [6]. Studies have shown that the tracking of head, hands and feet together increased the SoE and spatial presence for male participants [14].

According to existing knowledge, a virtual avatar's motion can be mapped through real-time motion detection and pre-scripted animation. This approach allows for a direct and immediate connection between the user's physical gestures and the avatar's movements and provides a strong sense of embodiment [18]. On the other hand, pre-scripted animation involves creating predefined animations or actions for the avatar. These animations are either pre-recorded or pre-animated to capture and perform specific movements or actions and can be triggered by user inputs (e.g., button press), predefined events, or scripted interactions within the virtual environment.

By examining the existing literature in iVR retailing, the control mechanism of self-embodiment avatars was designed with a combination of real-time motion detection and pre-scripted animation, presenting user with for a more comprehensive and dynamic avatar experience. In Dzardanova et al. [12], the avatar's motion status was changed in real time based on the participants' movement. Pre-scripted walking animation could be triggered when participants held a button on the controllers and would be switched to an idle animation loop when participants released the button. Participant were allowed to collect their virtual clothes from the register, and the pick-up animation would be activated when they pressed the pickup button. In Morotti et al. [29], although no pre-scripted animation was used in the avatar design, participants could control their avatar by moving their hands, arms, and head in real-time and teleport through the HTC Vive and two hand controllers. Similarly, Verhulst et al.[43] proposed a real-time full body-tracked motion mechanism, where participants were allowed to control their avatar's head and body movement through an HMD and a motion capture suit with 35 markers attached to their body. In Nasser et al. [30], motion-tracked controllers were adopted to control the movement of their avatars and shopping carts through teleportation techniques in a grocery store.

Interactivity The concept of interactivity pertains to the degree to which individuals perceive that communication enables them to experience a sense of control and to what extent they can engage in synchronous and reciprocal communication [7]. The interaction design encompasses the user's ability to respond to and manipulate the virtual object and other entities, as well as to engage in different activities in virtual environments. The commonly used mechanisms

for interaction design included non-verbal interactions such as gaze interaction, controller, and hand tracking. Actions such as grasping, pushing, pulling, or manipulating virtual objects using input devices can be regarded as non-verbal interaction. Facial expression and body language could also be used to convey emotions and intentions and engage in non-verbal communication with the user. By examining the existing papers, we noticed that the non-verbal interaction design differed from different virtual retailing contexts due to the specific nature of the products and user needs.

In Nasser et al. [30], users were allowed to use their controllers as a tracker to pick virtual products that they desired and fill them in the shopping cart. Moreover, a text-based interaction panel were also used in this study to guide users' purchasing activities. In another study, Verhulst et al.[43] designed a gaze-based interaction metaphor for participants to select virtual products and add them to their shopping basket. Moreover, a text-based panel with add and remove buttons was designed and displayed on a virtual TV monitor in the store so that participants could modify their shopping basket purchases.

In the selected studies, a graphic menu was used in a virtual fitting room with 2D virtual garment models displayed for users to view, select and try on in VR [24]. In another study, participants can use the controllers to select and choose the available shirts, pants, and accessories to wear on a 3D graphic interface [29]]. In Dzardanova et al. [12], a text-based instruction was designed to instruct participants to perform activities in the fashion store.

To create a more realistic and engaging communication, verbal interaction can also be used in embodied avatar design such as voice and speech recognition. Users could give verbal commands using their own voice and engage in back-and-forth dialogue interactions through voice recognition and natural language processing techniques. The avatar's voice can also be generated by a computer based on the avatar's personality and characteristics within different iVR scenarios [9]. However, the verbal interaction design was not found in the existing VEA studies, specifically in virtual retailing, which provides directions for the avatar design and virtual retailing scenario development. By implementing the verbal and non-verbal design elements on avatars, researchers can provide users with a more natural and realistic interaction experience in the immersive virtual reality environment.

3.2 Non-Player Avatars (NPA)

In iVR, the concept of NPAs, also known as non-player characters, refers to the human entities that users can perceive other than themselves within the virtual environment. They have been widely adopted in both industry and academia, from facilitating the VR gaming storyline and enabling collaborative experience in virtual meetings to assisting personal training and contributing to the design and implementation of a fully-fledged iVR environment [26]. In retailing, the NPAs normally simulate human entities that users commonly encounter in real life, such as shop assistants, cashiers, or customers. Thus, these avatars were designed to replicate the social aspects of traditional retail experiences such as helping, engaging in conversations, or acting as interactive elements in an iVR store. In this case, it is crucial to create realistic NPAs to generate an authentic and believable iVR retail environment for users to fully engage with the experience.

Pioneering works have explored the design and impact of NPAs in VR, demonstrating that various elements, such as appearance, behaviours, engagement, or the mere presence of NPAs, impact user's perceived social presence and behaviour in the iVR environment. Moreover, it also played a crucial role in enhancing the overall shopping experience for customers and driving sales in iVR stores. Thus, to ensure an effective interaction and engagement with users, the design elements for NPA were proposed to guide researchers for a better understanding of the avatar's attributes and the corresponding effects in iVR. By examining the existing literature, we classified the NPA design into 3 elements: sensory feedback, characteristics, and behaviour. Seven out of nine studies described this type of the avatar design, see table 3.

3.2.1 Sensory Feedback. Users can only perceive other avatars in the iVR space from a third-person point of view, and the visual feedback encompasses not only how users can see other avatars but also the appearance and behaviour of the NPA. Thus, the visual feedback is addressed separately in the subsequent sections of NPA's characteristics design and behaviour design.

Auditory Feedback While the auditory feedback design for VEA aims to reinforce the user's SoE and presence, the design for NPAs focuses on creating convincing perceptions of other character interactions in the iVR environment. Common auditory effects of avatar motions such as footsteps, object interactions, breathing, or gesture sounds have been considered in NPA designs to enhance the user's experience and immersion. The auditory effects could also help users identify the spatial location and distance of the NPAs in the virtual space [19]. Moreover, verbal cues can be delivered by NPAs to provide users with well-executed voice instructions. To bring the NPAs to life, their voice can also be designed to match the character's personality, emotions, and traits to enhance the player's understanding and connection with the NPA.

By examining the existing literature, all 6 studies of NPAs included auditory feedback in the design of the NPAs, providing users with verbal instructions or assistance. First, users were able to hear verbal instructions either pre-recorded or spoken in real time [12] and verbal greetings [47, 49, 51] from virtual staff members presented in various virtual retail context. Specifically, NPAs representing store staff were able to provide simple greetings that normally appear in a retail store, such as 'Welcome', 'Hello', 'Thank you' and 'Hope you enjoy' to users. Other sound cue designs related to the store environment, such as background music, air conditioning sound, or advertisement sound, were also mentioned in these studies, providing users with a realistic shopping environment and an immersive virtual experience. Regarding having real-time conversations, Morotti et al. [28, 29] proposed two studies that use Amazon Alexa as an integration on NPA to interpret user's commands and provide users with equivalent information. Through these effective auditory designs in virtual retail stores, NPAs become dynamic and relatable, enhancing the player's sense of presence and enjoyment in the virtual world.

Haptic Feedback The haptic feedback design for NPAs focuses on providing physical sensations to enhance the player's sense of presence and interaction with the avatars. Studies showed that

Table 3: Non-player Avatar Studies.

	Sensory Feedback		Characteristics			Behaviour		Scenario
	Auditory	**Haptic**	**Appearance**	**Representation**	**Amount**	**Control Mechanism**	**Interactivity**	
[12]	Scripted verbal instructions	None	Realistic anthropomorphic male avatar	Salesperson	One	Computer control	None	Clothing store
	Real time verbal instructions	None	A random anthropomorphic male avatar	Salesperson	One	Human Control	None	Clothing store
[28, 29]	Amazon Alexa	None	Smiling Emoticon	Virtual assistant	One	Computer control	Voice-based interaction	Virtual Dressing Room
[30]	Users can hear each other	None	Cartoonish avatars with username presented	Shopper	One	Human Control	Interacting with the participants	Grocery Store
[47, 49]	Avatar's verbal greetings	None	Three male and three female anime avatars with different appearance and same height (1.6m)	Salesperson	One	Human and Computer Control	NPA's position manipulating	Electronics retail store
[51]	Verbal greetings and background music	None	Cartoonish female avatars	Salesperson	One	Computer control	None	Stationery store
	Verbal greetings and background music	Feeling of touch on the shoulder	Cartoonish female avatars	Salesperson	One	Computer control	None	Book store

incorporating haptic feedback to facilitate interactions with NPAs in iVR has the potential to enhance users' initial perceptions of both the NPCs and the virtual environment [11]. To simulate sensations, equivalent haptic devices mentioned in section 4.1.2 were also used here to provide various types of haptic sensations, such as vibrations, pressure, texture, or even temperature changes. The haptic feedback can be designed to simulate the sensation of touch or resistance when the user interacts with an NPA. For instance, haptic feedback was used to mimic the feeling of contact or provide a sense of resistance when participants reached out to touch an NPA or were touched by an NPA. Zhao et al. [51] found that the artificial social touch from an NPA increased social cues and increased participants' perceived realism in the virtual store, proving that implementing haptic feedback for NPAs has the potential to enhance the shopping experience in iVR stores.

To sum up, through a carefully crafted combination of visual, auditory, and haptic elements, the NPC can come to life, enhancing the player's sense of presence and interaction in iVR retail environments.

3.3 Characteristics

Appearance Unlike VEAs, which are usually designed in a way to resemble the user's real attributes, the design for NPAs exhibits a wider variety of appearances to represent diverse shoppers or employees that could possibly exist in a retail store, allowing for greater visual diversity and a sense of encountering unique individuals. To resemble real-life entities in iVR retail environment, most studies from our selection used anthropomorphic appearance for NPA design in either realistic appearance with high levels of details and textures, cartoonish appearance with bold, vibrant colours and simplified shapes or anime avatars with big eyes, pale face and solid colour clothes with no texture . Previous research showed that the comparison of the emotional valence and arousal results when using cartoonish avatars versus anthropomorphic avatars shows that anthropomorphic avatars improve the confidence level of participants' judgments without changing their assessment of valence and arousal [13]. Second, gender was also one of the considerations in the design of NPAs. Th usage of male avatars and female avatars was evenly distributed among the selected studies. When NPA represented shop assistants, Dzardanova et al. [12] used male

avatars while Zhao et al. [51] used female avatars. In Yamazaki et al. [47] and Zempo et al. [49], both female and male salespersons were designed and used in the experimental conditions.

Even though previous studies have mentioned the importance to have anthropomorphic avatars in iVR retail environment, non-anthropomorphic designs may be more plausible if they serve specific roles that benefit from unique characteristics. For instance, Morotti et al. [28, 29] proposed studies to investigate the benefits of having verbal interaction with a virtual assistant in the store, where the virtual assistant was designed as a smiling emoticon instead of a real human. This form of avatar design was used to activate participants recalling the minimally invasive design of the Amazon Echo Dot interface since Amazon Alexa was integrated into the NPA. In this case, a non-anthropomorphic appearance may be used to facilitate an NPA and provide an enhanced sense of novelty and technological sophistication. Elements such as expressive eyes, body language, or unique visual effects could also be used to resemble a human connection through visual cues to enhance the user's engagement and satisfaction in the iVR retail experience.

It's important to note that these appearance styles are not mutually exclusive, and avatars can incorporate elements from multiple styles or blend different art directions based on different research aims. The listed avatar appearance styles only provide insights for developers and designers to understand the intended visual direction, aligning them with the overall design goals and the target audience's preferences.

Roles Representation In general, NPAs can fulfil various roles, such as instructors, story characters or companions, who contribute to the overall experience and interaction within the virtual environment. When specifically considering retail stores or iVR stores, the roles one could play between individuals can be categorized as service providers and service recipients. NPAs can assume additional social roles that are tailored to the retail context as a service provider, such as a virtual salesperson, cashier, virtual assistant, or service recipient like a customer. Among the studies that we selected, except for one paper that introduced NPAs as peer shoppers in a grocery store [30], the NPAs were mainly used in the rest of the studies as service providers. Specifically, NPAs were designed as a representation of either virtual salespersons in a virtual clothing store [12], electronics retail store [47, 49], stationery store and bookstore [51] or virtual voice assistant in [28, 29].

Amount The number of NPAs designed in an IVR store can vary depending on different research aims. In general, several factors such as the virtual store type, store capacity, NPA's roles or functions and system's capabilities are which researchers need to consider when introducing more than one NPA in an IVR store environment. In the selected studies, single NPA were used across studies, allowing researchers to design and implement multiple NPAs in iVR retail environment.

3.3.1 Behaviour. **Control Entity** The main distinction in control mechanism design between NPAs and embodiment avatars is who executes the controls of the avatar. While the embodiment avatar design focuses on how users control and embody a virtual representation of themselves, the NPA control mechanism design centres on how human or computer programs control other avatars in the virtual environment. In terms of human control, it is similar to the VEA design, where a human performs a series of real-time motions. Even though human control can rely on computers to control for some functionality in some cases, such as performing prescript animations, the human is still the main input entity that executes the motions of the avatar. In this case, various motion capture techniques such as cameras (e.g., Microsoft Kinect), reflective markers and wearable sensors can be used to capture and interpret the user's real-world movements, gestures, or input in real-time and map them onto the NPAs.

In Dzardanova et al. [12], the researcher who controlled the staff avatar was able to perform a series of movements such as raising hands, blending, and squatting. The actions were then calibrated into physical movement and transferred to the NPA in real-time. In Yamazaki et al. and Zempo et al. [47, 49] participants could freely manipulate the avatar's position in the radial direction using their VR controller. In another study proposed by Nasser et al. [30], participants had the option to extend invitations to their friends, inviting them to engage in joint shopping experiences within a communal virtual retail setting. Within this context, the virtual non-player shoppers in the virtual store were controlled by the invited friends of the participant.

Computer-controlled NPA refers to the digital entity or character that is controlled by computer algorithms within a virtual environment. Unlike human-controlled avatars, NPAs movements and behaviour are primarily driven by Artificial Intelligence (AI) algorithms or predetermined programming [15, 22]. For instance, in our selected studies, the NPAs verbal behaviour can be controlled either by the AI voice assistant from Alexa [28, 29], generating real-time conversation and providing verbal assistance to the participants in a virtual fashion store, or script audio [12, 47, 49, 51], talking to the participants with scripted auditory instruction or greeting. Regarding the body movements, the NPAs representing shop assistants can be controlled by scripted animation [51], such as walking to the corner of the shop and looking around. These methods are commonly used to populate NPAs into virtual worlds, interact with users, and provide a sense of immersion, depth, and realism to virtual reality experiences.

Interactivity The design of interactivity for NPAs shares commonalities with the design of VEAs, primarily because the interactions that an embodiment avatar engages in with virtual objects and other entities can serve as a reference for how NPAs interact within their environment.

For instance, the verbal and non-verbal communication between the embodiment avatar and the environment objects, such as movements, gestures, virtual object manipulation, text-based interaction, and verbal interactions, can be mirrored in the interactivity design for NPAs. The detailed design elements are also based on the context of the virtual retail setting and the role that the NPAs played within those settings. However, in the selected literature, only one study incorporated a staff NPA endowed with the ability to walk and look around within the virtual retail store. Thus, it is noteworthy that limited studies have so far introduced NPAs in virtual retail environments that could engage in shopping-related activities and interact with the virtual object or other entities. These interactions include but are not limited to browsing, examining products, picking up items, and placing them in shopping carts.

While the literature has limitations regarding the interaction between NPAs and virtual objects, it is important to highlight that the interaction between NPAs and users remains a crucial aspect of NPA interaction design. This aspect has received significant attention and has been extensively explored in the selected literature. In this case, the interaction specifically refers to the NPA's ability to engage in two-way communication with the users, which can be classified as verbal and nonverbal communication. For instance, the NPAs were able to provide verbal assistance in response to user's vocal inputs [28, 29] and verbal instructions for users to explore the store and try out an outfit [11]. Moreover, users were able to hear NPA's verbal greetings [47, 49, 51], voice [30] and to manipulate NPA's position [47, 49]. Regarding to non-verbal communication, the NPAs were able to perform certain behaviours within the virtual stores, such as watching the participants during their virtual body's exposure [12], interacting with the participants while shopping in a grocery store [30] and having physical contact with the participant by touching the participant on the left upper arm [51].

4 Avatars' Impact

4.1 VEA Studies

A total of 5 studies examined the impact of virtual embodiment on shoppers' perception, behaviour, and shopping experience in virtual retail environments.

Verhulst et al. [43] investigated the impact of an obese virtual body on participants' perception and purchase behaviour in a virtual food store. While the results did not show any changes in the purchase behaviour, the weight of the avatar was proved to have an impact on participants' perception of food products. Participants who embodied in an obese avatar perceived Coke as healthier and Apple as tastier compared with the normal avatar. Yoo et al. [48] investigated how operating an elder avatar affected shoppers' purchasing behaviour and perceptions. They found the age of avatars impacted the walking speed in the virtual environment. Specifically, an elderly avatar made participants walk slower than a normal avatar. Liu et al. [24] proposed a VTO system to investigate the impact of personalized virtual avatar on user's shopping experience. Results proved that the personalized avatar offered a realistic shopping experience with an entertaining interaction between their avatars and the virtual products. Moreover, participants felt a stronger sense of enjoyment in the virtual store. Also, the virtual shopping experience was more effective than the desktop VTO. However, the representation of avatars with limited human-like expression and body motions in the VR environment showed low fidelity compared with participants' real appearance and activity.

4.2 NPA Studies

A total of 7 papers investigated the impact of social cues from other avatars in a virtual retail environment on shoppers' perceptions, behaviour, and emotions.

First, studies have confirmed the impact of avatars in the fashion retail industry. Dzardanova et al. [12] studied whether the exposure of a user's naked virtual body to another avatar would impact their shopping experiences by placing individuals in a virtual fashion store. Results showed that participants who encountered the virtual salesman experienced a stronger sense of embarrassment and discomfort when their avatars were exposed in the virtual fashion store. Morotti et al. [28] explored the benefits of introducing a voice assistant in a virtual fashion store by integrating Amazon Alexa skills into an avatar. The study confirmed that the presence of voice assistants made the VR system easier to use for non-expert participants. Then, Morotti et al. [29] further evaluated the performance of voice assistant in the virtual fashion store by comparing it with a VR-based fitting room without any assistant. Contrary to the findings of the previous study, the virtual store with a voice assistant scored lower in perceived use and enjoyment than the VR-based fitting room due to the complexity and restraint of the voice command.

Similar findings have been identified in supermarkets and grocery stores. Nasser et al. [30]addressed an avatar-mediated social interaction and its effects on shoppers' experience in a virtual supermarket. They found that social interaction significantly enhanced shopper's enjoyment immersion and telepresence. Another study proposed by Zhao et al. [51], focused on the effects of social touch on shopper's behaviour in a virtual store. The results indicated that participants who were touched by the virtual assistant spent more time in the virtual stationary shop and more money in the virtual bookshop and evaluated their shopping experiences more positively in both scenarios than those who were not touched. Moreover, Yamazaki et al. and Zempo et al. [47, 49] demonstrated that rapport can be improved by intruding the sound image of the salesperson avatar closer to the participants when serving them in a virtual store. This would potentially improve participants' shopping experience and increase brand value and sales for the store.

5 Discussion

In this paper, we reviewed 9 articles published between 2015 and 2023, which investigate the impact of different forms of avatars on in-store shopper's behaviour, perception, and shopping experience in a virtual retailing environment. This literature review focused on avatar design in iVR retail environments by proposing the VRAD framework to guide researchers on designing and implementing avatars in iVR retail stores and locating specific design elements to make avatars more effective for various research goals.

5.1 How to Design Avatars

We present a set of guidelines that is useful for future researchers and are based on our findings with respect to the 9 papers selected to answer RQ1.

Firstly, the type of avatar's adoption in iVR retail environment needs to be considered to determine whether the virtual avatar indicates user themselves (VEA) or other entities user can perceive (NPAs) in the virtual store. Although there are shared design elements between embodiment avatars and NPAs, the considerations within each design element can be differed from one another.

For the embodiment avatar, the representations of the user's virtual body need to be considered to achieve the sense of embodiment by using two user perspectives, first-person viewpoints and third-person viewpoints. The first-person viewpoint is the most common user perspective that has been used in iVR retail studies providing a more accurate interaction, a stronger sense of presence, and perform better in navigation tasks. It has been used across most

of the studies in iVR retail studies [12, 28, 30, 43], while only one study [24] adopted the third person point view for users to see their avatars face to face.

Regarding the sensory feedback for embodiment avatars, research adopting a first-person perspective often includes virtual elements like mirrors or windows tailored to specific retail contexts, enhancing users' visual feedback by allowing them to perceive their avatars [30]. These elements are employed differently in virtual fashion stores and virtual grocery stores, with mirrors being crucial for clothing assessment and windows prioritizing product visibility. The auditory feedback design in iVR embodiment involves matching sounds to avatar attributes, including gender, age, weight, and body movements [12, 40, 42, 43, 46]. Both VEAs and NPAs benefit from well-designed auditory feedback, utilizing sound effects, voice acting, and spatial audio to create a realistic experience, reinforcing a sense of embodiment and emphasizing character interactions and special locations for NPAs. Both haptic and olfactory feedback can be simulated using standard VR controllers and/or additional devices could be considered when provide users a more fulfilling and realistic experience [36, 51] and evaluating the impact of store atmospherics in IVR [39].

In terms of characteristics design, avatars' appearance, such as age, gender, body shape, and outfit, are crucial considerations for creating a convincing virtual environment and enhancing user experiences. Some studies focus on the effects of specific avatar attributes on user perception and behaviour, while others aim to closely resemble users, especially in virtual fashion stores or try-on systems [12, 43]. The design of avatar appearances can be intricately linked with their role representations, promoting consistency and enhancing user experience. In the iVR retail context, roles include service providers (e.g., salespersons and virtual assistants) and service recipients (i.e., shoppers). Notably, the number of avatars in the iVR store is a key consideration for NPA design, with most studies using a single avatar, suggesting potential future research directions.

Regarding behaviour typology, the design elements are categorized as control mechanisms for VEAs and control entities for NPAs. The control mechanisms for VEAs mainly focus on how users control their avatars, often involving real-time movement, motion-tracked controllers, or pre-scripted animations. In contrast, NPA control mechanisms centre on the entities controlling other avatars, including scripted animations, AI, and real actors. The interaction design for both embodiment avatars and NPAs aims to fulfil specific roles through verbal and non-verbal communication, encompassing movements, gestures, virtual object manipulation, text-based interaction, and verbal interactions. Interaction technique include non-verbal interaction such as gaze interaction, controller, and hand tracking.

In summary, the proposed VRAD framework in this literature review can enhance avatar design in iVR retail environments and guide future researchers in their design by considering the various discussed design elements.

5.2 Impact Avatars Have on Shopper Behaviour, Perception, and Experiences

Answering RQ2, we conducted a detailed analysis of the selected paper and summarized the avatar's impact on user's perception, behaviour, and shopping experiences in various virtual retail contexts. Firstly, studies have confirmed the impact of the appearance of user's avatars, such as body shape [43], and physical attributes [24] on user's perception and shopping experiences. Similar findings have been proposed by Yoo et al. [48], who investigated how an elder avatar affected shoppers' purchasing behaviour and perceptions in desktop VR retailing stores. They found that the age of avatars impacted walking speed in the virtual environment. An elderly avatar made participants walk slower than a normal avatar. The findings highlighted the significant influence of avatars' physical attributes, such as body shape and age on user perceptions and experiences in virtual retail environments.

Second, results showed a positive impact of NPA's on participants enjoyment and telepresence in a virtual grocery store [30], shopping experience [47, 49] in virtual electronics retail store, ease of use [28] in virtual fashion store and purchase behaviour [51] in virtual bookstore. The positive effects of NPAs on enjoyment, telepresence, and purchase behavior suggested that avatars are not merely representations but also have the potential to enhance the overall shopping experience. Virtual retailers can employ NPAs to create more interactive and enjoyable shopping experiences. Although one study mentioned that the AI-generated conversation reduces participants' perceived use and enjoyment, it provides suggestions for a fluent and rapid conversation flow for future AI avatar design and highlighted the importance of a seamless interaction in virtual retail environment.

5.3 Limitations of Current Avatar Research and Future Agenda

Answering RQ3, we identified limitations and gaps that are worth further investigation when introducing avatars into an immersive virtual retail environment. It is important to define as the first limitation the number of items selected for this review, due to the keywords that were selected within the queries. In the future, we aim to expand the queries by including other aspects of the shopping experience to broaden the results. Moreover, no studies have adopted haptic feedback for embodiment avatar design in the iVR retail environment. Haptic feedback in iVR includes tactile cues that simulate interactions with virtual objects and other entities. Previous research [5] emphasized that the lack of haptic feedback in the virtual world could cause slower actions as users might not know exactly when the collision has occurred, which makes the haptic feedback essential for avatar and iVR environment design. For instance, when the user touches a virtual object, interacts with other entities, or performs an action in the virtual environment, a form of haptic feedback can be provided to users by triggering the vibrations motors built-in in the controllers or haptic gloves.

Second, no studies so far have focused on the design of an avatar's diverse physical attributes such as varies age groups, non-binary genders, different height, and facial appearance in the virtual retail store. Studies have found that by changing the avatar's physical attributes, users who operate it were more likely to behave based

on the avatars' body stereotypes or their previous observations of how individuals with similar body types behaved. Future research may also focus on customizing NPAs' physical attributes to align with individual shopping preferences and investigate how avatars with different appearances influence users' perceptions, behaviour, and experiences in a virtual store. Considering the avatars can profoundly influence user perceptions and actions, the ethical implications of using avatars in iVR retail such as the possibility for manipulation, privacy violations by collecting the data about consumers' physical characteristics and shopping habits needs to be considered and focused in future research.

Third, the avatar's roles representation in virtual stores is notably limited to two specific categories: shoppers represented by VEAs (the users themselves), and salesperson represented by NPAs. This constraint in avatar design within the virtual retail domain provides insight for future studies that introduce dynamic avatars with different roles in a retail context, such as shopper NPA. In terms of the presence of other customers, the opportunity to socialise with other shoppers is the main motivation for some individuals to engage in a physical shopping trip while for others it poses a disturbance, and they would rather avoid mingling with crowds of other shoppers. Interestingly, Li et al. [23] found a positive relationship between pleasure and perceived human crowding at Taiwan retail stores, which indicated the attitude toward crowding may be influenced by cultural dimension. In this case, the researcher may focus on introducing more than one NPA with different roles in the virtual stores to investigate the avatars' amount impact on users' perception and behaviour in the iVR store.

Last, this literature review has shown insufficient interaction among NPAs, users and virtual objects. Currently, NPAs are primarily lacking the dynamic behaviours and two-way communications to provide users with and truly immersive shopping experiences. Commonly, interaction between individuals includes but is not limited to gaze interaction, facial expression, body language and verbal conversations with lip-syncing. These behaviours could also be used to convey emotions and intentions, engage in realistic communication with the user and enhance user experiences. Future studies can focus on virtual avatars' behaviour in the iVR store using scripted animation or AI to generate verbal or non-verbal behaviours between individuals that might happen in a physical store [39].

6 Conclusion

Through a comprehensive review of existing research and industry trends, this paper proposed the VRAD framework specifically for iVR retail experiences. We have highlighted the key components of avatar design, including visual fidelity, animation quality, facial expressions, and customization options. These design elements contribute to creating avatars that not only reflect the user's identity and preferences but also establish a sense of presence and authenticity in the iVR retail environment. The VRAD framework also emphasizes the importance of creating avatars that are visually appealing, realistic, and relatable to enhance user engagement and immersion.

The impact of avatars on user experiences and behaviours within this context was also examined in this paper. Our analysis of user perception, experience and behaviour indicates that well-designed avatars significantly impact the overall retail experience, enhancing users' immersion and presence. Avatars serve as virtual representations of users, allowing them to navigate the virtual store, interact with products, and engage in social interactions with other users and virtual sales assistants. Avatars that are aesthetically appealing and closely aligned with users' self-image positively influence user satisfaction, emotional connection, and purchase intentions.

We believe this literature review has revealed several noteworthy research gaps and implications for the field of virtual retail and human-computer interaction. The VRAD framework presented in this paper offers valuable insights for designers, retailers, and researchers in creating compelling and effective avatars within iVR retail settings. By following the VRAD framework, we can shape more immersive, engaging, and successful iVR retail environments that can simulate or even improve physical shopping experiences.

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