Fashion and Textiles

RESEARCH 

# Feasibility and user experience of virtual reality fashion stores

Minjung Park[1*], Hyunjoo Im[2] and Do Yuon Kim[2]

*Correspondence: parkm@susqu.edu
[1] Sigmund Weis School of Business, Susquehanna University, 514 University Ave., Selinsgrove, PA 17870, USA
Full list of author information is available at the end of the article

**Abstract**
Virtual reality (VR) is a computer-simulated, realistic three-dimensional environment. VR heightens a user's sense of being in the environment and enables the user to interact with the environment. We propose that VR can be a very cost-effective way to evaluate fashion retail store designs because of the ease of developing and adjusting the store designs as well as its ability to allow users to closely mimic the real store shopping experience. Also, these benefits create an opportunity for consumer researchers to investigate realistic shopper behaviors. In order to assess the effectiveness of using VR fashion retail store models in developing store designs and in understanding the way shoppers interact with the stores, an experiment with 40 female undergraduate students was conducted. This case study was written to share the advantage of using VR and the challenges VR uniquely presents with both fashion retailers and scholars. Implications for fashion retail store designers and managers as well as consumer researchers are discussed.

**Keywords:** Virtual reality, Fashion store, Shopping behavior, Telepresence, Virtual store, Store design

## Introduction

Virtual reality (VR) is one of the recent technological advancements that has a great potential for fashion industry because VR creates a very realistic computer-simulated environment. Fashion retailers were quick to introduce and experiment with VR in stores to gain consumer attentions (Arthur 2016). Fashion brands such as Tommy Hilfiger and Topshop set up VR runway shows in their retail stores so that shoppers experience a three-dimensional, front-row view of runway shows (Johns 2016; Tabuchi 2015). Also, J.C. Penney brought VR into their stores in the holiday season to engage consumers by providing memorable experiences (Jiang 2017). While the use of VR in retail stores is still limited to a few special events, VR is expected to make a stable and significant portion of the regular business soon.

VR has already proven its effectiveness and usefulness as a research tool in several fields. For example, VR has been used to treat patients with phobias and anxiety disorders (e.g., Rothbaum et al. 1995), to control pain (Hoffman et al. 2001), and to teach skills (Padgett et al. 2005). The realistic rendering of simulated environments in VR and the efficiency of creating such environments are very attractive to researchers in an applied field. Although retail researchers have not used VR much yet, VR can be an extremely attractive tool for researchers who are interested in investigating in-store experiences of consumers because VR can create and modify virtual stores very easily.

While the benefits are intuitive, some of the technical difficulties the VR technology poses to fashion retailers are largely unknown because of lack of VR studies conducted in the fashion retail context. For example, the previous use of VR is most popular in architecture where the focal interest is in the structural design of buildings with the minimum number of decorative items. However, fashion retail researchers are likely to deal with a large number of items. A typical GAP store holds 1820 SKUs, which translates to several thousand items in a single store. Therefore, for fashion retailers, the large number of items displayed in a store can create unique challenges in using VR.

Moreover, research indicates that understanding consumers' response to new technology such as VR and sharing barriers and requirements for technology implementation is key to designing effective virtual shopping environments and enhancing consumers' shopping experiences (Ballantine 2005; Dacko 2017). This study contributes to the body of literature concerning the use of technology in retail and provides an overview for practitioners and scholars regarding advantages and challenges of using VR and consumer response to VR stores; further highlighting how realistic experiences of virtual stores can be strategically implemented to create engaging and entertaining experiences.

Lastly, despite the powerful impacts of an immersive VR system, a limited number of research used a truly immersive system to examine the difficulties and benefits of using it. Developing an immersive VR environment that simulates a real shopping experiences with users' movements is critical in enriching users' shopping experiences as well as understanding in-store consumer behavior.

Acknowledging this need, the research questions of this study were: (1) What are some costs and benefits of immersive VR fashion stores? and (2) how do VR fashion stores influence consumer behavior? Therefore, the objectives of this study were: (1) to identify advantages and challenges of using an immersive VR technology in the fashion retail context for practitioners and scholars and (2) to understand VR user experience of virtual stores and how it affects shopping outcomes.

## Literature review

### Types of VR systems

VR is computer-simulated, real-time interactive graphics that allow the user to be immersed in the simulated world and to directly interact with the world (Bishop et al. 1992). Virtual reality systems largely fall into two categories, immersive systems and non-immersive systems (Shahrbanian et al. 2012). The main difference between the two systems lies in the realistic responses of the system to the user's movement, the scale of the environment, and the size of the projected virtual environment (see Table 1 below for a comparison of VR systems). In non-immersive systems, a user experiences the virtual environment through a high-resolution monitor. Compared to the immersive systems, the non-immersive systems do not require high-performance hardware and special equipment (Costello 1997). However, because the user navigates the simulated environment that is displayed in a smaller scale using a device (e.g., mouse), the non-immersive systems do not make the users feel present in the virtual environment as strongly as immersive systems do.

**Table 1 Characteristics of VR Systems**

| | Immersive system | | Non-immersive system |
|---|---|---|---|
| | HMD | CAVE | |
| Size of the environment | Real life size | Real life size | Smaller scale |
| User navigation control | Device (e.g., wireless controller)<br>Body movement (e.g., walking, turning head) | Device (e.g., Joystick, data gloves) | Device (e.g., keyboard, mouse) |
| System requirement (resource requirement) | Higher performance hardware and software | Higher performance hardware and software | Lower performance hardware and software |
| Virtual environment presentation | Projected in the headset | Projected to fixed walls of a room | Displayed on desktop computer monitors |
| Feedback to user movement | Responsive to user head position and angle | Responsive to the controller movement | Responsive to the controller movement |
| User awareness of the real world | Low | Low | High |
| Example | Oculus rifts, HTC Vive | CAVE | Desktop systems |
| Realism | High | Medium | Low |
| Sense of presence | High | Medium | Low |

On the other hand, immersive systems provide the user with a realistic experience of virtual environments (Costello 1997) created by highly interactive VR systems (Shahrbanian et al. 2012). Two frequently used output devices that render the virtual environment in immersive VR systems are HMD (Head mounted display) and CAVE (Cave Automatic Virtual Environment) (Ausburn and Ausburn 2004). Such systems require a great amount of resources such as high-performance processors, software, graphic cards, and tracking systems to provide a satisfactory level of realism (Costello 1997). As a result, the user feels a great sense of being in that environment.

## VR user experience

### *Telepresence*

Telepresence is a user's subjective experience of being in an environment created by a medium (Steuer 1992; Weibel et al. 2008). Telepresence is characterized by the immersive experience of a user in a mediated environment, the "medium-induced sense of presence (Steuer 1992, p. 76)," and sometimes also noted as immersion in VR literature (Carrozzino and Bergamasco 2010). Telepresence is a critical variable to describe VR experience because the sense of a user's being in a virtually created environment determines the success of the VR experience. Telepresence predicts the belief, attitude, emotion, and behavioral response of users about the VR system (Klein 2003; Li et al. 2002; Song et al. 2007). Higher level of telepresence caused the participants to have a stronger belief and more positive attitude toward the advertised product (Klein 2003). In addition, in the virtual apparel shopping experience, telepresence positively influenced fantasy, consumer enjoyment, and willingness to purchase (Song et al. 2007).

Characteristics of the virtual environment can increase or decrease telepresence. Vividness, the richness of the mediated environment presentation, and interactivity, the degree of responsiveness of the environment to the user's movement and control, have been identified as key determinants of telepresence (Fortin and Dholakia 2005; Klein

2003; Steuer 1992). Users feel stronger telepresence when the mediated environment is vivid and interactive (e.g., Fortin and Dholakia 2005). VR environments are interactive because they respond to the users' movement or input commands. They are also vivid because the environment depicted is detailed and made with high resolution images. Immersive VR environments are extremely vivid because they provide a life-like environment to experience. Therefore, it is likely that VR users experience a high level of telepresence in the virtual environment.

#### *Perceived realism*

Perceived realism is defined as the subjective realism that users feel (Green 2004). Because VR aims to provide realistic experiences, perceived realism is an important performance variable. VR researchers investigated ways to produce more realistic VR models and experiences. For example, Longhurst et al. (2003) suggested that the accuracy of the computer modeling and illumination calculations, the display device, and the visual process to use information are positively related to the perceived realism. McGloin et al. (2011) also found that how intuitive the controller of virtual video game works is positively associated with the perceived realism of the game.

Perceived realism is associated with positive outcomes. When three-dimensional immersive experience was examined for the clinical education, perceived realism was positively related to the improvement in performance and the feeling of enjoyment (Bridge et al. 2007). In addition, perceived realism can positively influence the sense of presence. In the study of Bae et al. (2012), the sense of presence was elevated when users perceive a high level of realism in the 3D video game. Telepresence also mediated the effect of realism on the strengths of belief and attitude toward the product (Klein 2003).

#### *Emotions*

Previous research documents a close relationship between telepresence and the emotional state. VR environments elicits emotions such as pleasure and arousal when users feel a high level of telepresence. According to Lehtonen et al. (2005), telepresence created by the VR environment allows people to experience things with their senses and engage, which elicits an emotional response. Similarly, Macedonio et al. (2007) demonstrated that telepresence (i.e., immersion) correlates with physiological arousal. Oh et al. (2008) found that VR furniture shopping environments positively influenced participants' pleasure, arousal, and enjoyment with the decision-making process. Neuroscience evidence also provide support for the relationship between telepresence and emotions. The brain regions that orchestrate the experience of presence in a virtual environment are also responsible for sensory and emotion processing (Baumgartner et al. 2008).

#### *Simulator sickness*

Simulator sickness is a visually induced motion sickness (Draper et al. 2001) and is a form of motion sickness characterized by an increase in nausea, headache, and general discomfort when exposed to a virtual reality environment (LaViola 2000). The symptoms include headache, sweating, drymouth, nausea, dizziness, drowsiness, disorientation, and vomiting (Kennedy and Fowlkes 1992). Previous research suggests that simulator sickness is caused by mismatched motion (Groen and Bos 2008), motion parallax

(Jinjakam and Hamamoto 2011), viewing angle (Ruddle 2004), limited reproduction of real environment (Moss and Muth 2011), and the imperfect simulation of human–world interactions (Draper et al. 2001). The simulator sickness is caused by the discrepancy between the visual system and the vestibular system which perceive the direction and the acceleration of motion (Reason 1978). Simulator sickness is a major reason for users to abandon VR (Draper et al. 2001).

### A content analysis of VR studies in retail

To understand how VR was studied in retail, a content analysis was conducted to review the method, variables, contexts, and devices used in the previous studies. To select the studies to be examined, two independent researchers collected studies from databases. Combinations of the keywords, "virtual reality", "consumer", "shopping", "retail", and "store", were used to search the relevant studies. The search resulted in two hundred articles. These articles were reviewed to evaluate the relevance of the articles to the interest and scope of the current study (i.e., VR use in retail). Many of these studies were not relevant because they either briefly introduced VR concept without truly investigating VR or their focus was technical methods to develop parts of a VR system. After the evaluation, 20 out of 200 studies were determined as relevant and used for further analyses.

Two researchers independently coded each of these 20 articles for the type of study (e.g., conceptual, empirical), research methods (e.g., interview, experiment), sample characteristics, the number of participants, study context (e.g., web based shopping mall, virtual grocery store), VR system components such as VR output (e.g., headsets, screen) and input/control devices (e.g., joysticks, mouse), the type of output device (i.e., immersive, non-immersive), and the type of participants' interaction with the system (e.g., zooming, selecting products, navigating) (Table 2).

Out of 20, the majority (85%, n = 17) of articles was empirical studies while only three (15%, n = 3) were conceptual studies. Among the empirical studies, the majority of the studies (82.4%, n = 14) used a non-immersive system, having the users view the virtual environment on a computer screen. Only three studies (17.6%) used an immersive VR system. Participants interacted with the VR environment using input devices in many studies (e.g., zooming in and out, rotating, clicking, etc.). Regardless of the VR system type, all studies had their participants seated in a chair (either in front of a computer monitor in non-immersive systems or in a room wearing a headset in immersive systems). Therefore, the participants did not change their location physically when they interacted with the VR environments.

While the sample size ranged greatly from 5 to 1313, the studies using an immersive VR system had a relative small sample size (10–41). The study contexts can be largely grouped into two types: online shopping mall (30%, n = 6) and brick-and-mortar store (40%, n = 8). Online shopping mall included e-commerce site which display products using VR techniques and virtual shopping mall where participants can navigate the environment. Several kinds of brick-and-mortar stores were used in the studies such as grocery stores, tobacco store, convenience stores, and restaurant.

The presence and absence of VR were used as independent variables to compare the differences caused by VR application in the previous studies. The perception of the environment (e.g., perceived crowding) or the display cues (e.g. the visibility of cigarette

**Table 2 Research on the virtual reality and retailing in chronological order**

| Author(s) | Method | Context | VR system type | Input/output devices | User interaction |
|---|---|---|---|---|---|
| Williams and Hobson (1995) | Conceptual | N/A | N/A | N/A | N/A |
| Chittaro and Ration (2000) | Conceptual | N/A | N/A | N/A | N/A |
| Oh et al. (2004) | Conceptual | N/A | N/A | N/A | N/A |
| Jiang and Benbasat (2004) | Experiment (N = 84) | E-commerce site (sports watch) | Nonimmersive | Mouse/PC monitor | Rotating, zooming in and out, and moving the images |
| Suh and Lee (2005) | Experimental (N = 85) | E-commerce site (computer table and desktop computer) | Nonimmersive | Mouse/PC monitor | Rotating, zooming in and out |
| Lee and Chung (2005) | Experimental (N = 80) | Virtual shopping mall | Nonimmersive | Mouse/PC monitor | Browsing, clicking |
| Whitney et al. (2006) | Experimental (case study) (N = 5) | Virtual grocery store | Nonimmersive | Controller/BNAVE: the balance NAVE automatic virtual environment | Holding the controller and postural control for multi-sensory interactions |
| Papadopoulou (2007) | Interviews, observation (N = 43) | Virtual shopping mall | Nonimmersive | Mouse/PC monitor | Text-based chat |
| Lee and Chung (2008) | Experimental (N = 102) | Virtual shopping mall | Nonimmersive | Control panel/PC monitor | Navigating, browsing |
| Park et al. (2008) | Experimental (N = 10) | Simulation of virtual product (mp3, game, phone) | Immersive | Keyboard, mouse, data glove/HMD | Push buttons, moving the product |
| Oh et al. (2008) | Experimental (N = 92) | Furniture shopping | Nonimmersive | Keyboard, mouse/PC monitor | Rotating, zooming in and out, manipulating products |
| Spiers et al. (2008) | Experimental (N = 40) | Grocery store | Nonimmersive | Mouse, joystick/PC monitor | Navigating |
| Jin (2009) | Experimental (N = 48) | Second life with spokes-avatar | Nonimmersive | None/PC monitor | None |
| Paris et al. (2011) | Experimental (N = 24) | Convenience store | Immersive | Game pad/HMD | Navigating, browsing |
| Hwang et al. (2012) | Experimental (N = 61) | Restaurant waiting area | Nonimmersive | Joystick/PC monitor | Navigating, browsing |
| Pantano and Laria (2012) | Experimental (N = 36) | Virtual shopping mall | Nonimmersive | Joystick/two projectors and a computer | Navigating, browsing data sheets |
| Kim et al. (2014) | Experimental (N = 1216) | Tobacco store | Nonimmersive | Mouse/PC monitor | Clicking |
| van Herpen et al. (2016) | Experimental (N = 100) | Supermarket, aisle, promotion | Nonimmersive | Keyboard, mouse/PC monitor | Navigating |
| Bigné et al. (2016) | Experimental (N = 41) | A supermarket aisle with beer category | Immersive | Head-tracking system, wireless eye-tracking glasses/CAVE | Viewing |
| Nonnemaker et al. (2016) | Experimental (N = 1313) | Tobacco store | Nonimmersive | Joystick/PC monitor | Navigating, purchasing |

and health signs) were also investigated as independent variables. Dependent variables included emotion, attitude, and intention for the retail stores as well as the evaluation of the virtual reality experience (e.g., perceived discomfort, feeling of presence). The product or environment created by VR system caused higher level of pleasure and arousal (Oh et al. 2008), more positive attitude, and higher purchase intention (Lee and Chung 2005; Suh and Lee 2005) than VR absent condition.

The content analysis revealed the shortage of immersive device usage compared to non-immersive device in VR literature. With the emergence of immersive VR systems in the consumer market, it will be important to investigate the immersive VR systems to provide insights to the retailers. Moreover, no previous study created or investigated VR apparel stores. Compared to supermarkets or tobacco stores where the products are often packaged and displayed in boxes and the store layouts are simple grids, apparel stores tend to emphasize artistic and free layouts and have soft surface products. Therefore, the findings of previous VR studies may not be applicable to the apparel stores (Fig. 1).

## Methods

### Developing VR apparel stores

As the content analysis revealed, little previous research used a truly immersive system to understand the costs and benefits of using such a system. Thus, the focal interest of this study was to develop a VR environment that simulates a real shopping experience that allows users to move freely without using an input device.

The 3D modeling computer program "SketchUp" was used to create the virtual apparel stores. SketchUp is widely used for architectural and interior design in addition to mechanical and product design. Four models were developed in SketchUp to represent various kinds of store layouts and design themes that reflect typical fashion stores. Specifically, two store models were designed based on natural design themes (e.g., hardwood floors, wood walls) while the other two store models reflected modern design themes (e.g., metal wall panels). After the SketchUp models are created they were exported, converted to CAD data, and then converted again to VR data. Because CAD data are usually in a parametric form whereas VR data are in the form of tessellated polygons, a mesh of triangles (Purschke et al. 1998), CAD data need to be converted to polygons which define the surfaces of visual objects in VR. For example, if the surface of an object is curved in CAD data, arrangements of polygons that closely match the curved surface replace the surface in VR. Only this polygonal representation of a model allows for simultaneous rendering for VR (Beier 2000).

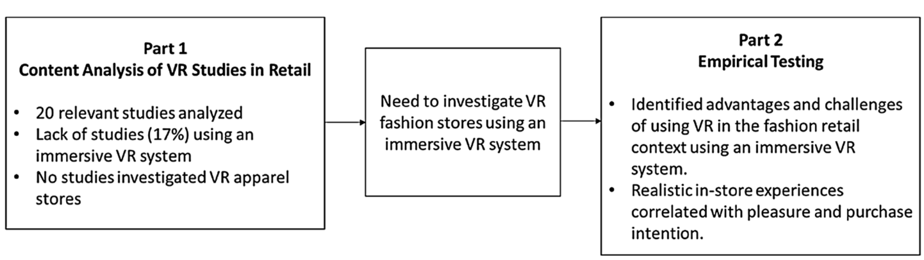


**Fig. 1** Summary of research processes and results

One common issue in creating a VR model is concerned with a number of polygons in the model. Because software renders objects by drawing polygons that approximate the target objects, modeling is simpler when the object is created with flat and angular faces (e.g., a box, pyramid). As the complexity of objects in a model increases, the number of polygons also increases (Nilsson et al. 2004). A large number of polygons is problematic as it requires a large amount of processing which slows down the VR system significantly (Marks et al. 2014). A VR model with more polygons reduces the rendering speed of the system, causing delayed display of the scene following the user's head movement (Kim 2016). This affects a VR system's ability to provide immersive experiences, and is known to induce simulator sickness (Kim 2016). To prevent this problem, model optimization tools [e.g., Level of Detail (LOD)] that reduce the number of polygons rendered for an object (Yilmaz et al. 2004) are used. However, such optimization processes may decrease the details and visual realism of models which interrupts user immersion (Kim 2016).

This polygon issue was particularly problematic for fashion VR retail stores due to the complexity of the products and various objects that are unique to fashion stores. A fashion retail store carries full product lines including over a thousand products and has a number of mannequins that display such products. These products and objects are made with a lot of curved surfaces and details (i.e., textures, trims, patterns) which poses a major challenge for developing a VR model store since it increases the number of polygons in the model. Possible solutions to resolve this issue may include using the most up-to-date computational resources (Berg and Vance 2017a, b) and optimization software tools (Martinez 2015).

## Empirical testing with VR model stores

### *Apparatus*

The testing of the VR stores was conducted at the Virtual Reality Design Lab, located in the public courtyard (25-by-25-foot) at the University of Minnesota. This VR lab is equipped with the necessary technologies to create an immersive VR experience. Four major technologies are needed to develop a truly immersive VR store: (1) the virtual headsets that provide the visual displays to the user and block out the real world sensory information, (2) the graphics rendering system that creates the visual sensations that are output to the user, (3) the tracking system that detects and reports the user's position and orientation, and (4) the database construction and maintenance system that manages the models (Burdea and Coiffet 1994; Brooks 1999) (Fig. 2).

The lab is set up based on coordination between two systems: the tracking system and the graphics system [VRDL (n.d.)]. The tracking system traces a user's real-time location, movement, and head positioning within the courtyard. The tracking system consists of the PhaseSpace Impulse camera system, LED markers, and camera server. The coordination and communication between these three elements allow the VR system to track the user positions immediately and accurately.

In the center of the courtyard, a truss is installed which serves as a framework for mounting the camera system. The camera system consists of 36 PhaseSpace camera modules placed in groups of three at 12 nodes of the truss. Each module contains a binocular pair of cameras and a processor. The cameras capture images of movement at the rate of 960 frames per second. The processor analyzes the images to find LED markers

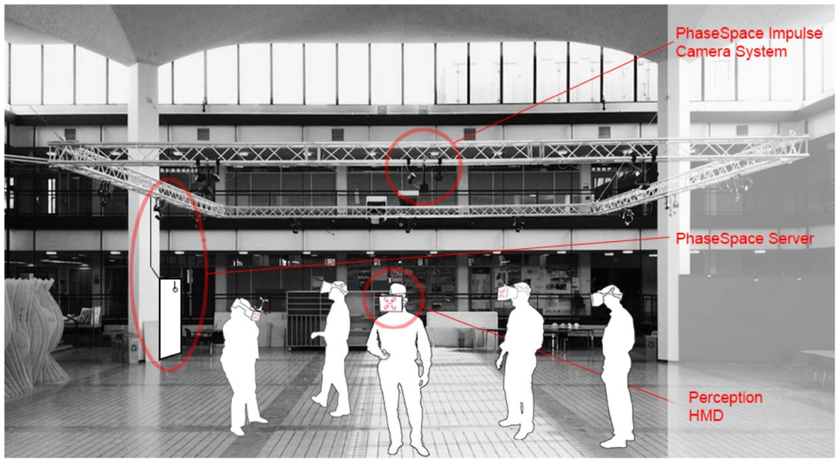


**Fig. 2** Virtual reality design lab system setup

and determines their location in the courtyard. The LED markers are attached to head-mounted displays (HMDs). Each user wears a HMD with LED markers that emit unique light signals visible to the camera system. The camera server, the last part of the tracking system, process the data collected from each camera module to locate the actual positions of the participants within a 1-mm accuracy.

The graphic system translates the user location and head position data and creates 3D visual scenes that correspond to the user's point of view. Unlike previous trackable HMDs that required heavy equipment on the users, this HMD uses tablets and cellphones, which makes it cost-effective and lightweight. The devices were loaded with a custom app that retrieves the location data from the camera server via Wifi and renders 3D visual scenes in stereo. In the testing, four Apple iPad mini tablets were used.

### *Procedures*

Females between age 18 and 40 were invited to participate in a study of VR store experience from a large Midwestern University in the U.S. Only females were recruited because the VR model stores were designed to target female customers. Moreover, previous research reported gender difference for experiencing a sense of presence (Felnhofer et al. 2012) and acquiring navigational knowledge in a virtual environment (Cutmore et al. 2000).

Once the interested participants signed up for the study, they were contacted with details of the study and a link to an online survey. This pre-survey included questions regarding their prior experience with VR and general exploratory tendency. The VR testing sessions were scheduled 7–10 days after their completion of the pre-survey.

During the 1-h individual VR sessions, the participant first reviewed the consent form and was informed about the testing procedure in the reception area. Then, the participant was escorted to the entry point of the VR store in the courtyard. Four headsets preloaded with different VR stores were set up in the entry point. A researcher randomly picked one headset out of four and asked the participant to wear the headset. In the VR environment, the participant was standing in a virtual shopping mall. The participant could see several storefronts on both sides of the path. The participant was asked to try interacting with the VR environment by slowly walking along the path she was on and then walking back to the spot she started. This trial was not only to help participants get adjusted to the VR environment and learn to navigate in the environment but also to ensure they do not experience sickness.

After they came back to the entry point, a researcher guided the participant to the target VR storefront and introduced her to the model store. The store was located in the middle of the path. The participant was asked to enter the store and freely explore it as much as she wanted to. Another researcher recorded what the participant viewed during the session through the computer connected to the headset and measured the time each participant spent in the target store. The participants were asked to raise a hand once she completed exploring the store.

After the VR experience, the participant was escorted to a partitioned private area and completed a paper-based questionnaire for telepresence, perceived realism, emotion (pleasure, arousal), attitude toward the store, purchase intention, and simulator sickness (see Table 3). All measures were adapted from prior research.

## Results and discussion

A total of 40 females (mean age = 21.05) participated in the study. Four participants (10%) have experienced VR prior to this study. Among 40 participants, one experienced severe dizziness during the trial period and dropped out of the study. On average, participants spent 80.53 s (SD = 38.50) exploring a store.

### Using VR technology in creating virtual apparel stores

One of the purposes of this study is to evaluate the feasibility of using VR apparel stores. In the following section, challenges and advantages of using VR technology for virtual apparel stores are discussed to examine practical benefits and costs of VR apparel store creation.

#### *Challenges*

As discussed earlier, managing the number of polygons is the biggest challenge in developing VR models. The products almost always have complex curves due to the soft nature of textile products. Mannequins in the store are also created with very complex curves. In addition, textile surfaces are very complicated to render compared to flat, shiny surfaces such as plastics, glass, or metal. A high level of detail is needed to realistically render textile surfaces (e.g., knitted and woven fabric). The researchers had to go through several simplification processes to reduce the number of polygons while maintaining a reasonable level of details. The details and texture of the apparel objects in the stores had to be compromised and the number of different unique products had to be reduced to make the VR stores operable in the VR system.

Another challenge arose when developing products to be placed inside the virtual stores because SketchUp was not specifically designed for developing fashion retail stores. A great portion of work had to be done manually. For example, SketchUp does not have a tool that automatically detects the silhouette of clothes and converts it to 3D

**Table 3 Measurement items**

| Variable | Measurement items | Scale | Mean (SD) |
|---|---|---|---|
| Telepresence (Fiore et al. 2005) | This store would let me easily visualize what the actual store is like<br>This store would give me as much sensory information as I would experience in a store<br>This store would create an experience similar to the one I'd have when shopping in a store | 1 (strongly disagree) to 7 (strongly agree) | 5.10 (1.14) |
| Perceived realism (Prothero et al. 1995) | How real did the virtual store seem to you? | 1 (not at all) to 7 (very much) | 4.76 (1.09) |
| Pleasure (Mehrabian and Russell 1974) | Unhappy–happy<br>Annoyed–pleased<br>Unsatisfied–satisfied<br>Melancholic–contented<br>Despairing–hopeful<br>Bored–relaxed | 7-point semantic differential scale | 5.04 (1.03) |
| Arousal (Mehrabian and Russell 1974) | Relaxed–stimulated<br>Calm–excited<br>Sluggish–frenzied<br>Dull–jittery<br>Sleepy–wide awake<br>Unaroused–aroused | 7-point semantic differential scale | 4.31 (1.44) |
| Attitude (Bezjian-Avery et al. 1998) | Bad–good<br>Awful–nice<br>Unappealing–appealing<br>Not attractive–attractive<br>Boring–interesting | 7-point semantic differential scale | 4.62 (1.21) |
| Purchase intention (Dodds et al. 1991) | I would consider buying products at this store<br>I will purchase products at this store<br>There is a strong likelihood that I will purchase products at this store | 1 (strongly disagree) to 7 (strongly agree) | 3.68 (1.35) |
| Simulator sickness (Kennedy et al. 1993) | General discomfort<br>Fatigue<br>Headache<br>Eyestrain<br>Difficulty focusing<br>Increased salivation<br>Sweating<br>Nausea<br>Difficulty concentrating<br>Fullness of head<br>Blurry vision<br>Dizzy (eyes open)<br>Dizzy (eyes closed)<br>Vertigo<br>Stomach awareness | 1 (not at all) to 7 (very much) | 2.72 (1.33) |

images. Therefore, the product and item development was time-consuming and labor intensive.

### *Advantages*

During this study, the researchers created four different store layouts, completely changing the fixtures, window display setups, and walking paths of customers while using the same merchandise in the store. Once the first store was created after resolving the polygon issues, manipulating the initial store to create additional stores was relatively easy and smooth. Moving merchandise, removing and placing a new type of fixture, creating or deleting inner walls and partitions, and changing the design of storefront windows were quick and mostly problem-free. Loading and testing multiple VR stores with users was also easy. During the VR testing session, the researchers were able to switch between models easily by preloading four store models on different HMDs and controlling the VR model to project from the computer system. The transition between models took less than 2 min. This is an important advantage of using VR in developing and testing fashion store designs. Practically, multiple stores designs can be loaded one after another for quick and easy comparison.

#### Experience of VR users

Another goal of the study was to understand user experience in the VR apparel stores. Examining experience of the VR users is important for several reasons. First of all, the users must perceive the VR stores as realistic and engaging for VR stores to be successfully implemented. Secondly, it was of interest of the researchers to see if the users feel positive (or negative) emotions and form attitude and intention in response to the VR stores. Lastly, the severity of the negative user experience factor, simulator sickness, needed to be examined and considered. Therefore, the users' perception of the environment, emotional states, their attitudinal and behavioral responses to the environment, and felt simulator sickness after the session were evaluated. These experiences were measured through the self-administered post-session survey. Prior to the analysis, it was confirmed that there was no significant mean difference in the measured variables among the four VR stores. Therefore, the findings are consistent in all four models.

The participants generally reported high telepresence ($M = 5.10$, $SD = 1.14$) and perceived realism ($M = 4.76$, $SD = 1.09$), suggesting the overall positive evaluation of these two measures. Participants' exploratory tendency did not affect their telepresence or perceived realism scores. The results imply that the virtual stores provided participants with an immersive experience that can be comparable to real store experiences.

In order to examine how participants' immersive experience with the virtual store influenced shopping outcomes (i.e., pleasure, arousal, attitude toward virtual stores, purchase intention, time spent), bivariate correlation analyses were conducted. The results showed a significant positive correlation between telepresence and perceived realism ($r = .49$, $p < .01$), pleasure ($r = .383$, $p < .05$), attitude ($r = .356$, $p < .05$), and purchase intention ($r = .47$, $p < .01$). These findings are consistent with previous research that telepresence of virtual apparel stores positively influences consumers' shopping outcomes such as enjoyment and purchase intention (Song et al. 2007).

Inconsistent with previous research that reported positive relationships between telepresence and arousal (Baumgartner et al. 2008; Lombard et al. 2000), telepresence was not significantly correlated with arousal ($r = .21$, $p = .21$) or time spent in the store ($r = -.02$, $p = .90$). This conflicting finding may be due to the different experiment designs and how arousal was measured. Baumgartner et al. (2008) used continuous EEG and psychophysiological measures (i.e., skin conductance response, heart rate) to detect arousal while the current study relied on a self-reported questionnaire to measure arousal. The reported arousal level at the end of VR store experience could be different from the real-time fluctuation of arousal levels during their experience. Alternatively, the scenes created by Baumgartner et al. might not have induced as high arousal. Considering how arousal has an inverted-U shaped relationship with many outcome variables, a very high level of arousal induced by VR experience may not have been detected through bivariate correlation tests. Additional analysis revealed that there was a significant quadratic relationship between pleasure and arousal ($R^2 = .47$, $F(2,35) = 15.70$, $p < .001$).

The participants experienced notable symptoms of simulator sickness. While only one participant out of forty felt sick enough to terminate the session, simulator sickness affected a good portion of participants. Almost 40% of the participants felt some level of discomfort, 35% of them experienced dizziness, 33% of them experienced eyestrain, and 30% experienced nausea. This is consistent with other studies that the major simulator sickness includes general discomfort (Jinjakam and Hamamoto 2011) and eyestrain and nausea (Ruddle 2004). This implies researchers and retailers must use caution when implementing VR in their business or studies and plan for necessary breaks especially when the users are exposed to the environment for an elongated period.

## Conclusion and implications

The current study provided a content analysis of previous studies on VR usage for retail and filled the gap in the literature by developing VR apparel stores and empirically testing them using a truly immersive VR system. The overview and findings provide important implications to practitioners and scholars that immersive VR can be a promising tool to use even though there are a few challenges.

First of all, the results showed that the immersive experience of VR was positively related with important shopping outcomes such as pleasure, attitude toward virtual stores, and purchase intention. This signifies that VR can be used as a new shopping method to enhance consumers' experience and engagement. For example, virtual reality stores can enable consumers to be better informed about the upcoming or current products and services beyond two-dimensional photos or videos. These realistic visual presentations of products and services will generate more positive emotions and attitudes toward the store, and eventually prompt more purchases. Therefore, fashion marketers should take advantages of virtual reality to provide consumers with memorable, distinctive experiences and realistic experiences of products or stores without physical locations.

Next, the immersive VR systems are a promising tool to understand consumers' in-store exploratory behavior and their evaluations of store designs as well as to minimize time and money associated with developing physical fashion stores. Because VR allows users to experience full-scale, realistic store designs in a computer-simulated virtual world, the experience and evaluation is relatively accurate. Moreover, developing and adjusting store designs with VR is cost-efficient (Dunston et al. 2007), shortens the development time by facilitating communication among people (Majumdar et al. 2006; Maldovan et al. 2006), and allows the researchers and designers to draw conclusions based on evidence (Dunston et al. 2007). Particularly for researchers, VR can be a superior tool to study in-store consumer behaviors. Its ability to provide quality real-time data of user experience and behavior can complement the weakness of self-reported data such as reporting errors (Tourangeau 1984, p. 74). Also, researchers can create multiple store designs while completely controlling all aspects of the store, minimizing confounding factors in the environment.

The challenges of using a truly immersive VR system include simulator sickness and the investment cost. How the simulator sickness impacts the user's impression of the store should be considered in the application of VR. The initial cost to install an immersive VR system includes equipment (e.g., headsets, the tracking system, software and computer system) and human resources (e.g., skilled programmers). The unique challenges of creating apparel stores require competent and experienced programmers and designers.

## Limitations of the current study and future suggestions

The VR system used in the study did not allow users to touch or move virtual products, limiting realism of the VR environment. It is one of the major limitations of studies using VR considering haptic perception plays an important role in evaluating clothing (McCabe and Nowlis 2003). While the scope of study was limited to exploration behaviors, how much this limited interaction influenced the users is unknown. A future study comparing the VR shopping experience with the real shopping experience can provide insights on that matter.

In the current study, participants explored the VR store alone. In a realistic shopping environment, customers are often in a store with other customers and salespersons. Considering the significant impact in-store crowding and the social aspects of shopping have on customers (e.g., Li et al. 2009; Machleit et al. 2000), future research could investigate customer experience in a setting with multiple users.

Another potential area for the future research is an examination of the retail atmospherics effects on consumer behavior with the use of VR. Traditionally, retail atmospherics has been examined using surveys, role-playing, and simulations on computer screens. With VR models, various factors such as music, scent, and tactile information can be incorporated easily to test their impacts on consumer behavior.

Moreover, the current study only investigated female users. In VR literature, gender difference has been documented. Compared to females, males experienced a higher sense of presence (Felnhofer et al. 2012) and were better at acquiring navigational knowledge (Cutmore et al. 2000). Investigation of gender difference in VR shopping experience will provide valuable information for retailers.

Lastly, this study used a customized HMD (Head mounted display) that used an iPad to investigate VR fashion stores. However, there are other commercial HMD options available such as Oculus Rift, PlayStation VR, HTC Vive, and Samsung gear VR. Moreover, researchers or practitioners may also consider using a CAVE (Cave Automatic Virtual Environment) to explore VR fashion stores which may be less immersive but provide advantages of allowing multiple people to examine with natural interaction and providing less simulator sickness to users (Visbox 2016).

**Authors' contributions**
MP, HI, DK contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors read and approved the final manuscript.

**Author details**
[1] Sigmund Weis School of Business, Susquehanna University, 514 University Ave., Selinsgrove, PA 17870, USA. [2] Retail Merchandising, University of Minnesota, 240 McNeal Hall, 1985 Buford Avenue, St. Paul, MN 55108, USA.

**Acknowledgements**
*Fashion and Textiles* is supported by the Korean Federation of Science and Technology Societies Grant funded by the Government of the Republic of Korea (Ministry of Education).

**Competing interests**
The authors declare that they have no competing interests.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 6 December 2017 Accepted: 8 May 2018
Published online: 03 December 2018

**References**

Arthur, R. (2016, Jan 26). *The Future Of Retail: Beyond Stories Told, To Stories Experienced.* Retrieved January 26, 2016, from https://www.forbes.com/sites/rachelarthur/2016/01/26/the-future-of-retail-beyond-stories-told-to-stories-experienced/#77dc95455b64.

Ausburn, L. J., & Ausburn, F. B. (2004). Desktop virtual reality: A powerful new technology for teaching and research in industrial teacher education. *Journal of Industrial Teacher Education, 41*(4), 1–16.

Bae, S., Lee, H., Park, H., Cho, H., Park, J., & Kim, J. (2012). The effects of egocentric and allocentric representations on presence and perceived realism: Tested in stereoscopic 3D games. *Interacting with Computers, 24*(4), 251–264.

Ballantine, P. W. (2005). Effects of interactivity and product information on consumer satisfaction in an online retail setting. *International Journal of Retail and Distribution Management, 33*(6), 461–471.

Baumgartner, T., Speck, D., Wettstein, D., Masnari, O., Beeli, G., & Jäncke, L. (2008). Feeling present in arousing virtual reality worlds: prefrontal brain regions differentially orchestrate presence experience in adults and children. *Frontiers in Human Neuroscience, 2,* 8.

Beier, K. P. (2000). Web-based virtual reality in design and manufacturing applications. In *Proceedings of COMPIT* (pp. 45–55).

Berg, L. P., & Vance, J. M. (2017). Industry use of virtual reality in product design and manufacturing: A survey. *Virtual Reality, 21*(1), 1–17.

Bezjian-Avery, A., Calder, B., & Lacobucci, D. (1998). New media interactive advertising vs. traditional advertising. *Journal of Advertising Research, 38,* 23–32.

Bigné, E., Llinares, C., & Torrecilla, C. (2016). Elapsed time on first buying triggers brand choices within a category: A virtual reality-based study. *Journal of Business Research, 69*(4), 1423–1427.

Bishop, G., Bricken, W., Brooks, Jr., F., Brown, M., Burbeck, C., Durlach, N., Wenzel, E. (1992). *Research directions in virtual environments: Report of an NSF invitational workshop*. Retrieved March 23–24, 1992, from https://pdfs.semanticscholar.org/b155/f6cd9b5ae545fb0fba1f80529699f074e8ab.pdf.

Bridge, P., Appleyard, R. M., Ward, J. W., Philips, R., & Beavis, A. W. (2007). The development and evaluation of a virtual radiotherapy treatment machine using an immersive visualisation environment. *Computers and Education, 49*(2), 481–494.

Brooks, F. P. (1999). What's real about virtual reality? *IEEE Computer Graphics and Applications, 19*(6), 16–27.

Burdea, G. C., & Coiffet, P. (1994). *Virtual reality technology*. London: Wiley-Interscience.

Carrozzino, M., & Bergamasco, M. (2010). Beyond virtual museums: Experiencing immersive virtual reality in real museums. *Journal of Cultural Heritage, 11*(4), 452–458.

Chittaro, L., and Ration, R. (2000). Adding adaptive features to virtual reality interfaces for e-commerce. In *International Conference on Adaptive Hypermedia and Adaptive Web-based Systems* (pp. 86–97). Berlin: Springer.

Costello, P. J. (1997). In *Health and safety issues associated with virtual reality: a review of current literature* (pp. 1–23). Advisory Group on Computer Graphics.

Cutmore, T. R., Hine, T. J., Maberly, K. J., Langford, N. M., & Hawgood, G. (2000). Cognitive and gender factors influencing navigation in a virtual environment. *International Journal of Human-Computer Studies, 53*(2), 223–249.

Dacko, S. G. (2017). Enabling smart retail settings via mobile augmented reality shopping apps. *Technological Forecasting and Social Change, 124,* 243–256.

Dodds, W. B., Monroe, K. B., & Grewal, D. (1991). Effects of price, brand, and store information on buyers' product evaluations. *Journal of Marketing Research, 28*(3), 307–319.

Draper, M. H., Viirre, E. S., Furness, T. A., & Gawron, V. J. (2001). Effects of image scale and system time delay on simulator sickness within head-coupled virtual environments. *Human Factors, 43*(1), 129–146.

Dunston, P. S., Arns, L. L., and Mcglothlin, J. D. (2007). An immersive virtual reality mock-up for design review of hospital patient rooms. In *7th International Conference on Construction Applications of Virtual Reality*.

Felnhofer, A., Kothgassner, O. D., Beutl, L., Hlavacs, H., and Kryspin-Exner, I. (2012). Is virtual reality made for men only? Exploring gender differences in the sense of presence. In *Proceedings of the International Society on presence research* (pp. 103–112).

Fiore, A. M., Kim, J., & Lee, H. H. (2005). Effect of image interactivity technology on consumer responses toward the online retailer. *Journal of Interactive Marketing, 19*(3), 38–53.

Fortin, D. R., & Dholakia, R. R. (2005). Interactivity and vividness effects on social presence and involvement with a web-based advertisement. *Journal of Business Research, 58,* 387–396.

Green, M. C. (2004). Transportation into narrative worlds: The role of prior knowledge and perceived realism. *Discourse Processes, 38*(2), 247–266.

Groen, E. L., & Bos, J. E. (2008). Simulator sickness depends on frequency of the simulator motion mismatch: An observation. *Presence, 17*(6), 584–593.

Hoffman, H. G., Patterson, D. R., Carrougher, G. J., & Sharar, S. R. (2001). Effectiveness of virtual reality-based pain control with multiple treatments. *The Clinical Journal of Pain, 17*(3), 229–235.

Hwang, J., Yoon, S. Y., & Bendle, L. J. (2012). Desired privacy and the impact of crowding on customer emotions and approach-avoidance responses: Waiting in a virtual reality restaurant. *International Journal of Contemporary Hospitality Management, 24*(2), 224–250.

Jiang, E. (2017). *Virtual Reality: Growth Engine for Fashion?* Retrieved February 28, 2017, from https://www.businessoffashion.com/articles/fashion-tech/virtual-reality-growth-engine-for-fashion.

Jiang, Z., & Benbasat, I. (2004). Virtual product experience: Effects of visual and functional control of products on perceived diagnosticity and flow in electronic shopping. *Journal of Management Information Systems, 21*(3), 111–147.

Jin, S. A. A. (2009). The roles of modality richness and involvement in shopping behavior in 3D virtual stores. *Journal of Interactive Marketing, 23*(3), 234–246.

Jinjakam, C., & Hamamoto, K. (2011). Study on parallax affect on simulator sickness in one-screen and three-screen immersive virtual environment. *Proceedings of The School of Information and Telecommunication Engineering Tokai University, 4,* 34–39.

Johns, A. (2016). *4 Reasons Why Fashion Brands Are Adopting Virtual Reality.* Retrieved May 24, 2016, from http://www.huffingtonpost.ca/awane-jones/virtual-reality-fashion_b_10069340.html.

Kennedy, R. S., & Fowlkes, J. E. (1992). Simulator sickness is polygenic and polysymptomatic: Implications for research. *The International Journal of Aviation Psychology, 2*(1), 23–38.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology, 3*(3), 203–220.

Kim, J. (2016). Modeling and optimization of a tree based on virtual reality for immersive virtual landscape generation. *Symmetry, 8*(9), 93.

Kim, A. E., Nonnemaker, J. M., Loomis, B. R., Shafer, P. R., Shaikh, A., Hill, E., et al. (2014). Influence of point-of-sale tobacco displays and graphic health warning signs on adults: Evidence from a virtual store experimental study. *Journal Information., 104*(5), 888–895.

Klein, L. R. (2003). Creating virtual product experiences: The role of telepresence. *Journal of interactive Marketing, 17*(1), 41–55.

LaViola, J. J., Jr. (2000). A discussion of cybersickness in virtual environments. *ACM SIGCHI Bulletin, 32*(1), 47–56.

Lee, K. C., & Chung, N. (2005). A web DSS approach to building an intelligent internet shopping mall by integrating virtual reality and avatar. *Expert Systems with Applications, 28*(2), 333–346.

Lee, K. C., & Chung, N. (2008). Empirical analysis of consumer reaction to the virtual reality shopping mall. *Computers in Human Behavior, 24*(1), 88–104.

Lehtonen, M., Page, T., and Thorsteinsson, G. (2005). Emotionality considerations in virtual reality and simulation based learning. In *CELDA* (pp. 26–36).

Li, H., Daugherty, T., & Biocca, F. (2002). Impact of 3-D advertising on product knowledge, brand attitude, and purchase intention: The mediating role of presence. *Journal of Advertising, 31*(3), 43–57.

Li, J. G. T., Kim, J. O., & Lee, S. Y. (2009). An empirical examination of perceived retail crowding, emotions, and retail outcomes. *The Service Industries Journal, 29*(5), 635–652.

Lombard, M., Reich, R. D., Grabe, M. E., Bracken, C. C., & Ditton, T. B. (2000). Presence and television. *Human Communication Research, 26*(1), 75–98.

Longhurst, P., Ledda, P., and Chalmers, A. (2003). Psychophysically based artistic techniques for increased perceived realism of virtual environments. In *Proceedings of the 2nd international conference on Computer graphics, virtual Reality, visualisation and interaction in Africa* (pp. 123–132). New York: ACM.

Macedonio, M. F., Parsons, T. D., Digiuseppe, R. A., Weiderhold, B. A., & Rizzo, A. A. (2007). Immersiveness and physiological arousal within panoramic video-based virtual reality. *Cyberpsychology and Behavior, 10*(4), 508–515.

Machleit, K. A., Eroglu, S. A., & Mantel, S. P. (2000). Perceived retail crowding and shopping satisfaction: what modifies this relationship? *Journal of Consumer Psychology, 9*(1), 29–42.

Majumdar, T., Fischer, M. A., and Schwegler, B. R. (2006). Conceptual design review with a virtual reality mock-up model. In *Joint International Conference on Computing and Decision Making in Civil and Building Engineering*.

Maldovan, K. D., Messner, J. I., and Faddoul, M. (2006). Framework for reviewing mockups in an immersive environment. In *CONVR*, *2006*, 6th *International Conference on Construction Applications of Virtual Reality*.

Marks, S., Estevez, J. E., & Connor, A. M. (2014). Towards the Holodeck: Fully immersive virtual reality visualisation of scientific and engineering data. In *Proceedings of the 29th International Conference on Image and Vision Computing New Zealand* (pp. 42–47). New York: ACM.

Martinez, B. (2015). *Adapting architectural models for visualization using virtual reality headsets*. https://digitalcommons.andrews.edu/cgi/viewcontent.cgi?article=1127&context=honors. Retrieved 10 May 2017.

McCabe, D. B., & Nowlis, S. M. (2003). The effect of examining actual products or product descriptions on consumer preference. *Journal of Consumer Psychology, 13*(4), 431–439.

McGloin, R., Farrar, K. M., & Krcmar, M. (2011). The impact of controller naturalness on spatial presence, gamer enjoyment, and perceived realism in a tennis simulation video game. *Presence: Teleoperators and Virtual Environments, 20*(4), 309–324.

Mehrabian, A., & Russell, J. A. (1974). *An approach to environmental psychology*. Cambridge: MIT Press.

Moss, J. D., & Muth, E. R. (2011). Characteristics of head-mounted displays and their effects on simulator sickness. *Human Factors, 53*(3), 308–319.

Nilsson, T., Ahlqvist, J., Johansson, M., & Isberg, A. (2004). Virtual reality for simulation of radiographic projections: validation of projection geometry. *Dentomaxillofacial Radiology, 33*(1), 44–50.

Nonnemaker, J., Kim, A., Shafer, P., Loomis, B., Hill, E., Holloway, J., et al. (2016). Influence of point-of-sale tobacco displays and plain black and white cigarette packaging and advertisements on adults: Evidence from a virtual store experimental study. *Addictive Behaviors, 56,* 15–22.

Oh, H., Yoon, S. Y., & Hawley, J. (2004). What virtual reality can offer to the furniture industry. *Journal of Textile and Apparel, Technology and Management, 4*(1), 1–17.
Oh, H., Yoon, S. Y., & Shyu, C. R. (2008). How can virtual reality reshape furniture retailing? *Clothing and Textiles Research Journal, 26*(2), 143–163.
Padgett, L. S., Strickland, D., & Coles, C. D. (2005). Case study: using a virtual reality computer game to teach fire safety skills to children diagnosed with fetal alcohol syndrome. *Journal of Pediatric Psychology, 31*(1), 65–70.
Pantano, E., & Laria, G. (2012). Innovation in retail process: from consumers' experience to immersive store design. *Journal of Technology Management and Innovation, 7*(3), 198–206.
Papadopoulou, P. (2007). Applying virtual reality for trust-building e-commerce environments. *Virtual Reality, 11*(2–3), 107–127.
Paris, M. M., Carter, B. L., Traylor, A. C., Bordnick, P. S., Day, S. X., Armsworth, M. W., et al. (2011). Cue reactivity in virtual reality: The role of context. *Addictive Behaviors, 36*(7), 696–699.
Park, H., Son, J. S., & Lee, K. H. (2008). Design evaluation of digital consumer products using virtual reality-based functional behaviour simulation. *Journal of Engineering Design, 19*(4), 359–375.
Prothero, J. D., Parker, D. E., Furness, T., Wells, M. (1995). Towards a robust, quantitative measure for presence. In *Proceedings of the conference on Experimental Analysis and Measurement of Situation Awareness* (pp. 359–366).
Purschke, F., Rabätje, R., Schulze, M., Starke, A., Symietz, M., & Zimmermann, P. (1998). *Virtual reality (VR)—new methods for improving and accelerating vehicle development. In virtual reality for industrial applications* (pp. 105–122). Berlin: Springer.
Reason, J. T. (1978). Motion sickness adaptation: a neural mismatch model. *Journal of the Royal Society of Medicine, 71*(11), 819–829.
Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., & North, M. (1995). Virtual reality graded exposure in the treatment of acrophobia: A case report. *Behavior Therapy, 26*(3), 547–554.
Ruddle, R. A. (2004). The effect of environment characteristics and user interaction on levels of virtual environment sickness. In *Proceedings IEEE Virtual Reality, 2004.* (pp. 141–285). IEEE.
Shahrbanian, S., Ma, X., Aghaei, N., Korner-Bitensky, N., Moshiri, K., & Simmonds, M. J. (2012). Use of virtual reality (immersive vs. non immersive) for pain management in children and adults: A systematic review of evidence from randomized controlled trials. *European Journal of Experimental Biology, 2*(5), 1408–1422.
Song, K., Fiore, A. M., & Park, J. (2007). Telepresence and fantasy in online apparel shopping experience. *Journal of Fashion Marketing and Management: An International Journal, 11*(4), 553–570.
Spiers, M. V., Sakamoto, M., Elliott, R. J., & Baumann, S. (2008). Sex differences in spatial object-location memory in a virtual grocery store. *CyberPsychology and Behavior, 11*(4), 471–473.
Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of communication, 42*(4), 73–93.
Suh, K. S., & Lee, Y. E. (2005). The effects of virtual reality on consumer learning: An empirical investigation. *Mis Quarterly., 29,* 673–697.
Tabuchi, H. (2015). *Tommy Hilfiger introduces virtual reality headsets for shoppers*. https://www.nytimes.com/2015/10/21/business/tommy-hilfiger-introduces-virtual-reality-headsets-for-shoppers.html. Retrieved 10 May 2017.
Tourangeau, R. (1984). Cognitive sciences and survey methods. In T. B. Jabine, M. L. Straf, J. M. Tanur, & R. Tourangeau (Eds.), *Cognitive aspects of survey methodology: Building a bridge between disciplines*. Washington, D. C.: National Academy Press.
van Herpen, E., van den Broek, E., van Trijp, H. C., & Yu, T. (2016). Can a virtual supermarket bring realism into the lab? Comparing shopping behavior using virtual and pictorial store representations to behavior in a physical store. *Appetite, 107,* 196–207.
Visbox (2016). *CAVE vs HMD*. http://www.visbox.com/technology/cave-vs-hmd/. Retrieved 10 May 2017.
VRDL (n.d.). *Virtual reality design lab*. http://vr.design.umn.edu/. Retrieved 10 May 2017.
Weibel, D., Wissmath, B., Habegger, S., Steiner, Y., & Groner, R. (2008). Playing online games against computer- vs. human-controlled opponents: Effects on presence, flow, and enjoyment. *Computers in Human Behavior, 24,* 2274–2291.
Whitney, S. L., Sparto, P. J., Hodges, L. F., Babu, S. V., Furman, J. M., & Redfern, M. S. (2006). Responses to a virtual reality grocery store in persons with and without vestibular dysfunction. *CyberPsychology and Behavior, 9*(2), 152–156.
Williams, P., & Hobson, J. P. (1995). Virtual reality and tourism: fact or fantasy? *Tourism Management, 16*(6), 423–427.
Yılmaz, E., Maraş, H. H., & Yardımcı, Y. (2004). PC-based generation of real-time realistic synthetic scenes for low altitude flights. *Enhanced and Synthetic Vision., 5424,* 31–40.