6-14-2021

How can Older Adults Shop Online in the Future? Developing Design Principles for Virtual-Commerce Stores

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HOW CAN OLDER ADULTS SHOP ONLINE IN THE FUTURE? DEVELOPING DESIGN PRINCIPLES FOR VIRTUAL-COMMERCE STORES

Research Paper

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Abstract

The Covid-19 crisis has significantly affected retailers in interacting with their customers. Now more than ever, retailers innovate and strive for effective replication of in-store experiences in an online environment. Virtual reality can be effective in emulating experiential shopping at home. However, particularly older adults (OAs) experience difficulties in using these novel technologies as they undergo several age-related changes, such as deteriorating vision or weakened hand-eye-coordination. Thus, we identify the requirements of OAs and develop seven design principles for virtual-commerce stores for OAs. We follow a design science research approach with a staged research process and iterative cycles. The requirements and design principles are evaluated and refined by conducting semi-structured interviews and focus groups. This study offers prescriptive knowledge in form of design principles for virtual retail and a specific customer segment and contributes to customer-centred design literature. These principles can further guide developers in designing digital systems for OAs.

Keywords: Design Principles, Virtual Reality, Older Adults, Digital Retail.

1 Introduction

Most consumers show a growing preference for a memorable shopping experience in interactive environments, such as virtual store environments, over acquiring products on a traditional website (Brown and Lubelczyk, 2018). Online virtual stores are an evolution of traditional web stores, offering retailers an opportunity to enrich online interactions with their customers (Hassouneh and Brengman, 2015). The visual intricacies of a virtual store environment draw the attention of users and affect their emotional and behavioural responses (Jang et al., 2018). Using virtual environments like a virtual (v)-commerce store (Xue, Parker and Hart, 2020), retailers can particularly enhance the hedonic experience (Babin, Darden and Griffin, 1994) offered to their customers, thus improving customer satisfaction in the online environment (Kim and Forsythe, 2008). Hedonic experience stems from the emotional state that may involve all elements such as background, music, light, and other design elements that can contribute to pleasurable and memorable feelings (Xue, Parker and Hart, 2020).

Due to the Covid-19 pandemic, the current time is defined by uncertainties and changes. Governments worldwide issued restrictions to public life, in particular physical meetings (Hacker et al., 2020). Especially for older adults (OAs), who are some of the most vulnerable, alternatives for shopping to

traditional brick-and-mortar stores are highly necessary (Papagiannidis et al., 2017). For purpose of this study, we define OAs as those who are 50 years or older (Barrett et al., 2011; Ahmad, Richardson and Beecham, 2020). One way of offering such an alternative to OAs could be the provision of a v-commerce store, as they emulate the traditional shopping environment and thus provide a comparable shopping experience (Xue, Parker and Hart, 2020). Besides, v-commerce stores can be an attractive option for OAs to have a delightful shopping experience from the comfort of their home.

The early uptake of new technologies by OAs is still limited, especially regarding interactive technologies, such as virtual reality (VR) (Santos Silva, Mol and Ishitani, 2019). Partly, this results from the development of VR applications being disconnected from OAs and their usage contexts (Liang, 2018). However, retailers must not dismiss these technologies for OAs as the overall technology usage among this group is increasing substantially (Lee and Coughlin, 2015). According to a recent study, 67% of adults aged 65-year-old or older stated that they use the internet, 42% owned a smartphone, and 32% owned a tablet computer (Dwerby and Chaparro, 2020). Moreover, OAs represent the strongest group economically (Lee and Coughlin, 2015). OAs spend more than $7.6 trillion annually and control approximately 80% of household wealth in the USA (Coughlin, 2017). This motivates the development of technological applications specifically suited to the needs of OAs (Mol, Silva and Ishitani, 2019).

The requirements of OAs have not yet been sufficiently considered in the design of most VR and augmented reality (AR) applications, even though these types of applications may help to overcome certain aspects of age-related challenges and limitations that they experience (McGlynn and Rogers, 2017; Liang, 2018). Following, we see it as an important task to identify specific requirements of OAs and better understand how they experience VR technology for designing v-commerce stores that are suited to their needs. It has been shown that the implementation of OA-specific design principles can improve the acceptance and success of v-commerce stores (Liang, 2018). Therefore, this research aims to establish a set of design principles for VR designers to develop v-commerce stores that are OA-friendly by answering the following research question: *What are the principles that can guide the design of non-immersive v-commerce stores considering the requirements of older adults?*

To investigate this research question, we first derive an initial set of requirements of OAs in a technological context (mostly in the context of electronic (e)-commerce use) from a literature review. We further enrich and validate these requirements by conducting seven interviews with OAs. In the next step, we develop a preliminary set of design principles, which are iteratively refined by discussions among the co-authors and the analysis of the two focus groups. When developing the principles, we focus on a non-immersive v-commerce store, as we regard this technology as the most suitable and easily available to OAs. Our research contributes to theory and practice by providing a set of requirements of OAs in a v-commerce context as well as design principles to guide the design of a v-commerce store suited to the needs of OAs. We further shed light on the discussion of a customer group-centred design and provide a basis for further research in this area.

The rest of the paper is structured as follows. Theoretical background and related work are presented in Section 2. In Section 3, we discuss our research approach (i.e., Design Science Research). The final design requirements and principles are presented in Section 4. In Section 5, we discuss the implications of this research and conclude the paper in Section 6.

2 Theoretical Background

2.1 V-commerce store

V-commerce stores are characterized by a computer-simulated, interactive, and real-time three-dimensional shopping environment, offering opportunities for a more functional, interactive, realistic, and engaging experience for customers (Xue, Parker and Hart, 2020). There exist various forms of v-commerce which can be differentiated by their level of immersion, i.e., non-immersive or immersive

systems (Shahrbanian et al., 2012). In non-immersive systems, the virtual environment is accessed via a computer monitor and controlled by keyboard and mouse, leading to a lowered feeling of presence in the environment and lower realism, but also to fewer requirements regarding hardware and software (Park, Im and Kim, 2018). On the contrary, immersive systems allow for a realistic environment with a high sense of presence (Jain and Werth, 2019). Virtual reality is accessed, for example, by a head-mounted display and controlled with, for instance, data gloves, controllers, or body movements, which lead to higher requirements for soft- and hardware (Park, Im and Kim, 2018). As this research study is specific to OAs who may have lower access to immersive technology in terms of adoption and available hardware, we investigate the design of a non-immersive v-commerce store.

As v-commerce is still an emerging topic in research (Xue, Parker and Hart, 2020), most articles concerning design elements of v-commerce stores focus on the investigation of one or few elements, such as the store layout (Vrechopoulos et al., 2004) or the general visual complexity (Jang et al., 2018), and their influence on consumer perception or behaviour. Other research focuses on specific contexts, such as high-street fashion retail v-commerce (Xue, Parker and Hart, 2020) or retailing stores in social virtual worlds, e.g. Second Life (Hassouneh and Brengman, 2015).

Visual design elements of a store can be divided into two dimensions, aesthetic factors, such as colour, texture or patterns, that help customers to feel pleasure in a store, and functional factors, such as layout, comfort, or signage (Baker, 1986). The aesthetic factors have a high influence on the visual complexity of a store, i.e., the amount of detail and variety of visual stimuli and information in a v-commerce store (Jang et al., 2018). This refers, for example, to general design elements, such as floors, walls, and furniture as well as the diversity of products. Too complex environments can negatively affect customers' perceived attractiveness or approach intentions (Jang et al., 2018). Also, ambient factors, e.g., sounds, are important for the customer experience (Hassouneh and Brengman, 2015). The store layout of a virtual store can have, similarly to the layout of physical stores, a high influence on users' buying and interaction behaviour (Vrechopoulos et al., 2004).

Furthermore, v-commerce-specific design factors, such as the mode of navigation (i.e., flying or walking) (Hassouneh and Brengman, 2015) or assistant systems (Xue, Parker and Hart, 2020) should be considered. To attract customers and increase their trust in v-commerce, designing an authentic and pleasant environment is essential (Xue, Parker and Hart, 2020). Other elements facilitating the v-commerce customer journey are elements at the point of purchase, as the type of product presentation and organization or the type of information provision (Hassouneh and Brengman, 2015).

2.2 Characteristics of older adults

OAs experience several changes in their abilities while ageing. The underlying factors for those changes are manifold and cover several aspects. Literature provides a plethora of discussions around various concepts, as discussed in the following. Following Fisk et al. (2009) and Czaja et al. (2019), the most significant changes can be broadly grouped into the categories "Sensation & Perception", "Cognition" and "Movement Control". Sensation and perception abilities comprise vision and hearing, whereas cognitive abilities refer to processing speed, attention, memory, and spatial cognition (Kondo and Kochiyama, 2018; Czaja et al., 2019). Movement control abilities address motoric-related abilities, such as manual dexterity or hand-eye coordination (Czaja et al., 2019).

Within the sensation and perception category, the deterioration in the vision represents a major limitation for OAs. Usually, with ageing, loss of visual capabilities come along. As a consequence, the inability to perceive graphical elements correctly can inhibit effective interaction with technology (Zajicek, 2004; López-Martinez et al., 2011; Patsoule and Koutsabasis, 2014). Furthermore, the inability to focus on objects (Vasconcelos et al., 2012), as well as potential reductions in the fields of vision, colour perception and depth/contrast perception (Ijsselsteijn et al., 2007) can occur. Deterioration in hearing implies a loss in effective hearing which affects the correct perception of environmental noise and can cause difficulties in interactions with systems (Czaja et al., 2019). From a website-interaction point of view, this type of impairment represents a rather neglectable inability, as

the majority of interaction is covered by visual elements (Hanson, 2001). Nevertheless, increased use of different media in applications (such as VR) can change the significance of auditive abilities (Kamollimsakul, 2016).

Cognitive abilities also change while ageing and involve several significant aspects. Reduced processing speed represents a major change as OAs take much more time to process information. This usually affects pattern recognition, such as letters or numbers, and general reading abilities (Czaja et al., 2019). As a result, the response time when interacting with systems is lowered (Raza and Sahar, 2013). Moreover, OAs are confronted with the reduction of their attention span (López-Martinez et al., 2011) which increases the time for processing information and general comprehension, such as identifying visual elements (Dodd, Athauda and Adam, 2017). Focusing on particular elements becomes very difficult, as other elements distract by moving and flashing (Balakrishnan, Salim and Hong, 2012). Moreover, following tasks and steps requires a longer attention span – OAs, however, easily lose track of the steps and eventually make mistakes in completing tasks (Granata et al., 2013; Dodd, Athauda and Adam, 2017). Spatial recognition, i.e., the ability to orient oneself within everyday environments, also experiences a decline while ageing, making it difficult for OAs to orient in new and complex environments or focus on landmarks (Morganti et al., 2009; Santos Silva, Mol and Ishitani, 2019).

Limitations in movement control address the phenomenon that ageing affects muscle strength and tone negatively and inhibits effective movement abilities (Liang, 2018; Czaja et al., 2019). Gripping and holding devices becomes more difficult with age (Farage et al., 2012). On a smaller scale, manual dexterity can cause issues while operating devices, such as a mouse or keyboard (Czaja et al., 2019). Usually, OAs need longer time and lack precision in their movements compared to younger users (Sjölinder, Höök and Nilsson, 2000; Sjölinder et al., 2005; Czaja et al., 2019).

Besides the above-mentioned characteristics, the literature also addresses the following age-related aspects. For example, McGlynn and Rogers (2017) argue that emotional changes are also observable in OAs besides cognitive and physical changes. OAs appear to be more positive and emotionally stable as they age. They propose that OAs are more prone to stimuli that are framed with a positive, emotional tone, compared to experiential or cognitive ones (Fung and Carstensen, 2003), and should therefore be deliberately addressed to take advantage of. An emotional tone affects information processing and memorizing positively during interaction (McGlynn and Rogers, 2017).

Another change addresses the social aspects of interacting with technology. The literature argues that technology-based services can facilitate social exchange and participation for OAs, as it is evident that OAs are confronted with social isolation in later years (e.g., Burmeister, 2010; Chattaraman et al., 2011; Saldaño et al., 2013; Spinelli and Jain, 2014). Shrinking personal networks in combination with increased health problems make it more difficult for OAs to be socially active as they age.

2.3 Technology design for older adults

The extant literature on the design of interactive online environments for OAs is limited, as shown in Table 1. In the context of VR, there have been some recent studies on the development of OA-friendly games (Mol, Silva and Ishitani, 2019) and mobile platforms (Brown, 2019). However, most research in OA-friendly design is related to traditional websites (e.g., Zaphiris, Kurniawan and Ghiawadwala, 2007; Patsoule and Koutsabasis, 2014) and smartphone applications (e.g., Ahmad, Richardson and Beecham, 2020). A v-commerce store combines elements from VR products (such as VR games) with traditional e-commerce websites. This difference necessitates specific guidelines for v-commerce stores. There is no agreed-upon definition of OAs in the gerontology research on the design of AR, VR, and websites. Researchers have used 50, 60 and 65 as the minimum age to define OAs as shown in Table 1. We decided to use the lowest age limit for OAs to ensure consideration of all relevant studies in our review.

Article	Context	Contribution	Research Methods	Def. of OAs
Mol, Silva and Ishitani, 2019	VR games	Identified design elements that make VR games more suited for OAs.	Qualitative analysis (grounded theory)	60 years or older
Santos Silva, Mol and Ishitani, 2019	VR & AR applications	Studied the extant AR and VR research for OAs and proposed possible applications of these technologies for OAs.	Systematic literature review	60 years or older
Brown, 2019	Mobile VR platform	Examined the usability, preferences, and application considerations of a mobile VR platform for OAs.	Semi-structured interviews, thematic analysis	60 years or older
McGlynn and Rogers, 2017	Immersive VR systems	Identified characteristics of OAs that could influence the way OAs experience VR. Provided design recommendations for enhancing VR presence for OAs.	Conceptual research, literature review	65 years or older
Liang, 2018	AR systems	Developed AR design principles and evaluated their usefulness for the design of AR applications that address OA's requirements.	Focus groups	65 years or older
Patsoule and Koutsabasis, 2014	Websites	Studied the redesign of a touristic web portal to make it OA-friendly.	Case study (interviews and questionnaires)	60 years or older
Zaphiris, Kurniawan and Ghiawadwala, 2007	Websites	Developed web design guidelines for OAs.	Card sorting, focus groups	60 years or older
Ahmad, Richardson and Beecham, 2020	Smartphone appl.	Proposed design recommendations for OA-friendly smartphone applications.	Mixed methods	50 years or older

Table 1. Studies related to technology design for older adults.

3 Research Methodology

We adopted a cyclic design science research approach (Hevner and Chatterjee, 2010; Mullarkey and Hevner, 2019), in line with Blaschke et al. (2019) and Seidel et al. (2018), who carried out a similar method to formulate design principles for digital value co-creation and sensemaking. We used a staged research process, informed by the work of Peffers et al. (2007) and Sonnenberg and Vom Brocke (2012) that allowed for multiple iterations in the identification of the requirements of OAs and the formulation of the design principles. Table 2 summarizes our research process.

Stage	Activity	Applied Research Method	Output
1	Identification of the problem	Review of retailers' initiative	Justified problem statement
2	Formulation of requirements	Literature review (Webster & Watson, 2002)	Initial set of requirements
	Evaluation of the requirements' relevance	Semi-structured interviews (Creswell and Poth, 2017)	Final set of requirements
3	Conceptual development of features of a non-immersive v-commerce store	Logical reasoning, review of v-commerce store development	Exemplary set of features

	Formulation of design principles		Initial set of design principles
4	Evaluation of the design principles' feasibility, completeness, and efficacy.	Focus groups (Krueger, 2014)	Validated set of design principles

Table 2. Overview of the research process.

We started with the identification and formulation of the problem and objectives (Stage 1). For requirement elicitation (Stage 2), we firstly conducted a literature review (Webster and Watson, 2002) to identify the requirements of OAs in VR and adjoining applications, such as AR or e-commerce. We enriched these findings with the insights from seven semi-structured interviews (Creswell and Poth, 2017) with OAs. We assessed the interview participants via our networks and selected them ensuring a diverse set of gender, age and e-commerce experience (Creswell and Poth, 2017). The interviews were conducted in German or English by following a previously derived interview guide. The details of the participants are shown in Table 3. After collecting personal information about the participants, such as their age or experience with e-commerce and VR, we provided them with an exemplary v-commerce store of an interior company, which is currently available online (see: https://deskelly.ie/virtual-tour/). We chose this example, as it represents a non-immersive v-commerce store and is, in our opinion, suitable for a first introduction to the topic. Further, we wanted to collect feedback and requirements from the interview participants in a suitable environment and not only theoretically. Our research project is not linked to the v-commerce store or the associated company. We encouraged the interview participants to ask questions to ensure their understanding of how the v-commerce store worked (Brown, 2019). We asked the participants to talk freely while using the store and comment on their thoughts and expressions. The interviews were recorded, and template analysis was performed by three of the co-authors to analyse the data (Creswell and Poth, 2017).

ID	Age Interval	Gender	Experience with VR Applications	Experience with E-Commerce	Duration of Interview
I1	60+	male	no experience	occasional user	~ 40 minutes
I2	50-55	female	no experience	rare user	~ 30 minutes
I3	60+	female	no experience	occasional user	~ 30 minutes
I4	56-60	female	no experience	regular user	~ 25 minutes
I5	50-55	male	limited experience	regular user	~ 20 minutes
I6	56-60	female	no experience	rare user	~ 35 minutes
I7	50-55	female	no experience	occasional user	~ 25 minutes
Total Participants (7)	50-55 (3), 56-60 (2), 60+ (2)	male (2), female (5)	no experience (6) limited experience (1)	rare user (2) occasional user (3) regular user (2)	~ 205 minutes

Table 3. Details of the interview participants.

To conceptually develop v-commerce store features (Stage 3), we first identified possible features based on the requirements of the OAs. In the second step, we created design principles based on the exemplary features of a non-immersive v-commerce store and requirements specific to OAs. For the evaluation of our design principles (Stage 4), we conducted two focus groups with three VR designers or researchers with experience in VR design (see Table 4 for details). We decided to conduct a small focus group as this encourages greater participation and in-depth evaluation from each participant. Large focus groups can be difficult in design research due to the complexity of the research (Tremblay, Hevner and Berndt, 2010). We evaluated the completeness, feasibility and efficacy of the design principles (Venable, Pries-heje and Baskerville, 2012; Gregor and Hevner, 2013). The focus

groups were conducted in four phases in line with the focus group framework developed by Krueger (2014). The phases are opening, introduction, transition, and key phase. The focus groups were moderated by the first author, while two of the other co-authors took notes during the discussion. The recordings of the focus groups were transcribed by an audio-to-text software (Otter.ai) and manually adjusted. Afterwards, the transcripts were combined with notes from the authors, which focused more on expressions and meaning than simply content. We used the insights of the first focus group to refine the design principles. As the second focus group did not come up with any further suggestions on adjusting the design principles, we regarded them as feasible.

Focus Group	ID	Role	Design Experience
1	F1	Researcher / Mixed reality designer	Has designed mixed/virtual reality products for retail application.
	F2	Senior VR designer	Extensive VR design experience with agricultural and retail products.
	F3	VR designer	VR design experience with marine and retail products.
2	F4	Researcher in HCI	Research projects conducted in the area of VR, experience in VR design.
	F5	Researcher in AR	Experience in designing AR products.
	F6	Researcher in AI and HCI	Collaboration in AR/VR projects.

Table 4. Details of focus group participants.

3.1 Problem identification

Due to the meeting restrictions issued by governments, Covid-19 has significantly affected the ability of retailers to interact with their customers (Roggeveen and Sethuraman, 2020). Especially OAs, who are particularly at risk from Covid-19 are recommended to not engage in unnecessary activities (Brooke and Jackson, 2020). Thus, they are missing out on a stimulating and engaging shopping experience, while retailers experience lower purchase rates. Even though OAs have the opportunity of shopping online, traditional e-commerce is not suitable to reflect an in-store shopping experience (Danaher, Wilson and Davis, 2003). On the other hand, v-commerce offerings, which are suitable to address hedonic shopping values (Pizzi et al., 2019), are mostly not tailored towards OAs, so they struggle to use and enjoy these applications (Silva, Mol and Ishitani, 2019). So far, to the best of our knowledge, no OA-tailored design guidelines have been considered in academic v-commerce literature.

3.2 Requirements formulation and evaluation

The extant literature provides a wide range of different requirements for website design, e-commerce, AR or VR, addressing the needs of OAs outlined in section 2.2. For identifying relevant requirements for this study with a focus on non-immersive v-commerce, the literature was screened following the concept-centric approach of Webster and Watson (2002). Findings were drawn on the four themes for VR platform design, provided by Xue et al. (2020), as they represent crucial and ideal aspects of delivering a shopping experience in a virtual environment (Xue, Parker and Hart, 2020). The four themes are “Accessibility” (AC), “Functionality” (FU), “Assistant System” (AS) and “Content Design” (CD).

Initially, a total set of 43 papers was identified by searching for the keywords “older adults” (also considering synonyms such as “senior*”, “elderly” or “age-friendly”) in conjunction with “v-commerce” (including related keywords such as “e-commerce”, “VR store” or “web-shop”) and “requirements” in the databases Google Scholar, Scopus, and Web of Science. Eventually, 18 papers were considered as highly relevant, as they provide contributions on OAs’ requirements in a web or

VR/AR environment. The identified requirements were consolidated across the four themes and adapted to the v-commerce context. We refer to this as the initial set of requirements. In a second step, we evaluated, refined, and finalised this initial set through insights from seven semi-structured interviews with OAs. The final list of requirements is provided in Section 4.1.

3.3 Design principles formulation and evaluation

Before formulating design principles, we identified exemplary v-commerce store features to address the requirements of our target group. Next, we derived six initial design principles by combining requirements and features. Table 5 shows both the exemplary set of features and our initial design principles. In the following, we discuss the changes made to the principles and show the final set of design principles in Section 4.2.

Initial Design Principles (DP)	Exemplary Features and Related DPs
DP1. Reflect the atmosphere of the physical store	• Background music (*DP1*) • Adequate space between different products (*DP2, DP3, DP6*) • Easily identifiable and always available "Undo"-button (*DP3, DP6*) • Tutorial (*DP4*) • Product description by audio and text (*DP5*)
DP2. Provide an adequate amount of information	
DP3. Allow a tolerance for errors	
DP4. Provide suitable assistance	
DP5. Provide a complementary set of formats	
DP6. Provide distinguishable objects	

Table 5. Initial design principles and exemplary features.

After formulating the initial six design principles, we evaluated these principles by conducting two focus groups. Based on the analysis of the first focus group, we substantially modified two of the initial six design principles (DP1, DP5) and added another principle (DP7). We modified DP1, as we received the feedback from the focus group that "[…] you'd have to take elements from a physical store environment, of course. But I don't think that should be a […] central point of the application" (F1). Further, the participants stated that "… in a VR store every touchpoint needs to be assessed in terms of the utilitarian and hedonic relevance of it, more than just simulating the physical function" (F1). Thus, we changed the DP1 to state that only key touchpoints of a physical store should be integrated instead of simulating the complete store. The focus group participants agreed with the necessity of providing different formats for transporting information (e.g., pictures and explanatory texts) as we state in DP5, but emphasized the importance to give "Customers […] the option of choosing a format" (F1), as they could be overwhelmed easily: "If all options exist at the same time, you could overload older people with too much information" (F2). Thus, we included this in the DP5. Additionally, the participants reflected on the navigation in the store, which was not yet addressed in the design principles. They suggested to "make it as simple as possible for people to get to a product" (F2), because "it's just not going to be a nice experience that people get disoriented and lost" (F3). Following, we added DP7 to address the navigation mode.

The second focus group confirmed the completeness, feasibility and efficacy of the design principles and did not suggest any further changes in the design principles. F5 noted, "The design principles can stay the same, but you might add more examples in the description". Similarly, F4 noted, "These design principles are adequate and well-structured for me as a VR designer".

4 Results

4.1 Final design requirements

In this section, we provide the final design requirements as derived from literature and interviews. The final set of requirements is shown in Table 6. AC requirements include those requirements that address

difficulties in accessing technology in general (AC1) and specifically allow for an eased access for OAs. Depending on the design and the employed technology, the need for OAs to change their current shopping habits differs. A substantial behaviour change and thus the need to adapt to a new situation could overwhelm OAs and negatively affect the adoption rate (AC2). Technological barriers reflect the general reluctance of OAs in approaching technology such as a web-shop environment, or a v-commerce store.

FU addresses requirements regarding the features and functions of a v-commerce environment. Literature and interviews show that there is a need to provide room for errors in interactions, as errors are more likely for OAs compared to younger adults (FU1). Secondly, there is evidence showing interaction demanding a high-reaction speed as being very unfavourable for OAs, as processing speed and movement control are highly inhibited at a later age (FU2). The AS theme is reflected by the need for an increased provision of guidance and explanation of functions and features within the v-commerce store. It reflects the assistive element within an application and its role in the context of usage by OAs (AS1). OAs can suffer from decreased memory and reduced spatial cognition and require guidance to mitigate these limitations.

The CD theme is comprised of requirements that address the constraints related to the content of the v-commerce store. For example, presenting only one type or format of information provision (e.g., text as the only source to describe a product) is regarded as inconvenient, because older people suffer more likely from deteriorating sensing abilities, such as vision, hearing, or reading comprehension (CD1). Thus, more formats should be provided to address these issues. Moreover, it is shown that OAs are more sensitive to stimuli with a positive emotional tone and should therefore be deliberately served with corresponding themes (e.g., smiling faces, positively connotated background music) (CD2). As a further important requirement, CD3 addresses the need for an increased perception of the products, as OAs may have difficulties in differentiating between important and non-important objects. Also related to the content, CD4 emphasises the need to consider reduced abilities for long-time attention periods while interacting in the v-commerce environment. Finally, CD5 addresses various cognitive and physical limitations and proposes the clear distinction of visible objects through different shapes or colouring.

Theme	ID	Requirements for this Study	References	Exemplary Quotes from Interviews
Accessibility	AC1	Consider technology acceptance barriers	Smith, 2008; Niehaves and Plattfaut, 2014; Spinelli and Jain, 2014; Coldham and Cook, 2017; Czaja et al., 2019; Roberts et al., 2019	"First, I needed some time to understand. It is difficult to see everything." (I7)
	AC2	Consider the need for OAs to change shopping behaviour	Liu, Uang and Chang, 2009; Liu and Uang, 2016	"The placement of the products should be made in such a way that it is easy for me to move around ..." (I2)
Functionality	FU1	Consideration of mistakes and errors while interacting	Spinelli and Jain, 2014; Dodd, Athauda and Adam, 2017	"When I click along the aisle, sometimes it goes too far …" (I7)
	FU2	Consideration of reduced reaction speed	Zaphiris, Kurniawan and Ghiawadwala, 2007; NIA, 2009; Burmeister, 2010; Saldaño et al., 2013; Spinelli and Jain, 2014; McGlynn and Rogers, 2017; Liang, 2018b; Czaja et al., 2019; Mol, Silva and Ishitani, 2019	"It is not too fast and no ego-shooter-perspective." (I4)

Assistant System	AS1	Consider the need for detailed user guidelines & explain features	Hudson et al., 2008; NIA, 2009; Saldaño et al., 2013; Spinelli and Jain, 2014; Dodd, Athauda and Adam, 2017; Osman and Hwang, 2018; Czaja et al., 2019	"I don't know, what are the three points for?" – "Guides and signposts would be useful like in a real shop." (I7)
Content Design	CD1	Consider limitations of only one format for information provision	NIA, 2009; Chattaraman et al., 2011	"I didn't find any big problem in its usage except that the price was not clear for many products." (I3)
	CD2	Consider providing a positively connotated environment	McGlynn and Rogers, 2017	"It looks like a storage room." – "I don't like it." (I5)
	CD3	Consider the need for increased product perception	Liu, Uang and Chang, 2009; Chattaraman et al., 2011; Liu and Uang, 2016	"Some products were difficult to find." (I1)
	CD4	Consider limitations of long-time attention spans	Zaphiris, Kurniawan and Ghiawadwala, 2007; NIA, 2009; Kamollimsakul, 2016; Dodd, Athauda and Adam, 2017; McGlynn and Rogers, 2017; Liang, 2018; Osman and Hwang, 2018; Czaja et al., 2019; Mol, Silva and Ishitani, 2019	"I think it will be overwhelming for me to look at the whole inventory of the store as it is." (I2)
	CD5	Consider the need for clear differentiation between shapes, colours, etc.	NIA, 2009; Spinelli and Jain, 2014; Kamollimsakul, 2016; McGlynn and Rogers, 2017; Liang, 2018; Osman and Hwang, 2018; Czaja et al., 2019; Mol, Silva and Ishitani, 2019; Derby and Chaparro, 2020	"I could also judge the quality of the items as it was easy to zoom in and see clearly." (I4)

Table 6. Requirements of older adults in a v-commerce store.

4.2 Final design principles

Based on Stage 3 and Stage 4 of our research methodology, we identified seven principles for the design of OA-friendly v-commerce stores. These design principles are interrelated and complement one another and might not achieve the desired outcome if applied isolated (Blaschke et al., 2019). We structured the principles following the structure proposed by Gregor, Kruse, & Seidel (2020), i.e., differentiated between the principle's mechanism, aim, and rationale, which are provided in the following sub-sections. The context is a non-immersive v-commerce store for all seven design principles.

4.2.1 Design principle 1: Integrate key touchpoints of the physical store

Mechanism: Integrate the key touchpoints of the physical store in the composition of the v-commerce store. For example, if the physical store employs a person to welcome customers, this should be replicated in the v-commerce store. The key touchpoints can vary for different stores.

Aim: This DP addresses the OAs' hedonic needs and minimizes the need to re-adapt to the v-commerce store. It also seeks to provide a shopping experience comparable to the physical store.

Rationale: Most v-commerce stores are based on a physical store. From the designer's perspective, it is extremely important to find a balance in keeping the main essence of the physical store, which OAs can relate to (McGlynn and Rogers, 2017), and removing the complexities of the physical store, which can affect OAs' ease of use (Chen and Chan, 2014). Thus, key touchpoints of a physical store that

serve the hedonic needs of customers should be kept in the v-commerce store, as OAs are prone to stimuli with a positive emotional tone, compared to experiential or cognitive approaches (Fung and Carstensen, 2003). Moreover, OAs are often not willing or able to change their behaviour (compared to young adults or kids) (Liu and Uang, 2016), which makes it even more important to provide OAs with similar key touchpoints in the virtual environment to ease their adoption.

4.2.2 Design principle 2: Provide an adequate amount of information concurrently

Mechanism: Limit the number of elements and amount of information concurrently visible on the screen and ensure that it is easily identifiable and understandable. In the design, it should be ensured that the visible information is limited to what is required at that particular instance (Story, 2001). Moreover, the information should be easily understandable, e.g., by avoiding complex language, and identifiable, e.g., by choosing a readable font and size of the text.

Aim: This DP allows OAs to navigate the v-commerce store without getting overwhelmed by too much information.

Rationale: Information provision is a fundamental aspect of a v-commerce store, as the users should be able to use the information to make decisions in terms of navigation, product purchase etc. However, too much information concurrently available can easily overwhelm OAs, as they generally find it hard to relate to multiple sources of information (Burmeister, 2010; Xue, Parker and Hart, 2020). Moreover, focusing on particular information becomes difficult for OAs when other elements/information distracts them (Balakrishnan, Salim and Hong, 2012).

4.2.3 Design principle 3: Allow a tolerance for errors

Mechanism: Allow a tolerance for errors in the interaction with elements of the v-commerce store. For example, adding a confirmation requirement before a new phase can be entered. Further, an "undo"-button could be provided to easily undo actions, that were made by mistake.

Aim: This DP allows OAs to use a v-commerce store without requiring precise actions. Moreover, the effects of unintended actions are minimized.

Rationale: OAs generally find it difficult to interact with unfamiliar technologies that require precision to effectively use them. They are more likely to struggle with performing accurate actions, due to their often relatively weak hand-eye coordination (Czaja et al., 2019). Moreover, OAs are generally reluctant in accepting new technologies, so a greater tolerance for errors is likely to ease their technology adoption (Roberts et al., 2019), as they get positive feedback by being easily able to interact with the technology.

4.2.4 Design principle 4: Provide suitable assistance

Mechanism: Provide easily accessible, simple, and timely assistance, that guides the user of a v-commerce store. For example, provision of a tutorial at the beginning or an always available and easily accessible help button can be implemented.

Aim: This DP allows OAs to use the v-commerce store independently without help from others.

Rationale: OAs can suffer from decreased memory and reduced spatial cognition. The provision of easily accessible and simple assistance can help them to mitigate these limitations in their use of the v-commerce store and ease adaptation to the v-commerce store (Liu and Uang, 2016).

4.2.5 Design principle 5: Give the choice between a complementary set of formats

Mechanism: Provide a complementary set of formats for information provision and a choice between these formats. For example, product information, like product details, price, and delivery time, could

be provided by a textual description, complemented by a button to play an audio file that reads the information out loud.

Aim: This DP ensures that individual needs and preferences of OAs are covered.

Rationale: The rate of hearing and vision issues is substantially higher for OAs, which makes it more significant for them to have a choice between complementary formats. Providing information in only one format can cause low usage rates of v-commerce stores among OAs. For example, a lack of audible feedback for people with vision difficulties can affect their cognitive processing leading to stress in the use of the v-commerce store (Story, 2001).

4.2.6 Design principle 6: Make objects distinguishable

Mechanism: Make different types of v-commerce store elements distinguishable from each other. For example, designers could use a colour coding scheme for different elements of the store or reduce complexity in patterns and shading.

Aim: This DP aims to help OAs to easily identify and understand different elements of the v-commerce store, so they can quickly decide on the elements they want to interact with.

Rationale: OAs are more likely to suffer from deterioration in the vision that comes with ageing. As a consequence, the inability to perceive graphical elements correctly can inhibit effective interaction with v-commerce stores (Patsoule and Koutsabasis, 2014). When the objects are clearly distinguishable, the interaction with the v-commerce store is eased for OAs.

4.2.7 Design principle 7: Simplify the navigation

Mechanism: Make navigation as simple as possible, for example, by implementing predefined paths in the v-commerce store. Another option could be, to choose an easily understandable layout (e.g., having only one or a few aisles).

Aim: This DP aims to ease OAs' movement in the v-commerce store and prevent them from orientation loss or confusion regarding product placements.

Rationale: OAs generally find it difficult to orient in new and complex environments (Silva, Mol and Ishitani, 2019). In terms of navigation time, it was observed that OAs require roughly twice the time compared to younger users (Sjölinder, Höök and Nilsson, 2000). Simplified navigation will significantly improve ease of use and is critical to a pleasant virtual shopping experience.

5 Discussion

This research focuses on the intersection of human-computer interaction (HCI) and gerontology research and addresses the development of VR products specifically for OAs by providing interrelated requirements and design principles for an OA-friendly v-commerce store. The study provides significant contributions to theory. Firstly, we contribute to the knowledge base on the development of design principles by conducting a design science research project building on the works by Blaschke et al. (2019) and Seidel et al. (2018). We developed and iteratively refined the proposed design principles by insights from theory (i.e., via a literature review) and practice (i.e., semi-structured interviews and focus groups) and thus provide targeted design principles. This method can guide further design science research in other areas and application fields such as gerontology.

Secondly, we advance the knowledge on guiding the development of VR-based products in the retail industry. The results from the focus group highlighted the general usefulness and importance of design principles for the development of any online store but mentioned a lack of those principles, especially in the v-commerce area. This has also been highlighted in recent research by Hollebeek et al. (2020) and Xue, Parker and Hart (2020). This area requires insights from researchers, as VR applications are growing rapidly, but lack significant input from academia to guide these developments. Derived

knowledge from this study in terms of the requirements of OAs and design principles in a v-commerce context can be used as a basis for further research in this and related areas.

Thirdly, we add to the literature on integrating and considering the needs of a specific customer group in the design of digital applications. The specific characteristics of a customer group must be considered to design useful digital applications for the group. For example, in the case of OAs, the consideration of specific characteristics such as digital literacy, health issues etc. is critical in designing the v-commerce store that they can use compared to the general public. The study provides avenues for further research concerning groups with particular needs, such as older adults. We provide prescriptive knowledge in the form of design principles about designing OA-friendly systems. We extend the research on OA-friendly design in different contexts, adding to the recent studies by Brown (2019), McGlynn and Rogers (2017), and Silva, Mol and Ishitani (2019) on OA-friendly VR systems.

In terms of practical implications, we propose seven design principles that can be used by v-commerce store designers to guide the development of a store that focuses on the specific needs of OAs. The study highlighted that it is not just enough to reflect a physical store in the virtual environment, as the hedonic elements of the physical store should rather be balanced with the required simplicity of a virtual environment. Only then, v-commerce stores can start to become a significant channel for the customers. Our research also points to the significance of adopting new technologies and designing them with the targeted customer group, in our case OAs, in mind. As in current times, this customer group is specifically vulnerable and in need of alternative shopping formats, we see great potential in this, especially since most of our interview participants regarded this format as a suitable alternative.

The design principles can not only be used in a hedonic shopping context but may be projectable to different shopping contexts, such as functional shopping (e.g., in a grocery store). Further, they may also be at least partly suitable for immersive v-commerce stores and different contexts, such as tourism. As we derived the requirements from the literature on e-commerce and different digital applications, we could imagine the design principles to also be suitable in the context of game design for OAs or the design of therapeutical applications.

6 Conclusion

Resulting from the design science research project, we developed design principles for the design of a v-commerce store directed to OAs. The design principles address the key elements of the shopping experience in the v-commerce store, such as navigation in the store, display of products, and general store design, and typical requirements of OAs, especially regarding their motoric, cognitive, and emotional needs and preferences. Thus, we contribute with our research by offering prescriptive knowledge in form of design principles for a specific customer group, which is, particularly in the current crisis due to Covid-19, most vulnerable and in need of alternative offerings. This study has some limitations that can provide opportunities for further research. Firstly, our design principles were not instantiated in a v-commerce store, i.e., the design and implementation of a v-commerce store. The evaluation after implementing the v-commerce store might lead to further refinement and validation of the design principles, which we also regard as an opportunity for future research. Secondly, we limited ourselves to the development of design principles for the specific context of a non-immersive, hedonic shopping environment. Future studies can test the projectability of the design principles for different contexts such as functional shopping or immersive v-commerce scenarios. Guided by the used methodology, further research could also focus on the development of design principles for other customer groups of hedonic v-commerce stores, such as disabled or young customers.

7 Acknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 765395 and was supported, in part, by Science Foundation Ireland grant 13/RC/2094_2.

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