Shopping in virtual reality: A literature review and future agenda

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1. Introduction

Today, at the beginning of 2020, virtual reality (VR) is considered as one of the technological megatrends progressing the digitization of all areas of human life (Koivisto & Hamari, 2019; Lee et al., 2020; Suh & Prophet, 2018). According to a report from Orbis research (2018), the global virtual reality market was valued at USD 3.13 billion in 2017 and is expected to reach USD 49.7 billion by 2023. To date, VR technology is being used in several areas such as entertainment (Stapleton et al., 2002), advertising (Lombard & Snyder-Duch, 2001), product design and display (Kan et al., 2001), the construction sector (Whyte, 2003), and tourism (Guttentag, 2010). One of the most promising application areas of VR in a business context is considered to be shopping and retail (Cowan et al., 2016), advertising (Lombard & Snyder-Duch, 2001), product design and display (Kan et al., 2001), the construction sector (Whyte, 2003), and tourism (Guttentag, 2010). One of the most promising application areas of VR in a business context is considered to be shopping and retail (Cowan & Ketron, 2019; Ketoma et al., 2018; Moes & van Vliet, 2017; Sikström et al., 2016). Retail giants such as Amazon (VR kiosks), Alibaba (Buy + mobile VR platform), eBay (VR Department Store app) and IKEA (virtual reality kitchen showroom) have been making effort to embed virtual reality into their e-commerce services and trying to transform the future of the shopping ecosystem. With the aid of virtual reality technology such as head-mounted displays, haptic devices, body-tracking sensors, motion-tracked controllers, 360-treadmills (that allow unlimited movement in space while stationary) and other innovative wearableables, these visions of future shopping and smart (omnichannel) retailing are coming ever closer to reality (Zhang et al., 2014; Margetis et al., 2019). VR technology is thus believed to solve limitations of space and time and to enable the replication and creation of any shopping environment that is accessible for consumers at any time (Serrano et al., 2016). Beyond an alluded-to increased overall cost-efficiency of shopping, VR is especially being touted because of the belief that it can enrich the shopping experience beyond that of brick-and-mortar shopping, as it is believed to afford a more immersive experience that can be further augmented with similar information retrieval systems as found in web-based shopping. It is evident that VR technology is shaping consumer-to-business relationships (Mulher Queiroz et al., 2018), and therefore creating huge market value in the retail and marketing sectors (ABI research, 2018). However, while the potential affordances of VR for shopping have become more prominent (Speicher et al., 2017), there has been a dearth of pervasive adoption of VR by retail companies, and the comparative benefits and detriments of brick-and-mortar versus web-based settings are still unclear on an anecdotal level.

In parallel, academic research on the use of VR in the shopping context is rapidly increasing. For example, VR has been studied in the context of product presentation (Zhao et al., 2017), in-store advertisement (Ketelaar et al., 2018), and customer service (Zhao et al., 2018). Given this rapid but sporadic increase in related literature, the corpus now has a mature critical mass that can be reviewed in order to shed an overview to help understand a) what kind of shopping experience VR can bring compared with other shopping environments; b) whether and how VR influences consumers’ psychology and behavior during shopping; and c) how different VR technologies have been implemented in...
the shopping context, including e.g., the choice of modalities, method of consumer navigation, modeling the shopping environment, the selection of products, and the replication or enhancement of reality (Sherman & Craig, 2002; Stuart, 1996). To address these questions, the aim of this study is to develop a comprehensive understanding of the current state of literature and knowledge on how VR technology has so far been used for shopping, its advantages and disadvantages, the contexts in which it has been used, what effects it has had on consumers’ shopping psychology and further behavior, and what future avenues of research are presented.

Accordingly, this study systematically identifies, retrieves and reviews the existing papers that are related to VR and the shopping experience (N = 72, including 83 studies). The paper is organized as follows. First, the concepts and features of VR are presented in the background section. Second, the search procedures for literature identification are described in section 3. Third, the retrieved literature is analyzed according to the research methods, relevant theories, output and input devices, tracking technologies, product types, simulated environments, antecedents and consequences. Fourth, the results of 51 experiment-based empirical studies from 45 reviewed papers are further discussed. Fifth, a four-way future research agenda of 16 sub-agendas are proposed in section 5. The conceptual inconsistency leads us to propose a more broad umbrella definition of VR as the technologies for substituting the perceived reality. The three key features of the VR shopping experience are also identified. The study’s contribution and limitations are discussed in the final section.

2. Background

During recent decades, the term “virtual reality” has been loosely used to refer to things such as the internet as a whole, the virtual world, 3D interface or 360-degree stereoscopic media. Therefore, VR is often referred to as immersion or presence inducing technology through the use of large screens (Zikic, 2007) or head-mounted displays (Pizzi et al., 2019a), which can provide an immersive sensory experience in real-time (Flavián et al., 2019). Some prominent examples of VR technology are the VR headset and Cave Automatic Virtual Environment (CAVE). In the CAVE system, users enter an environment where projectors are directed at between three and six walls of a room-sized cube (Zanaty et al., 2008).

Accordingly, VR becomes apparent in this review, although phenomenologically VR technology in contemporary discussions is mainly anchored in visual technology, vision on its own is not necessarily enough, and as will become apparent in this review, although phenomenologically VR technology in contemporary discussions is mainly anchored in visual technologies, logically and conceptually, VR technology is and should be agnostic of and unbounded by any singular human sense. Therefore, as a conclusion drawn later in the present paper (see future agenda), we define VR as “technologies for substituting the perceived reality”.

3. Literature review process

We mainly followed the guidelines of the systematic review process given by Petticrew and Roberts (2005), which includes the steps of defining the question, carrying out the literature search, screening the identified literature, assessing the eligibility of remaining studies, data extraction, critical appraisal and finally a synthesis of the literature. As a systematic literature review does not require e.g., the harvesting of quantitative data of prior studies (as would be the case with a quantitative meta-analysis), the screening and eligibility steps were able to be combined as thematic fit and the match with quality criteria could be simultaneously assessed. The literature coding and synthesis were carried out based on the guidelines of Webster and Watson (2002) and Snyder (2019). The process proceeded as follows: stage 1 identification: 1a) exploratory literature search to map relevant keywords related to the phenomenon of interest, 1b) systematic literature search; stage 2 screening and eligibility check procedures and 1c) backward and forward search; stage 3 synthesis: 3a) author-centric coding, 3b) concept-centric coding, 3c) reporting of findings (Webster & Watson 2002). In addition, we also referred to the study of Pare et al. (2015) to ensure the
synthesis quality such as rigor and relevance.

The literature search was carried out on 27/07/2020 and resulted in 1883 records from the Scopus database. The Scopus database was queried using the following search string: TITLE-ABS-KEY ("virtual real*" OR "VR") AND TITLE-ABS-KEY (shop* OR retail* OR mall OR supermarket OR store) AND LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ch"). The keyword "virtual real*" OR "VR" includes all forms of the word virtual reality and their abbreviations. The keywords "shop*" OR retail* OR mall OR supermarket OR store” were used to include literature related to shopping or retail experience. The search was limited to peer-reviewed articles in journals, conferences and book chapters.

The screening and eligibility checks proceeded as follows. Step 1) By investigating the titles and abstracts, 26 duplicate returns were identified. Step 2) The records were superficially screened for having a thematic match with at least either VR or shopping to indicate potential eligibility. Step 3) We investigated whether those records flagged as pertaining to VR were also related to shopping experience from the perspective of consumers (rather than from retail strategy and industry). Returns that did not hold relevance for shopping were omitted (e.g., VR product itself, hardware and VR for product design). Step 4) The same process was conducted for returns flagged as pertaining to shopping. Step 5) From the remaining pool of 84 eligible records, five records were inaccessible, three records were not English and three records were literature review. In Step 6), six more records were identified through forward and backward reference searches, screened and deemed eligible (see Table 1). In step 2) for omitted papers, VR matched e.g., with Variable Ratio Scheduling, VR-S, Vision-Related Quality of Life (VR-QoL), Visual Rhythm and other unrelated terms. For omitted papers that matched with shopping search terms, words such as shop floor (related to manufacturing plants), store used as storage of information, and other unrelated terms were common. In steps 3) and 4), in most cases the omission was due to a completely lacking relevance for VR or shopping. In many cases, VR might have referred to virtual worlds (such as Second Life), 3D virtual model or 360-degree contents of a product on a website that was commonly presented on a standard size computer screen such as VRML (Zhao et al., 2004), virtual try-on interface (e.g., Yaoyuneyong et al., 2014) and web-based online shops/stores (Baek et al., 2020; Lee & Chung, 2008). However, in accordance with the scope of the study, such records were omitted. In step 4, papers satisfying eligibility in terms of a thematic match with VR but not shopping might have included e.g., a shop being used only as a context for other than shopping-related studies, such as for learning (Liu & Jou, 2008), cognitive training (Gallegos-Nieto et al., 2014), and health-care purposes (Josman et al., 2009); and pure psychological tests such as the user’s spatial knowledge (Napieralski et al., 2014), memory assessment (Plechata et al., 2019), and navigation tasks (Kizony et al., 2017). Thus, papers related to virtual action planning supermarkets (VSP-S) were also omitted since they only related to a web-based 3D research background (neither virtual reality nor shopping experience: e.g., Klinger et al., 2014). Moreover, during the coding of the extant literature (Step 7), eight records were further omitted as four records only included a research plan and four records were conceptual studies.

4. Findings: The synthesis of the literature

In this study, we reviewed 46 journal articles, 23 conference papers and 3 book chapters (see Fig. 1). More than half of the reviewed papers (n = 43) were published between 2018 and 2020 (July), which suggests that VR shopping is quite a novel research area. It should be noted that nearly one-fifth of the papers were published in the first half of 2020. We then synthesized the findings of 83 studies from 72 papers according to the research methods used, relevant theories, output and input devices, tracking technologies, and antecedents and consequences in the VR shopping context. In order to infer differences between non-VR and VR environments, and between the different implementations of VR, we further analyzed the results from 45 experiment-based papers (involving 51 studies), which provide reliable information and empirical evidence.

4.1. Methods

In terms of the methods used in the body of literature on VR shopping (see Table 2), experiments were most frequently used among 83 studies, either as a within-subject experiment design (n = 13, 15.66% of the reviewed studies) or between-subject experiment design (n = 35, 42.17%). Three studies used a mixed experiment design (see e.g., Arce-Lopera et al., 2018; Tonkin et al., 2011; Wölfel & Reinhardt, 2019). This is quite understandable as the emphasis in the discussion of the potential of VR in shopping has focused on psychological factors and consumer behaviors, and the difference they have compared with non-VR shopping (Table 11 presents more detailed results from 51 experiment-based studies, accounting for 61.5%). In order to gauge and infer such differences, laboratory or field experiments are seen as an appropriate methodology. In addition, the evaluation of prototypes (experiment with one condition) related to shopping was commonly based on survey (n = 15), interview (n = 3), observation (n = 2), mixed data (n = 2) and user datasets (n = 1). Beyond experiments and prototypes, there are studies that used interview (n = 3), survey (n = 2), prototyping (n = 2), case study (n = 1), and field study (n = 1).

Table 1

| Step | Description | Change | Amount |
|------|-------------|--------|--------|
| 0 | Literature search: TITLE-ABS-KEY ("virtual real*" OR “VR”) AND TITLE-ABS-KEY (shop* OR retail* OR mall OR supermarket OR store) AND LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ch") | + 1883 | 1883 |
| 1 | Duplicated records | - 26 | 1857 |
| 2 | No relation to either VR or shopping | - 1177 | 680 |
| 3 | Only related to virtual reality but not the shopping experience | - 217 | 201 |
| 4 | Only related to the shopping experience, but not virtual reality | - 11 | 73 |
| 5 | Inaccessible or non-English or literature review | + 7 | 80 |
| 6 | Other relevant (forward and backward) | - 8 | 72 |

1 Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. Therefore, Scopus is quite generally accepted de facto source when conducting systematic literature in the VR retail area. This strategy also greatly enhances the repeatability of the study.

2 In this study, the shopping experience is defined as the feelings, experiences and transactions that mainly exist in shopping sites such as retail stores, shop/shopping systems, malls and supermarkets (Falk & Campbell, 1997).

3 VRML (Virtual Reality Modelling Language) is independent of HTML and specifically designed to describe 3D scenes (Cao, 2012).

4 The Virtual Action Planning-Supermarket (VAP-S) is a virtual supermarket that was developed to meet the need for a clinically feasible and ecologically valid tool for planning a component of executive functions (EF). The VAP-S was shown to be a valid assessment of EF for people with schizophrenia and mild cognitive impairment (Josman et al., 2014)
4.2. Theories

Table 3 presents the relevant theories and research frameworks related to VR shopping used in the reviewed papers. Some papers applied theories previously used in online and traditional shopping environments to the virtual reality environment, such as affective appraisal theory, presence theory, flow theory, self-persuasion theory, uses and gratification theory and expectation-confirmation theory. Social-related theories (e.g., social agency, social cue, social presence) were also referred to, in order to investigate social interaction and social presence in the VR environment. The theory of sensory conflict, postural instability theory and poison theory were commonly used to explain the cybersickness caused by VR (see e.g., Israel et al., 2019). Based on the media richness theory, VR can be seen to have a higher media richness compared with traditional communication media, which can further enhance the users’ shopping experiences. Moreover, some studies adopted existing theoretical frameworks such as stimulus-organism-response (S-O-R), theory of reasoned action (TRA), the technology acceptance model (TAM), unified theory of acceptance and use of technology (UTAUT) model, and the perceived shopping value model for developing hypotheses.

4.3. Device and technologies

4.3.1. Output devices

Fig. 2 presents the main four types of vision-based VR systems (monitor, powerwall / projector, CAVE, and HMD) that feature in studies of current literature. After the advent of the current VR trend, the head-mounted display (HMD) has become the most prominent and visible piece of technology pertaining to VR. In the extant body of literature, approximately half of the studies have focused on HMD one way or the other (see Table 4). HMD devices such as HTC Vive (n = 21), Smartphone-based (n = 11), and Oculus Rift (n = 10) were commonly used. However, VR does not necessitate the use of an HMD, and any display technology that can sufficiently create an immersive experience (i.e., cover the FOV of the user) can be used. Therefore, it was seen in the extant literature that monitors, projectors / powerwalls, CAVE and other implementations had been tested as VR technology.

Moreover, other sensory modalities were used to provide additional information, in the sense of sound (n = 9), touch (n = 1) and smell (n = 1) in addition to the visual output. However, it should be noted that it has not been categorically established as what degree of “immersive-ness” is enough for a set of technology to be regarded as VR, and the implicit idea in the extant literature is that the display needs to be able to more or less fully cover the FOV of the consumer.

4.3.2. Input device and tracking technologies

In order for consumers to naturally and effectively conduct shopping in virtual reality, there is a high demand for accurate and multimodal input devices so that consumers can interact with different objects in the VR shopping environment. Such input devices can range anywhere from a typical pointing device such as a mouse, to a direct neurological link. In the existing literature on VR shopping, movement-based input modalities can be divided between input devices that are typically controlled by the hands, legs, head / eye-movement or general body movement (see Table 5). Not surprisingly, for hand-input, “VR controllers” such as those commonly bundled in HMD product packages were the most frequently employed input devices (n = 29, accounting for 34.94%). These are wireless controllers that afford (“hand”) position and movement tracking, as well as buttons. Nine studies employed gloves or hand trackers that offer similar interactivity but provide increased granularity in the form of finger movement tracking, affording e.g., selecting, grabbing, holding and rotating products. In 2 cases, the touchscreen of a mobile device was used as a means to make shopping decisions (Ketelaar et al., 2018; Ohta et al., 2015). However, the extant literature also employed more traditional input modalities in the forms of keyboards and mice (n = 10) and gamepads (n = 7). This was often the case in research where the participant himself / herself was not movement-tracked within the physical space but instead used an input device to move a virtual representation of the customer in the VR environment. Input devices controllable by leg movement were used to support stationary walking as an input to move in the virtual space (n = 5). An important aspect of navigation and browsing in a store is where the consumer is looking and focusing their gaze. In VR technology and shopping, head movement and orientation (n = 13), as well as eye-tracking (n = 8), are used as some of the primary modalities of human–computer interaction, both as ways to interact with the VR shop, but also to capture important measures of consumer behavior in terms of their attention allocation. Whereas head movement and orientation are used to capture macro-level attention allocation, eye tracking devices have been used both inside the HMD and attached to a monitor to capture the micro attention allocation focused on products. In addition to the movement-based interactive technologies, sound-based input devices facilitated users with voice control (n = 2) (see Table 5 for more details).

In addition, one of the most important aspects of VR shopping is that it is able to afford body movement in space, similar to “real” shopping and contrary to web shopping. In extant research, various categories of input have been used to control the consumer movement within the VR space, including hand, eye / head and leg movement-based control. Regardless of the mode of input for enabling movement, participants were allowed to teleport themselves from one point to another, either sit
Table 2
Summary of the research methods (72 papers, 83 studies).

| Method type                      | Source                                                                 | %   |
|----------------------------------|------------------------------------------------------------------------|-----|
| **Experiment**                   |                                                                        |     |
| Between-subject                  | Brannley et al. (2018)-study 1; Bressoud (2013); Carlsson et al. (2011); Dzardanova et al. (2017); Fang et al. (2020); Goedegebure et al. (2020); Kang et al. (2020); Ketelar et al. (2018); Khan et al. (2012); Liang et al. (2019); Liu (2010); Liu & Uang (2011); Liu & Uang (2013)-study 2; Liu & Uang (2016); Lombart et al. (2019); Lombart et al. (2020); Meilner et al. (2020); Moes and van Vliet (2017)-study 1 & study 2; Peukert et al. (2019b); Nordbo et al. (2015); Peukert et al. (2019a)-study 1 & study 2; Pizio et al. (2019a); Pizio et al. (2019b); Ploydani et al. (2017); Schnack et al. (2019); Siegrist et al. (2019)-study 1 & study 2; van Herpen et al. (2016); Van Kerrebroeck et al. (2017); Verhulst et al. (2016); Verhulst et al. (2018); Wu et al. (2019)-study 2; Wu et al. (2020)-study 2 | 42.17 |
| Within-subject                   | Altarre et al. (2016); Heu et al. (2020); Liu & Uang (2013)-study 1; Martinez-Navarro et al. (2019); Renner et al. (2010); Sikstrom et al. (2016); Speicher et al. (2017)-study 2; Speicher et al. (2018); Tomon et al. (2011); Wu et al. (2019)-study 1; Zhao et al. (2017)-study 1 & study 2; Zhao et al. (2018) | 15.66 |
| Mixed-subject                    | Arce-Lopez et al. (2018); Tonkin et al. (2011); Wölfel & Reinhardt (2019) | 3.61 |
| **Prototype evaluation based**   |                                                                        |     |
| User survey                      | Allman-Farinelli et al. (2019); Altarre & Charissa (2019); Bigné et al. (2016); Israel et al. (2019); Jang et al. (2019); Ko et al. (2020)-study 2; Lau & Lee (2019); Meilner et al. (2019); Moretti et al. (2020); Pantano & Laria (2012); Park et al. (2018); Pfieffer et al. (2017); Speicher et al. (2017)-study 1; Violante et al. (2019); Wu et al. (2020)-study 3 | 18.07 |
| Interview                        | Han et al. (2020); Ketoma et al. (2018); Lau et al. (2014)              | 3.61 |
| Observation                      | Schnack et al. (2020); Wu et al. (2020)-study 1; Donatiello et al. (2018); Huang et al. (2019) | 2.40 |
| Mixed (n = 2)                    | Ko et al. (2020)-study 1                                               | 2.40 |
| Algorithm based on real datasets (n = 1) |                                                     | 1.20 |
| Interview                        | Farih et al. (2019); Ruppert (2011); Yue et al. (2020)                 | 3.61 |
| Survey                           | Bramley et al. (2018)-study 2; Oha et al. (2015)                       | 2.40 |
| Prototyping                      | Laria & Pantano (2011); Shuai et al. (2018)                            | 2.40 |

Table 2 (continued)

| Method type                      | Source                                                                 | %   |
|----------------------------------|------------------------------------------------------------------------|-----|
| **Field study**                  |                                                                        |     |
| (n = 1)                          | Kaprosy & Largo (2017)                                                 | 1.20 |
| (n = 1)                          | Elboudali et al. (2020)                                                | 1.20 |

Note. We counted the amount of studies of reviewed manuscripts in each category. Elboudali et al. (2020) used 1-year consumer logged navigation data. Huang et al. (2019) used (prototype evaluation based) observation, interview and survey; Donatiello et al. (2018) conducted interview and survey. Both Peukert et al. (2019a) and Siegrist et al. (2019) had two between-subject experiment studies (study 1 & study 2). Only one study in Tomon et al. (2011) was related to VR.

(e.g., Goedegebure et al., 2020; Ploydani et al., 2017; van Herpen et al., 2016), stand (e.g., Carlson et al., 2011; Lau & Lee, 2019), or freely walk around (e.g. Khan et al., 2012; Siegrist et al., 2019) within the space while their position is being tracked.

4.4. Products and environments

4.4.1. Product types

According to Table 6, food (n = 25) was commonly selected as the purchase object among 30.12% of the reviewed studies, including fruits and vegetables (van Herpen et al., 2016; Verhulst et al., 2018), cereals (Siegrist et al., 2019; Tonkin et al., 2011), baking mixture (Meilner et al., 2019; Pfieffer et al., 2017). Additionally, 12 studies used clothing as purchase objects in the VR shopping environment. In 6 studies, alcohol beverages such as beer (e.g., Bigné et al., 2016; Martinez-Navarro et al., 2019) and wine (e.g., Zhao et al., 2017) were used as specific products that consumers could interact with, in order to investigate their shopping psychology and behavior. Products such as stationeries (n = 4), luxury bags (n = 3), electronics (n = 3) and car devices (n = 2) have been investigated in the minority of studies. Seventeen studies created more general grocery stores or shops in a virtual reality environment, which commonly used mixed products instead of mentioning a specific product category.

4.4.2. Simulated environments

Table 7 describes different simulated retail environments that were designed in virtual reality. 37.35% of studies usually presented most of the products mentioned above in a retail store / shop (n = 31) and 16.87% of studies created the supermarket (n = 14), where consumers can easily immerse themselves in the simulated shopping environment. It is worth mentioning that Speicher et al. (2018) built their VR shop in a non-retail environment by using an apartment metaphor. In addition, shopping mall (n = 4) and marketplace (n = 3) were also digitally created in the minority of reviewed studies to investigate a larger shopping environment. For simplifying the experimental design, a “product shelf” began to be considered as the experimental environment, as an alternative to a VR store or shop. Fourteen studies required participants to stand in the front of these shelves and investigated participants’ specific interactions with virtual products. Also, a virtual dressing room was discussed in one prototype-based study (see fashion island, Donatiello et al., 2018).

4.5. Antecedents and consequences

The S-O-R theory has been widely used to verify that the external cues (stimuli) of a store affect shoppers’ cognitive reactions and emotional states (organism), which then influence their shopping behavioral outcomes (responses) (Chang et al., 2011; Eroglu et al., 2003). Starting from the research questions featured in the reviewed literature, in this study, we further divided the relevant antecedents and consequences in the VR shopping context into categories of external stimulus, psychological state, and behavioral response.
### Table 3 (continued)

| Theory                                      | Explanation (example)                                      | Source                                                                 |
|---------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------|
| Presence (telepresence) theory              | The extent to which an individual perceives himself or herself to be present in a medium-mediated environment (e.g. VR) as if they were in the real world. | Allman-Farinelli et al. (2019); Jang et al. (2019); Lau et al. (2014); Liu & Uang (2011); Liu & Uang (2016); Martinez-Navarro et al. (2019a); Pizzi et al. (2019b); Pizzi et al. (2019a); Schnack et al. (2019); Säätämmö et al. (2016); Van Kerrebrouck et al. (2017) |
| Flow theory                                 | Flow refers to the optimal state of user experience when one is fully immersed in the activity; the enhanced experiences of consumer flow is positively related to the behavioral intentions to use VR technology. | Han et al. (2020)                                                      |
| Self-persuasion theory                      | Self-persuasion is indirect and entails placing people in situations where they are motivated to persuade themselves to change. The theory suggests that VR can provide more open and intrusive ads because the process of deciphering the indirect metaphorical claim serves as a form of self-persuasion. | Ketelaar et al. (2018)                                                 |
| Expectation-confirmation theory             | The interactivity of VR allows consumers to more clearly understand how a product can be used, or if the fit of the product can be evaluated, consumers should feel more comfortable making purchase decisions. | Meilner et al. (2020)                                                 |
| Uses and gratification theory (U&G)         | U&G theory have demonstrated that entertainment is a crucial psychological factor for users; VR shopping can significantly enhance the feeling of pleasure that consumers can derive while shopping. | Hsu et al. (2020)                                                     |
| Involvement theory                          | Brands can use VR through both routes – high and low involvement– to boost consumer outcomes, such as purchase behavior, satisfaction, and brand loyalty | Cowan and Ketron (2019)                                               |
| Cyber sickness-related theory               | According to the sensory conflict theory, these discrepancies in information can cause cybersickness: This lack of control causes temporal postural instability and therefore, cybersickness until the user has adapted; cybersickness is based on a maladaptive process, which originally helped the body to get rid of toxic substances. | Israel et al. (2019); Liu & Uang (2011); Liu & Uang (2016) |
| Unified theory of acceptance and use of technology (UTAUT) | Whether a user has experienced the VR environment before or not will affect key constructs related to user acceptance. | Peukert et al. (2019a)                                             |
| Perceived experiential value                | It represents the degree of benefit perceived by | Altarteer et al. (2016); Jang et al. (2019) |

(continued on next page)
4.5.1. External stimuli

Table 8 shows the six categories of antecedents that were investigated in the reviewed 83 studies from 72 papers. Product-related, system-related and technology-related factors are the main stimulus seen in the VR shopping context. To be more specific, product content (e.g., 2D and 3D: Altarteer et al., 2016; Liu & Uang, 2011, 360-degree photo and 3D image: Martínez-Navarro et al., 2019), product type (e.g., muesli or baking mixtures: Pfeiffer et al., 2017), and product information (e.g., product advertisement: Ketelaar et al., 2018, package information: Zhao et al., 2017) play important roles in influencing consumer psychology and behavior. Nineteen studies investigated the general VR shopping system and interface and compared VR with other shopping interfaces such as physical shopping (see, e.g., Lombart et al., 2020) and online shopping (see, e.g., Hsu et al., 2020). Some studies discussed the interactivity (n = 5), immersiveness (n = 4) and customization (n = 3) of featured VR system on enhancing the shopping experience. In terms of technology-related factors, different display technologies (n = 8) and interactive technologies (n = 9) were mainly discussed in the reviewed literature. Interactive technologies such as magic wand and human joystick (Khan et al., 2012), grab and beam (Speicher et al., 2018) and gamepad, arm movement, and step in place (Verhulst et al., 2016) generate differences in the VR shopping experience, and the magic wand has been seen as a superior technique in terms of shopping efficiency (Khan et al., 2012). Additionally, shopper-related factors (e.g., shopper type), social-related factors (sales assistant or agent) and other in-store elements (e.g., in-store information and auditory stimuli) were taken into consideration in a few studies.

4.5.2. Psychological states

According to Table 9, in extant research the organism-related psychological aspects related to VR shopping can be divided into areas of affection, immersion, cognition, attitude, and usability. Generally speaking, consumers can gain positive affective experiences in the VR environment such as enjoyment (n = 11, see e.g., Israel et al., 2019; Ketoma et al., 2018), emotion arouse (n = 5, see e.g., Dzardanova et al., 2017; Martínez-Navarro et al., 2019) and hedonic experiences (n = 3, see Kang et al., 2020; Lau & Lee, 2019). Additionally, due to a visual output that covers the user’s entire FOV and interactive device, most consumers can easily immerse themselves in the VR shopping environment, which leads to a highly perceived presence and immersion (n = 14), perceived level of realism (n = 5), and perceived novelty (n = 3), etc. In addition, some VR shopping-related studies examined the influence of relevant antecedents on cognitive aspects, mainly including the perceived value (n = 10), memory recall (n = 7), information process (n = 6), familiarity (n = 2) and perceived intrusiveness (n = 1). In addition, 12 studies were related to product evaluation and 9 studies were highly relevant to consumers’ attitudes and satisfaction. It is obvious that VR has been postulated to bring several advantages to the shopping experience, i.e., to enhancing the psychological experience of shopping and also shopping behavior. However, the virtual reality environment cannot always provide positive experiences, especially in terms of usability. 20.48% of the reviewed studies investigated the perceived usability of VR shopping (n = 19). Some participants reported that it is difficult to control motion in the VR shopping system (Lau et al., 2014). When wearing VR devices such as an HMD, some participants felt uncomfortable (Martínez-Navarro et al., 2019) and even dizzy (Lau et al., 2014). Thus, some studies have started to pay attention to the experience of cybersickness (n = 10), especially in elderly users (Liu & Uang, 2011 & 2013 & 2016).

4.5.3. Behavioral responses

More than half of the reviewed studies discussed the behavioral aspect of the shopping experience in virtual reality, including intentions to use / purchase (n = 17), time spent (n = 9), purchase decision (n = 6), task performance (n = 6), information search (n = 4), product / brand choice (n = 3), general shopping behavior (n = 3), money spent (n = 2), word of mouth (n = 2), legacy bias (n = 2), and navigation (n = 1) (see Table 10 for more details).

4.6. Sample and results

The sample information, experimental design and results were analyzed for all of the 51 studies from 45 experiment-based papers featured in the review (see Table 11). It can also be seen from the table that the research questions and research goals of the 45 papers are considerably different and too scattered to link, which makes it relatively difficult to summarize the results systematically. However, we were able to summarize and extract four important points based on the results of studies where hypotheses were examined.

In the overall 51 experiment-based studies, the minimum number of valid samples drawn on was 16 (Speicher et al., 2018) and the maximum was 400 (Bressoud, 2013). To increase the external validity of the experiments, 10 studies (19.61% of the 51 experiment-based studies) recruited real consumers or regular shoppers as participants (regular shop visitors: Pizzi et al., 2019a, Van Herpen et al., 2016; Van Kerrebrock et al., 2017; real and potential consumers: Bramley et al., 2018, Kang et al., 2020; Pizzi et al., 2019b; Goedegebure et al., 2020 and Ketelaar et al., 2018; luxury brand customers: Altarteer et al., 2016; buyers of cereals: Bressoud, 2013). In addition, as student samples are usually considered as either convenience samples or more homogeneous than representative samples, 19 studies were identified that clearly collected data from young university students. Five studies used mixed samples with different age groups (ranging from 18 to 74 years old), whereas four studies only concentrated on an elderly group (ages ≥ 65 years old). However, only one study considered cultural differences by recruiting participants with different nationalities (see Zhao et al., 2018). As a further consideration, to control the impact of gender differences on the shopping experience, 13 studies from 10 experiment-based papers averaged their sample size by gender (see Fang et al., 2020; Hsu et al., 2020; Kang et al., 2020; Khan et al., 2012; Liu, 2010;
### Output devices in VR shopping.

Table 4

| Type (Sum) | Source | % |
|------------|--------|---|
| Head-mounted display | Allman-Farinelli et al., 2019; Han, An, Han, & Lee, 2020; Martínez-Navarro, Bigné, Guexeres, Alcaniz, & Torrecilla, 2019; Meiñiner, Pfeiffer, Peukert, Dietch, & Pfeiffer, 2020; Morott, Donatiello, & Marfa, 2020; Peukert, Pfeiffer, Meiñiner, Pfeiffer, & Weinhardt, 2019; Ketoma et al., 2018; Peukert et al. (2019a); study 1 & study 2; Pizzi et al. (2019b); Schnack et al. (2019); Schnack et al. (2020); Shuai et al. (2018); Siegrist et al. (2019); study 1 & study 2; Speicher et al. (2018); Wu et al. (2019) | 25.30 |
| Smart phone-based (n = 1) | Arce-Lopera et al. (2018); Bramley et al. (2018); study 1; Dzardanova et al. (2017); Goedegebuure et al. (2020); Hou et al. (2020); Israel et al. (2019); Jang et al. (2019); Moes & van Vliet (2017); study1&study2; Speicher et al. (2017); study 2; Wolf & Reinhard (2019) | 13.25 |
| Oculus Rift (n = 10) | Fang et al. (2020); Kang et al. (2020); Ketoma et al. (2018); Lombart et al. (2019); Lombart et al. (2020); Nordbo et al. (2015); Ohta et al. (2015); Silkström et al. (2016); VanKerrebroeck et al. (2017); Verhulst et al. (2018) | 12.05 |
| Not specified (n = 10) | Elboudali et al. (2020); Farah et al. (2019); Huang et al. (2019); Lau et al. (2014); Lau & Lee (2019); Liang et al. (2019); Liu & Uang (2011); Park et al. (2018); Pizzi et al. (2019a); Zhao et al. (2018) | 12.05 |
| NVIS nVisor SX60 (n = 2) | Zhao et al. (2017) | 2.40 |
| Projector / powerwall | One large-screen powerwall/projector (n = 5) | 6.02 |
| | Altearte & Charitnis (2019); Bressoud (2013); Martínez-Navarro et al. (2019); Tonkin et al. (2011); Verhulst et al. (2016) | 2.40 |
| | Laria & Pantano (2011); Pantano & Laria (2012) | 2.40 |
| | Carlson et al. (2011) | 1.20 |
| | Meiñiner et al. (2019) | 1.20 |
| | Three big screens (n = 2) | Renner et al. (2010); Tomono et al. (2011) | 2.40 |
| | Four walls (n = 2) | Ketelaar et al. (2018); Khan et al. (2012) | 2.40 |
| | Two screens (front and floor forming an L-shape) (n = 1) | Pfeiffer et al. (2017) | 1.20 |
| | Three walls and one floor (n = 1) | Bigné et al. (2016) | 1.20 |
| | Five walls (n = 1) | Carlson et al. (2011) | 1.20 |
| | TFT LCD (two studies with glass / lens) (n = 5) | Liu (2010); Liu & Uang (2011); Liu & Uang (2013)-study 1 & study 2; Liu & Uang (2016) | 6.02 |
| | 24” PC monitor (n = 3) | Martínez-Navarro et al. (2019); Meiñiner et al. (2020); Peukert et al. (2019b) | 3.61 |
| | PC with three monitors (n = 2) | Phoydanal et al. (2017); Van Herpen et al. (2016) | 2.40 |
| | 3D TV set (n = 1) | Allman-Farinelli et al. (2019) | 1.20 |

### Table 4 (continued)

| Type (Sum) | Source | % |
|------------|--------|---|
| Smart mirror (n = 1) | Kapany & Loglo (2017) | 1.20 |
| Sound output (n = 9) | Laria & Pantano (2011); Lau & Lee (2019); Pizzi et al. (2019a); Schnack et al. (2019); Sikstrom et al. (2016); Schnack et al. (2020); VanKerrebroeck et al. (2017); Wu et al. (2020) | 10.84 |
| Haptic output (n = 1) | Zhao et al. (2018) | 1.20 |
| Olfactory output (n = 1) | Tomono et al. (2011) | 1.20 |

Note. Tomono et al. (2011) used three big screens and liquid-crystal time-multiplexed shuttering glasses; absorbent cotton impregnated with liquid fragrance was placed inside a small lidded container for smell presentation. Zhao et al. (2018) developed a specific arm band which can provide the feeling of being touched.

Pizzi et al., 2019b; Siegrist et al., 2019; Tomono et al., 2011; Wu et al., 2019; Zhao et al., 2017

**Result 1** There is mixed results regarding the difference between VR and other shopping environments. In general, not only can VR create a similar shopping experience as a physical store, but also it can bring more positive outcomes compared to other shopping interfaces in certain situations. Among the studies which compared the VR shopping environment with the real shopping environment (usually as the control group), three studies showed that participants have similar experiences in the VR environment as they do in a real shopping environment, which indicates that a VR shop can be a representation of a real shopping environment (e.g., Bressoud, 2013; Lombart, 2020; Siegrist et al., 2019). Not surprisingly, five studies confirmed that VR could bring more positive outcomes than real shopping in some aspects (see Bramley et al., 2018; Martínez-Navarro, 2019b; Pizzi et al., 2019a; VanKerrebroeck et al., 2017; Van Herpen et al., 2016). The advantages of virtual reality technology were also examined through comparisons between a VR shop and a pictorial or video-based shop (see e.g., Altearte, Vassils, Harrison, & Chan, 2016; Kang, Shin, & Ponto, 2020; Moes & van Vliet, 2017; Peukert et al., 2019a; Schnack et al., 2019). The existing studies have shown that VR can generate higher experiential value for shopping. However, the exception is that a VR shop seems to have no advantage over physical shops in terms of the efficiency of searching products (Tonkin et al., 2011).

**Result 2** The applications of advanced visual interfaces and interactive technologies play important roles in increasing the usability and efficiency of VR shopping environments. Various visual output devices such as five-wall display and on-wall display (Carlson et al., 2011), powerwall and HMD (Martínez-Navarro et al., 2019), and TFT-LCD and 3D monitor (Liu & Uang, 2011) have differentiated results in terms of their usability, presence and elicited cognitive responses. These display technologies can generate stimulations which cover a full or significant part of the human visual system. More importantly, technology-driven VR experience (e.g., screen size, image motion, stereoscopic presentation, or a realistic and detailed design) were also investigated from the ergonomic perspective of VR visualization display in three studies (see Liu & Uang, 2013; Liu & Uang, 2016; Lombart et al., 2019). In terms of interactive technologies, the magic wand fared better than the human joystick (Khan et al., 2012), game-pad rather than full-body gestures (Verhulst et al., 2016), a combination of ray-casting and

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5 We included studies that clearly mentioned or presented sample information such as sample size, gender distribution, age range and nationality.
walking in place (Renner et al., 2010) and pointing used in combination with the abstract cart concept (Speicher et al., 2018) provide greater advantages in shopping efficiency in areas such as searching for cost, time consumption and memory accuracy. Overall, it can be seen that interactive technologies involving part or all of the human body and interactive mechanisms influence the user’s experience of the VR shopping system.

**Result 3** Besides the visual experience, multisensory technologies and sensory devices could enhance shopping experience and affect the consumer’s perception, judgment, and behavior in virtual environments. Communicating haptic, olfactory and even gustatory information related to products, services and the shopping environment can be conveyed digitally and vividly in virtual reality. For example, extra olfactory stimuli can enhance the memory accuracy of product name and the display position (Tomono et al., 2011), and an external touch display could serve to attract shoppers to spend more time and money on purchasing (Zhao et al., 2018). Sound information was added into the VR shopping environment to improve perceived realism (see e.g., Laria & Pantano, 2011; Schnack et al., 2020; Van Kerrebroeck et al., 2017). However, auditory feedback seemed not to have much effect on the overall VR shopping experience (Pizzi et al., 2019a; Sikström et al., 2016).

**Result 4** Social factors such as the presence of others (e.g., shoppers and sales assistants) and forms of social relationships could influence the VR shopping experience. In the 51 experiment-based studies, social-related factors were only examined in three studies. However, it is indeed one of the important aspects of VR research since consumers’ shopping behaviors are never individual activities. As an example, the existence of an avatar of a salesman (Dzardanova et al., 2017), voice assistant (Morotti et al., 2020) or a shopping assistant’s virtual touch (Zhao et al., 2018) can significantly influence shoppers’ experience, especially their change of emotion response and purchasing behavior. Due to the limitations of current VR technologies and devices, researchers have to use alternative experiment designs, such as artificially creating the illusion of others’ presence by making use of touch, sound, and other senses. Another interesting perspective is the investigation of the effect of the different types of relationships customers have with others (e.g., single, collaboration, and competition) on the shopper’s navigation behavior and spatial memory recall in the VR shopping interface (Li et al., 2019).

5. Future agenda

This paper presents a systematic review of virtual reality applications in the retail context. In this review, we have followed the suggestions by Webster & Watson (2002) and Petticrew & Roberts (2005) to ensure its quality, in terms of both rigor and relevance. By reviewing the 83 studies from 72 papers, we analyzed and discussed the findings according to the research methods used, relevant theories, output devices, input devices,
and tracking technologies, the antecedents and consequences of the shopping experience. The results were further drawn from 45 experiment-based empirical papers (51 studies). The review shows that the literature on VR shopping is still in its infancy and that there remains ample room for progression in both breadth and depth in the literature on VR shopping in terms of methodological rigor and theoretical application. Based on the analysis of the extant corpus, we have identified a four-way agenda for future research on VR shopping, structured along the lines of conceptual, thematic, methodological, and technological agenda.

5.1. Conceptual agenda

5.1.1. What is a VR shopping experience?

Virtual Reality and VR shopping have been touted to provide disruption and paradigm shifts to shopping, as well as to provide new kinds of shopping experiences for consumers. However, as this literature review reveals (see Table 3), literature to-date on VR shopping has mostly investigated aspects of consumer experience that are common in legacy theory and traditional environments (such as emotional arousal, and tracking technologies, the antecedents and consequences of the shopping experience. The results were further drawn from 45 experiment-based empirical papers (51 studies). The review shows that the literature on VR shopping is still in its infancy and that there remains ample room for progression in both breadth and depth in the literature on VR shopping in terms of methodological rigor and theoretical application. Based on the analysis of the extant corpus, we have identified a four-way agenda for future research on VR shopping, structured along the lines of conceptual, thematic, methodological, and technological agenda.

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Table 8
The stimuli in the VR retail context.

| Construct (Sum) | Source | % |
|-----------------|--------|---|
| **Product-related factors** | | |
| Product content (n = 12) | Altarate et al. (2016); Arce-Lopera et al. (2018); Bressoud (2013); Israel et al. (2019); Kang et al. (2020); Liu (2010); Liu & Uang (2011); Liu & Uang (2016); Lombart et al. (2019); Martínez-Navarro et al. (2019); Piizzi et al. (2019b); Wölfel & Reinhard (2019) | 14.46 |
| **System-related factors** | | |
| General interface / system environment (n = 19) | Altarate & Charisius (2019); Fang et al. (2020); Farah et al. (2019); Han et al. (2020); Hsu et al. (2020); Huang et al. (2019); Kapsy & Logo (2017); Lombart et al. (2020); Morotti et al. (2020); Peukert et al. (2019a); Pedret et al. (2019a); study1 & study2; Piizzi et al. (2019a); Piizzi et al. (2019b); Schnack et al. (2020); Siegrist et al. (2019)-study 1; Tonkin et al. (2011); van Herpen et al. (2016); Wölfel & Reinhard (2019) | 22.89 |
| Vividness / Interactivity (n = 5) | Jang et al. (2019); Kang et al. (2020); Lau et al. (2014); Park et al. (2018); Vianelte et al. (2019) | 6.02 |
| Immersiveness (n = 4) | Lara & Pantano, 2011; Meilïner, Pfeiffer, Peukert, Dietrich, & Pfeiffer, 2020; Peukert, Pfeiffer, Meilïner, Pfeiffer, & Weinhardt, 2019b; Vianelte, Vezzetti, & Piazzolla, 2019 | 4.82 |
| Customization / Personalization (n = 3) | Elboulali et al. (2020); Pantano & Lara; 2012; Shuai et al. (2018) | 3.61 |
| Stereoscopic (n = 2) | Kang et al. (2020); Lau and Lee (2019) | 2.40 |
| Scene rotation speed and scene inclination angle (n = 1) | Liu & Uang (2013)-study1 | 1.20 |
| Gamefulness (n = 1) | Donatiello et al. (2018) | 1.20 |
| Fuzzy warning (n = 1) | Liu & Uang (2013)-study2 | 1.20 |
| **Technology-related factors** | | |
| Interactive technology (n = 9) | Khan et al. (2012); Renner et al. (2010); Speicher et al. (2017)-study 2; Speicher et al. (2018); Verhulst et al. (2016); Wu et al. (2019)-study1 & study2; Wu et al. (2020)-study1 & study3 | 10.84 |
| Product / information display (n = 8) | Liu & Uang (2011); Liu & Uang (2016); Martínez-Navarro et al. (2019); Moe & van Vliet (2017)-study1 & study2; Otta et al. (2015); Schnack et al. (2019); Speicher et al. (2017)-study 2 | 9.64 |
| Multi / single wall environment (n = 1) | Carlson et al. (2011) | 1.20 |
| Multi-kinect sensors (n = 1) | Ketoma et al. (2018) | 1.20 |
| Shopper type / behavior (n = 2) | Bigne et al. (2016); Van Kerrebrouck et al. (2017) | 2.40 |

Table 8 (continued)

| Construct (Sum) | Source | % |
|-----------------|--------|---|
| **Shopper-related factors** | | |
| Motivation (n = 1) | Siegrist et al. (2019)-study2 | 1.20 |
| Gender (n = 1) | Liang et al. (2019) | 1.20 |
| Virtual body/body perception (n = 1) | Verhulst et al. (2018) | 1.20 |
| Duration of exposure (n = 1) | Liu & Uang (2013)-study1 | 1.20 |
| **In-store-related factors** | | |
| In-store information (n = 3) | Bramley et al. (2018)-study 1; Allman-Farinelli et al. (2019); Nordbo et al. (2015) | 3.61 |
| Auditory stimuli (n = 2) | Piizzi et al. (2019a); Sikstrom et al. (2016) | 2.40 |
| Lay-out of the store (n = 1) | Ploymani et al. (2017) | 1.20 |
| Virtual Shopping cart (n = 1) | Speicher et al. (2018) | 1.20 |
| Low / high perceived crowding (n = 1) | Van Kerrebrouck et al. (2017) | 1.20 |
| **Social-related factors** | | |
| Sales assistant / agent (n = 3) | Dzardanova et al. (2017); Morotti et al. (2020); Zhao et al. (2018) | 3.61 |
| Cooperation / competition / single (n = 1) | Liang et al. (2019) | 1.20 |

Before venturing fully into “what could be”. We therefore argue that VR shopping holds novel dimensions of experience that business, retail and marketing research need to investigate.

First, the prerequisite for exploring the VR shopping experience is to understand what VR is and what VR is not, which is also the basis of reconstructing the shopping environments as well as the consequent consumer experience. A bulk of contemporary VR research (e.g., as seen in the present review) “fails to see the forest for the trees” – i.e. there is a myopic focus on studying select pieces of VR technology such as the current wave of stereoscopic head-mounted displays. Future research should have a broader and more comprehensive and abstract conceptual understanding of what VR is and can be, rather than a) being limited in definition by the instances of VR technology immediately available to the researcher. For example, in the wake of head-mounted displays, VR is often wrongly equated with just being a visual technology while in fact involving a much larger class of technologies. This understanding disregards a whole heft of human sensing and cognitive facilities that are used to compose a coherent overall sense of reality, as well as the technologies used to stimulate them. Surely, VR is related to substituting any and all of our senses, and therefore it logically follows that VR has to be “sense-agnostic” in its definition. b) VR has also been unrealistically used to refer to many completely different classes of technology such as virtual worlds, the internet, and any other digital assets and environments. While it is mostly a semantic question; while it is understandable what it attempts to refer to many completely different classes of technology such as virtual worlds, the internet, and any other digital assets and environments. Thus, VR should not be defined just by “what it is” based on the technologies at our disposal but based “what it attempts to do” – i.e., substitute the current reality we perceive. c) There is a conceptual chaos within the realm of what is commonly referred to as mixed (MR) or extended reality (XR) technologies. In order for future research to attain conceptual clarity and a consistent continuum, we need to map what is and what is not VR. By way of this review and other background knowledge of the domain, we have attempted to form a definition of VR that can be employed as the departure point in future studies, while remaining agnostic to its specific application. Therefore, we propose VR technologies to be defined as: “Technologies for
Table 9: The cognitive reactions and emotional states in the VR retail context.

| Construct (Sum) | Source | % |
|-----------------|--------|---|
| Affection       | Bramley et al (2018)-study2; Israel et al. (2019); Ketoma et al. (2018); Moes & van Vliet (2017)-study1&study2; Peukert et al. (2019a); Peukert et al. (2019b)-study1&study2; Sikstrom et al. (2016); Verhulst et al. (2016); Violante et al. (2019) | 13.25 |
| Emotion arousal | Bressoud (2013); Dzardanova et al. (2017); Martínez-Navarro et al. (2019); Violante et al. (2019); Zhao et al. (2017)-study2 | 4.82 |
| Hedonic (n = 3) | Kang et al. (2020); Khan et al. (2012); Lau & Lee (2019) | 6.02 |
| Immersion / VR-assumed dimensions | Allman-Farinelli et al. (2019); Dzardanova et al. (2017); Jang et al. (2019); Liu & Uang (2011, 2016); Martínez-Navarro et al. (2019); Peukert et al. (2019b); Peukert et al. (2019a)-study1&study2; Schnack et al. (2019); Sikstrom et al. (2016); Speicher et al. (2017)-study2; Speicher et al. (2018); Tonkin et al. (2011) | 16.87 |
| Perceived realism (n = 5) | Carlson et al. (2011); Meiñer et al. (2019); Nordbo et al. (2015); Schnack et al. (2019); Tonkin et al. (2011) | 6.02 |
| Perceived novelty / attractiveness (n = 3) | Moes & van Vliet (2017)-study1&study2; Khan et al. (2012) | 4.82 |
| Body ownership / awareness of own movement (n = 2) | Dzardanova et al. (2017); Sikstrom et al. (2016) | 2.40 |
| Cognition | Altarteer et al. (2016); Altarteer & Charissis (2019); Farah et al. (2019); Huang et al. (2019); Jang et al. (2019); Kapuny & Logo (2017); Moes & van Vliet (2017)-study1&study2; Pizzi et al. (2019a); Pizzi et al. (2019b) | 12.05 |
| Memory call (spatial, store / brand recall) (n = 7) | Bramley et al (2018)-study1; Liang et al. (2019); Liu (2010); Martínez-Navarro et al. (2019); Moes & van Vliet (2017)-study1&study2; Tomono et al. (2011) | 8.43 |
| Information process / attention (n = 6) | Kang et al. (2020); Ketoma et al. (2018); Pfeiffer et al. (2017); Siegrist et al. (2019); Tonkin et al. (2011); Violante et al. (2019) | 7.23 |
| Familiarity (towards brand) (n = 2) | Arce-Lopera et al. (2018); Zhao et al. (2017)-study2 | 2.40 |
| Perceived intrusiveness (n = 1) | Ketea et al. (2018) | 1.20 |
| Attitude and evaluation | Bramley et al (2018)-study1; Bramley et al. (2018)-study2; Kang et al. (2020); Laria & Pantano (2011); Lombart et al. (2019); Lombart et al. (2020); Meiñer et al. (2020); Moes & van Vliet (2017)-study1&study2; Pantano & Laria; Peukert, Pfeiffer, Meiñer, Pfeiffer, & Weinhardt, 2019b; Zhao, Huang, Spence, & Wan, 2017; Wulfel and Reinhardt, 2019-study2 | 14.46 |

Table 9 (continued)

| Construct (Sum) | Source | % |
|-----------------|--------|---|
| Attitude / satisfaction / loyalty (n = 9) | Altarteer & Charissis (2019); Bressoud (2013); Donatiello et al. (2018); Ketelaar et al. (2018); Meiñer et al. (2020); Pizzi et al. (2019a); Van Kerrebroeck et al. (2017); Moes & van Vliet (2017)-study1&study2; Laria & Pantano (2011); van Herpen et al. (2016) | 10.84 |
| Perception of the point of sale / price promotion (n = 2) | Allman-Farinelli et al. (2019); Arce-Lopera et al. (2018); Donatiello et al. (2018); Khan et al. (2012); Ko et al. (2020)-study1&study2; Morotti, Donatiello, & Marfia, 2020; Peukert, Pfeiffer, Meiñer, Pfeiffer, & Weinhardt, 2019b; Nordbo et al., 2015; Ohta et al. et al. (2015); Peukert et al. (2019a)-study1&study2; Schnack et al. (2019); Sikstrom et al. (2016); Speicher et al. (2017)-study2; Speicher et al. (2018); Verhulst et al. (2016); Wu et al. (2019)-study1&study2 | 2.40 |
| Comfortable / cybersickness / stress (n = 10) | Carlson et al. (2011); Israel et al. (2019); Lau et al. (2014); Liu & Uang (2011); Liu & Uang (2013)-study1&study2; Liu & Uang (2016); Martínez-Navarro et al. (2019); Speicher et al. (2017)-study2; Speicher et al. (2018) | 12.05 |
| Usability | Perceived usability (n = 19) | Morotti et al. (2020); Ohta et al. (2015); Peukert et al. (2019a)-study1&study2 | 22.89 |
| Perceived ease of use (n = 4) | Morotti et al. (2020); Ohta et al. (2015); Peukert et al. (2019a)-study1&study2 | 4.82 |

substituting the perceived reality".5

To be more specific, a) by “technologies”, we refer to all kinds of technologies, methods and approaches that are being used for the following purposes: b) “substituting” the sensed or perceived reality, i.e., providing another set of (i.e., sensory or otherwise) stimuli that simulates the artificial reality, while blocking and inhibiting the (i.e, sensory or otherwise) information or stimulus of the prominent reality. For example, head-mounted displays which are the currently popular VR devices provide a visual (commonly stereoscopic and FOV spanning) stimulus that is designed to interact with peoples’ psychology in a way to make them act and think like the reality being simulated to them is “real”, while also attempting to block outside visual (and sometimes auditory and olfactory) stimuli from entering the users’ attention. c) By “perceived reality”, we draw attention to something that might be obvious but is still worth mentioning, in that VR does not per se substitute reality as it exists in objective reality. VR technologies surround the perceptual experience include e.g., visual, aural, olfactory, tactile, movement and taste experiences created by different multi-modalities. Thus, in order for VR research to become more integrated and mature, future research pursuits should attempt to see themselves under this larger banner of VR technologies.

Given that all sensory information regarding e.g., product, shopping environment, interaction, etc. can be substituted by virtual reality, shopping activities can be conducted in different ways which leads to substituting the perceived reality".6

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5 As opposed to Augmented Reality (AR) that refer to technologies for modifying the perceived reality.
novel and unique experiences germinating in the VR shopping context. We wish to propose three aspects that may begin to define what the VR shopping experience can be, as well as to propose further research directions in the VR retail field.

**Non-consequentiality.** Instead of brick and mortar, virtual reality shopping environments and the products within them are constructed completely out of digital assets which are indestructible in a traditional sense. Therefore, VR shopping will be free of many of the constraints and consequences that govern shopping and consumption in the real world. This facet will afford completely new shopping behaviors and practices, where products and shopping environments set no limitations as to how much the products can be played with. Moreover, it will transform the shopping environments into playgrounds of free experimentation. VR has been believed to provide opportunities for a variety of activities that are typically either not done well or safely in real life (Schultheis et al., 2019; Konradt et al., 2019; Lombart et al., 2020; Martínez-Navaarro et al., 2019; Moe & van Vlerken et al., 2017). Therefore, VR shopping will be free of many of the constraints and consequences that govern shopping and consumption in the real world.

**Disentanglement.** Sensory modalities in virtual reality can be reorganized and distorted. Since the individual’s perceptual field would be surrounded by the simulated environment (Blascovich et al., 2002), consumers can liberate and release their perceptions, beliefs and attitudes towards stimuli and even themselves, from those of the physical world. Therefore, VR provides opportunities for disconnections between stimulus (e.g. product) and inherent sensory features. For example, in virtual reality, bulky machines can be as light as feathers, or meat products can be designed to taste like fruit (as famously simulated in the real world by world-renowned chef Heston Blumenthal). These possibilities may sound counterintuitive, while at the same time constructing a potentially new understanding of reality. In addition, in virtual reality individuals can release themselves from traditionally biologically and physiologically directed ways, where, for instance, they could have new attitudes towards body ownership and movement, and a willingness to explore novel ways of interaction (e.g. Alzayt & Lee, 2021).

**Polyidentity.** In the virtual world, individuals have the empowerment to construct and manage virtual identities for self-presentation (e.g. as seen with in-game behaviors: Mancini et al., 2019), and seamlessly alter identities in different realities which would further impact shopping behaviors as demonstrated by the proteus effect.

| Table 10 | Behavioral outcomes in VR retail. |
|----------|----------------------------------|
| Construct (Sum) | Source | % |
| Intention to purchase / use / visit (n = 17) | Allman-Farinelli et al. (2019); Elboudali et al. (2020); Hou et al. (2020); Jang et al. (2019); Kang et al. (2020); Liu & Lee (2019); Lombart et al. (2020); Martínez-Navaorro et al. (2019); Moe & van Vlerken et al. (2017) | 20.48 |
| Time spent (n = 9) | Arce-Lopera et al. (2018); Bressoud (2013); Carlton et al. (2013); Ketoma et al. (2016); Khan et al. (2012); Liu (2010); Renner et al. (2011); Sierist et al. (2019); Zhao et al. (2018) | 10.84 |
| Purchase decision (n = 6) | Bigne et al. (2016); Bressoud (2013); Fang et al. (2020); Goedegebre et al. (2020); Verhulst et al. (2018); Ketoma et al. (2018) | 7.23 |
| Task performance (n = 6) | Liang et al. (2019); Liu & Uang (2016); Speicher et al. (2017); Speicher, Hell, Daiber, Simeone, & Krüger, 2018; Zhao, Huang, Spence, & Wan, 2017; Verhulst et al., 2018; study1 | 7.23 |
| Information search (n = 4) | Laria & Pantano (2011); Meierer et al. (2020); Tonkin et al. (2011); van Herpen et al. (2016) | 4.82 |
| Product / Brand choice (n = 3) | Ketelaar et al. (2018); van Herpen et al. (2016); Wölfel & Reinhardt (2019) | 3.61 |
| General shopping behavior (n = 3) | Pantano & Laria (2012); Floydian et al. (2017); Schnack et al. (2020) | 3.61 |
| Money spent (n = 2) | van Herpen et al. (2016); Zhao et al. (2016) | 2.40 |
| Recommendation / word of mouth / sharing (n = 2) | Pizzi et al. (2019a); Violante et al. (2019) | 2.40 |
| Legacy bias (n = 2) | Wu et al. (2020); study2 | 2.40 |
| Navigation (n = 1) | Ketoma et al. (2018) | 1.20 |

Note: N. Xi and J. Hamari

Proteus effect refers to the phenomenon that users make inferences about their expected dispositions from their avatar’s appearance and then conform to the expected attitudes and behavior (Yee et al., 2005).

Virtual consumption refers to the phenomenon of exchange of real world money to virtual goods (Lehdonvirta et al., 2009).
Table 11
The empirical results of 51 studies from 45 experiment-based manuscripts.

| Author (year)       | Study design                                                                 | Key findings                                                                 |
|---------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Altarteer et al. (2016) | - Within-subject, n = 33 – 2 conditions: 3D VR shopping system vs. 2D personalization system (as control) | Subjects in both conditions were positively perceived in usability, and enhance user engagement, brand recall, and brand perception. |
| Arce-Lopera et al. (2018) | - Mixed design: Within-subject design, 2 conditions: 1) gamification-ball tossing game; 2) VR shelf - Measured pre-experience, immediate post-experience and 24 h post-experience | VR (vs. standard message testing techniques) more effectively accounts for the real world experience, as well as being less likely to result in the over-claim of message clarity. VR adds to the survey experience in terms of enjoyment and engagement. |
| Bramley et al. (2018)-study 1 | - Between-subject, n = 347, each of the alternatives had the same number of participants – 5 conditions of the retail bay display: 1) current configuration, n = 72 (as control); 2) current configuration with devices, n = 64; 3) with devices and change main message order, n = 76; 4) no devices changed image, main primary and secondary message, n = 64; 5) with devices and changed image, main primary and secondary message, n = 71 | Participants in the five-wall immersive environment were significantly faster in locating the objects, and it provided an increased sense of immersion; 2) participants in the five-wall condition reported that the shopping cart was easier to use than in the one-wall condition. |
| Bresseoul (2013) | - Between-subject, n = 400 – 2 conditions: 1) VR shop (shelf), n = 200; 2) 4 experimental real shops, n = 200 | When testing consumers’ responses to new products in the experimental real store and the virtual store, attitudinal measures were similar in terms of cognition and conation, but affect and behavior cannot be compared between the two kinds of store. |
| Carlson et al. (2011) | - Between-subject, n = 17 – 2 conditions in a virtual store: 1) five-wall display condition, n = 10; 2) one-wall display condition, n = 7 | Individuals feel more compelled to abide by a specific social context in conditions 2 and 3. The mere presence of the second character did not enhance or decrease presence or BOI (body ownership illusion), but it did cause a drastic emotional response. |
| Dzardanova et al. (2017) | - Between-subject, n = 54 – 3 conditions: 1) no virtual salesman in VR, n = 18; 2) NPC virtual salesman in VR, n = 19; 3) 3D human model virtual salesman in VR, n = 17 | The hypothetical bias with virtual reality is not significantly different from those using text or pictures, although it is less. Among participants who did not exhibit high simulator discomfort; virtual reality can significantly reduce hypothetical bias in choice experiments. |
| Fang et al. (2020) | - Between-subject, n = 256, approximately 50 for each treatment – 5 conditions of choice experiment: 1) hypothetical: plain text; 2) hypothetical: pictures; 3) hypothetical: virtual grocery store; 4) non-hypothetical: virtual grocery store; 5) non-hypothetical: plain text | Consumers are more likely to choose light products when these are combined with a popularity cue. In contrast, the popularity cue did not affect choice for the regular alternatives. |
| Goesdegeure et al. (2020) | - Between-subject, n = 300 – 3 conditions of popularity cue in the virtual supermarket context: 1) none; 2) regular product popular; 3) light product popular | Entertainment value, informativeness, perceived ease-of-use, and perceived usefulness are the primary factors influencing the intention to use the VR HCI for online shopping. |
| Huo et al. (2020) | - Within-subject, n = 98 – 2 conditions of shopping: 1) VR shopping app; 2) online shopping website | Interactivity and visual-spatial cues significantly enhance perceived informativeness and playfulness; however, the role of graphics quality was found to be more critical for 2D displays than for the 3D VR environment. 2) informativeness and playfulness influence the purchase decision-making process in distinct ways. |
| Ketelaar et al. (2018) | - Between-subject, n = 120 – 4 conditions in a VR supermarket: 2 ad types (open vs. closed) × 2 location types (congruent vs. incongruent) | Openness in mobile ad design resulted in more favorable attitudes towards the ad and a higher likelihood of choosing the advertised brand, by reducing the perceived intrusiveness of the ad. Effect was more pronounced when the ad was presented at the location where the advertised product was available. |
| Khan et al. (2012) | - Between-subject – 2 conditions in a simulated 3D supermarket: 1) human joystick interaction technique, n = 22; 2) magic wand interaction technique, n = 22 | The Magic Wand is the superior technique when it comes to efficiency. But human joystick and magic wand interactions are similar in terms of cognition and conation, but affect and behavior cannot be compared between the two kinds of store. |
| Liang et al. (2019) | - Between-subject – 2 conditions in a 3D virtual shopping mall: 1) single (SIN) group, n = 5; 2) cooperation (COO) group, n = 10; 3) competition (COM) group, n = 10 | The virtual store with an autostereoscopic display with high quality depth perception cues produces good landmarks are important for the elderly as they attempt to locate goods within a 3D virtual store, no matter what types are used. 2) The combined effect of goods-classification and landmarks in a 2D image would be best for the elderly in terms of acquired spatial cognition and the location of goods within a 3D virtual store. (Elderly) participants in high level depth perception cues with a 3D monitor experience greater presence than other displays (HMD and TFT-LCD). Although the feeling of presence in TFF-LCD display is poorer than 3D monitor and HMD, the symptoms of cybersickness are the slightest. |
| Liu (2010) | - Between-subject, n = 128 – 16 conditions in a 3D virtual store: 2 goods-classification (absence vs. presence) × 8 types of landmarks (none, alphanumeric, 2D, 3D, alphanumeric + 2D, alphanumeric + 3D, 2D + 3D and alphanumeric + 2D + 3D) | Landmarks are important for the elderly as they attempt to locate goods within a 3D virtual store, no matter what types are used. 2) The combined effect of goods-classification and landmarks in a 2D image would be best for the elderly in terms of acquired spatial cognition and the location of goods within a 3D virtual store. (Elderly) participants in high level depth perception cues with a 3D monitor experience greater presence than other displays (HMD and TFT-LCD). Although the feeling of presence in TFF-LCD display is poorer than 3D monitor and HMD, the symptoms of cybersickness are the slightest. |
| Liu & Uang (2011) | - Between-subject, n = 60 – 6 conditions in a 3D virtual store: 2 level of depth cues × 3 mode of display (HMD, TFT-LCD and 3D monitor) | The rate of simulator sickness questionnaire (SSQ) scores increases significantly with rotating speed and duration of exposure. |
| Liu & Uang (2013) | Study 1: Within-subject, n = 32. The experiment used a 4 (scene rotation speed) × 4 (scene inclination angle) × 4 (duration of exposure) within subject repeated measure design Study 2: Between-subject, n = 32 – 2 conditions: one is with fuzzy warning system vs no warning system | S2: The proposed system can efficiently determine the level of cybersickness based on the associated subjective sickness estimates and combat cybersickness induced within a 3D virtual store. The virtual store with an autostereoscopic display with high quality depth perception cues produces good sense and realism in stereopsis to allow the elderly to experience presence within a virtual store. Shoppers tend to purchase a similar number of FaVs whatever their level of deformity. 2. Perceptions of the appearance and quality of the FaVs depend on the degree of abnormality. |
| Liu & Uang (2016) | - Between-subject, n = 60 – 6 conditions in a 3D virtual store: 2 level of depth perception cues × 3 type of display (autostereoscopic, stereoscopic and monocular displays) | (continued on next page)
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Lombart et al. (2020) - Between-subject, n = 192; 3 conditions of store environments: 1) Physical store, n = 64; 2) immersive virtual store with a VR HMD, n = 68; 2) non-immersive virtual store with 17” computer screen, n = 68

Martínez-Navarro et al. (2019) - Between-subject, n = 178–180 conditions: 3 display devices (PC monitor, powerwall, and HTC Vive HMD) × 2 VR content formats (360° vs. 3D) and physical supermarket as control, n = 30

Mellitzer et al. (2020) - Between-subject, n = 257; 2 conditions of consumer choice from virtual shelves: 1) high-immersive VR environment with HMD, n = 132; 2) low-immersive environment with desktop computer screen, n = 125

Moes & van Vliet (2017) - Study 1: Between-subject - 3 media richness conditions in clothing store: regular photo, n = 54; 2) 360-degree photo, n = 46; 3) VR photo, n = 51

Moes & van Vliet (2017) - Study 2: Between-subject - 2 media richness conditions in clothing store: 1) 360-degree photo, n = 52; 2) VR photo, n = 55

Nordbo et al. (2015) - Between-subject, n = 27; 2 conditions in virtual food court: 1) with regular food-court prices; 2) with taxes on food and beverages.

Peukert et al. (2019a) - Study 1: Between-subject, n = 194; 2 conditions of basic VR Shopping environment: 1) VR1Experienced with HMD, n = 132; 2) VR1Video, n = 62

Peukert et al. (2019b) - Between-subject, n = 257; 2 conditions of immersion of shopping environment: 1) highly immersive VR shopping environment with HMD, n = 132; 2) low immersive shopping environment with desktop computer screen, n = 125.

Nordbo et al. (2015) - Note: the two main groups were again divided into subgroups, one of which executed the last 2 choice tasks in front of a real shopping shelf.

Pizzì et al. (2019a) - Between-subject, n = 200, 50 for each condition – 4 conditions, 2 store environment (physical-short video vs. virtual reality) × 2 presence of auditory sensory stimuli (absent vs. present).

Pizzì et al. (2019b) - Between-subject, n = 100–2 conditions: 1) shelf in physical store, n = 50; 2) shelf in VR-based store, n = 50

Ploydanai et al. (2017) - Between-subject, n = 241; 4 store layout conditions in a virtual supermarket: 2 shelf lengths × 2 shelf orientations

Renner et al. (2010) - Within subject, n = 49

Scoholic et al. (2019) - Study 1: Between-subject, n = 68–2 conditions of shelf: 1) real shelf, n = 37; 2) VR shelf, n = 31

Scoholic et al. (2019) - Study 2: Between-subject, n = 46–2 motivation conditions: 1) health group, n = 23; 2) hedonic group, n = 23

Silkö et al. (2016) - Within subject, n = 22–3 conditions in the shelf of VR supermarket: 1) no auditory feedback; 2) impact only auditory feedback; 3) impact and continuous auditory feedback

Speicher et al. (2017) - Study 1: Between-subject, n = 16–16 conditions: 2 input methods (head pointing, speech input) × 2 output methods (desktop-based shop, smartphone VR based shop) × 4 search terms

Speicher et al. (2018) - Within-subject, n = 16–4 conditions in a apartment metaphor shop: 2 product interaction (grab vs. beam) × 2 shopping cart representation (basket vs. sphere)

Tomon et al. (2011) - Within-subject, n = 12–2 conditions in a virtual flower shop: 2) with smell presentation; 2) without smell presentation

Tonkin et al. (2011) - Mixed-design subject, n = 28–6 conditions: 2 environments (physical shelf vs. virtual shelf) × 2 box types × 2 box placements. Note: each participant performed two trials, with environment and box type reversed in the second trial, counterbalancing trial combinations.

van Herpen et al. (2016) - Between-subject, n = 100–3 shop types: 1) real supermarket; 2) pictorial supermarket; 3) virtual supermarket

Key findings

Consumers’ perceptions of FaVs in both non-immersive and immersive virtual stores (VS) are similar to those in a physical store. By contrast, consumers buy more FaVs in both non-immersive and immersive stores compared to a physical store.

Virtual stores are more effective in generating cognitive and conative responses compared with physical store. No differences are shown in sense of presence and affect by VR format and device.

Consumers in high-immersive VR choose a larger variety of products and are less price-sensitive. Choice satisfaction, however, did not increase in high-immersive VR.

The two studies show that consumers who saw the virtual reality photo of the shop have a more positive online visit satisfaction than those who have only seen the regular photo or the 360-degree photo of the shop. Enjoyment and novelty seem to partly explain these effects.

The virtual food court is a realistic representation of a real food court. Taxation on food and beverages can have a positive influence on people’s food choices.

Two studies showed that the hedonic variable of perceived enjoyment as well as the VR specific variable of perceived telepresence are underestimated when participants only imagine (based on a video) being in a VR shopping environment, while there is no difference with respect to the behavioral intention to use the system.

Highly immersive shopping environments positively influence a hedonic path through telepresence, but they negatively influence a utilitarian path through product diagnosticity.

Individuals exposed to a VR retail environment perceive higher levels of presence than those exposed to a more traditional, physical store environment. Moreover, this positive effect does not depend on individuals’ self-efficacy perceptions.

Consumers’ shopping orientations are affected by the virtual channel, which can lead to both utilitarianism and hedonism, and which can further lead to store satisfaction.

Store layout attributes, specifically the interaction of shelf length and shelf orientation, influence the number of products selected. The use of a virtual store facilitates the study of consumer responses.

The usability and efficiency are different among the five methods for navigation and two for selection in VR. The combination of Ray-Casting and Walking in Place turned out to be the fastest.

S1: No statistically significant differences were observed in the selection of the cereals by the two groups in the hedonic condition.

S2: Participants in the healthy condition paid more attention to the nutrition information than those in the hedonic condition. Participants in the immersive VSS group experienced stronger feelings of immersion and perceived naturalness of interactions with the store environment compared to the desktop VSS group. Both factors potentially lead to enhanced perceived telepresence.

Auditory feedback didn’t change the participants’ experience of VR shopping.

Searching for a product in a VR online shop using speech input in combination with VR output proved to be the best regarding user performance (speed, error rate) and preference (usability, user experience, immersion, motion sickness).

Product interaction using pointing in combination with the abstract cart concept performs best with regard to error rate, user experience and workload.

Olfactory stimuli produced an enhancement of correct answer rate remembering flower name and position.

The physical environment afforded significantly faster search performance than the virtual projected image.

VR can improve realism in responses to shelf allocation. Participants bought more products and spent more money and responded more strongly to price promotions in both VR and pictorial representations than in the physical store.

(continued on next page)
| Author (year) | Study design | Key findings |
|---------------|--------------|--------------|
| Van Kerrebroeck et al. (2017) | Between-subject, n = 183 – 2 conditions in the shopping mall: 1) regular users did not experience VR sleigh ride, n = 80; 2) VR users-experience VR sleigh ride, n = 103. Note: regular shoppers did not experience the VR sleigh ride, they did see the regular Christmas ornaments present in the shopping mall (as did the VR users). | Consumers reported more positive responses on all measured outcome variables (attitude, approach behavior, satisfaction) after being exposed to the VR experience. The effect on mall attitudes, satisfaction and loyalty is more pronounced when crowding is perceived to be high. |
| Verhulst et al. (2016) | Between subject, n = 80 – 4 conditions in a virtual supermarket: 1) using the game-pad; 2) game-pad and head tracking; 3) arm movement and head tracking; 4) step in place and head tracking | Participants were more efficient in terms of performance using the game-pad rather than using full body gestures. However, they had more fun performing the task under these conditions. |
| Verhulst et al. (2018) | Mixed design subject, n = 70 – 2 product types (milk vs. wine) × 8 environments (4 shelf levels in store, 3 types of product offering quantity in store, 7 different sizes of product in store, empty environment, shelf in retail store, shelf in environment, matching environment and non-matching environment). Note: The entire experiment consists of a total of 16 different environments, of which 8 environments with the milk or wine variant are shown to the test person. Whether the subject sees the milk or wine variant is decided by chance. | There were no significant differences in shopping patterns (e.g. more unhealthy products bought) between the groups. |
| Wölfel & Reinhardt (2019) | - Study 1: Between-subject, n = 60 – 2 conditions: 1) first gesture elicitation, n = 30; 2) second gesture elicitation, n = 30 | S1: This study developed a gesture taxonomy and generated a user-defined gesture set. |
| Wu et al. (2019) | - Study 2: Between-subject, n = 30 – 3 conditions of input method for VR interaction: 1) user-defined gestures; 2) virtual handle controller; 3) ray-casting technique. | S2: The freehand-gesture-based interaction technique was rated to be the best in terms of task load, user experience, and presence without the loss of performance (i.e., speed and error count). |
| Wu et al. (2020) | Between-subject, n = 744 conditions of user-defined gestures for VR shopping: 1) non-priming in individual design (NPI), n = 30; 2) priming in individual design (PI), n = 30; 3) non-priming in group design (NPG), n = 7; 4) priming in group design (PG), n = 7 | No significant difference was found between priming treatments and non-priming treatments in terms of average number of groups of identical gestures, and average agreement scores. |
| Zhao et al. (2017) | Within subject, n = 24 – 4 conditions in a virtual supermarket: 2 target orientation (downward- or upward-pointing) × 2 block orders (the first or last 4 blocks) | S1: Participants identified the bottle with a downward-pointing triangle on its label more rapidly than when looking for an upward-pointing triangle on the label, which is demonstrated the DPTS effect (downward-pointing triangle superiority). |
| Zhao et al. (2018) | - Study 1: Within subject, n = 44 – 4 conditions: 2 target orientations (downward- or upward-pointing) × 2 block orders (the first or last 4 blocks) | S2: The DPTS effect was modulated by the location of the target on the shelf. |
| Zhao et al. (2018) | - Study 2: Within subject, n = 24 – 4 conditions: 2 target orientations (downward- or upward-pointing) × 2 block orders (the first or last 4 blocks) | Participants were touched by the virtual shop assistant, they spent more time, more money on purchasing, and their overall shopping experience evaluation was more positive. Touch influenced time spend in the shop only in the stationary shop. |
future research.

5.2.2. The effectiveness and efficiency of VR shopping

According to the antecedents and consequences in VR retail summarized from previous studies, it is obvious that most research questions were related to the two important indicators in assessing and measuring (loose vs. strong) between virtual shopping context and physical space, activity (Berger et al., 2018). It is unclear in which conditions (e.g., time the virtual reality shopping environment. Factors such as different product types (hedonic vs. utilitarian, see e.g., Kempf, 1999), shopping tasks (information seeking vs. overall experience) and even social aspects (single shopper vs. group shoppers, see e.g., Sommer, 1992) might have potential influences on effectiveness in the VR shopping context which have not yet been sufficiently addressed in the extant literature. In addition, shopping efficiency is more related to the cost of the shopping journey, such as time and other relevant temporal and psychological resources (Yang & Kim, 2012), which is one of the important elements of usability evaluation for a shopping system. An efficient VR system not only has a relatively high requirement for hardware devices and programming techniques but also requires users to have good eyesight and flexible body movement, expend mental effort, and demonstrate mature operating skills. However, the discussion on how to increase the usability of VR technology from the perspective of shopping efficiency is still insufficient. Future researchers should, therefore, expand the investigation on different dimensions of effectiveness and efficiency and their influencing factors in the virtual reality shopping environment.

5.2.3. Exploring the boundary conditions of VR shopping

Future research should further investigate the boundary conditions of VR shopping, addressing when, where, and how VR facilitates the shopping experience. For example, time pressure (a cost of information processing) can influence decision making through actions such as choice deferral (Dhar & Nowlis, 1999) and compulsive buying (Kukar-Kinney et al., 2016), and has the potential of diminishing cognitive activity (Berger et al., 2018). It is unclear in which conditions (e.g., time pressure: high vs. low) consumers have superior shopping experiences in virtual reality. Another boundary condition example is the coupling (loose vs. strong) between virtual shopping context and physical space, which may also play a moderating role, especially in vision-oriented VR shopping. The degree of connection between the physical space and the digitalized experience contributes to the user’s immersion (Reid et al., 2005), and while two papers in the reviewed literature researched the physical shopping environment (see e.g., food court, Aiman-Farinelli et al., 2019; shopping mall, Van Kerrebroeck et al., 2017), they did not investigate the coupling phenomenon to any meaningful degree. Thus, the exploration of moderators and gaining an in-depth understanding of boundary conditions can strengthen the advantages of VR in retail practice.

5.2.4. The role of shoppers in VR shopping experience

Future research should further examine the role of shoppers and their individual characteristics in influencing VR shopping experiences. Specific types of shoppers might be more susceptible to VR retail. Personal attributes such as personality traits (Bosnjak et al., 2007), cultural and ethnic background (Tosun et al., 2007) and demographic factors all influence the shopping experience and behavior. In addition, different shopping motivations (Rohm & Swaminathan, 2004), and prior knowledge, immersive tendency and familiarity towards VR technology also differentiate the shopper’s perceptions of the value, benefits and their attitudes towards the VR shopping. However, it seems that few empirical studies have explored such important person-related variables in the application of virtual reality in the shopping context. Besides, given the negative outcomes that were examined in some studies, VR technology might bring physical and psychological risks for specific consumers (e.g., the elderly, children, or disabled groups). Thus, the study of the influence of shoppers’ attributes and characteristics on VR shopping experiences can help researchers and practitioners explore and design better personalized and customized VR systems in the future.

5.2.5. VR as a platform for consumer research

The simulated VR shopping environment can be designed as a research background for investigating almost any consumer-related research questions, including information seeking, product evaluation, decision making, and post-evaluation in the shopping process. The differentiated effect of the shopping process caused by actual and simulated shopping environments (see Burke et al., 1992) has posed a research dilemma for a considerable time. VR has provided the chance for current researchers to realistically and efficiently mimic the original shopping environment, and facilitates consumers’ interactive explorations of products (e.g., food preferences and consumption, see Lombart et al., 2019), and overcome the systematic biases found in laboratory simulations (e.g., “hypothetical bias” in choice experiments, see Fang et al., 2020). With the aid of current VR technology, researchers can easily and accurately monitor consumers’ dynamic processes such as searching, evaluation, selection, and even post-purchase evaluation in a naturalistic experimental environment (see e.g., in-store visual search for wine bottles, Zhao et al., 2017; food selection behavior, Siegrist et al., 2019; the authenticity of shopper behavior, Schnack et al., 2020; mobile advertising, Ketelaar et al., 2018). VR is expected to solve the trade-off between experimental control and ecological validity (Meiñner et al., 2019). Thus, in the future, many interesting and important research questions that cannot be investigated in a real shopping environment, can be examined in the VR context.

5.3. Methodological agenda

5.3.1. Comparative study design in VR retail research

A comparison between VR and other shopping contexts can be carried out through different research methods such as experiments, surveys, case studies in future research. Given that there are mixed results on the differences between VR and other shopping environments (e.g., the VR shop is the same as a real shop, Siegrist et al., 2019; the VR shop creates a better experience than a real shop, Martínez-Navarro et al., 2019; the VR shop seems to have no advantage over physical shops, Tonkin et al., 2011), the role and value of VR in the shopping experience is still unclear. Thus, there is a lack of rigorously comparative study between the VR shop and other shopping contexts (e.g., physical shop, traditional online store, stores with immersive technologies such as augmented and mixed reality). In addition, when seen as a visual output technology, VR can also be compared with various content display media (e.g., text, video, 2D picture and web-based 3D interfaces) in regard to influencing different aspects of shopping experiences in future studies.

5.3.2. Richness in product and VR environment

Future research should investigate the consumer’s shopping experience of interacting with different types of products in various shopping environments. According to the literature review from 83 studies, the majority of existing research has used consumer packaged goods such as food, clothing, beverages and stationeries as virtual objects in the VR grocery shop or store, which has limited the research results to a small portion of retail sectors. Hedonic products and luxury goods have not been discussed well in the VR shopping context. Thus, future studies could design different shopping environments and give product diversity further consideration.
5.3.3. **Experiment control in VR retail research**

Future research should also improve the experimental design of studies for increasing the validity of results. It is obvious that many prior studies neither manipulated nor measured the internal variables of their datasets effectively (e.g., the shelf was simply designed as a shopping environment; video was used as the representative of the physical store; the measurement scales with high reliability and validity were not considered), nor strictly controlled their external variables (e.g., the consumer’s familiarity with the shopping environment, Van Kerrebroeck et al., 2017; prior knowledge of the product, Speicher et al., 2018; time constraints, Pantano & Laria, 2012), which reduced the validity of the experimental results. It has also been overlooked that most participants are regular shoppers who are quite familiar with the daily commodities and have their own selection preferences. Thus, to increase the validity of VR shopping-related research based on experiment methods, future research should exercise more control over external variables, improve measurement techniques, and add control or placebo group. Experiment methods such as field experiments (see e.g., Van Kerrebroeck et al., 2017) in the natural setting rather than strict laboratory experiments could also be considered as a means to increase the external validity of future research.

5.3.4. **Size and diversity of the sample**

Future research should expand the scope of samples in terms of quantity, gender, age, education, income and nationality to increase the reliability of experiments. The sample sizes seen in existing experiment-based studies ranged from 16 to 400, with half using convenience samples comprising undergraduate or graduate students. The small sample size was associated with a low statistical power and low reproducibility, which was unable to meet the experimental requirements in a few of the experiment-based studies that were reviewed. As previously mentioned, consumers’ demographic features can also influence the outcomes of VR shopping. Therefore, it is recommended that future research employs participants of e.g., balanced gender distribution, a wide range of age, a diverse income level and educational background, and participants from various cultures.

5.3.5. **Multiple data sources**

Future research should use multiple data collection methods. Most of the existing studies use questionnaires and scales to measure emotional and cognitive perceptions. For improving accuracy and avoiding bias (particularly for measuring emotional arousal levels of immersion, presence or enjoyment), future studies can be enriched by collecting biological and body data from different sensors and tracking devices in virtual reality, such as a wireless portable electroencephalogram (EEG) device (Clemente et al., 2014), blood pressure monitor (Zeng et al., 2017), eye-tracking technology for measuring the numbers and duration of fixations (Meitner et al., 2019), and body movement trackers (Won et al., 2015). Physiological indices can provide an understanding of consumer behavior at an implicit level, and supplement results obtained from subjective evaluations and self-reports. In addition, for understanding the industry around VR and VR retail in its infancy, qualitative data from materials in practice such as newspapers and periodicals, business documents, websites and social media posts, and interviews can also be used for the purposes of discourse and textual analysis.

5.4. **Technological agenda**

5.4.1. **The ergonomics of VR devices**

Future research should use more advanced HMD (such as wireless, lightweight and broader field of view) for improving the comfort and efficiency of shopping. Clumsy virtual reality devices and low resolution displays usually cause discomfort and distraction, which may negatively affect a consumer’s interactivity with products and shopping environment, and further reduce the validity of any results (Liu & Uang, 2011, 2013). Especially for studies related to a comparison of VR shopping and other shopping contexts, participants are more likely to report a low shopping efficiency and negative shopping experience due to the limitations of the VR devices that are used (Tonkin et al., 2011). Thus, advanced HMD devices such as wireless PC-based HMD and All-in-one headsets should be applied in future VR research to address ergonomic considerations.

5.4.2. **Cybersickness issue induced by VR**

Exposure to the virtual system and environment (e.g., VR) can cause nausea, oculomotor issues, and disorientation (Ng et al., 2020; Liu et al., 2020), which might lead to an inferior shopping experience and pose risk to retailers. Provocative motion simulation (visual, non-visual or multisensory) seems to increase the likelihood of cybersickness (Arcioni et al., 2019). During VR shopping, consumers have been more likely to experience discrepancies in the information received from different sensory modalities (see the theory of sensory conflict), prolonged postural instability, difficulties in programming eye/head movements (see poison theory), and other cybersickness-related causes (Israel et al., 2019). We suggest that future research could investigate the causes, types and effects of cybersickness in VR shopping, and come up with a solution for cybersickness through technology improvements and behavioral countermeasures (Liu et al., 2020).

5.4.3. **Increase interactivity in VR retail**

Future research should increase the shoppers’ interactions with objects in the VR shopping environment to create more natural and realistically simulated shopping experiences. One of the important features of virtual reality is interactivity. However, in some of the studies, participants’ movements were limited to a simple interaction with virtual products such as pointing (e.g., Speicher et al., 2018) and clicking (e.g., Allman-Farinelli et al., 2019), which undermines the prominent advantages of virtual reality compared to other shopping-related contexts. Thus, future researchers should consider creating more natural and necessary interactions with products and the environment in the simulated virtual shopping world, such as by designing interactive programs of rotating, moving, touching, dropping, picking and shaking, as well as using more advanced and multi-functional interactive devices.

5.4.4. **Expand movement space**

Future research should provide more movement change and space for participants in the stimulated VR-based shopping environment, in order to increase the external validity of experiments. According to the reviewed literature, participants either sat (Ploydanai et al., 2017), stand (Lau & Lee, 2019), or walked around (Siegrist et al., 2019) within a narrow space. Due to the limitation of current tracking devices, participants can only move in a limited space supported by HMD and CAVE, which may help to explain why most laboratory experiments were related to small-sized grocery shops or stores. Future studies should consider how to provide participants more activity space and simulate other shopping venues such as larger retail stores and shopping malls. Using a treadmill can also be considered to create a perspective of space, and has been widely used in many purely psychological experiments in virtual reality (e.g., Cuperus et al., 2018). With the aid of a treadmill, participants are allowed to walk infinitely, even in small physically confined spaces.

5.4.5. **Multisensory technologies**

Future research should simulate more sensory experiences by using technology such as haptic devices (vibrations, forces or motion), auditory output devices, and taste and olfactory technologies. Generally, our perception towards the real world is inherently multisensory, often involving visual, auditory, tactile, olfactory, gustatory, and, on occasion, nociceptive stimulation (Gallace et al., 2011). Products and retail environments are increasingly being designed to emotionally and rationally appeal to consumers across multiple senses (Spence et al., 2014). A few studies have conducted VR shopping-related experiments in the real
environment (e.g., with the sounds and smells found in real food courts, Allman-Farinelli et al., 2019), aiming at providing perceived realism. However, the majority of current VR applications in shopping research have only involved the stimulation of vision, which hardly provides a fully immersive shopping experience and presence in virtual reality. Thus, exploring the application of these multisensory interactive technologies in VR retail is full of potential, as they are able to provide consumers with a wider sensation range, richer sensation experiences, as well as contributing to the understanding of how different sensational shopping experiences influence each other.

6. Conclusions

This study makes several important key contributions by synthesizing, analyzing and conceptualizing the current state of VR retail literature. The study presents a clear summary with regard to research methodologies, theories, devices and technologies, products and environments, which can inspire researchers to conduct more interdisciplinary studies between areas of information science and retail management. More importantly, this study also refines the antecedents and consequences of VR shopping under the guidance of the SO-R (stimulus-organism-response) framework, which provides a systematic understanding of the research questions and content featured in prior studies. By reviewing the 51 experiment-based empirical studies from 45 papers, four important results are discussed. The study further provides 16 future avenues in terms of concepts, themes, methods and technologies, which can guide researchers to understand the current virtual reality retail phenomena, select valuable research questions, design experiments, and use different tracking technologies. Thus, this study provides insights into several aspects of virtual reality and its implications for the retail field. What should be highlighted is that we have conceptualized VR as technologies for substituting the perceived reality and propose three key features of the VR shopping experience in the future agenda section, which makes a valuable contribution to current VR research and enlightens researchers on the progress in the field of VR retail.

This study has followed the suggestions of Pettigrew & Roberts (2005) and referred to Paré et al. (2015) to ensure the quality of the literature review, mainly including the rigor of review and its relevance. Thus, we have limited the search database to the Scopus database, which may have meant some publications have been missed. Therefore, future studies may consider using additional databases such as Google Scholar, JSTOR, Web of Science, EBSCO, etc. Furthermore, only literature written in English was reviewed in this study, and it is undeniable that VR shopping-related studies have been published in non-English journals and conferences. Thus, the search language can also be expanded in future studies. Regarding scope, some parts of the published material have not been reviewed or addressed in this paper (e.g., means of interaction, types of VR shop, and product modeling), and these can be further discussed in future studies. As a final consideration, in this study, we only looked at the shopping experience that usually occurred in the shop, store, or shopping site, but future studies could consider other business contexts related to consumer experiences such as aspects of entertainment, advertisement, hospitality, and tourism.

Declaration of Competing Interest
No potential conflict of interest was reported by the authors

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