AUGMENTED AND VIRTUAL REALITY IN E-COMMERCE

(Smith, 2016)

Master thesis in Communication Science
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Abstract

Over the past decades, e-commerce has changed the retail landscape and seriously influenced lives. Under the current uncertain economic circumstances caused by Covid-19, its growth and penetration into everyday life will increase. Although e-commerce is constantly evolving, it cannot deliver a shopping experience equivalent to brick-and-mortar. The integration of 3D product visualizations via augmented reality (AR) and virtual reality (VR) can convey a more authentic, interactive and sensory-stimulating e-commerce experience. Through a 3x2 experimental between-respondent design, which was manipulated for the visualization and product type and controlled for age and gender, this study tested the capability of AR and VR 3D product visualizations to deliver a more engaging e-commerce experience compared to the widely used 2D product images. Results show that 2D product images offered the most engaging e-commerce experience. However, when comparing AR and VR, irrespective of the product the e-commerce experience was better with AR than VR, especially for the older generation. Lastly, this study examined that neither AR nor VR is better suited for a particular product type. These findings illustrate that sticking to 2D product images would not harm a company's e-commerce performance. To outperform the competition, AR is essential when centered on delivering a 'one-of-a-kind shopping experience'.

Keywords: *e-commerce, 3D product visualization, augmented reality, virtual reality, consumer experience*

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I. Glossary of Abbreviations

e-commerce	**e**lectronic **c**ommerce
AR	**A**ugmented **r**eality
VR	**V**irtual **r**eality
VFR	**V**irtual **f**itting **r**ooms

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Chapter 1: Introduction

With the enormous development of technology in the past decades, a severe change to the digital world in everyday life became apparent (Altarteer et al., 2013; Nguyen, 2020). This shift could also be seen in the retail landscape and thus in people's shopping behavior (Nguyen, 2020). Where brick-and-mortar used to be the main point of sale, electronic commerce, abbreviated e-commerce, is steadily serving more customer needs and providing various service opportunities (Altarteer et al., 2013; Elboudali et al., 2020). As a result, nowadays, only 21% of all shopping activities are carried out in brick-and-mortar, 36% through multiple channels, and the remaining 43% exclusively online (Jaller & Pahwa, 2020). Global sales experienced an impact by the continuing growth of e-commerce, where 2.3 trillion U.S. dollars were allocated to e-commerce in 2017 and are predicted to double in the next five years (Hwang & Oh, 2020). However, this forecast does not consider the current uncertain economic situation caused by the Covid-19 pandemic and its associated lockdowns, which led to consumers' dependence on e-commerce for non-essential purchases (Xue et al., 2020). Hence, transforming online shopping in 2020 from a luxury activity to a social necessity consequently meant growing expectations on e-commerce (Xue et al., 2020).

Even though e-commerce is now the preferred transaction platform, it is currently impossible to deliver an equivalent or superior emotional, engaging experience as in traditional brick-and-mortar (Altarteer et al., 2013; Elboudali et al., 2020). This challenge is mainly because most online retailers rely on 2D product images, providing unilateral sensory stimulation (Hewawalpita & Perera, 2017; Y. Liu et al., 2020; Paz & Delgado, 2020). But why does only a small percentage of retailers apply in their e-commerce augmented reality (AR) and virtual reality (VR) 3D visualizations (Paz & Delgado, 2020)? Potentially stimulating almost all five senses through 3D product visualizations could be effective (Fiore et al., 2005; Rauschnabel et al., 2019; Sung, 2021)? AR comprises the integration of 3D computer-generated objects into the user's real environment, with which a real-time interaction can take place (Do et al., 2020; Laato et al., 2021). In the context of e-commerce, this means a new interactive 'first-hand experience' by digitally visualizing selected products, such as glasses or furniture, either on oneself or in a chosen spot (Ludwig et al., 2020; Sihi, 2018). Estimated at 2.5 billion U.S. dollar in 2017 and expected to grow at an annual rate of 22.7% by 2026, AR enables a more information-rich and realistic self-explanatory product experience (Dacko, 2017; Y. Liu et al., 2020; Romano et al., 2020). VR, on the contrary, does not create a 'mixed reality', but rather isolates the user from the natural environment and immerses them in a fully synthetic virtual world, in which he/she can interact with 3D objects and others in real-time by means of a personalized avatar (Cowan & Ketron, 2019; Haile & Kang, 2020; Park & Kim, 2021; Zenner et al., 2020). In e-commerce, VR is predominantly used to simulate a brand's real brick-and-mortar store in a digital setting, in which customers can move and act freely (Meißner et al., 2020; Tran et al., 2011b). Industry experts believe that AR and VR will play a key role in the retail industry due to the high interactivity and personalized experiences (Park & Kim, 2021). In addition, due to their direct product experience and better visualization of product features, AR and VR are expected to reduce the main disadvantage of online shopping (Su et al., 2020; Veneruso et al., 2020). Thus minimizing the discrepancy between the expectation and the actual product, while positively affecting the number of returns, which in the fashion industry amount to 62 billion U.S. dollars annually (Jang et al., 2019; Y. Liu et al., 2020; Nguyen, 2020; Wodehouse & Abba, 2016).

Given market oversaturation, it is no longer a question of the price-quality factor, but instead, personal added values provided by products, particularly the whole experience during the shopping process (Ludwig et al., 2020; Xue et al., 2020). While taking the influence of the delivered e-commerce shopping experience into account, retailers should see the current situation as an opportunity to put an end to existing shopping patterns and design a new online shopping era (Xue et al., 2020). As far as it is known, there has been no research yet conducted concerning the effects on consumers' shopping experience in e-commerce utilizing 3D product visualizations compared to 2D product images. Therefore, this study would contribute to the research on retail atmosphere, existing since the 1970s, that focuses on eliciting emotional responses based on a specific purchase environment (Paz & Delgado, 2020). The research question came about based on the changes mentioned above in shopping behavior, demands, and circumstances, as well as technological possibilities:

"To what extent do augmented reality and virtual reality 3D product visualizations influence consumers e-commerce experience compared to 2D product images?"

To achieve a stronger emotionally engaging experience in e-commerce and thus a higher consumer engagement, 3D product visualizations via AR and VR received increasing attention from retailers in recent years (Sihi, 2018). However, caution is required as an inadequate integration of a visualization type may negatively influence consumers' brand perception and the brand success in the long run (Y. Liu et al., 2020; Su et al., 2020). Therefore, this chapter focuses on both the theoretical contributions and practical implementations of AR and VR 3D product visualizations in e-commerce compared to the widespread 2D product images.

2.1. E-commerce

With the execution of the first electronical retail transaction on August 11, 1994, not only the term e-commerce was introduced into people's vocabulary, but also their entire way of life was changed (Jaller & Pahwa, 2020). By understanding and determining customer preferences, e-commerce has the advantage of delivering a personalized shopping experience by offering the right product at the right time via the preferred shopping platform for a reasonable price (Elboudali et al., 2020; Luo et al., 2020). This pre-selective product presentation can be enabled as the internet gives companies the possibility to market their products regardless of the geographic location and thus to expand their customer base both nationally and internationally (Paz & Delgado, 2020). Correspondingly, by suggesting products from multiple retailers, consumers also benefit, as decisions can be made on the basis of the price-performance ratio (Luo et al., 2020). It is therefore not surprising that e-commerce has received positive feedback and tremendous growth over the past decade; and it is forecasted that the rapid increase will carry on (Hwang & Oh, 2020; Jaller & Pahwa, 2020; Klaus, 2020).

This development can mainly be credited to the feature that, like companies, consumers are no longer bound by time or place and are provided greater flexibility in their scope of action (Hewawalpita & Perera, 2017; Jaller & Pahwa, 2020; Klaus, 2020; Morotti et al., 2020). Furthermore, the ease of use and the associated minimal effort are key drivers for accepting e-commerce (Klaus, 2020). Unlike in brick-and-mortar, the availability of products can be directly tracked, different offers can be compared and more accurate product information can be collected from various retailers (Klaus, 2020; Nguyen, 2020). Given these advantages, e-commerce's impact on everyday life and consequently the reshaped lifestyles becomes intelligible (Jaller & Pahwa, 2020).

Even though the fourth generation of e-commerce has arrived, a company's online performance still holds some obstacles regarding sensory stimulation in comparison to its brick-and-mortar, leading to incongruence in the customer shopping experience across channels (Paz & Delgado, 2020; Xue et al., 2020). Since the 1970s, the concept of retail atmosphere has been studied concerning the effect of design elements on customers' purchase intention (Paz & Delgado, 2020). Thereby it has been noted that not only the chosen design elements for the shopping environment of a physical store can influence customer perception and behavior, but also those of an electronic store (Paz & Delgado, 2020). Given this as well as the fact that of the five human senses, the visual sense alone processes 70% of information, it is paradoxical that most online retailers use 2D product images (Elboudali et al., 2020). Although brick-and-mortar is experienced in 3D and e-commerce is not limited in the way of visualizing products (K. H. Liu et al., 2020; Morotti et al., 2020; Paz & Delgado, 2020). While on the one hand an integration of 3D visualizations would have the advantage that product characteristics such as texture or wearability could be communicated, providing richer product information (Jessen et al., 2020; Y. Liu et al., 2020; Morotti et al., 2020; Nguyen, 2020; Papagiannidis et al., 2013; Sihi, 2018; Su et al., 2020). They could, on the other hand, also address the main weakness of e-commerce, pointed out by 56% of consumers, naming the lack of direct first-hand experience with products (Jang et al., 2019; Y. Liu et al., 2020).

By virtually "putting the product in the hand of the users" (Haile & Kang, 2020, p. 3) and allow them to twist and turn it according to their own needs to gather all the relevant information to make a purchase decision, e-commerce does not only ensure a greater interaction with products, but also more vivid and interactive shopping environments responsive to customers' actions (Hwang & Oh, 2020; Meißner et al., 2020; Paz & Delgado, 2020). Whereas in e-commerce vividness is defined by the expressive richness of the online shopping environment, interactivity refers to the degree to which consumers can influence the content and form of a shopping environment (Jang et al., 2019). However, it is important to take into account that the interfaces of a hyper-realistic online store need to have an appropriate degree of interactivity to enhance consumer engagement and shopping experience, and not appear disruptive and cognitive overwhelming (Do et al., 2020; Hwang & Oh, 2020; Sihi, 2018). It must be stated that the evaluation of the interactivity results from consumers' personal as well as cognitive involvement in the shopping activity (Nikhashemi et al., 2021; Park & Kim, 2021).

Given the potential for improvement through the integration of 3D product visualizations and consumers' expectation that interaction points and shopping experiences in e-commerce surpass those of brick-and-mortar, the question arises why the implementation has not yet happened by the majority of retailers (Klaus, 2020; Xue et al., 2020). So far, retail has already moved from a traditional product-centered approach to a customer-/service-centered perspective and the awareness of serving needs through delivered shopping experiences are given (İzmirli et al., 2020; Jaller & Pahwa, 2020; Kim et al., 2020; K. H. Liu et al., 2020; Paz & Delgado, 2020; Xue et al., 2020). Consequently, it is essential to examine how 3D product visualizations can be implemented in the unrestrictive display landscape of e-commerce as a key to success and to create a 'one-of-a-kind shopping experience' (Hwang & Oh, 2020; Y. Liu et al., 2020; Nguyen, 2020; Park & Kim, 2021).

2.2. 3D product visualizations

Even though technological developments like AR and VR have led to increasingly merge the virtual world with the real one in various business areas in past decades, retailers have only started to focus on them for their e-commerce in recent years (Rauschnabel, 2018; Romano et al., 2020; Sung, 2021; Xue et al., 2020). This change in focus is based on the following four points: First, retailers have realized that they can strategically use AR and VR to differentiate themselves from their competitors (Sihi, 2018). This leads to the second point: Because of this differentiation from the benchmark, consumers can more easily get attracted in a highly competitive market (Sihi, 2018). Third, products can be presented with richer and more detailed information, reducing the purchase risk, decreasing the discrepancy between the expectation and the actual product and therefore the amount of returns (Jessen et al., 2020; Lee & Xu, 2018; Y. Liu et al., 2020; Sihi, 2018; Veneruso et al., 2020). This results in the fourth and last point, due to the fact that more product knowledge and understanding is provided, the entire online shopping experience can be enhanced (Sihi, 2018).

2.2.1 Augmented reality

As stated by Y. Liu et al. (2020), AR refers to the overlay of computer-generated 3D objects on a physically real surrounding. Based on the study of Azuma in 1997, Dacko (2017) argues that the theory of AR is built on the following three pillars: 1) combining virtual and real objects, 2) interacting in real-time and 3) perceiving virtual objects in a real surrounding. Given the temporal co-existence of virtual and real objects, AR is also referred to by researchers as 'mixed reality continuum' or 'mixed reality' (Dacko, 2017; Do et al., 2020; Haile & Kang, 2020; Park & Kim, 2021). Related to retail, AR comprises any approach by which product information is provided to the consumer by means of stationary devices, illustrating 3D product visualizations via self- or environment augmentation and enabling a more engaging and richer shopping experience (Dacko, 2017; Park & Kim, 2021; Sung, 2021; Wodehouse & Abba, 2016). In the context of e-commerce, the implementation of AR includes camera-equipped mobile devices likes smartphones, as well as the download of a retailer or third-party supplier apps to transmit a realistic self-explanatory 3D product visualization (Haile & Kang, 2020; Y. Liu et al., 2020; Sung, 2021). In general, AR which has been around since the 1960s but only became widespread in the early 2000s, offers a new creative and playful dimension of interaction with products, while giving retailers the opportunity to distinguish themselves in the market (Do et al., 2020; Jessen et al., 2020; Sung, 2021).

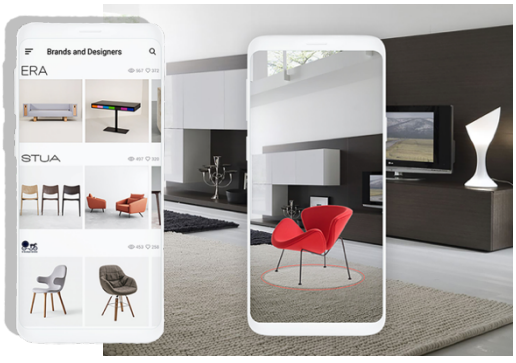

Figure 1. Environment-augmentation (Ar-Ty., 2017)

As previously mentioned, there are two application types of AR. First, the environment-augmentation, which can be seen in Figure 1. This type of fusion with reality enables customers to place objects such as furniture anywhere in their environment (Sihi, 2018; Smink et al., 2020). Also known as 'virtual try-on' or 'magic mirror' in the retail industry, the second application option allows consumers to virtually try products from various product categories, e.g., garments and accessories by means of self-augmentation on the entire body or body parts, as illustrated in Figure 2 (Y. Liu et al., 2020; Romano et al., 2020; Smink et al., 2020). By enabling a 'try before buying' through both application types, the biggest perceived drawback of e-commerce can be addressed (Veneruso et al., 2020). Given the fact that environment- and self-augmentation furthermore allow to check whether the selected product corresponds to personal preferences, the overall understanding of the product can be improved (Haile & Kang, 2020; Y. Liu et al., 2020; Ludwig et al., 2020; Park & Kim, 2021; Veneruso et al., 2020). As stated by Rauschnabel et al. (2019), AR mainly focuses on serving utilitarian benefits that underlie a goal-oriented action. Because these 3D visualization types can visually convey more complete product information and offer a virtual 'trialability', a more realistic expectation can be established, whereby reducing the purchase uncertainty

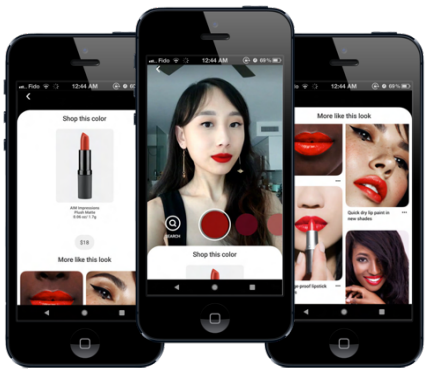

Figure 2. Self-augmentation (Grigonis., 2020)

(Dacko, 2017; Jessen et al., 2020; Meißner et al., 2020; Veneruso et al., 2020; Wodehouse & Abba, 2016).

While AR not only provides new, additional interaction points in e-commerce compared to 2D product images, it also increasingly binds consumers with their reality, disputing the argument of the loss of reality through digitalization (Do et al., 2020; Ekren & Kumar, 2021; Jocevski, 2020; Ludwig et al., 2020; Sung, 2021). This is particularly recognizable in the fact that AR can not only visualize one product in a defined place, but rather several products from a range of categories within the app (Haile & Kang, 2020; Jessen et al., 2020; Romano et al., 2020; Smink et al., 2020). By providing a 'creative playground' in which products can be moved back and forth and different combinations can be tried, a cognitive relief can be enabled, since the strain on the mental imagination decreases (Jessen et al., 2020). This becomes especially handy for products that require a lager spatial occupation and for which a mentally imagery of the fit is harder (Meißner et al., 2020). Even though AR is eager to increase efficiency in e-commerce, the approach of virtually handing over products to consumers also holds some entertainment during the information collection process, thereby fulfilling hedonic benefits (Dacko, 2017; Do et al., 2020; Haile & Kang, 2020). By providing an examination of products from all angles under own control terms, not only can the feeling of psychological ownership over products be transmitted given the tangibility, but also the touch and feel sense can be indirectly stimulated (Meißner et al., 2020; Romano et al., 2020; Smink et al., 2020). Caution should be drawn, however, to ensure that product visualizations are not considered as too distracting and intrusive, as mentioned by Smink et al. (2020). This statement is strengthened by Hwang and Oh (2020) and Rauschnabel et al. (2019) in Nikhashemi et al. (2021), who in addition state that the degree of interactivity offered is decisive, as too interactive interfaces can cause cognitive overload and consequently stress and negative emotions.

Nevertheless, even if the 24/7 on-the-go 3D product visualizations of AR in real-life situations present a more realistic and informative shopping experience (Nikhashemi et al., 2021; Park & Kim, 2021), this 3D visualization type comes at a price. Disclosing too much private data and authorizing access to cameras of end devices, are the most sever drawbacks of AR (Dacko, 2017; Do et al., 2020). Followed by the lack of high quality content, which is particularly conspicuous in virtual try-ons of garments (Sihi, 2018; Xue et al., 2020). According to Park and Kim (2021), this is due the fact that the current software used for this purpose is based on 2D product images and therefore incapable to project a realistic fit of a garment on a real body. Lastly, caused by the facts that the integration of AR in e-commerce is rather novel and that for information gathering a gamification approach has been installed, there is a risk involved that interactions with the features of AR will be purely for fun and not as support for transactions, as desired by retailers (Romano et al., 2020).

2.2.2 Virtual reality

Contrary to AR, VR, developed in 1980, refers to the immersion of users in a synthetic, virtual word in which they can freely interact in real-time with computer-generated 3D objects as well as others via customized avatars (Cowan & Ketron, 2019; Haile & Kang, 2020; Sihi, 2018; Su et al., 2020; Tran et al., 2011a; Xue et al., 2020). A virtual world can either be graphically designed as a purely artificial environment or analogy to the real world, realistically reflecting its components (Elboudali et al., 2020; Meißner et al., 2020; Tran et al., 2011c). Related to e-commerce, this means the simulation of an extensive shopping scenario in which consumers feel engaged by the sensory of being present and thus receive an experience equivalent to brick-and-mortar (Y. Liu et al., 2020; Su et al., 2020).

Two application types in online retail are used. Firstly, virtual fittings rooms (VFR) which are integrated by more than 84% of fashion retailers (Fiore et al., 2005). These VFR enable consumers to virtually try on garments on an avatar, which can be customized by manual input of body measurements and appearance (Figure 3) or automatically using a body scanning and camera-based software (Lee & Xu, 2018). The most decisive factor is the scope of customization, as this has an influence on self-perception and consequently on satisfaction (Y. Liu et al., 2020; Wodehouse & Abba, 2016). Secondly, the recreation of an existing shopping situation, which often refers to an entire brick-and-mortar store where consumers can interact with both the shopping environment and the products (Meißner et al., 2020; Park & Kim, 2021). As shown in Figure 4, not only can the shopping environment be designed in 3D, but also products, which can be then further examined in detail thanks to the 360° view (Hewawalpita & Perera, 2017). This 360° 3D product visualization is especially effective for design-focused and customizable products such as automobiles or fashion pieces, as product attributes can be conveyed (Cowan & Ketron, 2019). Currently, this application type dominates in e-commerce as it can deliver a familiar shopping experience due to its accurate representation of shelf levels, product portfolio and product placements to a brand's offline retail (Tran et al., 2011c). Nevertheless,

even if this visualization approach can satisfy the need to brows a store and collect detailed product information, VR brick-and-mortar simulations are not yet so advanced that full product interactions can take place and transactions be carried out (Park & Kim, 2021; Tran et al., 2011a).

What VR does enable, however, is not only the personalization of products and the visualization of retailer's product portfolio, but also the customization of entire online shopping environments (Elboudali et al., 2020; Papagiannidis et al., 2013). In addition, VR, like AR, offers a 'first-hand experience', whereby firstly the shopping experience becomes more tangible and secondly the purchase risk reduced, as product details like material and cut shape can be examined more closely (Cowan & Ketron, 2019; Fiore et al., 2005; Sihi, 2018; Su et al., 2020; Tran et al., 2011a).

Nonetheless, the integration of VR in e-commerce also entails its drawbacks. While VR worlds offer vivid environments, in most cases interactivity is limited (Jang et al., 2019). Furthermore, the low integration rate of VFR has the consequence that the software is not developed according to the needs, leading to poor visulizations of bodies and appearances as well as lack of representation of gestures and facial expressions, negatively affecting the online shopping experience (Y. Liu et al., 2020). As previously stated, VR simulations of brick-and-mortar are able to transmit detailed information only to a certain degree, which in combination with the missing payment system means that the benefits of using such an online shopping environment are not immediately evident to new users (Jang et al., 2019; Tran et al., 2011c).

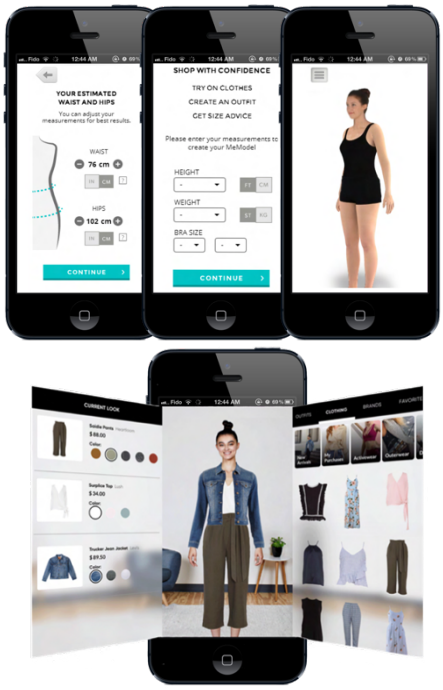

Figure 3. VFR (MySureFit., 2021; Stemmit Inc., 2019)

Figure 4. Gucci virtual fashion boutique (Garcia, 2017)

Although VR does not make a clear seperation between the virtual and real world, and behaviour is often spilt from one to another, just simulating brick-and-mortar as a virtual online store is insufficient (Papagiannidis et al., 2013; Tran et al., 2011c). Nevertheless, the virtual shopping experience is to be designed as realistic as possible (Sihi, 2018). However, while designing virtual shopping environments the realistic visualization of products should not be neglected (Wodehouse & Abba, 2016). In fact, care should be taken to not only enable passive exploration of products, but rather a more detailed examination and acquisition through interactive high quality rendered content (Meißner et al., 2020; Wodehouse & Abba, 2016).

2.3. Design & hypotheses

In general, retailers need to understand that the virtual shopping environments in e-commerce are there to make the already available retail channels more vivid and interactive for consumers and not to replace them (Jang et al., 2019; Tran et al., 2011a). However, when integrating 3D visualizations in e-commerce, attention should be drawn to whether the type of visualization is suitable for the product to be displayed (Nikhashemi et al., 2021). Therefore, retailers should be aware of the features and functions of their products as well as the degree to which they can be customized (Altarteer et al., 2013). Given the aforementioned line of arguments, the following hypotheses have been formulated:

H1: Both an AR and VR 3D product visualization enhance consumers e-commerce experience in comparison to 2D product images.

H2: An AR 3D product visualization enhances consumers e-commerce experience in comparison to VR 3D product visualizations.

H3: An AR 3D product visualization is more suitable for a product whoes spatial placement is crucial than for a product where attention to detail is important.

H4: An VR 3D product visualization is more suitable for a product where attention to detail is important than a product whoes spatial placement is crucial.

By means of an experiment with a between-respondent design, which has been manipulated for both the visualization and product type, it has been tested to what extent the visualization type can influence the e-commerce experience and how influenceable the e-commerce experience is by the visualization type of a certain product type. Given that AR is better suited for products with spatial ingestion, furniture was selected based on its dimensions. In the case of VR, due to the degree of customization and the attention to details shoes were chosen. An overview of the hypothesized relations between the variables under study are presented in the conceptual mode in Figure 5.

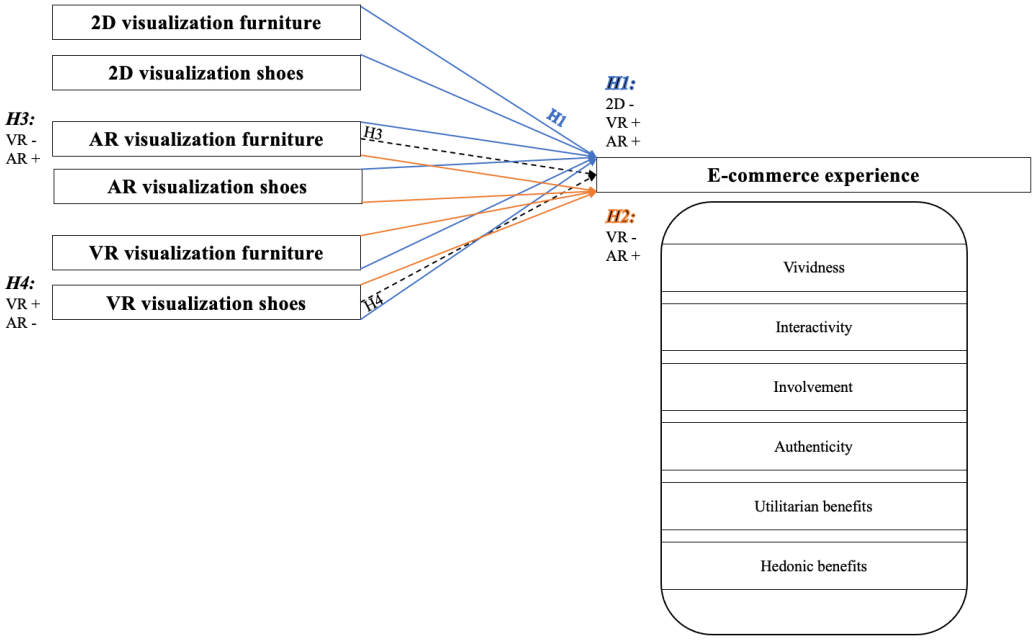

Figure 5. Conceptual model controlled for gender and age

3.1. Research design

The current study consisted of two independent variables. First, visualization type, comprising of the three attributes: virtual reality, augmented reality and 2D product images. Second, to further check if the acceptance or rejection of a product visualization was related to a product as indicated in the theoretical background, all three visualization types were selected for the two product types: furniture and shoes. The dependent variable e-commerce comprised of six constructs: vividness, interactivity, involvement, authenticity as well as utilitarian and hedonic benefits. In the context of online stores, presenting various product offers (hereinafter also named as online store offer), the overall influence of the independent variables and their strength on the dependent variable were examined.

In a 3x2 experiment between-respondent design the following six conditions of the independent variables (Figure 6) were tested:

		Visualization type		
		2D	Virtual reality	Augmented reality
Product type	Furniture	Online store offer 1	Online store offer 2	Online store offer 3
	Shoes	Online store offer 4	Online store offer 5	Online store offer 6

Figure 6. Instrument design

3.2. Selection of stimuli

To be able to investigate whether and to what extent the product visualization type has an impact on the e-commerce experience, effective stimuli had to be selected. For this purpose, the first step was to check the availability of retailers' online stores on the market with the respective visualization types implemented. By providing participants with as realistic as possible shopping environments, in which all interaction points of a purchase are already considered, error messages or non-execution of actions and thus negative experiences, at least in this regard, can be avoided. Second, to prevent potential bias towards the online stores and obtain a purely objective assessment of the delivered shopping experiences, the focus has been exclusively placed on unbranded online stores. Thirdly, as in terms of self-visualization VR is not capable to deliver a realistic self-reflection with the current technological applications, an environmental visualization has therefore been chosen for VR, meaning the simulation of a brick-and-mortar store. For AR it was not possible to agree on one application type due to the two product types and their completely different application areas. Accordingly, the shoes were illustrated with self-augmentation and the furniture with environment-augmentation. In the case of the AR online stores, additional attention had to be paid as this type of 3D product visualization can only be exploited using a separate app. Therefore, it was necessary to ensure that the apps were available, free of charge and useable without login for the two most widespread operating systems, Apple and Android. After several online stores had been chosen, the degree of comparison of the online stores' product portfolios with each other were examined as well as to what extent these shopping environments were controllable. Based on these points, a total of four retailers, two for each product type as twice one retailer offered both a 2D website and VR environment visualization, have been selected. Table 1 displays the individual online store offers under study.

Table 1

Online store offer overview

		Visualization types		
		2D visualization	VR visualization	AR visualization
Product types	Furniture	Roche Bobois https://www.roche-bobois.com/de-DE/produkte/sofas	Roche Bobois https://www.google.com/maps/@40.7772231,-73.9818496,3a,82.2y,115.38h,90.82t/data=!3m7!1e1!3m5!1sAF1QipMvz64LTkuO7kzRGQfdyAzM6NdTXFANHA3rFrLK!2e10!3e12!7i8192!8i4096	La-Z-Boy Iphone link: https://apps.apple.com/de/app/la-z-boy-ar/id1468901467 Andorid link: https://play.google.com/store/apps/details?id=com.la_z_boy.retail
	Shoes	Dune London https://www.dunelondon.com	Dune London https://brandlab360.vr-360-tour.com/e/Ne0BeCHFqMU/e?horizontal_transitions=true&initvars.autorotate.enabled=true&share_button=true	Wanna Kicks Iphone link: https://apps.apple.com/de/app/wanna-kicks/id1444049305 Andorid link: https://play.google.com/store/apps/details?id=by.wanna.apps.wsneakers

3.3. Procedure

The experimental stimuli all comprised of real online stores of unknown brands, whose e-commerce had no distortions in the display rendering on mobile devices. However, the obstacle of using existing online stores rather than creating own ones was that participants had to be redirected to external websites to investigate the stimuli. Resulting often in a barrier to further participate for some due to the lack of security confidence when clicking on a provided link. To bypass this hurdle as far as possible, participants were given a taste of the expected online store by means of a short GIF played inside a smartphone frame, as shown in Figure 7. Due to the continuous repetition the total viewing time was unlimited. The single images used for each of the six stimuli can be found in Appendix I.

Figure 7. Online store offer 2 (furniture/VR)

With the identification of the ideal retailers for the three visualization types, which are both comparable within the visualization type between the two product types as well as between the visualization types within the product type, the experiment had been set up in the program ‘Qualitrics’. In total, the structure of the survey consisted of nine question constructs, namely: shopping behaviour, familiarity with AR and VR 3D visualizations and the usage of those while shopping online, perception of the displayed online store with regards to its vividness, interactivity, personal involvement, authenticity as well as utilitarian and hedonic benefits offered, and overall brand perception. In Appendix III the details of each construct and the questions asked in the conducted experiment can be found.

The beginning of the experiment included a detailed introduction to the topic, the justification for the data collection, and information on the use, storage, and deletion of the data sets obtained. Furthermore, it was pointed out that the study conducted was not in collaboration with the brands presented. Subsequently, reference was made to the anonymity of participation, which was guaranteed throughout the entire process. Lastly, before the actual research questions were shown, participant’s consent was collected for voluntary participation, data collection and

further processing based on an informed consent. If a participant disagreed and thus selected no, the experiment was immediately terminated, and he/she was directed to the end of the survey.

First, general questions on demographics, shopping behaviour and familiarity with AR and VR, as well as their application in e-commerce were asked. Followed by the display of one stimulus per participant, which was selected by computerized randomization from the six available stimuli. Once the online shopping environment had been inspected in detail and participants returned to the survey, questions were asked about the respective stimulus just experienced and its offered vividness and interactivity as well as participants' involvement within the online store and its authenticity to brick-and-mortar. Thereupon questions were asked on the extent, if any, to which the online store and its product visualization type provided utilitarian and hedonic benefits.

In order to verify the extent to which the gathered data were truly unbiased and thus valuable for inference, the following four questions were additionally asked on a seven-point Likert scale at the end of the survey about the stimuli itself: 1) "How familiar are you with the displayed online shop?" (not familiar at all to extremely familiar), 2) "To what extent are you familiar with the brands displayed in the online shop?" (not familiar at all to extremely familiar), 3) "What kind of feelings emerge in you in relation to the displayed brand/s?" (negative to positive) and 4) "How do you feel about the displayed brand/s" (dislike to like). Finally, the experiment ended after approximately ten to fifteen minutes with the acknowledgement for participation.

To gather as much meaningful information as planned and not harm any of the participants, the research project was submitted to the Ethics Committee of the University of Twente. The approval of the application (210560, Appendix IV) can be found in Appendix V.

3.3.1. Pre-test – survey

To minimize operational blindness, bias and influence concerning the direction of the outcome in the structure of the experiment as well as in its individual components and questions, the survey was forwarded to three people among acquaintances with no prior knowledge of the study for review. See Appendix II for the tested layout of the survey. Firstly, the pre-test focused on the general understanding of the questions and their relevance to the overall study topic. Secondly, operational aspects were checked as to whether the procedure ran smoothly, problems occurred with the stimuli on the external platform and if the return to the survey worked. Finally, the subjectively perceived length of the survey in relation to the objective time range stated was tested.

Based on the feedbacks, the following four adjustments were made: (1) Introduction of the broadest definition of AR and VR in colloquial language under the questions: "How familiar are you with augmented reality (AR)/ virtual reality (VR)?", with additionally one to two images that clarify the scope and differences. (2) Simplification of sentence structures, and replacement of technical jargon by basic, more concrete words. (3) Insertion of a text block after returning to the survey and before the study-specific questions to point out that all subsequent questions exclusively relate to the online store just explored. (4) Integration of a text block before the last two question constructs, hedonic benefits and brand perception, to highlight that the survey was coming to an end: "You are almost done, two more slides.". As pointed out under 3.3., the final survey of the experiment with all these amendments is to be found in Appendix III.

3.4. Participants

3.4.1. Data collection procedure

The link and QR code to the experiment were shared in both the professional and personal environment of the researcher from April 17 to May 9, 2021. Pinboards and private message functions of social media such as LinkedIn, Xing, Facebook and Instagram served as indirect and direct communication pipes. In addition to the introduction and reasoning for the survey, it was always indicated that everyone was welcome to spread the survey further to acquaintance and friends who might be interested in the topic. Snowball sampling was selected as the approach for data collection because of its fast, efficient, and cost-effective aspects for finding participants in the predefined time slot of up to three weeks. In addition to the distribution within the private networks, the University's Survey Pool 'SONA' has been used as of April 30, 2021, after more than half of the data volume had been recorded. In general, the recruitment of participants was based on a non-probability sampling method, as mostly friends, family member and colleagues were included.

3.4.2. Sample

According to Bentler and Chou (1987) the ratio of the sample to the number of constructs in the model of an experimental quantitative research must be at least 5:1 or 10:1 in order to draw optimal conclusions. Since the conceptual model of this study consisted of 13 constructs, an appropriate sample size would be from 65 to 130, preferably equally distributed between genders.

A total of 281 participants took part in the online experiment. However, because 81 participants did not complete the survey and two participants did not give informed consent, only 198 participations were valid for further data analysis. Participants came from 24 different countries, but Germany (123 participants) and the Netherlands (19 participants) dominated. Of these 198 participants, 104 were women and 94 were men, ranging in age from 19 to 60 years (M = 30.56, SD = 7.59). Dividing participants further into two age groups in terms of 'Younger' (18-to-28-years) and 'Older' (29-to-60-years), 55.6% of participants were classified as older and 44.4% as younger. A chi-square test was performed for both gender and age to determine their distribution among the six conditions. For both, no expected cell frequencies were below 5 (gender - $\chi^2(5) = 6.316$, $p = .0277$, $\varphi = 0.277$; age - $\chi^2(5) = 9.877$, $p = .0079$, $\varphi = 0.079$). According to this, gender and age of participants were evenly spread across the six experimental conditions. Of all participants, over 75% had either a bachelor's (37.9%, 75 participants) or master's (37.9%, 75 participants) degree, only a minority hold a Ph.D. or higher (3%, 6 participants). The remaining 42 participants had either a high school diploma or equivalent (12.6%, 25 participants), a technical or occupational certificate (7.6%, 15 participants), or something else (1%, 2 participants).

In terms of preferred shopping channel, brick-and-mortar (47.5%) and e-commerce (52.2%) were about equal between participants. Even if one of the purchasing channels was ranked by participants over the other, only a small percentage of participants engage in an entire in-channel purchase approach for non-essential products, 8.1% only in stores and 6.1% exclusively online. Consequently, the majority of participants apply a mix of both retail channels to complete their purchases, but in doing so, 45.5% increasingly rely on e-commerce and 40.4% on brick-and-mortar. This trend towards e-commerce is also reflected in the strong familiarity of participants with online shopping (M = 6.17, SD = 1.10) as well as the monthly order frequency (M = 3.62, SD = 1.40). With reference to the familiarity with the two 3D visualization types under study, 63.6% indicated having used AR in general before and 61.6% VR. In the context of online shopping and the implementation of AR and VR, 66.2% highlighted that they have never used either visualization type in their purchase process. Solely 9.6% have integrated VR in their online shopping experience and 10.6% AR. Furthermore, 13.6% participants have indicated that they already made use of both AR and VR for their online shopping. The details of participants demographic characteristics for each experimental condition can be found in Table 2.

Table 2

Distribution of sample characteristics per condition

		2D visualization		AR visualization		VR visualization	
Furniture							
	Age [a]	1)	22 / 43.1%	1)	6 / 21.4%	1)	17 / 51.5%
		2)	29 / 56.9%	2)	22 / 78.8%	2)	16 / 48.5%
		3)	21 / 56	3)	23 / 48	3)	19 / 48
	Gender [b]	Female	31 / 15.7%	Female	9 / 4.5%	Female	18 / 9.1%
		Male	20 / 10.1%	Male	19 / 9.6%	Male	15 / 7.6%
	Shopping behaviour [c]	In stores	26 / 51.0%	In stores	6 / 21.4%	In stores	22 / 66.7%
		Online	25 / 49.0%	Online	22 / 78.6%	Online	11 / 33.3%
	Shopping approach [d]	1)	7.8%	1)	3.6%	1)	9.1%
		2)	2.0%	2)	10.7%	2)	3.0%
		3)	45.1%	3)	21.4%	3)	54.5%
		4)	45.1%	4)	64.3%	4)	33.3%
	Familiarity with 3D visualizations [e]	1)	70.6% / 29.4%	1)	64.3% / 35.7%	1)	51.5% / 48.5%
		2)	54.9% / 45.1%	2)	71.4% / 28.6%	2)	45.5% / 54.5%
	Shopping online with 3D visualizations [f]	1)	3.9%	1)	7.1%	1)	18.2%
		2)	13.7%	2)	10.7%	2)	3.0%
		3)	19.6%	3)	14.3%	3)	3.0%
		4)	62.7%	4)	67.9%	4)	75.8%

a) Count + Percentage: 1)Younger (18-28) 2)Older (29-99); 3)Youngest / Oldest (Categorization based on medium split at 29)

b) Count + Percentage division Female / Male

c) Count + Percentage division In stores / Online

d) Percentage: 1)Only in stores/ 2)Only online/ 3)Mix of both but more in stores/ 4)Mox of both but more online

e) Percentage: 1)AR usage (Yes/No)/ 2)VR usage (Yes/No)

f) Percentage: 1)AR/ 2)VR/ 3)Both/ 4)None

(continued)

Table 2

Distribution of sample characteristics per condition

		2D visualization	AR visualization		VR visualization	
Shoes						
Age [a]	1)	20 / 58.8%	1)	7 / 38.9%	1)	16 / 47.1%
	2)	14 / 41.2%	2)	11 / 61.1%	2)	18 / 52.9%
	3)	19 / 60	3)	22 / 48	3)	22 / 57
Gender [b]	Female	19 / 9.6%	Female	9 / 4.5%	Female	18 / 9.1%
	Male	15 / 7.6%	Male	9 / 4.5%	Male	16 / 8.1%
Shopping behaviour [c]	In stores	13 / 38.2%	In stores	10 / 55.6%	In stores	17 / 50.0%
	Online	21 / 61.8%	Online	8 / 44.4%	Online	17 / 50.0%
Shopping approach [d]	1)	5.9%	1)	5.6%	1)	14.7%
	2)	8.8%	2)	5.6%	2)	8.8%
	3)	32.4%	3)	50.0%	3)	38.2%
	4)	52.9%	4)	38.9%	4)	38.2%
Familiarity with 3D visualizations [e]	1)	67.6% / 32.4%	1)	61.1% / 38.9%	1)	61.8% / 38.2%
	2)	70.6% / 29.4%	2)	66.7% / 33,3%	2)	67.6% / 32.4%
Shopping online with 3D visualizations [f]	1)	11.8%	1)	0.0%	1)	8.8%
	2)	14.7%	2)	11.1%	2)	14.7%
	3)	14.7%	3)	11.1%	3)	14.7%
	4)	58.8%	4)	77.8%	4)	61.8%

a) Count + Percentage: 1)Younger (18-28) 2)Older (29-99); 3)Youngest / Oldest (Categorization based on medium split at 29)

b) Count + Percentage division Female / Male

c) Count + Percentage division In stores / Online

d) Percentage: 1)Only in stores/ 2)Only online/ 3)Mix of both but more in stores/ 4)Mox of both but more online

e) Percentage: 1)AR usage (Yes/No)/ 2)VR usage (Yes/No)

f) Percentage: 1)AR/ 2)VR/ 3)Both/ 4)None

3.5. Measures

3.5.1. Discriminant validity of measures

To verify that the six constructs of the dependent variable and their assigned scale items were perceived as these individual constructs in this study, a factor analysis has been performed. For this purpose, all 34 scale items for the e-commerce experience (Appendix VI) were selected and analyzed applying the commands extract data by eigenvalue greater than 1, suppress small coefficient below 0.50 and sorted by size. Moreover, the method Varimax has been chosen to obtain a rotated component matrix of all scale items. The analysis showed a rearrangement of the scale items for constructs as well as an exclusion of four scale items (Appendix VII). Resulting in the fact that the questionnaire of the experiment consisted of a total of eight constructs instead of the intended six, namely: interactivity, authenticity, involvement with displayed product, involvement with visualization type, utilitarian benefits, multi-sensory stimulation, vividness of stimuli environment and hedonic benefits.

3.5.2. Reliability

Given that a construct is only perceived as reliable with an alpha value of 0.7 or higher, the Cronbach's Alpha has been calculated for all e-commerce experience constructs to assess the internal consistency between each construct scale item (Boudreau et al., 2001). As can be taken from Table 3, all constructs expect the latter, hedonic benefits, did reach acceptable internal reliability. Consequently, the final construct was taken out for further analysis.

Table 3

Internal consistency of the dependent variable's constructs

Constructs	No. items	Percentage of variance	Cronbach's Alpha (α)	Comment
Interactivity	7	34.29%	0.90	Good
Authenticity	6	10.14%	0.89	Good
Involvement with displayed product	4	7.34%	0.92	Excellent
Involvement with visualization type	4	5.69%	0.84	Good
Utilitarian benefits	3	4.47%	0.80	Good
Multi-sensory stimulation	2	3.78%	0.74	Acceptable
Vividness of stimuli environment	2	3.60%	0.68	Acceptable
Hedonic benefits	2	3.40%	0.19	Unacceptable

Based on these findings, the conceptual model was revised considering the research design explained at the beginning of this chapter, as illustrated in Figure 8. See Appendix VIII for the coding scheme of the seven constructs of e-commerce experience and their composition of scaling items. In the following, these constructs and their scale items are named and explained in more detail. Unless otherwise stated, all questions have been measured on a seven-point Likert scale.

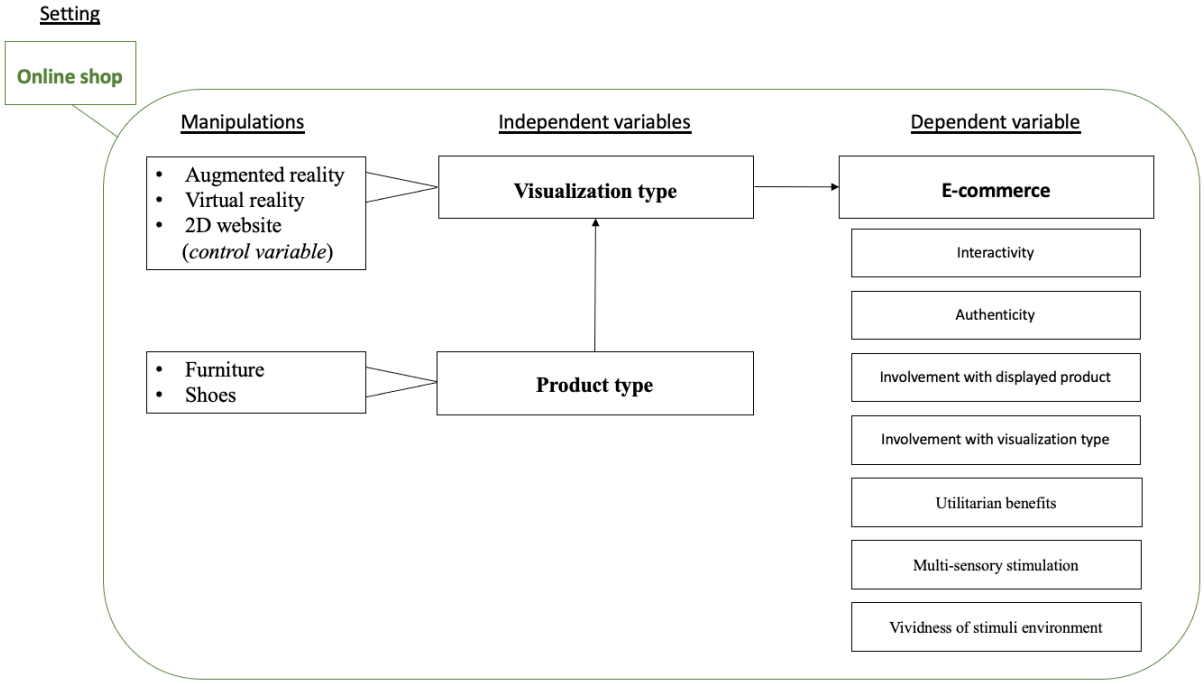

Figure 8. Revised conceptual model

3.5.3. Interactivity

Interactivity is defined as the provided degree of customization of the shopping environment in terms of content or form by the user himself (Jang et al., 2019). In particular, the perceived control in modifying the interfaces of the online store was examined, since this builds the core aspect of interactivity and leads to enhanced engagement (Hwang & Oh, 2020). Therefore, the measurement of this construct, consisting of items from Sundar et al. (2015), Song and Zinkhan (2008) as well as Shen and Joginapelly (2012), referred to the degree of perceived control and freedom in handling while collecting product information ($\alpha = 0.90$). Using a scale from (1) strongly disagree to (7) strongly agree, statements were proposed such as: "I felt that I had a lot of control over the online shopping environment.", "I felt that I could control my movements." and "I felt that I could interact with the products easily.".

3.5.4. Authenticity

The measures of the construct authenticity, consisting of six questions, referred to all possible impressions and feelings that consumers can experience during a brick-and-mortar shopping tour ($\alpha = 0.89$). To investigate the extent of a realistic stimulation of an offline shopping experience, established questions and their scales were taken from Algharabat and Dennis (2010) as well as Merle et al. (2012). In this case, two scale variants were applied: (1) not at all to (7) a lot and (1) strongly disagree to (7) strongly agree, and questions were asked like: "I enjoyed the online shopping experience in itself, not just for the products I could purchase.", "During the navigation, I felt the excitement of the hunt." and "The online shop let me fell as if I am really interacting with the products.".

3.5.5. Involvement with displayed product

Since involvement has an effect on the engagement in the shopping process, four questions related to the personal relevance of the products presented in the online store were asked to determine the extent to which participants cognitive engaged with the online shopping experience ($\alpha = 0.92$). Based on Zaichkowsky's (1994) personal involvement scale, four seven-point bipolar scales: unimportant / important, does not matter / matters to me, of no concern / of concern to me and irrelevant /relevant, have been proposed with the question: "How do you feel about the product type offered in the online shop?".

3.5.6. Involvement with visualization type

The construct involvement with visualization type has been measured by means of four questions (α = 0.84), adapted from Zaichkowsky's (1994) personal involvement scale. On four seven-point bipolar scales: uninvolving / involving, not beneficial / beneficial, mutant / fascinating and not needed / needed, participants were asked to evaluate the fit of the products in the online stores with their visualizations on the one hand and the necessity of the selected visualization type for the shopping experience on the other. All questions were asked uniformly as follows: "Do you think the visualization type of the products in the online shop is…".

3.5.7. Utilitarian benefits

With three questions, the utilitarian benefits construct aimed to determine whether the visualization type used in the online store can convey not only sufficient product information via visual language, but also more detailed and customer preferred information to transmit an accurate idea of the product (α = 0.80). With questions by Fiore et al. (2005) and Algharabat and Dennis (2010) that have been adjusted to the study, the aim was to investigate to what extent the discrepancy between the product expectation and the actual product can be reduced by the visualization type. Questions were as follows: "The visualization type of the product helps me evaluating the product.", and scales varied from: (1) not influential at all to (7) very influential and (1) strongly disagree to (7) strongly agree.

3.5.8. Multi-sensory stimulation

The construct multi-sensory stimulation comprised of two questions (α = 0.74) in which participants were asked to rate on a scale of (1) strongly disagree to (7) strongly agree the extent to which the design of the online store itself, as well as the product visualization stimulated several of their senses. With questions taken from Shen and Joginapelly (2012) such as: "The online shop offers rich media as flash, animation, etc." the intensity of the sensory online shopping experience was intended to be measured.

3.5.9. Vividness of stimuli environment

Based on two questions (α = 0.68) derived from Witmer's and Singer's (1996) immersive tendencies questionnaire and amended to the experimental environments of the study, the extent of participants adoption to the online shopping environment and interaction sequences was aimed to be examined. Through the questions: "How natural did your interactions with the online shop environment seem?" and "How quickly did you adjust to the online shop environment?", using scales of (1) not at all to (7) completely and (1) not adjusted at all to (7) very quickly, the degree to which the online shopping environment can convey information to the senses of participants, was to be measured.

3.6. Data analysis strategy

After the data collection has been completed and the data cleaned according to completeness and relevance, the actual analysis of the study took place by utilizing the software program SPSS, version 27. First, *t*-tests were performed to examine whether there are differences in terms of participants' familiarity and emotions towards the online stores and their brands in order to be able to determine if a comparison of the selected stimuli was possible as intended. For this purpose, the four questions on brand perception were analyzed by the visualization type as well as product type and checked for significant differences between the experimental conditions. Followed by follow-up tests, participants' level of familiarity and emotions towards the online stores and their brands overall as well as for the individual conditions has been determined. Subsequently, the descriptive statistics have been conducted for the seven constructs of e-commerce experience as well as the visualization and product type variables. Thereupon, a multivariant linear regression analysis has been performed to identify and describe the relation between the independent variables, visualization and product type, and the dependent variable, e-commerce experience, while controlling for age and gender (Frost., 2019). Since the seven constructs interactivity, authenticity, involvement with displayed product, involvement with visualization type utilitarian benefits, multi-sensory stimulation, and vividness of stimuli environment - represented the e-commerce experience a test of between-subjects effects was carried out in addition to the multivariate tests. The test of between-subject effects served the purpose to determine on which e-commerce experience construct the independent variables had exactly an influence. If an effect was significant, the mean scores of the descriptive statistics of the dependent variable constructs have been compared to examine the extent to which the influence applied to the attributes (AR, VR, 2D and shoes, furniture) of the independent variables. Finally, the mean scores and standard deviations for the influence of age and gender on the e-commerce experience were determined when an significant effect was given. All analyses have been evaluated based on a significance value of 5% (hereinafter referred to as Alpha level 0.05).

4.1. Manipulation check

Before the actual results are evaluated and discussed, participants' familiarity with and emotions towards the online stores and their brand portfolio were first checked to determine whether the stimuli were as intended unknown to participants and that there was an impartiality in the evaluation. For this purpose, *t*-tests were performed. As shown in Table 4, these tests indicated that there were no significant differences between the conditions in terms of familiarity and emotions. Subsequently, a comparison between the online stores could be made. In general terms the selected online stores ($M = 3.70$, $SD = 1.91$) as well as the brands therein ($M = 3.77$, $SD = 1.80$) were rather unknown to participants and the attitude towards the online stores and the displayed brand/s was more positive ($M = 4.73$, $SD = 1.18$) and they were slightly liked ($M = 4.82$, $SD = 1.22$), as to be seen in Table 5.

Table 4

Familiarity check of stimuli

		2D vs AR		2D vs VR		AR vs VR		Furniture vs Shoes	
		t(129)	*p*-value	*t*(150)	*p*-value	*t*(111)	*p*-value	*t*(196)	*p*-value
Familiarity [a)]	Online shop	0.51	0.612	130	0.195	0.68	0.498	-0.45	0.657
	Brands in online shop	-1.09	0.276	-0.93	0.356	0.28	0.783	-1.76	0.080
Emotions towards brand/s displayed [b)]	Attitude	0.83	0.408	0.43	0.668	-0.52	0.605	-0.78	0.435
	Likeability	0.33	0.739	0.59	0.551	0.20	0.843	-0.14	0.888

a) 7-point Likert scale (1=not familiar at all / 7=extremely familia

b) 7-point Likert scale (1=negative / 7=positive; 1=dislike / 7=like)

Independent t-test (midpoint = 4)

Table 5

Descriptive statistics of stimuli familiarity & likeability per condition

		2D visualization		AR visualization		VR visualization		Total	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Furniture									
Familiarity [a)]	Online shop	3.73	2.04	3.68	1.82	3.33	1.72	3.72	1.96
	Brands in online shop	3.45	1.77	3.36	1.56	3.94	1.76	4.02	1.88
Emotions towards brand/s displayed [b)]	Attitude	4.90	1.23	4.32	1.12	4.61	0.89	4.80	1.24
	Likeability	5.00	1.29	4.64	1.16	4.67	1.05	4.84	1.25
Shoes									
Familiarity [a)]	Online shop	4.00	2.13	3.61	1.72	3.50	1.92	3.60	1.89
	Brands in online shop	3.79	2.11	4.89	1.49	3.79	1.71	3.57	1.72
Emotions towards brand/s displayed [b)]	Attitude	4.65	1.41	5.06	1.11	4.82	1.14	4.67	1.13
	Likeability	4.71	1.38	5.06	1.16	4.85	1.18	4.81	1.20

a) 7-point Likert scale (1=not familiar at all / 7=extrem

b) 7-point Likert scale (1=negative / 7=positive; 1=dislike / 7=like)

One-sample t-test (midpoint = 4)

4.2. Descriptive statistics

In Table 6, the mean scores and standard deviations of the seven constructs of the dependent variable e-commerce experience per condition and the respective scales can be found. During the hypothesis testing these mean scores will serve as a foundation for a more detailed, directional and meaningful evaluation.

Table 6

Descriptive statistics of dependent variable constructs per condition

	2D visualization			AR visualization			VR visualization			Total product type		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Furniture												
Interactivity [a)]	5.06	1.08		4.71	1.07		4.53	1.09		4.77	1.08	
Authenticity [b)]	4.29	1.07		4.29	0.99		4.01	1.10		4.19	1.05	
Involvement with displayed product [c)]	4.79	1.27		4.76	1.31		4.66	1.41		4.74	1.33	
Involvement with visualization type [d)]	5.27	0.95		4.87	1.16		5.08	1.03		5.07	1.05	
Utilitarian benefits [e)]	5.34	0.90		5.17	1.11		4.84	1.20		5.11	1.07	
Multi-sensory stimulation [f)]	4.53	1.15		4.57	1.16		4.59	1.00		4.56	1.10	
Vividness of stimuli enviornment [g)]	5.19	1.06		4.77	1.06		5.02	1.06		4.99	1.06	
Total	4.92	1.07	51	4.73	1.12	28	4.67	1.13	33	4.78	1.11	112

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)

b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)

c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)

d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)

e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)

f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)

g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

Comparing means (midpoint = 4)

(continued)

Table 6

Descriptive statistics of dependent variable constructs per condition

	2D visualization			AR visualization			VR visualization			Total product type		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Shoes												
Interactivity [a]	5.36	0.93		5.26	0.99		4.95	0.76		5.19	0.89	
Authenticity [b]	4.21	1.41		4.33	1.40		3.50	1.17		4.01	1.33	
Involvement with displayed product [c]	4.88	1.47		5.08	1.25		4.60	1.11		4.85	1.27	
Involvement with visualization type [d]	5.16	1.09		5.24	1.18		4.54	1.21		4.98	1.16	
Utilitarian benefits [e]	5.13	1.40		4.85	1.20		4.21	1.33		4.73	1.31	
Multi-sensory stimulation [f]	4.76	1.30		5.47	0.85		4.54	1.38		4.93	1.18	
Vividness of stimuli enviornment [g]	5.35	1.18		4.78	1.37		4.54	1.27		4.89	1.27	
Total	4.98	1.25	34	5.00	1.18	18	4.41	1.18	34	4.80	1.20	86
Total visualization type												
Interactivity [a]	5.21	1.00		4.99	1.03		4.74	0.92				
Authenticity [b]	4.25	1.24		4.31	1.19		3.75	1.14				
Involvement with displayed product [c]	4.84	1.37		4.92	1.28		4.63	1.26				
Involvement with visualization type [d]	5.22	1.02		5.05	1.17		4.81	1.12				
Utilitarian benefits [e]	5.23	1.15		5.01	1.16		4.52	1.27				
Multi-sensory stimulation [f]	4.65	1.23		5.02	1.00		4.57	1.19				
Vividness of stimuli enviornment [g]	5.27	1.12		4.77	1.22		4.78	1.16				
Total	4.95	1.16	85	4.87	1.15	46	4.54	1.15	67			

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)
c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)
d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)
e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)
f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)
Comparing means (midpoint = 4)

4.3. MANOVA

A multivariance analysis, MANOVA, has been performed to test for the effect of visualization type and product type on e-commerce experience. Thereby, the visualization types (2D, AR and VR) as well as the product types (furniture and shoes) were used as independent variables and the seven constructs of e-commerce experience - interactivity, authenticity, involvement with displayed product, involvement with visualization type, utilitarian benefits, multi-sensory stimulation and vividness of stimuli environment - as dependent variables. Finally, since the conceptual model of this study was controlled for gender and age, both were integrated as additional fixed factors. It must be noted that the recoded version of age, categorizing it into younger (18 to 28 years) and older (29 to 99 years) based on a medium split, was used. The results of the analysis can be found in Table 7.

Table 7

Multivariate test for variance (GLM / MANOVA)

Multivariate Tests	*F*-value	*p*-value
Wilks' Lambda		
Visualization type	2.57	0.002
Product type	3.58	0.001
Visualization type * product type (interaction)	1.01	0.439
Gender	1.11	0.358
Visualization type * gender	0.76	0.712
Product type* gender	1.82	0.711
Age groups	2.42	0.022
Visualization type * age groups	2.01	0.017
Product type* age groups	0.65	0.711

Test of between-subjects effects	*F*-value	*p*-value
Visualization type		
Interactivity [a]	4.47	0.113
Authenticity [b]	5.80	0.113
Involvement with displayed product [c]	0.84	0.770
Involvement with visualization type [d]	4.33	0.151
Utilitarian benefits [e]	14.02	0.007
Multi-sensory stimulation [f]	3.41	0.292
Vividness of stimuli enviornment [g]	9.57	0.024

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)
c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)
d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)
e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)
f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

(continued)

Table 7

Multivariate test for variance (GLM / MANOVA)

Test of between-subjects effects	*F*-value	*p*-value
Product type		
Interactivity [a)]	5.53	0.021
Authenticity [b)]	2.86	0.142
Involvement with displayed product [c)]	0.25	0.692
Involvement with visualization type [d)]	0.23	0.657
Utilitarian benefits [e)]	9.05	0.011
Multi-sensory stimulation [f)]	3.61	0.108
Vividness of stimuli enviornment [g)]	0.04	0.857
Visualization type * product type (interaction)		
Interactivity [a)]	0.73	0.699
Authenticity [b)]	0.04	0.983
Involvement with displayed product [c)]	1.33	0.662
Involvement with visualization type [d)]	4.54	0.138
Utilitarian benefits [e)]	0.67	0.782
Multi-sensory stimulation [f)]	2.61	0.390
Vividness of stimuli enviornment [g)]	1.64	0.523
Gender		
Interactivity [a)]	0.22	0.640
Authenticity [b)]	2.86	0.142
Involvement with displayed product [c)]	7.57	0.031
Involvement with visualization type [d)]	1.62	0.234
Utilitarian benefits [e)]	1.57	0.284
Multi-sensory stimulation [f)]	0.65	0.494
Vividness of stimuli enviornment [g)]	0.91	0.397
Visualization type * gender		
Interactivity [a)]	0.47	0.794
Authenticity [b)]	1.73	0.519
Involvement with displayed product [c)]	2.81	0.419
Involvement with visualization type [d)]	3.57	0.211
Utilitarian benefits [e)]	1.91	0.496
Multi-sensory stimulation [f)]	0.83	0.741
Vividness of stimuli enviornment [g)]	3.45	0.256
Product type* gender		
Interactivity [a)]	0.00	0.976
Authenticity [b)]	0.14	0.749
Involvement with displayed product [c)]	0.55	0.559
Involvement with visualization type [d)]	2.27	0.159
Utilitarian benefits [e)]	3.72	0.990
Multi-sensory stimulation [f)]	5.77	0.042
Vividness of stimuli enviornment [g)]	0.01	0.929
Age groups		
Interactivity [a)]	0.12	0.735
Authenticity [b)]	0.07	0.818
Involvement with displayed product [c)]	1.64	0.314
Involvement with visualization type [d)]	0.01	0.916
Utilitarian benefits [e)]	1.16	0.356
Multi-sensory stimulation [f)]	1.65	0.275
Vividness of stimuli enviornment [g)]	9.89	0.006
Visualization type * age groups		
Interactivity [a)]	2.27	0.328
Authenticity [b)]	4.16	0.209
Involvement with displayed product [c)]	11.05	0.034
Involvement with visualization type [d)]	15.07	0.002
Utilitarian benefits [e)]	8.77	0.042
Multi-sensory stimulation [f)]	5.03	0.164
Vividness of stimuli enviornment [g)]	6.68	0.073

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)

b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)

c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)

d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)

e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)

f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)

g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

(continued)

Table 7

Multivariate test for variance (GLM / MANOVA)

Test of between-subjects effects	*F*-value	*p*-value
Product type* age groups		
Interactivity [a)]	0.02	0.880
Authenticity [b)]	1.44	0.296
Involvement with displayed product [c)]	0.03	0.896
Involvement with visualization type [d)]	0.08	0.794
Utilitarian benefits [e)]	0.45	0.566
Multi-sensory stimulation [f)]	0.43	0.576
Vividness of stimuli enviornment [g)]	1.32	0.306

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)
c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)
d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)
e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)
f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

4.3.1. Main effect of visualization type

For visualization type, there was a main effect on e-commerce experience given a *p*-value of 0.002 ($F = 2.565$). Comparing the total mean scores of the visualization types, it can be said that generally the online stores with 2D product images ($M = 4.95$, $SD = 1.16$) achieved overall a better e-commerce shopping experience than the online stores with AR ($M = 4.87$. $SD = 1.15$) or VR ($M = 4.54$, $SD = 1.15$) 3D product visualizations. However, the online stores with AR visualization versus the VR online stores delivered a more engaging online shopping experience. By taking a closer look at the individual constructs of e-commerce in the test between-subject effects, it becomes apparent that visualization type solely has a significant impact on utilitarian benefits ($F = 14.02$, $p = 0.007$) and vividness of stimuli environment ($F = 9.573$, $p = 0.024$). In terms of the three visualization types, according to participants the 2D product images ($M = 5.23$, $SD = 1.15$) transmitted more necessary product information for a realistic expectation of the actual product than the other two visualization types. Examining exclusively the two 3D product visualizations, AR was able in conveying more relevant product-related information ($M = 5.01$, $SD = 1.16$) compared to VR ($M = 4.52$, $SD = 1.27$). This tendency is also illustrated in the adaptation to the shopping experience, as participants found the 2D online stores to be the easiest and consequently the fastest to adjust ($M = 5.27$, $SD = 1.12$). Followed by the VR online stores ($M = 4.78$, $SD = 1.16$) and closely after by the AR online stores ($M = 4.77$, $SD = 1.22$). An illustration of the effect of visualization type on the two constructs can be found in Figure 9 and 19.

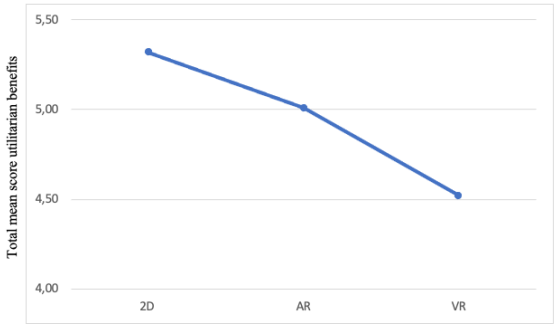

Figure 9. Visualization type's main effect on 'utilitarian benefits'

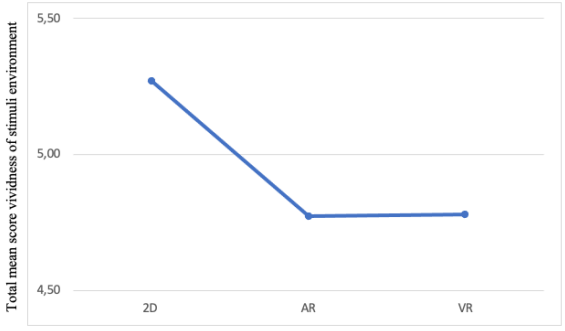

Figure 10. Visualization type's main effect on 'vividness of stimuli environment'

4.3.2. Main effect of product type

With regards to product type and its influence on the e-commerce experience, it can be said that a main effect was found here as well ($F = 3.58$, $p = 0.001$). Even if it is not the focus of the study, it is worth noting that shoes, regardless of their visualization type, offered participants a slightly more engaging e-commerce experience ($M = 4.80$, $SD = 1.20$) than furniture ($M = 4.78$, $SD = 1.11$). This was primarily due to the higher degree of interactivity ($F = 5.53$, $p = 0.021$; shoes – $M = 5.19$, $SD = 0.89$, furniture – $M = 4.77$, $SD = 1.08$). In addition to this, the utilitarian benefits construct yielded a significance based on a *p*-value of 0.011 ($F = 9.05$). However, participants felt that in the case of furniture ($M = 5.11$, $SD = 1.07$) a better expectation of products could be made on the basis of visual information than for shoes ($M = 4.73$, $SD = 1.31$).

4.3.3. Interaction effect of visualization & product type

Concerning the interaction effect of the combination of visualization and product type on e-commerce experience it can be said that this effect was not significant ($F = 1.01$, $p = 0.439$). If further looking at the e-commerce experience constructs of the interaction effect independently, it was also evident that the combination of visualization and product type has no significant influence of any of them, as all seven p-values are above the predefined Alpha level of 0.05.

4.4. Age & gender

The multivariance analysis revealed that gender has no effect on the e-commerce experience ($F = 1.11$, $p = 0.358$), nor in combination with either visualization type ($F = 0.76$, $p = 0.712$) or product type ($F = 1.81$, $p = 0.711$). For the age groups, in contrast, there is a main effect on e-commerce experience ($F = 2.41$, $p = 0.022$), as well as an interaction effect of the combination with visualization type ($F = 2.01$, $p = 0.017$). However, if examining the results of the test of between-subjects effects, it can be seen that age has only a main effect on the construct vividness of stimuli environment, given a p-value of 0.006 ($F = 9.89$). This means that the younger generation ($M = 4.88$, $SD = 1.16$) was more engaged in the e-commerce experiences (older generation – $M = 4.70$, $SD = 1.17$), while the older generation was able to adapt to the given shopping environments more easily and faster ($M = 5.07$, $SD = 1.16$) than the younger ($M = 4.86$, $SD = 1.18$). Concerning the interaction effect a significant effect was only found for three out of seven constructs, namely: involvement with displayed product ($F = 11.05$, $p = 0.034$), involvement with visualization type ($F = 15.06$, $p = 0.002$) and utilitarian benefits ($F = 8.76$, $p = 0.042$). Follow-up tests indicated, however, that only for involvement with displayed product (not for involvement with visualization type and utilitarian benefits) a significant difference ($t(196) = 2.30$, $p = 0.023$) between the younger and older generation was found. For the older participants the products in the AR online stores indicated a higher personal importance (AR – $M = 5.07$, $SD = 1.33$; 2D – $M = 4.30$, $SD = 1.37$; VR – $M = 4.46$, $SD = 1.15$) than for the younger ones, for who products in the traditional 2D online stores seemed to be more priority (2D – $M = 5.29$; $SD = 1.22$; AR – $M = 4.56$, $SD = 1.21$; VR – $M = 4.79$, $SD = 1.37$). An illustration of the statistically significant interaction effect can be seen in Figure 11. Summarizing, for the older generation, an AR 3D product visualization ($M = 5.04$, $SD = 1.13$) delivered the most engaging overall e-commerce experience and for the younger 2D product images ($M = 5.21$, $SD = 1.05$). Regarding the influence of the combination of age groups and product type on e-commerce experience, there was no interaction effect, given a p-value of 0.711 ($F = 0.65$). The descriptive statistics of the dependent variable constructs per age group as well as per condition and age group can be found in Appendix IX and X.

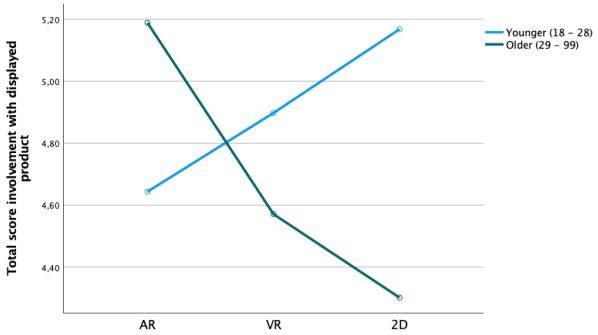

Figure 11. Interaction effect age group & visualization type on 'involvement with displayed product'

Chapter 5: Discussion

The current study aimed to investigate whether 3D product visualizations with AR and VR deliver consumers a more engaging e-commerce experience than the more widely used 2D product images. In addition, it has been examined if VR is indeed better suited for detail-oriented products than AR, while AR may be more appropriate for spatially absorbing products. The experiment showed that the visualization type of products influences the shopping experience in e-commerce, especially in terms of adapting to the shopping environment and creating a realistic expectation towards the actual product given the transmission of visually accurate product information. Contrary to assumptions, however, 2D product images outperformed AR and VR 3D visualizations in these aspects. Moreover, it could not be determined that an AR visualization is better suited for furniture than for shoes and VR is more appropriate for shoes than for furniture, and thus had an impact on the e-commerce experience. In this chapter, the results will be addressed to the formulated hypotheses. Lastly, limitations are listed and recommendations for both practice and research are drawn accordingly.

5.1. Influence of visualization type

Given the supporting literature, the first hypothesis was established as the foundation for the entire study:

H1: “Both an AR and VR 3D product visualization enhance consumers e-commerce experience in comparison to 2D product images.”

It was assumed that because of the 3D product visualizations and the detailed visual product information transmittable, both AR and VR can provide a better e-commerce shopping experience for consumers compared to the 2D product images (Fiore et al., 2005; Jessen et al., 2020). In contrast to the expectation, it has been found that 2D online stores were more engaging compared to online stores with AR and VR 3D product visualizations. This outcome could be explained by the fact that for the completion of orders the majority of participants apply a multi-channel shopping approach with either the focus on brick-and-mortar or e-commerce (Table 2). Participants’ shopping behaviour did not show any prominent preference for an exclusive e-commerce approach. Although participants are very familiar with online shopping and their e-commerce shopping frequency is high, e-commere seems to be purely a medium for carrying out transactions and not a main search and trial platform. Consequently, it appears that the demand on e-commerce of participants does not lie in the delivery of the most detailed and realistic product information. This shopping behaviour has also been studied by Klaus (2020), who stated that a large number of consumers make use of brick-and-mortar stores solely for finding brands, explore product material and the necessary size. This is also evident as 2D product images outperform AR and VR visualizations in terms of utilitiarian benefits and vividness of stimuli environment, indicating that e-commerce becomes relevant in the pre-purchase phase in relation to key product data and that precise details are then obtained in brick-and-mortar by direct self-experience. The explanation for the use of e-commerce as a pure transaction platform is also reinforecd by the fact that even though the majority of participants have used AR and VR before and are on average familiar with them, most of the participants have never integrated either AR nor VR in their online shopping experience (Table 2). Underlining the assumption that an accurate product expectation does not seem necessary for placing an order in e-commerce.

Regarding the second hypothesis: “An AR 3D product visualization enhances consumers e-commerce experience in comparison to VR 3D product visualizations”, it can be stated that by the experiment this has been confirmed. As expected, AR product visualizations delivered a more engaging e-commerce shopping experience for consumers compared to VR visualizations regardless of the product being displayed (Table 6). This is in particular due to the utilitarian benefits, as already proven in other studies. In relation to VR, 3D product visualizations via AR in e-commerce indeed offer more accuracte visual product information and thus an efficiency value in the shopping experience, as investigated by Dacko (2017). This advantage of AR was particularly more appreciated by the older generation. It seems that even though the younger generation builds the target group for companies when it comes to AR and VR enabled experiences and they showed a stronger attachment and composure in the implementation of such visualization types (CCV, 2020; Jessen et al., 2020; Kowalska, 2012; Xue et al., 2020), the stereotyping is not transferable to e-commerce. These findings could be explained by the fact that the younger generation values shopping trips in brick-and-mortar as a leisurely socializing event with no goals attached (Park & Kim, 2021). Whereas the older generation often defines brick-and-mortar as a time-consuming activity and therefore sees the integration of 3D product visualizations in e-commerce, particularly as found in this study AR (Appendix X), as a new valuable efficiency opportunity for everyday life that frees up time slots for other things (Dacko, 2017; Lim et al., 2016; Rauschnabel et al., 2019).

5.2. Influence of visualization & product type

Given the two hypotheses:

H3: “An AR 3D product visualization is more suitable for a product whoes spatial placement is crucial than for a product where attention to detail is important.”

H4: “An VR 3D product visualization is more suitable for a product where attention to detail is important than a product whoes spatial placement is crucial.”

Which were designed on the basis of the listed benfits in the literature of the individual 3D visualization types, no interaction effect of the combination of visualization and product type on e-commerce experience has been found. Although a main effect of product type on e-commerce experience was given, stating that shoes provide a more engaging, interactive and informative e-commerce experience than furniture. These results, which were fundamentally contrary to the expecations and assumptions of the hypotheses, may be explained by the fact that not the most adequate VR visualization for detail-oriented products could be selected. The focus during the selection process of the stimuli for the experiment was to obtain as many comparable individual conditions as possible while poviding the greated possible degree of control for the study. Correspondingly, for both product types, a simulation of brick-and-mortar stores was chosen of the two 2D retailers’ online stores. This decision was also based on the line of argumentation in several studies that given the state of the technology currently on the market for VR visualizations of products, a realistic 3D presentation with a smooth 360° image rendering is yet not available (Park & Kim, 2021). Thereby limiting the selection of stimuli to VR simulations of a brick-and-mortar store to deliver the most realistic online shopping experience possible. As stated by Meißner et al. (2020) and also evident in this study, a VR simulation of a brick-and-mortar store lacks a clear business plan for e-commerce. Even though e-commerce has grown and gained importance in the last decades, this VR 3D visualization type has never been adapted to the needs of online shopping. Consequently, future studies could investigate how VR should be integrated as a simulation of brick-and-mortar to reach a consumer-centric product visualization for e-commerce that is perceived as a transactional platform rather than a playful timeout (Tran et al., 2011a). Furthermore, it could also be studied whether a 360° 3D VR visualization of a detail-relevant product is really more suitable than self-augmentation (Xue et al., 2020).

5.3. Limitations & future research

Like any study, this study is subject to some limitations that provide possibilities for future research. First, to replicate an online shopping experience as truthfully as possible, much control was given to participants by an unconstrained research setting. However, this transfer of control resulted in many participants interrupting the survey and not resuming it. These dropouts were particularly noticeable when confronted with the stimuli, as of the 81 incompleted surveys, 55 participants alone quit after being presented with the assigned shopping environment. By integrating a visually appealing preview of the online stores based on the created GIFs, the barrier to switch to an external provider was intended to be reduced; this seemed to have limited effect and, considering the AR online stores, was the least effective, with 28 participants balking at the download. In order to collect valuable data like this in the future, a laboratory setting would be appropriate, in which participants are provided with the shopping environments under study on preassembled smart devices. Even if this does not correspond to the reality of online shopping, it would facilitate the data collection. Moreover, it would also address the issue of lack of technical capabilities, as a number of participants have fed back that complications occurred when returning to the survey portal, often causing them to start from scratch with a newly reassigned stimulus.

Leading to the second limitation, even though the individual stimuli could be actively explored in detail independently by participants in unlimited time and prefered scope, this independence had a weakness. Response time ranged from just under two minutes to several hours, which as mainly caused by the fact that a two-week processing window for a survey had been setup, to put as little stress on participants and thus potentially affecting the quality of the statements. To guarantee sufficient exposure of the stimuli, it would be adviseable to conduct a laboratory study in which a minimum and maximum time for the online shopping environment exploration is determined and controlled for.

Lastly, while previous studies have pointed out that the younger generation being the target audience for AR and VR based experiences given their digital skills and understanding (Jessen et al., 2020; van Deursen & Mossberger, 2018; Xue et al., 2020), this study was not able to identify a positive impact of it but rather a preference among the older generation towards these visualization types. Thus, future research could consider how exactly the digital skills of younger generations differ from those of the older ones, and to what extent these skills apply to online shopping.

5.4. Managerial & theoretical implications

The right integration of product visualizations in e-commerce is of high importance for managers to improve customer engagement and thereby shopping experience (Haile & Kang, 2020). This study provides a few managerial recommendations in this regard. Since the 2D product images delivered the most engaging e-commerce experience, the integration of 2D product images would not have a harmful impact on the company and its business. The usage of 2D product images would be particularly advisable for products that need to be evaluated in detail through a multi-channel approach, whereat e-commerce is serving exclusively as a pre-decision or transaction tool. In addition, a target group analysis of the products to be advertised should be carried out, because, as found, the younger generation was more engaged with 2D product images, unlike the older. However, if the aim is to stand out from the competition and improve brand image while attracting consumers in a more competitive market than ever before, the integration of AR and VR for 3D product visualization should be considered (Papagiannidis et al., 2013; Sihi, 2018). Thereby it should be taken into account that compared to VR, AR offers a more engaging as well as more product-informative online shopping experience. This visual accurate representation of product details is especially beneficial for consumers who know what they are looking for and thus an augmented virtual try-on of products can enhances a deeper product evaluation (Park & Kim, 2021). These findings contributed to the research on retail atmosphere and design elements, as this study illustrated that a customer-centric incorporation of AR in e-commerce has led to stronger customer engagement and hence online shopping experience given its utilitarian benefits (Paz & Delgado, 2020). However, it must be noted that the adaptation to the shopping environment be it self- or environment-augmented is a bit more difficult compared to an environment simulation through VR. The slightly easier adaptation to the VR shopping environment, could be due to the fact that the VR stimuli used were a 1:1 reflection of a real store of both retailers. By the realization that a VR simulation of a brick-and-mortar, which is the most realistic visualization of VR, is indeed equivalent authentic to the design of brick-and-mortar, a contribution the study of retail atmosphere has been made. Consequently, when integrating VR, it is crucial to stick to a simpler simulation identical to an existing brick-and-mortar store, which gives consumers a sense of familiarity, and not exploit the technical features available to the fullest. Nevertheless, before a VR simulation of brick-and-mortar is to be integrated into e-commerce, the integration goal must be known as well as the usage of the virtual environment by customers (Xue et al., 2020). Because only when a clear business model is in place technological features can be implemented accordingly (Park & Kim, 2021). Likewise, the target group should be analysed, since it was much easier for the older generation to adapt to the different shopping environments, independently of the displayed product. Furthermore, the older generation showed a higher involvement with presented products in AR online stores. In general, when integrating AR or VR care should be taken that the message to be delivered, rather than the medium used, is in the focus, while at the same time the way of transmitting information should be emphasized and not the information content (Haile & Kang, 2020).

Chapter 6: Conclusion

The main objective of this study was to investigate if 3D product visualizations through AR and VR can provide a more engaging shopping experience in e-commerce in comparison to the 2D product images used by the majority of retailers. Contrary to the findings in the literature, 2D product images were able to deliver the most engaging online shopping experience. The survey responses have further contradicted the statement from the literature that the application of AR and VR in e-commerce is dependent on the type of product being displayed. Correspondingly, it could not be proven that AR is more suitable for space-occupying products and VR for detail-oriented products. Additionally, the survey showed that generally the older generation can adapt more easily to the online shopping environments. Likewise, not the younger generation indicated a higher orientation and appreciation for the integration of AR and VR in e-commerce, but rather the older generation. This distinction was particularly evident for AR product visualizations, which enabled the most engaging e-commerce experience and a stronger involvement with products for the older generation.

To summarize, while 2D product images can deliver overall the most engaging e-commerce shopping experience to consumers than AR and VR, when zooming into the two 3D product visualizations AR outperforms VR in total as well as regarding visual product information transmission. As a result, a traditional 2D online store is a safe route for retailers to take. When aiming to deliver a 'one-of-a kind shopping experience', AR would be a better fit than VR, especially if the target group comprises consumers aged 29 and up. However, it should be noted that although e-commerce will continue to experience tremendous growth, 3D product visualizations can only outperform brick-and-mortar experiences at some point. Nevertheless, to be future-proof, companies might want to consider investing in self-and environment-augmentations to offer consumers realistic self-explanatory 3D product visualizations and thus an accurate product expectation.

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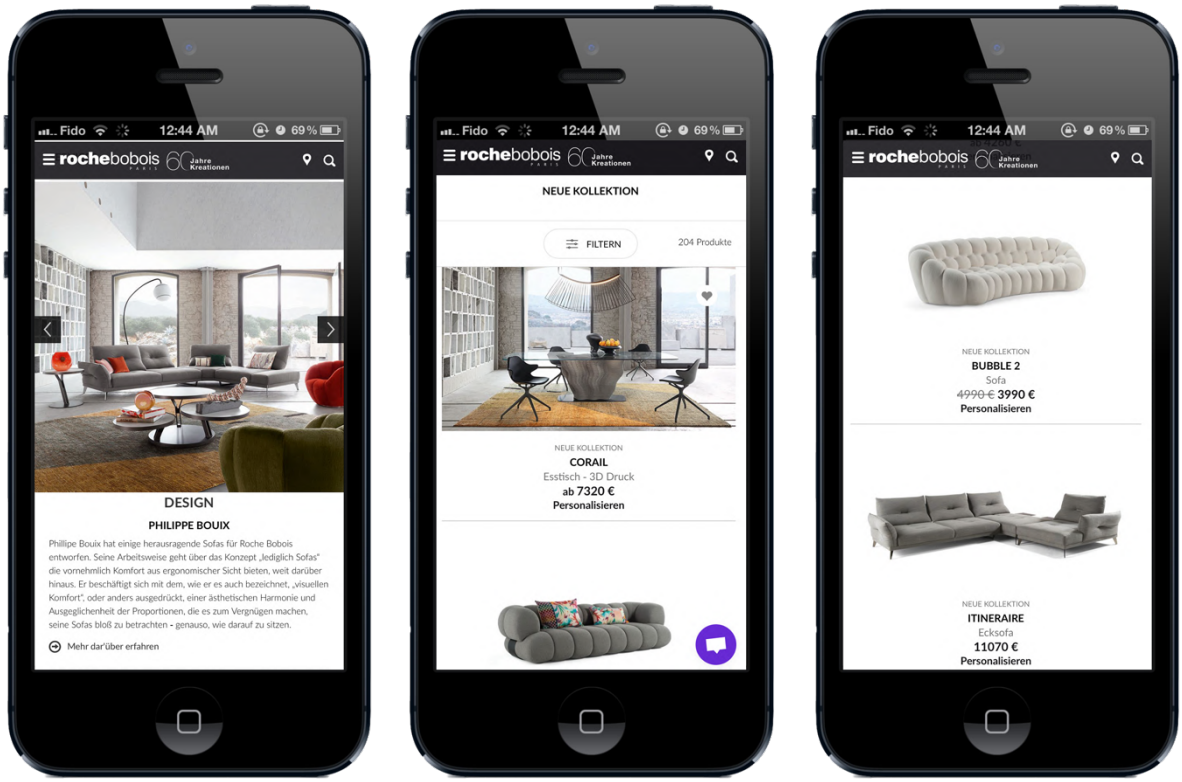
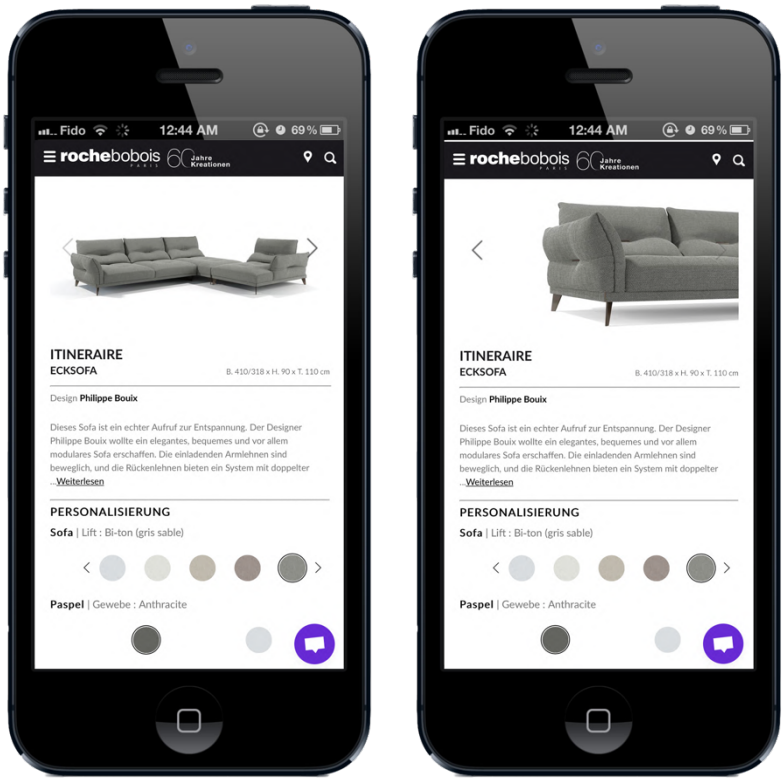
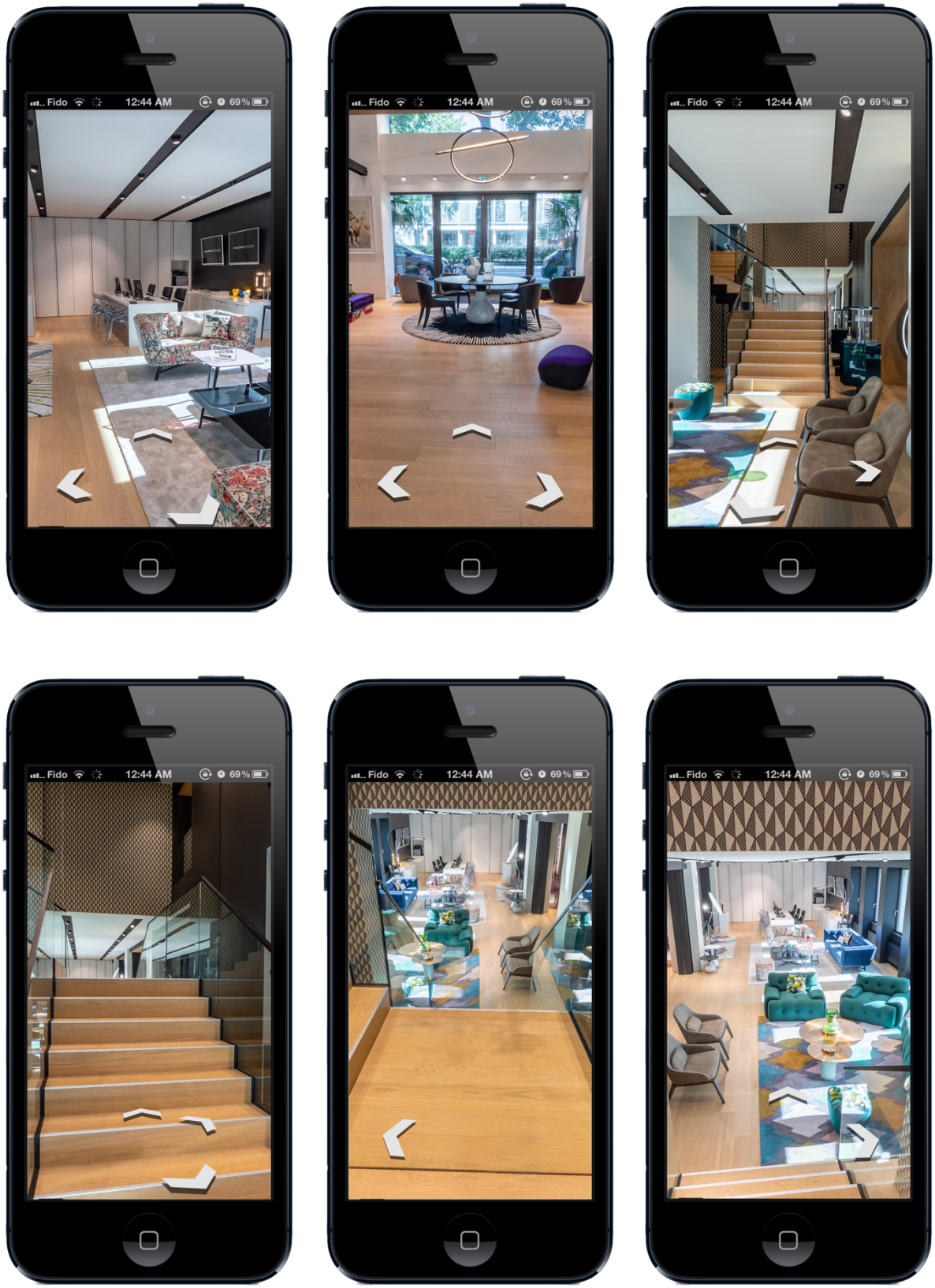
Appendix I – Overview Stimuli GIFs

Online store offer 1: Furniture Retailer – 2D online store





Online store offer 2: Furniture Retailer – VR online store

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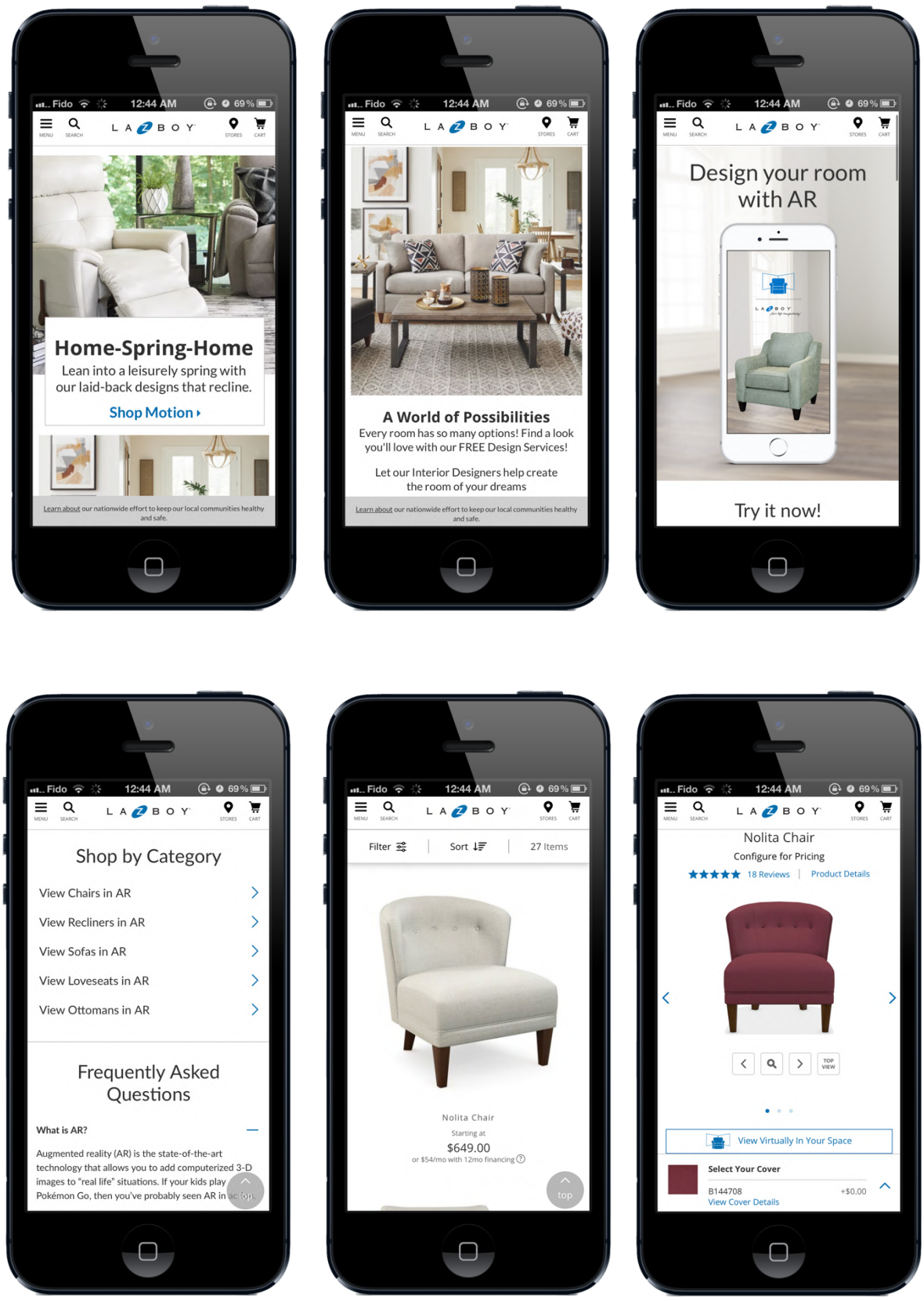
Online store offer 3: Furniture Retailer – AR online store

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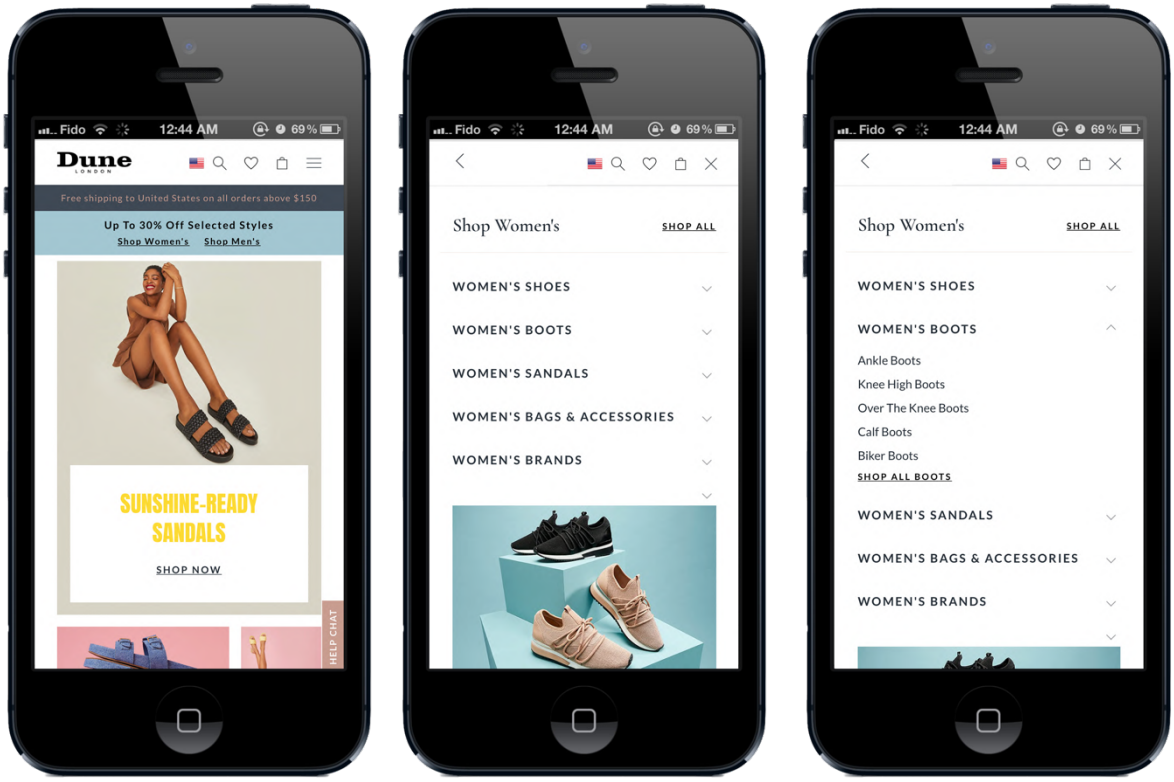
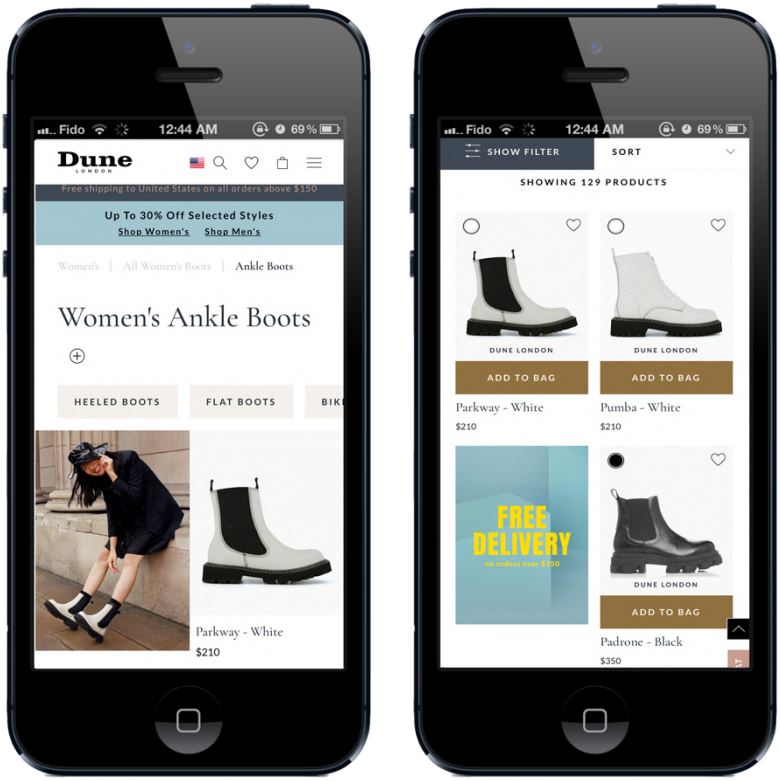
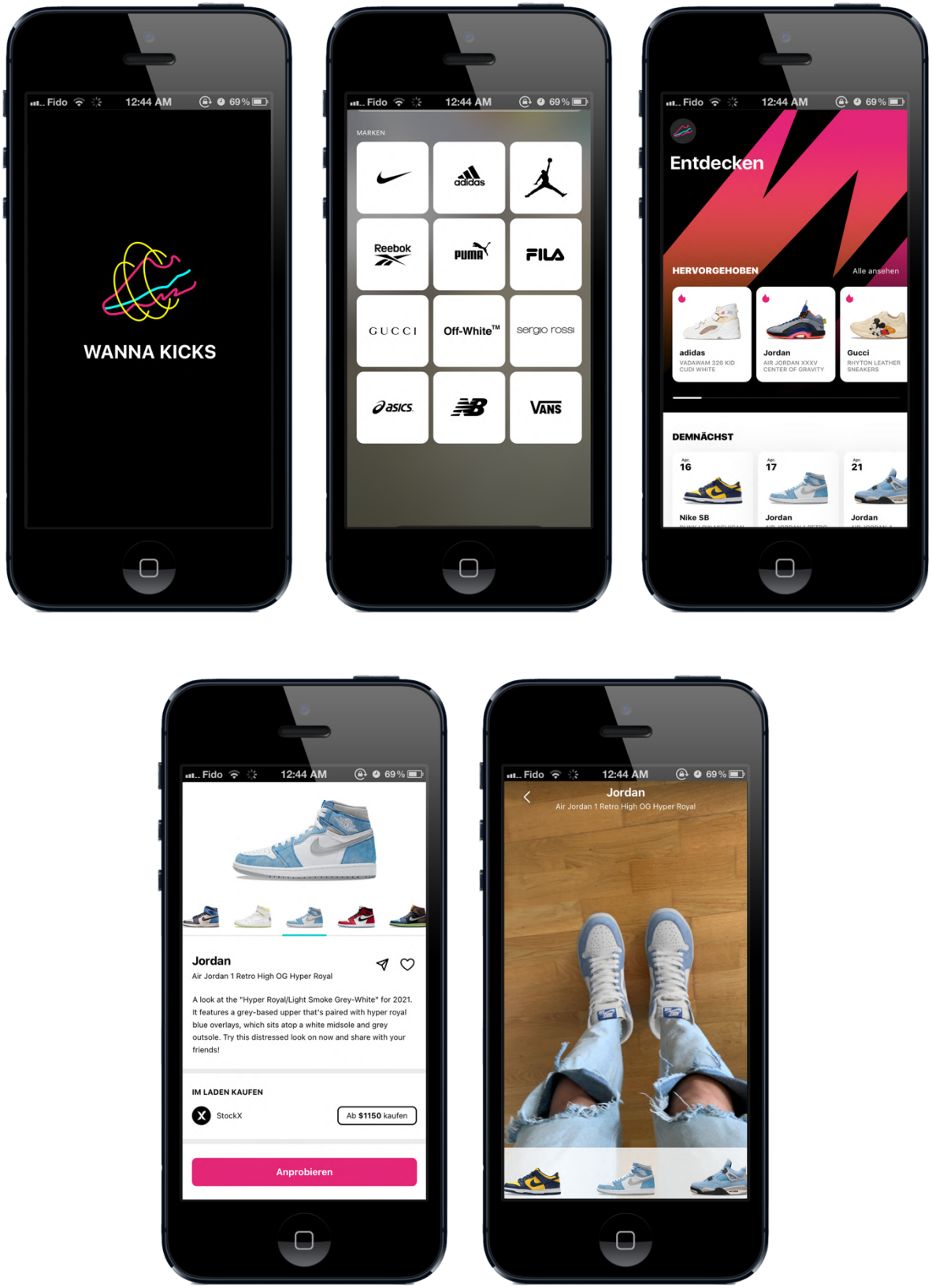
Online store offer 4: Shoe Retailer – 2D online store





Online store offer 5: Shoe Retailer – VR online store

Online store offer 6: Shoe Retailer – AR online store



Appendix II – Pre-test - Experiment

VR & AR visualizations in e-commerce

Survey Flow

Standard: Introduction and personal data (3 Questions)
Standard: Demographics and shopping behavior (8 Questions)
Standard: Digital Technology (6 Questions)

BlockRandomizer: 1 -

Block: Stimuli (7 Questions)

Standard: Stimuli (7 Questions)
Standard: Vividness (7 Questions)
Standard: Interactivity & Control (2 Questions)
Standard: Involvement (2 Questions)
Standard: Authenticity (3 Questions)
Standard: Utiliarian value (3 Questions)
Standard: Hedonic value (1 Question)
Standard: Brand perception (4 Questions)
Standard: End (1 Question)

Page Break

Start of Block: Introduction and personal data

Participant inform
Click to write the question text
Browser (1)
Version (2)
Operating System (3)
Screen Resolution (4)
Flash Version (5)
Java Support (6)
User Agent (7)

Intro
Dear participant,

First of all, thank you very much for participating in the study for my master thesis. The purpose of the study is to find out how product visualizations in online shops affect both your shopping experience and behaviour. Since the majority of online shopping is done on the go, I kindly ask you to fill out this survey on your mobile phone or another mobile device as you will be introduced to an online shop. Due to the fact that the online shop will open in a new window, please return back to the survey after you have thoroughly explored the online shop in all its details to answer the individual questions honestly. This study is not carried out in cooperation with the brand shown.

Your participation in this study is completely voluntary and you can discontinue your participation at any given time. I sincerely hope that you will complete the survey. The entire process will only take about 10 to 15 minutes. Be assured that all your responses remain

anonymous and confidential. All data will be stored in an electronic format protected with a password and will be deleted by August 31, 2021.

If you have any questions about the research, please contact me at:
a.befort@student.utwente.nl

Kind regards
Alevtina Befort

Consent
I hereby consent that for the purpose of the above mentioned master thesis my survey responses can be downloaded, analyzed and anonymously disclosed in the master thesis and its addendum and accessed by the University of Twente to assess the dissertation.

Do you agree to participate in this survey?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Consent = 2

End of Block: Introduction and personal data

Start of Block: Demographics and shopping behavior

Gender
What is your gender?

- ○ Female (1)
- ○ Male (2)
- ○ Other, namely: (3)_____

Age
What is your age?

_____

Shopping_1
Where do you prefer to shop?

- ○ In stores (1)
- ○ Online (2)

Shopping_2
How do you typically do your non-grocery shopping?

- ○ Only in stores (1)
- ○ Only online (2)
- ○ Mix of both but more in stores (3)
- ○ Mix of both but more online (4)

Shopping_3
What kind of products do you prefer to shop in stores? Name the two most important to you!

_____

Shopping_4
What kind of products do you prefer to shop online? Name the two most important to you!

_____

Shopping_5
How familiar are you with online shopping?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Shopping_6
How frequently do you shop online in a week?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Never	○	○	○	○	○	○	○	Almost ever day

End of Block: Demographics and shopping behavior

Start of Block: Digital Technology

Tech_General
To what extent are you familiar with the latest digital technologies?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Tech_AR1
How familiar are you with augmented reality (AR)?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Tech_AR2
Have you ever used augmented reality (AR) applications?

Augmented reality: A 3D computer-generated object is placed into the user's real-world environment via the front or back camera of the device whereby an interactive experience in real-time is created.

○ Yes (1)

○ No (2)

Tech_VR1
How familiar are you with virtual reality (VR)?

Virtual reality: A simulated experience in a 3D virtual sinthetic world that can be similiar to or completely different from the real world within which the user can nagivate and interact.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Tech_VR2
Have you ever used virtual reality (VR) applications?

○ Yes (1)

○ No (2)

Tech_Shopping
Have you ever used any of these digital technologies for your online shopping?

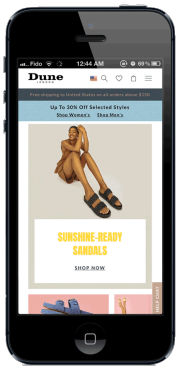
- ○ VR (1)
- ○ AR (2)
- ○ Both (3)
- ○ None (4)

End of Block: Digital Technology

Start of Block: Stimuli

Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Shoes_2D
Click on the link to explore the online shop: Dune London



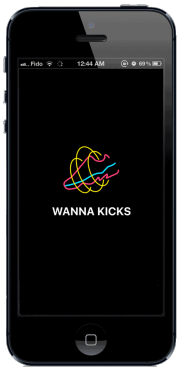
Shoes_AR
Download the app to explore the online shop:

IPhone: Wanna Kicks

Android: Wanna Kicks

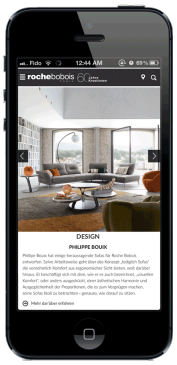
Please be aware that for starting the app, there is no need to log in or transfer any personal

information! After you have thoroughly checked the online shop and its AR functions, you can immediately delete the app from your mobile device.



Shoes_VR
Click on the link to explore the online shop: Duno London

Furniture_2D
Click on the link to explore the online shop: Roche Bobois

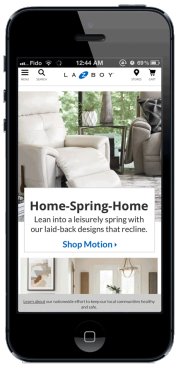


Funiture_AR
Download the app to explore the online shop:

IPhone: La Z Boy

Android: La Z Boy

Please be aware that for starting the app, there is no need to log in or transfer any personal information! After you have thoroughly checked the online shop and its AR functions, you can immediately delete the app from your mobile device.



Furniture_VR
Click on the link to explore the online shop: Roche Bobois

End of Block: Stimuli

Start of Block: Vividness

Vividness_1
To what extent do you disagree (1) or agree (7) with the following statements?

The online shop...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...offers rich media as flash, animation, etc.	○	○	○	○	○	○	○
...stimulates my senses.	○	○	○	○	○	○	○

Vividness_2
How much did your experience in the online shop seem consistent with your store experiences?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Completely

Vividness_3
How easy was it to form an impression of the product(s) presented via the visualizations?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not easy at all	○	○	○	○	○	○	○	Very easy

Vividness_4
How natural did your interactions with the online shop environment seem?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Completely

Vividness_5
How involved were you in the online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Completely

Vividness_6
How quickly did you adjust to the online shop environment?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not adjusted at all	○	○	○	○	○	○	○	Very quickly

Vividness_7
Do you think the online shop presented is vivid or boring?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Vivid	○	○	○	○	○	○	○	Boring

End of Block: Vividness

Start of Block: Interactivity & Control

Interactivity_1
To what extent do you disagree (1) or agree (7) with the following statements?

I felt that I...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...could interact with the online shopping environ-ment eas-ily.	○	○	○	○	○	○	○
...could interact with the products easily.	○	○	○	○	○	○	○
...had a lot of control over the online shopping environ-ment.	○	○	○	○	○	○	○
...could control my move-ments.	○	○	○	○	○	○	○

Interactivity_2
To what extent do you disagree (1) or agree (7) with the following statements?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
When I browsed through the online shop there was little waiting time between my action and the shops response.	○	○	○	○	○	○	○
The online shop environment is interactive.	○	○	○	○	○	○	○
The online shop environment is engaging.	○	○	○	○	○	○	○
The online shop environment is easy to navigate.	○	○	○	○	○	○	○
It is easy to find my way through the online shop.	○	○	○	○	○	○	○
The online shop environment provides information I am looking for quickly.	○	○	○	○	○	○	○

End of Block: Interactivity & Control

Start of Block: Involvement

Involvement_1
How do you feel about the product type offered in the online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Unimportant	○	○	○	○	○	○	○	Important
Does not matter	○	○	○	○	○	○	○	Matters to me

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Of no concern	○	○	○	○	○	○	○	Of concern to me
Irrelevant	○	○	○	○	○	○	○	Relevant

Involvement_2
Do you think the visualization type of the products in the online shop is...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Worthless	○	○	○	○	○	○	○	Valuable
Not beneficial	○	○	○	○	○	○	○	Beneficial
Mutant	○	○	○	○	○	○	○	Fascinating
Not needed	○	○	○	○	○	○	○	Needed
Uninvolving	○	○	○	○	○	○	○	Involving

End of Block: Involvement

Start of Block: Authenticity

Authenticity_1
How much would the product visualization quality distract you from placing an order?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Very much

Authenticity_2
Does the visualization type fit to the product type?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Very much

Authenticity_3
To what extent do you disagree (1) or agree (7) with the following statements?

The online shop...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...offered me an experience similar to the one I would have when visiting a store.	○	○	○	○	○	○	○
...let me feel as if I am visiting a store.	○	○	○	○	○	○	○
...let me feel as if I am really interacting with the products.	○	○	○	○	○	○	○

End of Block: Authenticity

Start of Block: Utiliarian value

Utiliarian_1
Do you think shopping in this online shop would make your life easier?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	A lot

Utiliarian_2
Do you think that if you wanted to buy a product online, the information and services in this online shop would be what you would look for?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Pretty much

Utiliarian_4
To what extent do you disagree (1) or agree (7) with the following statements?

The visualization type of the product type...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...helps me make a better decision about the product if I am consider buying it.	○	○	○	○	○	○	○
...helps me in evaluating the product.	○	○	○	○	○	○	○

End of Block: Utiliarian value

Start of Block: Hedonic value

Hedonic_1
To what extent to you disagree (1) or agree (7) with the following statements?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
During the navigation, I feel the excitement of the hunt.	○	○	○	○	○	○	○
Compared to other things I could have done, the time spent shopping on this online shops was truly enjoyable.	○	○	○	○	○	○	○

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
I enjoyed this online shopping trip for its own sake, not just for the products I could purchase.	○	○	○	○	○	○	○
This online shopping trip was not a very nice time out.	○	○	○	○	○	○	○

End of Block: Hedonic value

Start of Block: Brand perception

Brand perception_1
How familiar are you with the displayed online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Brand perception_2
To what extent are you familiar with the brands displayed in the online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Brand perception_3
What kind of feelings emerge in you in relation to the displayed brand/s?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Negative	○	○	○	○	○	○	○	Positive

Brand perception_4
How do you feel about the displayed brand/s?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Dislike	○	○	○	○	○	○	○	Like

End of Block: Brand perception

Start of Block: End

End Thank you for completing my survey!

I appreciate your valuable input.

End of Block: End

Appendix III – Experiment

VR & AR visualizations in e-commerce

Survey Flow

Standard: Introduction and personal data (3 Questions)
Standard: Demographics (4 Questions)
Standard: Shopping behavior (6 Questions)
Standard: Digital Technology (6 Questions)
Standard: Stimuli (8 Questions)
Standard: Intro to main survey (1 Question)
Standard: Vividness (5 Questions)
Standard: Interactivity & Control (2 Questions)
Standard: Involvement (2 Questions)
Standard: Authenticity (3 Questions)
Standard: Utiliarian value (3 Questions)
Standard: Status of survey (1 Question)
Standard: Hedonic value (1 Question)
Standard: Brand perception (4 Questions)

Page Break

Start of Block: Introduction and personal data

Participant inform
Click to write the question text
Browser (1)
Version (2)
Operating System (3)
Screen Resolution (4)
Flash Version (5)
Java Support (6)
User Agent (7)

Intro
Dear participant,

First of all, thank you very much for participating in the study for my master thesis. The purpose of the study is to find out how product visualizations in online shops affect both your shopping experience and behaviour. Since the majority of online shopping is done on the go, I kindly ask you to fill out this survey on your mobile phone or another mobile device as you will be introduced to an online shop. Due to the fact that the online shop will open in a new window, please return back to the survey after you have thoroughly explored the online shop in all its details to answer the individual questions honestly. This study is not carried out in cooperation with the brand shown.

Your participation in this study is completely voluntary and you can discontinue your participation at any given time. I sincerely hope that you will complete the survey. The entire process will only take about 10 to 15 minutes. Be assured that all your responses remain

anonymous and confidential. All data will be stored in an electronic format protected with a password and will be deleted by August 31, 2021.

If you have any questions about the research, please contact me at:
a.befort@student.utwente.nl

Kind regards
Alevtina Befort

Consent
I hereby consent that for the purpose of the above mentioned master thesis my survey responses can be downloaded, analyzed and anonymously disclosed in the master thesis and its addendum and accessed by the University of Twente to assess the dissertation.

Do you agree to participate in this survey?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Consent = 2

End of Block: Introduction and personal data

Start of Block: Demographics

Gender
What is your gender?

- ○ Female (1)
- ○ Male (2)
- ○ Other, namely: (3) _____

Age
What is your age?

_____

Level of education
What is the highest degree or level of school you have completed? If currently enrolled, highest degree received so far.

- ○ High school or equivalent (1)
- ○ Technical or occupational certificate (2)
- ○ Bachelor's degree (3)
- ○ Master's degree (4)
- ○ Ph.D or higher (5)
- ○ Others (6) _____

Country of living
In which country do you live?

_____

End of Block: Demographics

Start of Block: Shopping behavior

Shopping_1
Where do you prefer to shop?

- ○ In stores (1)
- ○ Online (2)

Shopping_2
How do you typically do your non-grocery shopping?

- ○ Only in stores (1)
- ○ Only online (2)
- ○ Mix of both but more in stores (3)
- ○ Mix of both but more online (4)

Shopping_3
What kind of products do you prefer to shop **in stores?** Name **one** specific product (e.g. shoes)!

_____

Shopping_4
What kind of products do you prefer to shop **online**? Name **one** specific product (e.g. shoes)!

_____

Shopping_5
How familiar are you with online shopping?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Shopping_6
How frequently do you shop online in a week?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Never	○	○	○	○	○	○	○	Almost ever day

End of Block: Shopping behavior

Start of Block: Digital Technology

Tech_General
To what extent are you familiar with the latest digital technologies?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Tech_AR1
How familiar are you with augmented reality (AR)?

Augmented reality: A 3D computer-generated object is placed into the user's real-world

environment via the front or back camera of the device whereby an interactive experience in real-time is created.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Tech_AR2
Have you ever used augmented reality (AR) applications?

- ○ Yes (1)
- ○ No (2)

Tech_VR1
How familiar are you with virtual reality (VR)?

Virtual reality: A simulated experience in a 3D virtual sinthetic world that can be similiar to or completely different from the real world within which the user can nagivate and interact.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Tech_VR2
Have you ever used virtual reality (VR) applications?

- ○ Yes (1)
- ○ No (2)

Tech_Shopping
Have you ever used any of these digital technologies for your online shopping?

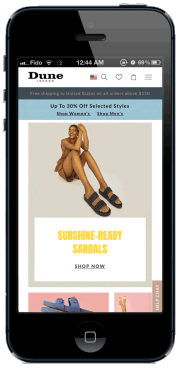
- ○ VR (1)
- ○ AR (2)
- ○ Both (3)
- ○ None (4)

End of Block: Digital Technology

Start of Block: Stimuli

Timer Stimuli
Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Shoes_2D
Click on the link to explore the online shop**:** Dune London

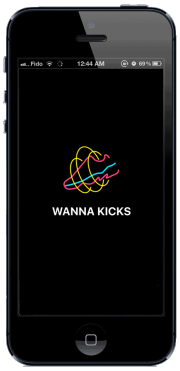


Shoes_AR
Please download the app to explore the online shop:

IPhone: Wanna Kicks

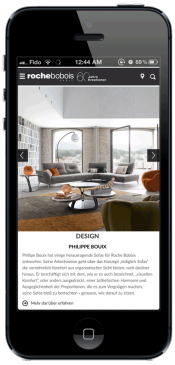
Android: Wanna Kicks

Be aware that for starting the app, there is **no need to log in or transfer any personal information**! After you have thoroughly checked the online shop and its AR functions, you can immediately delete the app from your mobile device.



Shoes_VR
Click on the link to explore the online shop: Duno London

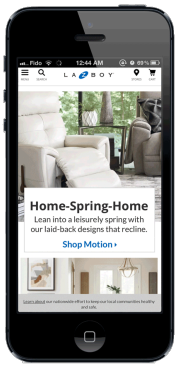
Furniture_2D
Click on the link to explore the online shop: Roche Bobois



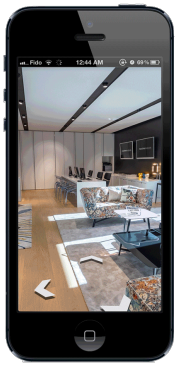
Funiture_AR
Please download the app to explore the online shop:

IPhone: La Z Boy
Android: La Z Boy

Be aware that for starting the app, there is **no need to log in or transfer any personal information**! After you have thoroughly checked the online shop and its AR functions, you can immediately delete the app from your mobile device.



Furniture_VR
Click on the link to explore the online shop**:** Roche Bobois



Intro_main survey
The following questions are all related to the online store just presented to you and the experience you had with it while browsing through.

End of Block: Stimuli

Start of Block: Intro to main survey

Intro_main survey
The following questions are all related to the online store just presented to you and the experience you had with it while browsing through.

End of Block: Intro to main survey

Start of Block: Vividness

Vividness_1
To what extent do you disagree (1) or agree (7) with the following statements?

The online shop...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...offers rich media as flash, animation, etc.	○	○	○	○	○	○	○
...stimulates my senses.	○	○	○	○	○	○	○

Vividness_2
How natural did your interactions with the online shop environment seem?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Com-pletely

Vividness_3
How involved were you in the online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Com-pletely

Vividness_4
How quickly did you adjust to the online shop environment?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not ad-justed at all	○	○	○	○	○	○	○	Very quickly

Vividness_5
Do you think the online shop presented is vivid or boring?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Vivid	○	○	○	○	○	○	○	Boring

End of Block: Vividness

Start of Block: Interactivity & Control

Interactivity_1
To what extent do you disagree (1) or agree (7) with the following statements?

I felt that I...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...could interact with the online shopping environment easily.	○	○	○	○	○	○	○
...could interact with the products easily.	○	○	○	○	○	○	○
...had a lot of control over the online shopping environment.	○	○	○	○	○	○	○
...could control my movements.	○	○	○	○	○	○	○

Interactivity_2
To what extent do you disagree (1) or agree (7) with the following statements?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
When I browsed through the online shop there was little waiting time between my action and the online shop's response.	○	○	○	○	○	○	○

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
The online shop environment is interactive.	○	○	○	○	○	○	○
The online shop environment is engaging.	○	○	○	○	○	○	○
It is easy to find my way through the online shop.	○	○	○	○	○	○	○

End of Block: Interactivity & Control

Start of Block: Involvement

Involvement_1
How do you feel about the product type offered in the online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Unimportant	○	○	○	○	○	○	○	Important
Does not matter	○	○	○	○	○	○	○	Matters to me
Of no concern	○	○	○	○	○	○	○	Of concern to me
Irrelevant	○	○	○	○	○	○	○	Relevant

Involvement_2
Do you think the visualization type of the products in the online shop is...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Uninvolving	○	○	○	○	○	○	○	Involving
Not beneficial	○	○	○	○	○	○	○	Beneficial
Mutant	○	○	○	○	○	○	○	Fascinating
Not needed	○	○	○	○	○	○	○	Needed

End of Block: Involvement

Start of Block: Authenticity

Authenticity_1
How much influence does the product visualization have for you on placing an order?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
No influential at all	○	○	○	○	○	○	○	Very influential

Authenticity_2
Does the visualization type fit to the product type?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Very much

Authenticity_3
To what extent do you disagree (1) or agree (7) with the following statements?

The online shop...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...offered me an experience similar as if I am visiting a store.	○	○	○	○	○	○	○
...let me feel as if I am really interacting with the products.	○	○	○	○	○	○	○

End of Block: Authenticity

Start of Block: Utiliarian value

Utiliarian_1
Do you think shopping in this online shop would make your life easier?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	A lot

Utiliarian_2
Do you think that this online shop could provide you with the information and service needed when buying a product?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not at all	○	○	○	○	○	○	○	Definitely

Utiliarian_3
To what extent do you disagree (1) or agree (7) with the following statements?

The visualization type of the product...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
...helps me make a better decision about the product if I am consider buying it.	○	○	○	○	○	○	○
...helps me evaluating the product.	○	○	○	○	○	○	○

End of Block: Utiliarian value

Start of Block: Status of survey

Status of survey You are almost done, two more slides.

End of Block: Status of survey

Start of Block: Hedonic value

Hedonic_1
To what extent to you disagree (1) or agree (7) with the following statements?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
During the navigation, I felt the excitement of the hunt.	○	○	○	○	○	○	○

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Compared to other things I could have done, the time spent shopping on this online shop was truly enjoyable.	○	○	○	○	○	○	○
I enjoyed the online shopping experience in itself, not just for the products I could purchase.	○	○	○	○	○	○	○
This online shopping trip was not a very nice time out.	○	○	○	○	○	○	○

End of Block: Hedonic value

Start of Block: Brand perception

Brand perception_1
How familiar are you with the displayed online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Brand perception_2
To what extent are you familiar with the brands displayed in the online shop?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Not familiar at all	○	○	○	○	○	○	○	Extremely familiar

Brand perception_3
What kind of feelings emerge in you in relation to the displayed brand/s?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Negative	○	○	○	○	○	○	○	Positive

Brand perception_4
How do you feel about the displayed brand/s?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Dislike	○	○	○	○	○	○	○	Like

End of Block: Brand perception

Appendix IV – Request for ethical review of research project

UNIVERSITY OF TWENTE.
FACULTY BMS

210560 REQUEST FOR ETHICAL REVIEW

Request nr: 210560
Researcher: Befort, A.
Supervisor: Scholten, H.
Reviewer: -
Status: Waiting for supervisor
Version: 2

1. START

A. TITLE AND CONTEXT OF THE RESEARCH PROJECT

1. What is the title of the research project? (max. 100 characters)

Augmented and virtual reality in e-commerce

2. In which context will you conduct this research?

Master's Thesis

3. Date of the application

06-04-2021

5. Is this research project closely connected to a research project previously assessed by the BMS Ethics Committee?

No/Unknown

B. CONTACT INFORMATION

6. Contact information for the lead researcher

6a. Initials:

A.

6b. Surname:

Befort

6c. Education/Department (if applicable):

M-COM

6d. Staff or Student number:

2419726

6e. Email address:

a.befort@student.utwente.nl

6f. Telephone number (during the research project):

+4917647807173

6g. If additional researchers (students and/or staff) will be involved in carrying out this research, please name them:

-

6h. Have you completed a PhD degree?

No

7. Contact information for the BMS Supervisor

7a. Initials:

H.

7b. Surname:

Scholten

7c. Department:

BMS-CS

7d. Email address:

h.scholten@utwente.nl

7e. Telephone number (during the research project):

+31534897448

8. Is one of the ethics committee reviewers involved in your research? Note: not everyone is a reviewer.

No

C. RESEARCH PROJECT DESCRIPTION

9a. Please provide a brief description (150 words max.) of the background and aim(s) of your research project in non-expert language.

The aim of the research is to determine how product visualizations designed via digital technologies like augmented and virtual reality in e-commerce are perceived by consumers compared to the still widely used 2D visualisations. Furthermore, it will also be investigated whether there is a difference in the need for the type of digital technology integrated, for example due to the product category. The general motivation for this study is to determine why 2D visualizations of products are continued to be used by the majority of retails in their e-commerce, when digital technologies that stimulate our senses more and can offer a better shopping experience are available to us. Especially under current circumstances due to the Covid-19 pandemic, which have made consumers depending on e-commerce, this study takes on an important significance for both literature as well as practice.

9b. Approximate starting date/end date of data collection:

Starting date: 2021-04-10

End date: 2021-06-29

9c. If applicable: indicate which external organization(s) has/have commissioned and/or provided funding for your research.

Commissioning organization(s):

Not applicable

Funding organization(s):

Not applicable

2. TYPE OF STUDY

Please select the type of study you plan to conduct:

My study will involve both existing and new data.

3. RESEARCH INVOLVING EXISTING DATA OR DOCUMENTS

A. WHICH DATA AND/OR DOCUMENTS WILL BE ACCESSED AND HOW?

10. Please provide a brief description of the data or documents that you plan to use (max. 2000 characters, including spaces).

One the one hand, I will use already existing data to set up the conceptualization of my variables and to construct the theoretical background as well as to underpin the hypotheses. This will mainly include articles and journals that have been published in the past decade. Occasionally, latest business articles on website and business homepages will be used to include the newest business practices on the development and implementation of both digital technologies, augmented and virtual reality. In the next phase, I will collect new data from individuals acting as participants in the research experiment. Here the data collection follows a quantitative approach.

11. Please indicate whether the data/documents you will use are:

- Publicly available

B. CONFIDENTIALITY AND ANONYMITY

12. Does the dataset contain information (or a combination of information) that can be traced back to specific individuals/organizations?

No

4. RESEARCH INVOLVING THE COLLECTION OF NEW DATA

A: RESEARCH POPULATION

20. Please provide a brief description of the intended research population(s):

Anyone over the age of 18 can take part in the experiment. The minimum age restriction was set due to the fact that only from the age of majority an unrestricted legal capacity, also in the context of online shopping, exists.

21. How many individuals will be involved in your research?

180 to 200 respondents

22. Which characteristics must participants/sources possess in order to be included in your research?

Exclusion criteria - respondents under 18 who do not have the legal right to place an order as they cannot assess the impact of online shopping. Accordingly, all participants need to be at least 18 years old. Furthermore, participants need to have access to a smartphone or other mobile device in order to receive similar stimulations to a real online shopping experience during the experiment.

23. Does this research specifically target minors (<16 years), people with cognitive impairments, people under institutional care (e.g. hospitals, nursing homes, prisons), specific ethnic groups, people in another country or any other special group that may be more vulnerable than the general population?

No

24. Are you planning to recruit participants for your research through the BMS test subject pool, SONA

No

B. METHODS OF DATA COLLECTION

25. What is the best description of your research?

- (Online) survey research

26. Please prove a brief yet sufficiently detailed overview of activities, as you would in the Procedure section of your thesis or paper. Among other things, please provide information about the information given to your research population, the manipulations (if applicable), the measures you use (at construct level), etc. in a way that is understandable for a relative lay person.

Information will be gathered via online survey by making use of the software Qualtrics.

How much time will each participant spend (mention the number of sessions/meetings in which they will participate and the time per session/meeting)?

Survey takes approximately 10-15 minutes to complete.

C: BURDEN AND RISKS OF PARTICIPATION

27. Please provide a brief description of these burdens and/or risks and how you plan to minimize them:

The online survey is designed in a way that it does not ask for personal data which could be tracked back to a specific participant. Thereby the anonymity to every research participant will be guaranteed. Generally, research transparency will be guaranteed throughout the entire research project and all rules guided by the GDPR will be followed.

28. Can the participants benefit from the research and/or their participation in any way?

No

29. Will the study expose the researcher to any risks (e.g. when collecting data in potentially dangerous environments or through dangerous activities, when dealing with sensitive or distressing topics, or when working in a setting that may pose 'lone worker' risks)?

No

D. INFORMED CONSENT

30. Will you inform potential research participants (and/or their legal repsentative(s), in case of non-competent participants) about the aims, activities, burdens and risks of the research before they decide whether to take part in the research?

Yes

Briefly clarify how:

Aim, activities, burdens and risks of the research are described on the introductory page of the online survey. Before participants can actually proceed to the questionnaire they need to decide whether or not to participate. Indicating a decision on the participation is mandatory.

32. How will you obtain the voluntary, informed consent of the research participants (or their legal repsentatives in case of non-competent participants)?

Active online consent

33. Will you clearly inform research participants that they can withdraw from the research at any time without explanation/justification?

Yes

34. Are the research participants somehow dependent on or in a subordinate position to the researcher(s) (e.g. students or relatives)?

No

35. Will participants receive any rewards, incentives or payments for participating in the research?

- No

36. In the interest of transparency, it is a good practice to inform participants about what will happen after their participation is completed. How will you inform participants about what will happen after their participation is concluded?

- Participants will receive the researcher's contact details, so that they can contact the researcher if they have questions/would like to know more.

E. CONFIDENTIALITY AND ANONYMITY

37. Does the data collected contain personal identifiable information that can be traced back to specific individuals/organizations?

No

39. Will you make use of audio or video recording?

No

5. DATA MANAGEMENT

- I have read the UT Data policy.
- I am aware of my responsibilities for the proper handling of data, regarding working with personal data, storage of data, sharing and presentation/publication of data.

6. OTHER POTENTIAL ETHICAL ISSUES/CONFLICTS OF INTEREST

40. Do you anticipate any other ethical issues/conflicts of interest in your research project that have not been previously noted in this application? Please state any issues and explain how you propose to deal with them. Additionally, if known indicate the purpose your results have (i.e. the results are used for e.g. policy, management, strategic or societal purposes).

The results of the research project might be used for following research in the area of e-commerce and digital technologies.

7. ATTACHMENTS

-

8. COMMENTS

-

9. CONCLUSION

Status: Waiting for supervisor

Appendix V – Research project approval by BMS Ethics Committee

APPROVED BMS EC RESEARCH PROJECT REQUEST

Dear researcher,

This is a notification from the BMS Ethics Committee concerning the web application form for the ethical review of research projects.

Requestnr. :	210560
Title :	Augmented and virtual reality in e-commerce
Date of application :	2021-04-06
Researcher :	Befort, A.
Supervisor :	Scholten, H.
Commission :	Galetzka, M.
Usage of SONA :	Y

Your research has been approved by the Ethics Committee.

The BMS ethical committee / Domain Humanities & Social Sciences has assessed the ethical aspects of your research project. On the basis of the information you provided, the committee does not have any ethical concerns regarding this research project.

It is your responsibility to ensure that the research is carried out in line with the information provided in the application you submitted for ethical review. If you make changes to the proposal that affect the approach to research on humans, you must resubmit the changed project or grant agreement to the ethical committee with these changes highlighted.

Moreover, novel ethical issues may emerge while carrying out your research. It is important that you re-consider and discuss the ethical aspects and implications of your research regularly, and that you proceed as a responsible scientist.

Finally, your research is subject to regulations such as the EU General Data Protection Regulation (GDPR), the Code of Conduct for the use of personal data in Scientific Research by VSNU (the Association of Universities in the Netherlands), further codes of conduct that are applicable in your field, and the obligation to report a security incident (data breach or otherwise) at the UT.

Scholten, H. (07-04-2021 15:57):

PDF sent back to Alevtina with comments

Appendix VI – Initial coding scheme

Group label	Qualtrics ID	Type	Question / Description	Scale	Source
General survey info					
	StartDate	Date	Start Date	None	
	EndDate	Date	End Date	None	
	IPAddress	String	IP Address	None	
	ResponseId	String	Response ID	None	
	Finished	Numeric	Finished	{0. False}...	
Introduction / Consent					
	Intro / Consent	Numeric	Active consent - I hereby consent that for the purpose of the above mentioned master thesis my survey responses can be downloaded, analyzed and anonymously disclosed in the master thesis and its addendum and accessed by the University of Twente to assess the dissertation.	{1. Yes / 2. No}	
Demographic variables					
	Gender	Numeric / Text	What is your gender? - Selected Choice	{1. Female}...	
	Age	Numeric	What is your age?	None	
	Level of education	Numeric / Text	What is the highest degree or level of school you have completed? If currently enrolled, highest degree received so far. - Selected Choice	{1. High school or equivalent}...	
	Country of living	Text	In which country do you live?	None	
Shopping behaviour					
	Shopping_1	Numeric	Where do you prefer to shop?	{1. in stores / 2. Online}	
	Shopping_2	Numeric	How do you typically do your non-grocery shopping?	{1. Only in stores}...	
	Shopping_3	Text	What kind of products do you prefer to shop in stores? Name one specific product (e.g. shoes)!	None	
	Shopping_4	Text	What kind of products do you prefer to shop online? Name one specific product (e.g. shoes)!	None	
	Shopping_5	Numeric	How familiar are you with online shopping?	{1. Not familiar at all}…	
	Shopping_6	Numeric	How frequently do you shop online in a week?	{1. Never}…	
Technology familiarity					
	Tech_General	Numeric	To what extent are you familiar with the latest digital technologies?	{1. Not familiar at all}…	
	Tech_AR1	Numeric	How familiar are you with augmented reality (AR)?	{1. Not familiar at all}…	
	Tech_AR2	Numeric	Have you ever used augmented reality (AR) applications?	{1. Yes / 2. No}	
	Tech_VR1	Numeric	How familiar are you with virtual reality (VR)?	{1. Not familiar at all}…	
	Tech_VR2	Numeric	Have you ever used virtual reality (VR) applications?	{1. Yes / 2. No}	
	Tech_Shopping	Numeric	Have you ever used any of these digital technologies for your online shopping?	{1. VR}…	
Vividness (dependent variable)					
	Vividness_1	Numeric	The online shop offers rich media as flash, animation, etc.	{1. Strongly disagree}…	Shen & Joginapelly, 2012
	Vividness_2	Numeric	The online shop stimulates my senses.	{1. Strongly disagree}…	
	Vividness_3	Numeric	How natural did your interactions with the online shop environment seem?	{1. Not at all}…	immersive tendencies questionnaire - Witmer & Singer (1996)
	Vividness_4	Numeric	How involved were you in the online shop?	{1. Not at all}…	
	Vividness_5	Numeric	How quickly did you adjust to the online shop environment?	{1. Not adjusted at all}…	
	Vividness_6	Numeric	Do you think the online shop presented is vivid or boring?	{1. Vivid}...	

(continued)

Group label	Qualtrics ID	Type	Question / Description	Scale	Source
Interactivity (dependent variable)					
	Interactivity_1	Numeric	I felt that I could interact with the online shopping environment easily.	{1. Strongly disagree}…	Liu& Shrum, 2002; McMillan & Hwang, 2002; Song & Zinkhan, 2008
	Interactivity_2	Numeric	I felt that I could interact with the products easily.	{1. Strongly disagree}…	
	Interactivity_3	Numeric	I felt that I had a lot of control over the online shopping environment.	{1. Strongly disagree}…	
	Interactivity_4	Numeric	I felt that I could control my movements.	{1. Strongly disagree}…	
	Interactivity_5	Numeric	When I browsed through the online shop there was little waiting time between my action and the online shop's response.	{1. Strongly disagree}…	Choi and Taylor, 2014
	Interactivity_6	Numeric	The online shop environment is interactive.	{1. Strongly disagree}…	
	Interactivity_7	Numeric	The online shop environment is engaging.	{1. Strongly disagree}…	Shen & Joginapelly, 2012
	Interactivity_8	Numeric	It is easy to find my way through the online shop.	{1. Strongly disagree}…	
Involvement (dependent variable)					
	Involvement_1	Numeric	How do you feel about the product category offered in the online shop?	{1. Unimportant}…	
	Involvement_2	Numeric	How do you feel about the product category offered in the online shop?	{1. Does not matter}…	
	Involvement_3	Numeric	How do you feel about the product category offered in the online shop?	{1. Of no concern}…	
	Involvement_4	Numeric	How do you feel about the product category offered in the online shop?	{1. Irrelevant}…	personal involvement scale - Zaichkowsky, 1994
	Involvement_5	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Uninvolving}…	
	Involvement_6	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Not beneficial}…	
	Involvement_7	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Mutant}…	
	Involvement_8	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Not needed}…	
Authenticity (dependent variable)					
	Authenticity_1	Numeric	How much influence does the product visualization have for you on placing an order?	{1. Not influenfial at all}…	
	Authenticity_2	Numeric	Does the visualization type fit to the product category?	{1. Not at all}…	Algharabat and Dennise, 2010
	Authenticity_3	Numeric	The online shop offered me an experience similar as if I am visiting a store.	{1. Strongly disagree}…	
	Authenticity_4	Numeric	The online shop let me feel as if I am really interacting with the products.	{1. Strongly disagree}…	
Utilitarian benefits (dependent variable)					
	Utilitarian_1	Numeric	Do you think shopping in this online shop would make your life easier?	{1. Not at all}…	Merle et al., 2012
	Utilitarian_2	Numeric	Do you think that this online shop could provide you with the information and service needed when buying a product?	{1. Not at all}…	
	Utilitarian_3	Numeric	The visualization type of the product helps me make a better decision about the product if I am consider buying it.	{1. Strongly disagree}…	Fiore, Kim et al., 2005
	Utilitarian_4	Numeric	The visualization type of the product helps me evaluating the product.	{1. Strongly disagree}…	
Hedonic benefits (dependent variable)					
	Hedonic_1	Numeric	During the navigation, I felt the excitement of the hunt.	{1. Strongly disagree}…	Merle et al., 2012
	Hedonic_2	Numeric	Compared to other things I could have done, the time spent shopping on this online shop was truly enjoyable.	{1. Strongly disagree}…	
	Hedonic_3	Numeric	I enjoyed the online shopping experience in itself, not just for the products I could purchase.	{1. Strongly disagree}…	
	Hedonic_4	Numeric	This online shopping trip was not a very nice time out.	{1. Strongly disagree}…	
Brand perception (stimuli check)					
	Brand perception_1	Numeric	How familiar are you with the displayed online shop?	{1. Not familiar at all}…	
	Brand perception_2	Numeric	To what extent are you familiar with the brands displayed in the online shop?	{1. Not familiar at all}…	
	Brand perception_3	Numeric	What kind of feelings emerge in you in relation to the displayed brand/s?	{1. Negative}…	
	Brand perception_4	Numeric	How do you feel about the displayed brand/s?	{1. Dislike}…	

Appendix VII – Factor analysis – rotated component matrix

Statements	Factor 1	2	3	4	5	6	7	8
Interactivity_4_To what extent do you disagree (1) or agree (7) with the following statements? I felt that I... - ...could control my movements. [a)]	0.813							
Interactivity_3_To what extent do you disagree (1) or agree (7) with the following statements? I felt that I... - ...had a lot of control over the online shopping environment. [a)]	0.784							
Interactivity_1_To what extent do you disagree (1) or agree (7) with the following statements? I felt that I... - ...could interact with the online shopping environment easily. [a)]	0.781							
Interactivity_8_To what extent do you disagree (1) or agree (7) with the following statements? - It is easy to find my way through the online shop. [a)]	0.769							
Interactivity_2_To what extent do you disagree (1) or agree (7) with the following statements? I felt that I... - ...could interact with the products easily. [a)]	0.734							
Interactivity_6_To what extent do you disagree (1) or agree (7) with the following statements? - The online shop environment is interactive. [a)]	0.610							
Interactivity_7_To what extent do you disagree (1) or agree (7) with the following statements? - The online shop environment is engaging. [a)]	0.514							
Authenticity_3_To what extent do you disagree (1) or agree (7) with the following statements? The online shop... - ...offered me an experience similar as if I am visiting a store. [a)]		0.734						
Authenticity_4_To what extent do you disagree (1) or agree (7) with the following statements? The online shop... - ...let me feel as if I am really interacting with the products. [a)]		0.724						
Hedonic_1_To what extent to you disagree (1) or agree (7) with the following statements? - During the navigation, I felt the excitement of the hunt. [a)]		0.716						
Hedonic_2_To what extent to you disagree (1) or agree (7) with the following statements? - Compared to other things I could have done, the time spent shopping on this online shop was truly enjoyable. [a)]		0.698						
Hedonic_3_To what extent to you disagree (1) or agree (7) with the following statements? - I enjoyed the online shopping experience in itself, not just for the products I could purchase. [a)]		0.685						
Utilitarian_1_Do you think shopping in this online shop would make your life easier? [b)]		0.678						
Utilitarian_2_Do you think that this online shop could provide you with the information and service needed when buying a product? [o)]								
Involvement_2_How do you feel about the product category offered in the online shop? [i)]			0.868					
Involvement_4_How do you feel about the product category offered in the online shop? [j)]			0.865					
Involvement_1_How do you feel about the product category offered in the online shop? [k)]			0.847					
Involvement_3_How do you feel about the product category offered in the online shop? [l)]			0.801					
Involvement_6_Do you think the visualization type of the products in the online shop is... [m)]				0.815				
Involvement_7_Do you think the visualization type of the products in the online shop is... [n)]				0.750				
Involvement_5_Do you think the visualization type of the products in the online shop is.... [o)]				0.644				
Involvement_6_Do you think the visualization type of the products in the online shop is... [p)]				0.632				
Utilitarian_3_To what extent do you disagree (1) or agree (7) with the following statements? The visualization type of the product... - ...helps me make a better decision about the product if I am consider buying it. [a)]					0.766			
Authenticity_1_How much influence does the product visualization have for you on placing an order? [d)]					0.692			
Utilitarian_4_To what extent do you disagree (1) or agree (7) with the following statements? The visualization type of the product... - ...helps me evaluating the product. [a)]					0.684			
Authenticity_2_Does the visualization type fit to the product category? [e)]								
Vividness_2_To what extent do you disagree (1) or agree (7) with the following statements? The online shop... - ...stimulates my senses. [a)]						0.745		
Vividness_1_To what extent do you disagree (1) or agree (7) with the following statements? The online shop... - ...offers rich media as flash, animation, etc. [a)]						0.735		
Vividness_6_Do you think the online shop presented is vivid or boring? [f)]						-0,518		
Vividness_5_How quickly did you adjust to the online shop environment? [g)]							0.738	
Vividness_3_How natural did your interactions with the online shop environment seem? [h)]							0.586	
Vividness_4_How involved were you in the online shop? [h)]								
Hedonic_4_To what extent to you disagree (1) or agree (7) with the following statements? - This online shopping trip was not a very nice time out. [a)]								0.790
Interactivity_5_To what extent do you disagree (1) or agree (7) with the following statements? - When I browsed through the online shop there was little waiting time between my action and the online shop's response. [a)]								0.603
% of variance explained:	34.29%	10.14%	7.34%	5.69%	4.47%	3.78%	3.60%	3.40%
Cumulative % of variance explained:	34.29%	44.44%	51.78%	57.46%	61.93%	65.71%	69.32%	72.72%
Eigenvalue:	10.289	3.043	2.202	1.705	1.341	1.134	1.081	1.021
Cronbach alpha:	0.90	0.89	0.92	0.84	0.80	0.74	0.68	0.19

7-point Likert scale = a) 1=strongly disagree / 7= trongly agree; b) 1=not at all / 7=a lot; c) 1=not at all / 7=definitely; d) 1=not influential at all / 7=very influential; e) 1=not at all / 7=very much; f) 1=vivid/ 7=boring; g) 1=not adjusted at all/ 7= very quickly; h) 1=not at all / 7=completely

7-point Zaichkowsky scale = i) 1=does not matter / 7=matters to me; j) 1=irrelevant / 7=relevant; k) 1=unimportant / 7=important; l) 1=of no concern / 7=of concern to me; m) 1=not beneficial / 7=beneficial; n) 1=mutant / 7=fascinating; o) 1=uninvolving / 7=involving; p) 1=not needed / 7=needed

The factor analysis revealed that the three items: Utilitarian_2, Authenticity_2 and Vividness_4, were not assigned to any construct and that one item, Vividness_6 had a negative value. Given its negative result, Vividness_6 was recoded accordingly. However, since the construct did not reach an internal reliability despite the positive value of the item, it was excluded for further steps. Correspondingly to accurately measure what was intended to be measured in the data analysis, these four times, highlighted in red in Table above, have been removed from the rest of the study. Subsequently, the factor analysis also reported the variance explained for each construct with an eigenvalue greater than 1 in percentage as well as in cumulative terms. With an information loss of about 30.68%, as the eighth construct, hedonic benefits, has been excluded for further analysis due to the lack of internal reliability, the now seven e-commerce experience constructs explained nearly 69.32% of the variability in the 28 items. This total variance can be explained by the seven constructs and their scale items used for further analysis as follows: 34.29% interactivity, 10.14% authenticity, 7.34% involvement with displayed product, 5.69% involvement with visualization type, 4.47% utilitarian benefits, 3.78% multi-sensory stimulation and 3.60% vividness of stimuli environment.

Appendix VIII – Adjusted coding scheme

Group label	Qualtrics ID	Type	Question / Description	Scale	Source
General survey info					
	StartDate	Date	Start Date	None	
	EndDate	Date	End Date	None	
	IPAddress	String	IP Address	None	
	ResponseId	String	Response ID	None	
	Finished	Numeric	Finished	{0. False}...	
Introduction / Consent					
	Intro / Consent	Numeric	Active consent - I hereby consent that for the purpose of the above mentioned master thesis my survey responses can be downloaded, analyzed and anonymously disclosed in the master thesis and its addendum and accessed by the University of Twente to assess the dissertation.	{1. Yes / 2. No}	
Demographic variables					
	Gender	Numeric / Text	What is your gender? - Selected Choice	{1. Female}...	
	Age	Numeric	What is your age?	None	
	Level of education	Numeric / Text	What is the highest degree or level of school you have completed? If currently enrolled, highest degree received so far. - Selected Choice	{1. High school or equivalent}...	
	Country of living	Text	In which country do you live?	None	
Shopping behaviour					
	Shopping_1	Numeric	Where do you prefer to shop?	{1. in stores / 2. Online}	
	Shopping_2	Numeric	How do you typically do your non-grocery shopping?	{1. Only in stores}...	
	Shopping_3	Text	What kind of products do you prefer to shop in stores? Name one specific product (e.g. shoes)!	None	
	Shopping_4	Text	What kind of products do you prefer to shop online? Name one specific product (e.g. shoes)!	None	
	Shopping_5	Numeric	How familiar are you with online shopping?	{1. Not familiar at all}…	
	Shopping_6	Numeric	How frequently do you shop online in a week?	{1. Never}…	
Technology familiarity					
	Tech_General	Numeric	To what extent are you familiar with the latest digital technologies?	{1. Not familiar at all}…	
	Tech_AR1	Numeric	How familiar are you with augmented reality (AR)?	{1. Not familiar at all}…	
	Tech_AR2	Numeric	Have you ever used augmented reality (AR) applications?	{1. Yes / 2. No}	
	Tech_VR1	Numeric	How familiar are you with virtual reality (VR)?	{1. Not familiar at all}…	
	Tech_VR2	Numeric	Have you ever used virtual reality (VR) applications?	{1. Yes / 2. No}	
	Tech_Shopping	Numeric	Have you ever used any of these digital technologies for your online shopping?	{1. VR}…	
Multi-sensory stimulation (dependent variable)					
	Vividness_1	Numeric	The online shop offers rich media as flash, animation, etc.	{1. Strongly disagree}…	Shen & Joginapelly, 2012
	Vividness_2	Numeric	The online shop stimulates my senses.	{1. Strongly disagree}…	
Vividness of stimuli enviornment (dependent variable)					
	Vividness_3	Numeric	How natural did your interactions with the online shop environment seem?	{1. Not at all}…	questionnaire - Witmer & Singer (1996)
	Vividness_5	Numeric	How quickly did you adjust to the online shop environment?	{1. Not adjusted at all}…	

(continued)

Group label	Qualtrics ID	Type	Question / Description	Scale	Source
Interactivity (dependent variable)					
	Interactivity_1	Numeric	I felt that I could interact with the online shopping environment easily.	{1. Strongly disagree}…	Liu& Shrum, 2002; McMillan & Hwang, 2002; Song & Zinkhan, 2008
	Interactivity_2	Numeric	I felt that I could interact with the products easily.	{1. Strongly disagree}…	
	Interactivity_3	Numeric	I felt that I had a lot of control over the online shopping environment.	{1. Strongly disagree}…	
	Interactivity_4	Numeric	I felt that I could control my movements.	{1. Strongly disagree}…	
	Interactivity_6	Numeric	The online shop environment is interactive.	{1. Strongly disagree}…	
	Interactivity_7	Numeric	The online shop environment is engaging.	{1. Strongly disagree}…	Shen & Joginapelly, 2012
	Interactivity_8	Numeric	It is easy to find my way through the online shop.	{1. Strongly disagree}…	
Involvement with displayed product (dependent variable)					
	Involvement_1	Numeric	How do you feel about the product category offered in the online shop?	{1. Unimportant}…	
	Involvement_2	Numeric	How do you feel about the product category offered in the online shop?	{1. Does not matter}…	personal involvement scale - Zaichkowsky, 1994
	Involvement_3	Numeric	How do you feel about the product category offered in the online shop?	{1. Of no concern}…	
	Involvement_4	Numeric	How do you feel about the product category offered in the online shop?	{1. Irrelevant}…	
Involvement with visualization type (dependent variable)					
	Involvement_5	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Uninvolving}…	
	Involvement_6	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Not beneficial}…	personal involvement scale - Zaichkowsky, 1994
	Involvement_7	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Mutant}…	
	Involvement_8	Numeric	Do you think the visualization type of the products in the online shop is..	{1. Not needed}…	
Authenticity (dependent variable)					
	Utilitarian_1	Numeric	Do you think shopping in this online shop would make your life easier?	{1. Not at all}…	
	Hedonic_1	Numeric	During the navigation, I felt the excitement of the hunt.	{1. Strongly disagree}…	Merle et al., 2012
	Hedonic_2	Numeric	Compared to other things I could have done, the time spent shopping on this online shop was truly enjoyable.	{1. Strongly disagree}…	
	Hedonic_3	Numeric	I enjoyed the online shopping experience in itself, not just for the products I could purchase.	{1. Strongly disagree}…	
	Authenticity_3	Numeric	The online shop offered me an experience similar as if I am visiting a store.	{1. Strongly disagree}…	Algharabat and Dennise, 2010
	Authenticity_4	Numeric	The online shop let me feel as if I am really interacting with the products.	{1. Strongly disagree}…	
Utilitarian benefits (dependent variable)					
	Utilitarian_3	Numeric	The visualization type of the product helps me make a better decision about the product if I am consider buying it.	{1. Strongly disagree}…	Fiore, Kim et al., 2005
	Utilitarian_4	Numeric	The visualization type of the product helps me evaluating the product.	{1. Strongly disagree}…	
	Authenticity_1	Numeric	How much influence does the product visualization have for you on placing an order?	{1. Not influential at all}…	Algharabat and Dennise, 2010
Brand perception (stimuli check)					
	Brand perception_1	Numeric	How familiar are you with the displayed online shop?	{1. Not familiar at all}…	
	Brand perception_2	Numeric	To what extent are you familiar with the brands displayed in the online shop?	{1. Not familiar at all}…	
	Brand perception_3	Numeric	What kind of feelings emerge in you in relation to the displayed brand/s?	{1. Negative}…	
	Brand perception_4	Numeric	How do you feel about the displayed brand/s?	{1. Dislike}…	

Appendix IX – Descriptive statistics of dependent variable constructs per age group

	M	*SD*	*n*
Younger (18 - 28)			
Interactivity [a)]	5.01	1.00	
Authenticity [b)]	4.21	1.22	
Involvement with displayed product [c)]	5.01	1.28	
Involvement with visualization type [d)]	5.16	1.15	
Utilitarian benefits [e)]	5.11	1.17	
Multi-sensory stimulation [f)]	4.83	1.13	
Vividness of stimuli enviornment [g)]	4.86	1.18	
Total	4.88	1.16	88
Older (29 - 99)			
Interactivity [a)]	4.94	1.05	
Authenticity [b)]	4.01	1.18	
Involvement with displayed product [c)]	4.59	1.29	
Involvement with visualization type [d)]	4.94	1.06	
Utilitarian benefits [e)]	4.83	1.26	
Multi-sensory stimulation [f)]	4.55	1.23	
Vividness of stimuli enviornment [g)]	5.07	1.16	
Total	4.70	1.17	110
Total visualization type			
Interactivity [a)]	4.97	1.02	
Authenticity [b)]	4.10	1.20	
Involvement with displayed product [c)]	4.77	1.30	
Involvement with visualization type [d)]	5.04	1.10	
Utilitarian benefits [e)]	4.96	1.23	
Multi-sensory stimulation [f)]	4.67	1.19	
Vividness of stimuli enviornment [g)]	4.98	1.17	
Total	4.78	1.17	198

a) 7-poir

b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)

c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)

d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)

e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)

f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)

g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

Comparing means (midpoint = 4)

Appendix X – Descriptive statistics of dependent variable constructs per condition & age group

	2D visualization			AR visualization			VR visualization			Total product type		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Furniture - Younger (18 - 28)												
Interactivity [a]	5.15	0.97		5.12	0.66		4.29	1.10		4.85	0.91	
Authenticity [b]	4.62	0.97		4.81	0.77		4.03	1.08		4.49	0.94	
Involvement with displayed product [c]	5.14	1.28		4.63	1.40		4.87	1.49		4.88	1.39	
Involvement with visualization type [d]	5.58	0.89		4.29	1.33		5.24	1.08		5.04	1.10	
Utilitarian benefits [e]	5.59	0.85		5.56	1.34		4.69	1.16		5.28	1.12	
Multi-sensory stimulation [f]	4.61	1.15		4.75	1.21		4.71	1.10		4.69	1.16	
Vividness of stimuli enviornment [g]	5.25	0.91		4.25	1.08		4.97	1.21		4.82	1.07	
Total	5.13	1.00	22	4.77	1.11	6	4.68	1.18	17	4.86	1.10	45
Shoes - Younger (18 - 28)												
Interactivity [a]	5.59	0.74		4.86	1.17		4.89	0.85		5.11	0.92	
Authenticity [b]	4.48	1.43		3.86	1.37		3.42	1.10		3.92	1.30	
Involvement with displayed product [c]	5.45	1.16		4.68	1.01		4.72	1.25		4.95	1.14	
Involvement with visualization type [d]	5.56	0.96		4.75	1.07		4.50	1.32		4.94	1.12	
Utilitarian benefits [e]	5.58	1.18		4.24	0.83		4.54	1.12		4.79	1.05	
Multi-sensory stimulation [f]	5.08	1.35		4.93	0.53		4.94	1.09		4.98	0.99	
Vividness of stimuli enviornment [g]	5.30	0.89		3.71	1.11		4.41	1.39		4.47	1.13	
Total	5.29	1.10	20	4.43	1.01	7	4.49	1.16	16	4.74	1.09	43
Total visualization type - Younger (18 - 28)												
Interactivity [a]	5.37	0.86		4.99	0.92		4.59	0.97				
Authenticity [b]	4.55	1.20		4.33	1.07		3.72	1.09				
Involvement with displayed product [c]	5.29	1.22		4.65	1.21		4.79	1.37				
Involvement with visualization type [d]	5.57	0.93		4.52	1.20		4.87	1.20				
Utilitarian benefits [e]	5.59	1.02		4.90	1.09		4.61	1.14				
Multi-sensory stimulation [f]	4.84	1.25		4.84	0.87		4.82	1.10				
Vividness of stimuli enviornment [g]	5.28	0.90		3.98	1.10		4.69	1.30				
Total	5.21	1.05	42	4.60	1.06	13	4.59	1.17	33			

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)
c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)
d) 7-point Zaichkowsky personal involvement scale (1=uninvolving / 7=involving; 1=not beneficial / 7=beneficial; 1=mutant / 7=fascinating; 1=not needed / 7=needed)
e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)
f) 7-point Likert scale (1=strongly disagree / 7=strongly agree)
g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

(continued)

Comparing means (midpoint = 4)

	2D visualization			AR visualization			VR visualization			Total product type		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Furniture - Older (29 - 99)												
Interactivity [a]	4.99	1.16		4.60	1.15		4.78	1.05		4.79	1.12	
Authenticity [b]	4.03	1.08		4.15	1.01		3.98	1.15		4.06	1.08	
Involvement with displayed product [c]	4.53	1.22		4.80	1.32		4.44	1.32		4.59	1.29	
Involvement with visualization type [d]	5.04	0.95		5.02	1.09		4.92	0.98		5.00	1.01	
Utilitarian benefits [e]	5.15	0.89		5.06	1.05		5.00	1.26		5.07	1.07	
Multi-sensory stimulation [f]	4.47	1.16		4.52	1.17		4.47	0.88		4.49	1.07	
Vividness of stimuli enviornment [g]	5.14	1.17		4.91	1.03		5.06	0.91		5.04	1.04	
Total	4.76	1.09	29	4.72	1.12	22	4.66	1.08	16	4.72	1.10	67
Shoes - Older (29 - 99)												
Interactivity [a]	5.03	1.10		5.52	0.81		5.00	0.69		5.18	0.87	
Authenticity [b]	3.82	1.33		4.64	1.40		3.57	1.26		4.01	1.33	
Involvement with displayed product [c]	4.07	1.52		5.34	1.36		4.49	0.99		4.63	1.29	
Involvement with visualization type [d]	4.59	1.03		5.55	1.19		4.57	1.14		4.90	1.12	
Utilitarian benefits [e]	4.48	1.47		5.24	1.27		3.91	1.46		4.54	1.40	
Multi-sensory stimulation [f]	4.32	1.14		5.82	0.84		4.19	1.54		4.78	1.18	
Vividness of stimuli enviornment [g]	5.43	1.53		5.45	1.08		4.67	1.18		5.18	1.26	
Total	4.53	1.30	14	5.37	1.14	11	4.34	1.18	18	4.75	1.21	43
Total visualization type - Older (29 - 99)												
Interactivity [a]	5.01	1.13		5.06	0.98		4.89	0.87				
Authenticity [b]	3.93	1.20		4.39	1.20		3.78	1.21				
Involvement with displayed product [c]	4.30	1.37		5.07	1.34		4.46	1.15				
Involvement with visualization type [d]	4.82	0.99		5.28	1.14		4.75	1.06				
Utilitarian benefits [e]	4.81	1.18		5.15	1.16		4.45	1.36				
Multi-sensory stimulation [f]	4.39	1.15		5.17	1.01		4.33	1.21				
Vividness of stimuli enviornment [g]	5.28	1.35		5.18	1.06		4.86	1.04				
Total	4.65	1.20	43	5.04	1.13	33	4.50	1.13	34			

a) 7-point Likert scale (1=strongly disagree / 7=strongly agree)

b) 7-point Likert scale (1=not at all / 7=a lot; 1=strongly disagree / 7=strongly agree)

c) 7-point Zaichkowsky personal involvement scale (1=unimportant / 7=important; 1=does not matter / 7=matters to me; 1=of no concern / 7=of concern to me; 1=irrelevant / 7=relevant)

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e) 7-point Likert scale (1=not influential at all / 7=very influential; 1=strongly disagree / 7=strongly agree)

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g) 7-point Likert scale (1=not at all / 7=completely; 1=not adjusted at all / 7=very quickly)

Comparing means (midpoint = 4)