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Is Augmented Reality Technology an Effective Tool for E-commerce? An Interactivity and Vividness Perspective

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Abstract

This study evaluates the effectiveness of augmented reality (AR) as an e-commerce tool using two products — sunglasses and watches. Study 1 explores the effectiveness of AR by comparing it to a conventional website. The results show that AR provides effective communication benefits by generating greater novelty, immersion, enjoyment, and usefulness, resulting in positive attitudes toward medium and purchase intention, compared to the web-based product presentations. Study 2 compares the paths by which consumers evaluate products through AR versus web with a focus on interactivity and vividness. It is revealed that immersion mediates the relationship between interactivity/vividness and two outcome variables — usefulness and enjoyment in the AR condition compared to the web condition where no significant paths between interactivity and immersion and between previous media experience and media novelty are found. Participants' subjective opinions about AR are examined through opinion mining to better understand consumer responses to AR.

Keywords: Augmented reality; Interactivity; Vividness; Immersion; Novelty; Previous media experience

Introduction

Thanks to the rapid advances in technology, a greater variety of promotional tools are currently available for presenting products more persuasively. One new emerging technology that has been receiving massive attention from many companies is augmented reality (AR). Cosmetic companies such as Sephora and L'Oréal introduced an AR mirror that enables customers to experience virtual facial makeup (Jaekel 2016). Other large companies such as Snap, Nike, Adidas, Mini, and eBay have been eagerly adopting various forms of AR, allowing consumers to more vicariously and realistically experience their products (Archer 2015). Perhaps more interesting is Pokémon Go, a mobile game in which AR digital graphics are overlaid onto gamers' real worlds through a mobile phone display which has had more than 500 million downloads in two months (Takahashi 2016) and generated revenues of $470 million in 82 days (Minotti 2016). The market size for AR was 640.2 million in 2015 and is expected to generate $120 billion in revenue by 2020 (Merel 2015). As such, AR is experiencing a huge popularity among companies and consumers.

AR is defined as "the superposition of virtual objects (computer generated images, texts, sounds etc.) on the real environment of the user" (Faust et al. 2012, p. 1164). AR is similar to virtual reality (VR) in aiming to enhance or enrich a viewer's experience. Unlike VR that electronically generates the image of the entire real life setting, AR creates a superimposed overlay of the viewer in the electronically generated setting (Milgram et al. 1994). Thus, AR is more beneficial than VR to both retailers and consumers in that it allows consumers to view themselves actually wearing diverse virtual products without physically trying them on in a store (Verhagen et al. 2014). In this way AR improves consumers' understanding about products, provides them with enjoyment of seeing themselves wearing

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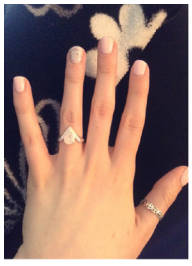
the item, and saves them transportation and shopping time, presumably resulting in its popular utilizations in e-commerce (Baek, Yoo, and Yoon 2015; Pantano and Servidio 2012). In spite of its popularity and potential, no evidence has confirmed that AR is a more persuasive tool than the existing traditional way of online product presentations in providing consumers' shopping experiences.

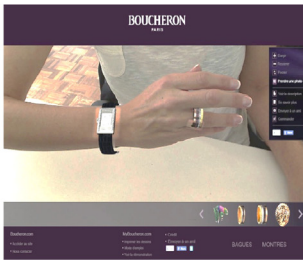
For this reason, we address two research questions in this study: 1) how effective are AR-based product presentations compared to traditionally used web-based product presentations; and, 2) what detailed process is used in AR compared to web to generate consumer evaluations. To these ends, we adopt two popular functional mechanisms that can predict the relative effectiveness of AR, namely *interactivity* and *vividness* (Jiang and Benbasat 2007; Keng and Lin 2006; Wu 2005). A great deal of new technology/media research has widely employed constructs such as (tele)presence, flow, mental simulation, and transportation in revealing their mediating role in explaining the effectiveness of new technologies (e.g., Bracken 2005; Fontaine 1992; Li, Daugherty, and Biocca 2002; Mathwick and Rigdon 2004; Yim, Cicchirillo, and Drumwright 2012). Yet as mediators these constructs do not provide direct explanations with respect to which controllable media features (e.g., interactivity, vividness) are associated with what specific consumer feedback thereby limiting our understanding as to how these controllable media feature(s) should be employed or further developed so as to enhance consumer evaluations. A majority of prior media studies have heavily focused on the role of interactivity (e.g., Downes and McMillan 2000; Newhagen, Cordes, and Levy 1995), while a growing number of new emerging display technologies are focusing on the effect of vividness (e.g., a better image quality) (e.g., Yim, Cicchirillo, and Drumwright 2012). By identifying how the two major media features of interactivity and vividness affect consumer evaluations when AR is used will enable marketing managers to more finely tune their e-commerce promotional strategies when using AR to boost consumer evaluations.

To address this issue as defined in the proposed research questions, two studies are conducted. Study 1 makes a direct comparison between AR design and traditional non-AR website design considering users' previous media experiences. Study 2 focuses on media features (e.g., interactivity and vividness) in identifying the process by which AR affects consumer evaluations by comparing it to the process by which traditional web features affect consumer evaluations. In addition, sentiment analysis and text analytics based on participants' general opinions about AR are used to flesh out and supplement these process findings.

Augmented Reality (AR)

The unique media features of AR are threefold. It "combines real and virtual", is "interactive in real time", and is "registered in 3-D" (Azuma 1997, p. 2). The feature of AR that most distinguishes it from other existing forms of virtual reality (VR) technologies is the media power of generating a "mixed reality" wherein the surrounding environment is real but the objects portrayed in the environment are virtual (Cho and Schwarz 2010, 2012; Drascic and Milgram 1996) (see Fig. 1). A web camera allows both physical (user's body part) and virtual objects (target product) to reside simultaneously in a user's video screen (Bell, Feiner, and Höllerer 2001). In the online shopping context this enriches a consumer's shopping experience by displaying product visualizations on images of consumers' physical features (Ma and Choi 2007). From this perspective, it appears that compared to previously adopted VR-based product presentations such as image interactivity technology (IIT), AR is a superior e-commerce tool. Specifically, IIT is fully dependent on VR in enabling consumers to experience products in a whole new world on a web site as they vicariously experience virtual products through a customizable avatar (e.g., My Virtual Model™) (Fiore, Kim, and Lee 2005). Technological limitations exist, however, in that the virtual avatar generated by IIT cannot precisely replicate the actual physical details of IIT online shoppers (e.g., appearance) as Kim and Forsythe (2008) identified in their focus group interview





Media type	Photo	Virtual reality technology Image interactive technology	Augmented reality technology
Image creation	Real images	Virtual images	Virtual images + Real images
Description	**Real me** wearing a **real** ring in the **real** world	**My avatar** wearing a **virtual** ring in the **virtual** world	**Real me** wearing a **virtual** ring in the **real** world
Tool	Camera generated	Computer generated	Camera & computer generated

Fig. 1. Real world, virtual reality, and augmented reality.

("… *the clothing didn't look like it would on the real me*", p. 51) (e.g., Merle, Senecal, and St-Onge 2012).

Functional Mechanisms of AR

Interactivity

Since every human action potentially involves interactivity (Heeter 2000), the concepts and definitions of interactivity vary widely (Kiousis 2002). Yet, two existing complementary perspectives provide a holistic definition of interactivity that facilitates an understanding of the role of interactivity in operationalizing AR effectiveness: (1) as technological outcome; and, (2) as user perception.

Scholars highlighting the importance of technological features define interactivity as an outcome resulting from properties of the technology employed (Downes and McMillan 2000; Steuer 1992) or from the technology's ability to enable users to more easily interact with and be involved with content (Hoffman and Novak 1996; Schneiderman 1987). Scholars in this school accentuate the importance of enhancing sub-components of technology to increase interactivity, including: *speed*, referring to how fast content in the mediated environment can be manipulated; *mapping*, referring to how similar the control used in the mediated environment is to the one in real world; and *range*, referring to how broadly content in the mediated environment can be manipulated (Steuer 1992). For example in using a touch screen phone, a media user who experiences a lagged response in a video game, will sense a low level of interactivity because the feedback from the medium is delayed.

Another popularly accepted view is that interactivity involves users' subjective perceptions with a focus on individual traits that induce a sense of interactivity (e.g., Downes and McMillan 2000; Newhagen, Cordes, and Levy 1995). For example, Newhagen, Cordes, and Levy (1995) insist that a sense of interactivity cannot be experienced without an individual's motivation to participate in interactive media. In spite of highly advanced technology with the potential to create a high level of interactivity the users may not experience interactivity if not motivated to participate. Thus a user's perception of interactivity is most effectively generated by creating a technologically effective delivery process in such a way as to readily enhance a user's subjective decision to participate.

Vividness

Vividness refers to "the ability of a technology to produce a sensorially rich mediated environment" (Steuer 1992, p. 80). It combines "the sensory experience of actual objects," with "hallucination," which is the "nonsensory experience of imaginary objects" (Lee 2004, p. 38). Other scholars similarly echo this concept, labeling it as realness, realism, or richness (Sadowski and Stanney 2002; Witmer and Singer 1998).

In the context of e-commerce vividness has been often interpreted as the quality of product presentations (Jiang and Benbasat 2007). More vivid portrayal of products is more likely to stimulate consumers' cognitive elaboration processes (Nisbett and Ross 1980). As with interactivity, vividness also helps consumers to mentally envision anticipatory experiences with products in future consumption contexts (Phillips, Olson, and Baumgartner 1995), thereby resulting in strengthened confidence in purchase decisions and longer memory about relevant information (Nisbett and Ross 1980). From a technological perspective, vividness is known to be enhanced by enriching *depth*, referring to the quality of the represented information as perceived by media users and *breadth*, referring to the number of sensory dimensions a communication medium can provide (Li, Daugherty, and Biocca 2002; Witmer and Singer 1998). A medium delivering stimuli with higher image quality to multiple sense receptors should produce a higher level of vividness. For example, in the context of e-commerce, the display technology that can be manipulated so as to generate the highest resolution (more visually vivid) product images accompanied by clearer multi-dimensional (more vivid audio) sound would be expected to enhance consumers' response to product promotions.

Consumer Responses

In this section we discuss and hypothesize how interactivity and vividness influence consumer purchase intentions as well as the mediating role of immersion in facilitating consumer evaluations. The effect of media novelty and previous media experience on immersion is also discussed.

Interactivity and Vividness Resulting in Media Usefulness for Shopping Experience

In the context of online shopping it is widely known that increased interactivity and vividness allow consumers to more effectively gather information about products by enabling visual examination of realistically displayed virtual products (e.g., shape, color, functions) (Ariely 2000). The displayed product is mentally consumed by means of the projection of an image of the viewer into the anticipatory consumption contexts (Phillips, Olson, and Baumgartner 1995). Such a consumption experience encourages consumers to proactively participate in more efficient message-information processing. This improves the quality of consumer search experiences, thereby enhancing perceived *media usefulness* in shopping experiences and purchase decisions (Bezjian-Avery, Calder, and Iacobucci 1998; Childers et al. 2001; Van Noort, Voorveld, and van Reijmersdal 2012). As such, media usefulness in this context captures how effectively and efficiently consumers can search for and obtain needed information to facilitate product evaluations and purchase decisions (Kim and Forsythe 2008).

VR systems have been used for years in educating pilots, soldiers, and surgeons in detailed procedures and operations. Similarly, VR technologies are known to effectively educate consumers in the use of virtually displayed products, providing them with a direct or close-to-direct product experience, resulting in improved knowledge about sought-after products (Li, Daugherty, and Biocca 2002; Lombard and Ditton 1997; Yim, Cicchirillo, Drumwright 2012). Daugherty, Li, and Biocca (2008) found that learning through VR-based product experiences

enhances consumer knowledge significantly more than does learning through either direct or indirect product experiences. Similarly, Lombard and Ditton (1997) found that 3-D visualization based on a virtual imagery so closely resembles a direct product experience that it can result in a richer product experience than does traditional, passive advertising (Dodgson 2005; Jin et al. 2007; Qian 1997). Thus, AR that is similarly based on VR systems is expected to effectively educate consumers and function as a useful tool for their shopping experience.

Interactivity and Vividness Resulting in Media Enjoyment

Enjoyment experienced through media viewing is also related to the two functional mechanisms — interactivity and vividness. Nicholas, Haldane, and Wilson (2000) found that individuals who experience more interactive functions (e.g., range) in playing video games tend to feel a greater sense of enjoyment. This relationship has been confirmed by Klimmt, Hartmann, and Frey (2007), who observed that interactivity is linked to the perception of control regarding objects visualized in VR. In the studies of vividness and enjoyment, Heeter (1992) found that subjects who interacted with computer-generated images of themselves rated enjoyment greater than those who interacted with only their shadow, thus highlighting the important effect of vividness on enjoyment. Similarly, Yim, Cicchirillo, and Drumwright (2012) and Yim, Drumwright, and Cicchirillo (2012) found that stereoscopic 3-D advertising that produces more vivid images results in greater enjoyment than does traditional 2-D television advertising.

In the context of e-commerce (online shopping) it was also found that interactive technologies that present more vivid product visualizations are linked to a more positive affective emotional experience. For example, IIT that shows the process of trying a variety of garments on a 3-D virtual model (i.e., avatar) stimulates consumers' mental play and fantasies when delivered using the technological features of IIT (Kim, Fiore, and Lee 2007). A variety of media features are capable of enriching consumers' imaginative construction processes in various ways to various degrees. Thereby it allows consumers, unrestrained to varying degrees by the reality of their actual environment, to experience the adventure of exploring new, like-real products. This in turn results in various levels of positive affective evaluations (i.e., enjoyment) experienced as playfulness and fun (Childers et al. 2001).

Mediating Role of Immersion in Generating Consumer Evaluations

While many empirical studies assert that interactivity and vividness enhance our cognitive and affective evaluations in utilizing new technologies/media, they also commonly point out the mediating role of the immersive experience (i.e., immersion) in generating an array of positive consumer evaluations. VR users often experience a sense of engrossment and deep focus free from distraction within the VR environment (Slater et al. 1996). Likewise, consumers using AR are expected to experience an equal, or hopefully greater, state of immersion as well.

Immersion is defined as the degree to which virtual systems make users feel absorbed in, involved with, and engrossed by virtual stimuli (Palmer 1995) or experience a sense of blocking out of stimuli from their physical world environment (Biocca and Delaney 1995). Immersion has been understood to be a mediating enhancer in a variety of virtual experiences (Schuemie et al. 2001). It has been shown that the joint effect of immersion and interactivity and/or vividness creates an increased real sense of being present in that image generated world, namely telepresence (Steuer 1992). Immersion also provides users a sense of experiencing virtual products as authentic products, called "para-authentic" product experiences (Lee 2004, p. 34). AR-based product presentations in particular appear to force users to have para-authentic product experiences (Lee 2004). This is mainly because with AR-based product presentations, consumer experiences are not actually blocked by VR (Azuma 1997; Yim and Chu 2012). Rather computer-generated virtual products such as sunglasses, watches, and rings are only added via a web camera to the portrayal of consumers' real worlds in a way that closely approximates a real physical presence within their real world (Azuma 1997).

As with other popular constructs in VR research, the level of immersion consumers experience in AR is dependent upon their subjective evaluations, yet induced by technological capabilities of AR such as interactivity and vividness (Lombard and Ditton 1997; Schuemie et al. 2001). To feel immersed, consumers need to be able to more freely interactively inspect vividly and realistically generated virtual product images from diverse three dimensional perspectives (Faust et al. 2012; Ryan 1999). Once consumers recognize potential technological limitations such as slow responses (low interactivity) and/or poor quality of computer graphics (low vividness) in using AR (e.g., computer system), the sense of immersion may be limited if not eliminated (Ryan 1999). Therefore, depending on how well AR provides fast responses and highly realistic visualizations of virtual products (i.e., interactivity and vividness) (Kim and Forsythe 2008), consumers will appear to perceive virtual products either as a part of their real world (a high immersion state) or as computer-generated objects added to their monitor screen to show approximate product representations (a low immersion state) (e.g., cartoony computer-generated images). Heeter (1995) demonstrated that those high (vs. low) in immersion show positive (vs. negative) consumer evaluations partly from a sense of disconnectedness from the real world, thereby resulting in lack of sense of elapsed time. Therefore, immersion is expected to mediate the relationship between interactivity/vividness and media usefulness/enjoyment as hypothesized below:

H1a. The positive relationship between interactivity and media usefulness will be mediated by immersion (Interactivity → Immersion → Media usefulness).

H1b. The positive relationship between vividness and media usefulness will be mediated by immersion (Vividness → Immersion → Media usefulness).

H2a. The positive relationship between interactivity and media enjoyment will be mediated by immersion (Interactivity → Immersion → Media enjoyment).

H2b. The positive relationship between vividness and media enjoyment will be mediated by immersion (Vividness → Immersion → Media enjoyment).

Subsequently it is expected that all of these positive consumer responses (as hypothesized in H1a, H1b, H2a and H2b) will influence their attitude formation process by instilling in them the belief that a particular technology, media, or system improves their shopping experience by making that task more enjoyable (Davis 1989). Accordingly, the net result will be to improve purchase decisions, as much prior literature has confirmed this relationship (MacInnis and Jaworski 1989; Petty and Cacioppo 1981). For example, Ducoffe's (1996) advertising value model empirically confirmed that in the web context, informativeness (cognitive process) and entertainment (affective process) both result in an improved valuation of web advertising, leading to a more positive attitude toward it. Therefore we propose the following hypotheses:

H3a. The greater consumers' perceived media usefulness in using AR, the more positive their attitude toward AR (Media usefulness → Attitude toward AR).

H3b. The greater consumers' perceived media enjoyment in using AR, the more positive their attitude toward AR (Media enjoyment → Attitude toward AR).

And the corollary:

H4. The more positive consumers' attitude toward AR, the more likely will be consumers' intent to purchase the displayed product (Attitude toward AR → Purchase intention).

Media Novelty and Previous Media Experience on Immersive Experience

Massetti (1996, p. 87) operationally defined novelty as the extent to which each response is "rated as new, unique, and different." Berlyne et al. (1963) viewed novelty as the combined attributes of new or unusual stimuli. In a similar vein, the concept of novelty corresponds to the degree of distinction between current thoughts and past experiences, and it incorporates the role of time (Pearson 1970).

The most dominant effect of novelty is found in information processing where it is seen as the power to draw the audience's attention, leading to the state of being engrossed (Kover and James 1993; Lang 2000; Thorson and Lang 1992). The human psychological response to novel stimuli appears to be innate, as infants at a very early age typically tend to engage with novel stimuli (Flavell 1977). Cue-utilization theory (Easterbrook 1959) explains that an unexpected or unusual sensory stimulus (e.g., sound and scene) shakes people's stable cognitive flow and leads them to experience a high level of arousal. The result is that people give more attention to the focal stimulus while ignoring other stimuli. In contrast, a familiar stimulus does not provide the functional cues needed to affect a person's cognitive processes, thereby resulting in a low level of arousal, leading to low selectivity or low attention. In other words, users with more prior AR media experience view AR as a more familiar stimulus, hence a reduced AR novelty effect.

Specifically, we operationalize the previous media experience construct as an individual's familiarity with a given medium based on the extent to which an individual has experienced that given medium (Kent and Allen 1994). The more users repeatedly experience a new innovative technology, the more the novelty effect of experiencing them is depleted as a result of increased consumer habituation (Sawyer 1981; Tellis 1997). The habituation–tedium theory (Sawyer 1981) proposes that the tension and uncertainty created by novel stimuli wear out as users are repeatedly exposed to and become familiar with the new stimuli. This leads users to become used to using the stimuli (habituation) thus creating positive effects, but simultaneously, causing boredom with the stimuli (tedium), resulting in negative effects. The theory also asserts that because the pace of growth of consumer tedium is faster than the pace of growth of habituation, the positive effect from habituation loses its positive impact as repetitions and the related tedium increase. Therefore, assuming that conceptual inconsistency exists between a viewer's current expectation and past experience with AR, increased AR medium familiarity resulting from increased time spent in AR medium use will reduce consumers' motivation to be mentally immersed when using AR. We hypothesize that media novelty experienced in using AR will enhance consumers' cognitive allocation of their attention to AR but that previous media experience with AR will reduce media novelty:

H5. The greater consumers' perceived AR media novelty, the greater will be consumers' immersive AR experience (Media novelty → Immersion).

H6. The greater previous media experience with AR, the lower will be consumers' perceived AR media novelty (Previous AR media experience (−) → AR media novelty).

Method

Overview

Two studies were designed to reveal the general effectiveness of AR in promoting products in an exploratory manner and, more specifically, how AR-based promotions work compared to how traditional website promotions work in influencing consumer evaluations. In Study 1 we used a 2 (AR vs. Web) × 2 (high vs. low previous media experience) between-subjects design and replicated it using stimuli from two different product categories – sunglasses and watches – for more generalizable findings. In Study 2 we empirically tested the proposed hypotheses (H1a and H1b–H6) represented as structural relationships in the conceptual model in Fig. 2. Study 2 also included an open-ended question in which participants' general opinions about AR were elicited. Their

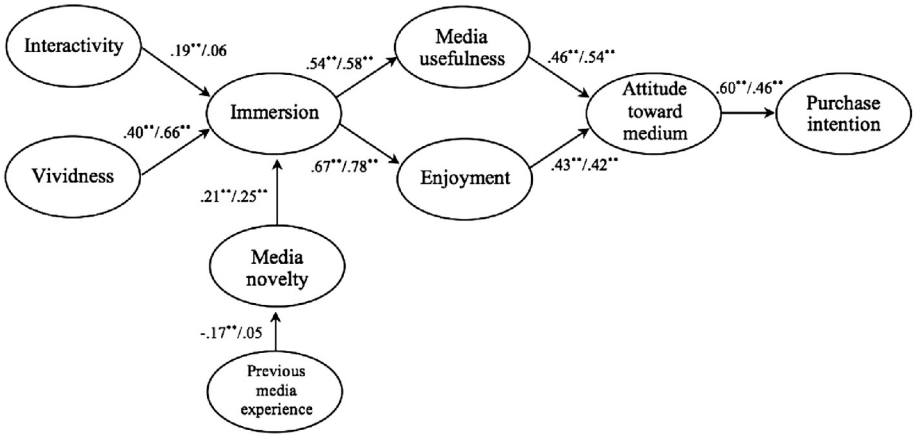


Fig. 2. Study 2: How media characteristics function to influence purchase intention. *Notes*: The former indicates AR, whereas the latter indicates web. **Significant at $p < .01$.

responses were analyzed by utilizing sentiment analysis and text analytics.

Measures

Following exposure to promotional stimuli, a questionnaire was administered asking participants about interactivity (Wu 2005), vividness (Babin and Burns 1998), novelty (Yim, Drumwright, and Cicchirillo 2012), immersion (Duncan and Nelson 1985), media usefulness, enjoyment (Kim and Forsythe 2008), and previous media experience (Kent and Allen 1994). Additional items measuring general attitudes toward the treatment medium used when shopping online (either AR or traditional web site), and purchase intention (Beerli and Martin Santana 1999; Lichtenstein, Netemeyer, and Burton 1990) were included. All the measures were taken on a seven-point Likert or semantic differential scale (see Appendix A). Finally, in order to gain insights into participants' questionnaire responses, they were asked to provide their opinions about AR-based product presentations in an open-ended format.

Stimuli

For both studies we chose sunglasses and watches as the treatment target products because college students recruited as study participants are considered potential customers of these two products. Consideration was also given to the seasonal timing of data collection in judging students' overall interest levels. These product categories were perceived by our participants as moderately to highly interesting items ($M_{sunglasses}$ = 5.21, SD = 1.25; M_{watch} = 4.39, SD = 1.30).

Study 1: Comparisons Between AR- and Web-based Product Displays

Study Procedure

Participants were randomly assigned to one of two conditions — AR or web. Those in the AR treatment condition were guided by the detailed instruction as to how to set up and use AR on the computer. Specifically, they were asked to download the necessary software and prepare a computer equipped with a web camera. Once all the settings for AR were ready, on their monitor screen participants could see themselves wearing numerous product designs. This shopping process enabled them to obtain detailed textual product descriptions such as product features. Participants were encouraged to examine a variety of products for at least five minutes. The five-minute time frame was determined by pre-test results that confirmed that participants could inspect at least five and up to ten different designs of products in sufficient detail to compare and evaluate them.

Participants were asked to choose the one particular model of the product that they would like to purchase or in which they were most interested. To secure participants' experiences with products in a given condition, we asked the question about the product model both before and after their exposure to the stimuli. This question was followed by a question asking to which product categories each participant was exposed to confirm their active participation. Respondents who included incorrect product categories in answering to this final question were excluded from the empirical analyses.

Manipulation Check

Because of the different characteristics and markets for the two treatment products, we constructed a separate web site for each, one for sunglasses and another for watches. To increase the external validity of our findings, two AR programs were directly obtained from corporate websites. To eliminate a potential scaling bias, the web-based product presentations were manipulated so as to generate levels of interactivity and vividness that were statistically equivalent to those of AR-based product presentations. There were two reasons for this manipulation. First, from a theoretical perspective, both interactivity and vividness are subjective constructs that each individual perceives differently, as numerous prior studies have illustrated (Coyle and Thorson 2001; Kiousis 2002; Witmer and Singer 1998). For this reason

web-based product presentations may be able to generate perceptual levels of interactivity and vividness equivalent to that available in AR. If so this would question whether AR truly has and/or benefits from superior interactivity and vividness. Second, from a practical perspective, we seek to reveal the effectiveness of current formats of AR-based product presentations developed by real companies, assuming that web-based product presentations may be able to generate similar or more positive consumer evaluations, attitudes and intentions. If, however, AR has greater media power in terms of interactivity and vividness, then web-based product presentations should be able to produce the same level of interactivity and vividness. This was not the case, as we easily created competing traditional web sites that generated levels of interactivity and vividness statistically equal to those of the two AR programs used in this study.

When we constructed web sites, the available number of clicks for browsing products (i.e., range leading to interactivity) and the number of product pictures (i.e., quality leading to vividness) (Steuer 1992) were manipulated, while all other factors were kept consistent across medium types (e.g., product lists, tone and manner) (see Appendix B). The differences in the levels of interactivity and vividness between media treatment variables were tested using an independent samples *t*-test. As a result, the two product presentations showed the statistically same levels of interactivity (sunglasses: $M_{AR} = 5.03$, $M_{web} = 4.84$, t (136) = .93, *n.s.*; watch: $M_{AR} = 5.06$, $M_{web} = 4.87$, t (118) = 1.03, *n.s.*) and vividness (sunglasses: $M_{AR} = 5.04$, $M_{web} = 4.89$, t (136) = .77, *n.s.*; watch: $M_{AR} = 5.08$, $M_{web} = 4.80$, t (118) = 1.25, *n.s.*).

Participants

College students are within the typical age range of those more proactive in online shopping for fashion items. They are more open to innovative technologies compared to other age groups of people (Wang 2013). For these reasons we felt it safe to assume that they are included in the potential groups of consumers who are among the most willing to use AR in the future (Lytle 2012; Owyang 2010).

We conducted an online experiment, offering extra credit as an incentive for completing the study. After data cleaning, a total of 258 ($n_{sunglasses} = 138$; $n_{watch} = 120$) college students in the U.S. were included in the final analysis. The average age of participants was 21.07 ($SD = 3.15$) of whom 62.4% were females. A majority of participants were White (66.7%), followed by Asian (13.6%), Hispanic (8.5%) and African American (7.4%).

Results

To identify the effect of high vs. low previous media experience, we used the method suggested by Gelman and Park (2009). We split the data into three groups representing low, medium and high levels of media experience. We dropped the middle group, resulting in significant separation of experience between the two groups. To test treatment effects, we conducted a series of ANCOVAs (analysis of covariance) using product involvement as a covariate and each other media characteristic measure in turn as the dependent variables. The results showed different patterns of independent and covariate variable significance between the two product categories. We found that product presentations using AR generally result in significantly higher values of consumer evaluations than do those using the web-based for all the measures from both product categories (see Tables 1 and 2). As for the influence of previous media experience, immersion was significantly higher for those low in previous media experience in both product categories than for those high in previous

Table 1
ANCOVA of effectiveness of media type and previous media experience: *F*-value.

Dependent variable	Source			
	Media type (M)	Previous experience (P)	M × P	Covariate: product involvement
Sunglasses (*df* = 1, 133)				
Novelty	101.78***	2.18	5.56*	11.68**
Immersion	21.92***	4.54*	.44	.53
Media enjoyment	113.97***	.00	.61	4.28*
Media usefulness	5.93*	.07	.90	.56
Attitude toward medium	7.36**	.03	.02	2.29
Purchase intention	2.22	1.91	.07	8.68**
Watch (*df* = 1, 115)				
Novelty	111.94***	3.09†	8.34**	.04
Immersion	36.14***	4.12*	9.71**	4.64*
Media enjoyment	90.57***	1.23	5.23*	2.04
Media usefulness	3.82†	.66	.51	2.36
Attitude toward medium	11.19**	.02	.75	.76
Purchase intention	56.20***	3.22†	.18	1.35

Notes:
† Significant at $p < .10$.
* Significant at $p < .05$.
** Significant at $p < .01$.
*** Significant at $p < .001$.

Table 2
Adjusted means of effectiveness of media type and previous media experience.

	High media experience		Low media experience	
	AR	Web	AR	Web
Sunglasses				
Novelty	5.41 (.15)	3.79 (.24)	6.21 (.20)	3.61 (.24)
Immersion	5.21 (.20)	4.12 (.31)	4.81 (.26)	3.36 (.31)
Media enjoyment	5.46 (.18)	3.71 (.27)	5.63 (.23)	3.51 (.27)
Media usefulness	4.90 (.20)	4.50 (.31)	5.09 (.26)	4.17 (.31)
Attitude toward medium	5.57 (.20)	4.79 (.31)	5.49 (.27)	4.78 (.31)
Purchase intention	4.91 (.23)	4.35 (.36)	4.39 (.31)	4.00 (.36)
Watch				
Novelty	5.49 (.22)	3.88 (.22)	6.46 (.19)	3.64 (.23)
Immersion	4.70 (.23)	4.05 (.22)	5.85 (.20)	3.81 (.24)
Media enjoyment	4.99 (.36)	3.62 (.26)	6.02 (.31)	3.25 (.28)
Media usefulness	5.22 (.28)	4.51 (.26)	4.81 (.23)	4.48 (.28)
Attitude toward medium	5.73 (.30)	4.53 (.28)	5.45 (.25)	4.74 (.31)
Purchase intention	5.46 (.31)	3.16 (.28)	4.81 (.26)	2.76 (.31)

Notes: Parenthesis indicates standard error.

media experience (sunglasses: $F(1, 133) = 4.54$, $p < .05$; watch: F (1, 115) =4.12, $p < .05$), while no significant difference was found in other measures. In the test of the interaction of media type by previous media experience, results were mixed: for sunglasses, the interaction effect was significant on novelty only (F (1, 133) =5.56, $p < .05$) but for watches, there were interaction effects on novelty (F (1, 115) = 8.34, $p < .01$), immersion (F (1, 115) =9.71, $p < .01$), and media enjoyment (F (1, 115) = 5.23, $p < .05$). Thus, it is concluded that AR has a great potential as a new marketing communication to persuade consumers in e-commerce but previous media experience may have varying effects on its overall effectiveness.

Study 2: How AR-based & Web-based Product Presentations Affect Consumer Evaluations

Study Procedure

Although Study 1 results provide meaningful findings about general AR effectiveness, it still does not delineate how AR works. To figure out what specific paths consumers take in performing consumer evaluations, we conducted Study 2 with a focus on the roles of two media features of interactivity and vividness. Particularly, we compared how AR-based and web-based product presentations affect consumer evaluations. To test the proposed model, a second online survey was conducted using college students as participants. To make findings more generalizable, we collected responses using two different products (i.e., sunglasses and watch) as treatment variables. We pooled the data sets for watches and sunglasses because of the lack of significant difference between the two with respect to key variables. This provided higher power for analysis and tests of hypotheses. Thus more precise statistical analysis with higher power is achievable (Lenth 2001).

Participants

A total of 801 college students in the U.S. (n_{AR} = 506; n_{web} = 295) participated in the online survey. Participants were offered extra credit as an incentive for completing the study. The average age of participants was 20.94 (SD = 2.76), 61.2% of whom were females. A majority of participants were White (70.4%), followed by Asian (11.6%) and Hispanic American (8.1%).

Testing Validity and Reliability of Measures

Cronbach's alpha for all sets of indicator variables of all constructs ($.76 \le \alpha \le .97$) exceeded the generally acceptable level of .70 (Hair et al. 1998) in both media types. To achieve more accurate reliability measures for latent variables used in a structural equation model (SEM), the composite reliability (CR) was calculated (Babin and Burns 1998). The result showed that for each set of indicator variables of all constructs CR exceeded .70 ($.81 \le CR \le .97$) (Hancock and Mueller 2006), thus establishing reliability. Convergent and discriminant validity tests were conducted using average variance extracted (AVE) and the squared correlation (ϕ^2), respectively. All factor loadings on each latent construct were significant and the AVE values were greater than .50, thus establishing convergent validity ($.51 \le AVE \le .87$) (Fornell and Larker 1981). All AVE values were greater than the squared correlation (ϕ^2) thus establishing discriminant validity (Lichtenstein, Netemeyer, and Burton 1990) (see Appendix A).

Structural Equation Model Testing Proposed Hypotheses

To empirically test the proposed hypotheses including our focus on interactivity and vividness in explaining consumer evaluations, a structural equation model (SEM) analysis was conducted using AMOS 24.0. The normality assumption for Maximum Likelihood (ML) estimation was tested and it was found that all the variables were within the range of ±1.96 in terms of skewness and kurtosis, thus it was safe to use ML estimation (Bollen and Stine 1992). The sample size was large enough that there was no concern with type II error which can be caused by insufficient variation in the data (Everitt and Skrondal 2010). Nevertheless, for more rigorous testing we performed bootstrapping based on n = 1000 at the 95% confidence level using bias-corrected intervals (Bollen and Stine 1992). Empirical tests found the proposed model to be acceptable with respect to goodness-of-fit measures (AR: χ^2 (620) =1,921.06, $p < .001$, CFI = .92, NNFI = .92, RMSEA = .06, AIC = 2,087.06, BIC =2,437.86; web: χ^2 (620) = 1,516.07, $p < .001$, CFI = .91, NNFI = .91, RMSEA = .07, AIC = 1,682.07, BIC = 1,988.09).

The significance level of the test statistic for the paths in the structural model was used to test whether the proposed hypotheses were supported or not. However, to test the mediating role of immersion between interactivity/vividness and usefulness/enjoyment (i.e., interactivity/vividness →

Table 3
Standardized SEM structural path coefficients and significance levels based on samples for AR and Web.

Hyp.	Path direction	Std. Estimate		Unstd. Upper/lower	
		AR	Web	AR	Web
H1a	Interactivity → Immersion → Media usefulness	.10**	.04	.23/.05	.16/−.05
H1b	Vividness → Immersion → Media usefulness	.21**	.39**	.40/.16	.86/.43
H2a	Interactivity → Immersion → Enjoyment	.13**	.05	.22/.04	.18/−.06
H2b	Vividness → Immersion → Enjoyment	.27**	.52**	.39/.16	1.03/.52
H3a	Media usefulness → Attitude toward medium	.46**	.54**	.50/.31	.72/.44
H3b	Enjoyment → Attitude toward medium	.43**	.42**	.61/.34	.65/.34
H4	Attitude toward medium → Purchase intention	.60**	.46**	.80/.62	.67/.39
H5	Previous media experience → Media novelty	−.17**	.05	−.04/−.14	.09/−.04
H6	Media novelty → Immersion	.21**	.25**	.44/.12	.82/.14

Notes:
** Significant at $p < .01$.

immersion → usefulness/enjoyment), we conducted the mediation analysis by testing the significance of the indirect effect as a result of bootstrapping based on $n = 1{,}000$. This was considered a more rigorous method to test the proposed mediation hypotheses, given that the indirect effect in SEM using bootstrapped samples uses a full-information Maximum Likelihood technique, whereas regression based mediation tests (e.g., Sobel, PROCESS) do not (Bollen and Stine 1990).

The significances of the paths in the model based on AR were first tested and results showed that all the proposed hypotheses were supported (see Table 3). Specifically, both interactivity and vividness affected media usefulness and enjoyment when mediated by immersion (H1a, H1b, H2a and H2b, all $p < .01$). Media usefulness and enjoyment both had a significant effect on attitude toward AR, that in turn had a significant effect on purchase intention (H3a, H3b and H4, all $p < .01$). Meanwhile media novelty significantly enhanced immersion, while media novelty was significantly reduced by previous media experience (H5 and H6, all $p < .01$). In the web condition, the tests of the model's structural path parameters revealed major differences in significance in the paths of "interactivity → immersion" and "previous media experience → media novelty" (both *n.s.*). It also revealed that the web-based product presentation is not interactive enough to make people perceive the usefulness of the website, compared to AR.

Additional analyses were conducted to ensure that any possible issues caused by common method bias (CMB) that often occurs in surveys where causal relationships are tested within the same data set (MacKenzie and Podsakoff 2012) are not evident here. To this end, we conducted Harman's single factor test (Podsakoff, MacKenzie, and Podsakoff 2012). No evidence indicating the violation of CMB in both samples of AR and web was found. Specifically, each data set from the AR and web condition indicated 38.61% and 39.44%, respectively, revealing that both were smaller 50% of critical value. Thus, any issue regarding common method bias was not expected in this data analysis.

Sentiment Analysis and Text Analytics of Participants' Opinions About AR

To assess participants' opinions about AR-based product presentations, participants had the option of responding to open-ended items in the questionnaire. These optional responses were then analyzed using sentiment analysis and text analytics. Sentiment analysis was used to score the valence of opinions (i.e., positive, negative, or neutral), whereas text analytics was used to extract relevant information and transform opinions into usefulness implications (Sigler 2015).

Of the 506 participants from the AR condition, 190 responded to the open-ended item sharing their opinions about AR ($n = 4{,}957$ words). Sentiment analysis was first conducted, using Python NLTK text classification. The results revealed: neutral words = .1, polarity = .9 and within polarity, positive = .5, negative = .5. Thus we concluded that participants are having mixed and very balanced opinions on AR. Because this analysis result does not indicate detailed thoughts about their opinions

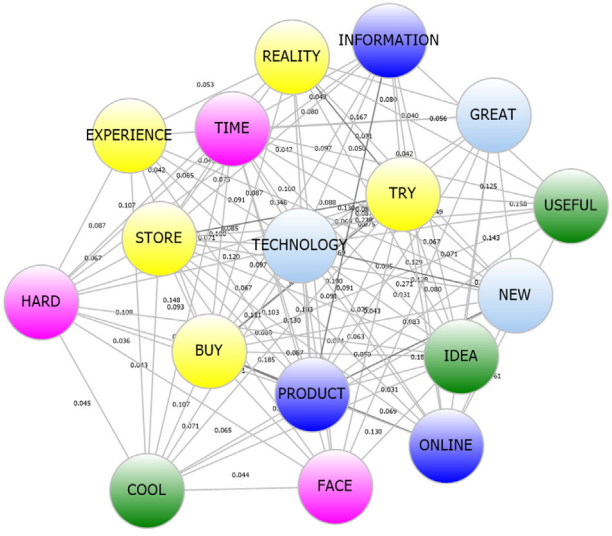


Fig. 3. Link analysis of keywords in 2-D map.

(Jia, Yu, and Meng 2009) we further conducted text analytics by using WordSTAT 7.1.2 for STATA. The result illustrated that the most frequently used word was "technology" (10.33%), followed by "cool" (9.51%), "fun" (8.42%), and "new" (7.88%). As shown in Fig. 3, the key words frequently used in describing AR were mainly linked to technology used, while some other word descriptions, such as "buy", "try", "store" and more are linked to shopping experience. Based on a criterion requiring an eigenvalue greater than 1.0, we identified four pairs of representative topic words, including "product; information", "try; store", "new; technology", and "hard; face". Considering major comments that represent the four topics, we found that in general participants are positive about AR because it is a new technology but ironically they are also negative about AR because the new technology offers a variety of forms of discomfort in the utilization process. For example, a subject said, "*this new technology was almost mind-blowing*", whereas another subject mentioned, "*… the technology had a hard time positioning the glasses on your face*" (see Table 4).

Importantly, in evaluating the effects of interactivity and vividness of AR, potential issues exist that need to be addressed for AR to be adopted as a tool for e-commerce. For example, some participants' complaints included slow response (e.g., "*slightly delayed response, lost my interest quickly*") and unrealistic computer graphics (e.g., "*the images aren't as real looking*"). That is, although our hypotheses tested in this model showed the positive influence of interactivity and vividness from AR on consumer evaluations, there is still a lot of room for AR to improve with regard to consumer engagement in virtual shopping so as to provide a most satisfactory media option.

General Discussion

The current study extensively investigated the potential of AR as a tool for e-commerce through two studies with a focus on the effect of the two functional mechanisms of interactivity and vividness. Study 1 compared the consumer evaluations of AR-based product presentations to traditional web-based product presentations with respect to diverse consumer evaluations. A structural equation model in Study 2 detailed the process of how interactivity and vividness in AR and web contexts differently and similarly result in consumer evaluations of products. Study 2 also solicited participants' subjective opinions about AR in an open-ended format item. The text mining technique was then used in analyzing their opinions to provide a supplement to our other findings in these two studies.

Study 1 results revealed that AR-based product presentations are generally superior to traditional web-based product presentations in the effect on media novelty, immersion, media enjoyment, usefulness, attitude toward medium, and purchase intention as consistently shown for the two different product categories. As for the mixed influence of previous media experience on consumer evaluations across two different product categories, we speculate that the benefits offered by AR are not as great with watches as they would be with sunglasses. Specifically, AR users with sunglasses can conveniently look at themselves much like they would with a mirror in seeing themselves wearing diverse designs of sunglasses. Conversely, with watches AR users would need to place their wrist immediately in front of the web camera to see themselves wearing virtual watches to get a sense of how well the watches match with their wrist. This irritation of holding the wrist up to the camera may lessen the overall effect of AR with low levels of previous media experience. Yet, the opposite is true for those with high previous media experience in forming the level of immersive experiences (Yim, Drumwright, Cicchirillo 2012). We also speculated that the majority of findings in Study 1 provide evidence that all the benefits of AR partly come from consumers' perceptions of its newness and uniqueness thereby producing a significant novelty effect (Kover and James 1993; Lang 2000). Given that novelty effect disappears at some point, the overall effectiveness of AR-based product presentations is believed to be limited in generating positive consumer evaluations. Yet, this was just our speculation until Study 2 results confirmed the structural path of constructs that explain how AR works in generating consumer evaluations.

The model tested in Study 2 details the process by which media features of interactivity, vividness, and media novelty in AR influence consumer evaluations, compared to web-based promotions. Prior studies empirically demonstrated that a user's immersive experience within various media is likely to generate a variety of positive consumer evaluations from both affective

Table 4
Frequency and valence of a representative sample of the open-ended comments and topics with both positive and negative valences.

Subject	Valence	Raw comment	Topic	Frequency	Cases (%)	Eigenvalue
276	Negative	"in terms of **product information** available, they didn't even have prices listed before you pressed buy these pair"	Product; information	57	10.91	2.71
317	Negative	"seems distracting to the overall presentation of **information**"				
19	Negative	"it is far more easier to go to a store and **try** the sunglasses on"	Try; store	68	12.98	1.46
25	Positive	"it would definitely make me want to go to the nearest **store** to **try** on a pair of glasses"				
66	Positive	"this **new technology** is a great way to get people to be interested in buying the product"	New; technology	96	19.47	1.40
443	Positive	"this **new technology** was almost mind-blowing"				
62	Negative	"the glasses were a bit augmented and it seemed like the technology had a **hard** time positioning the glasses on your **face**"	Hard; face	103	23.30	1.20
221	Negative	"my face is extremely small, so it's **hard** to tell on augmented reality if the glasses will actually fit/look good on my **face**"				

Note: The text analysis was made based on a total of 190 participants' opinions on AR (sunglasses = 120, watch = 70).

(e.g., enjoyment) and cognitive perspectives (e.g., product knowledge) (Coyle and Thorson 2001; Li, Daugherty, and Biocca 2002; Yim, Cicchirillo, and Drumwright 2012). Yet, prior research did not pay much attention to what increases or decreases the immersive experience nor how this experience may influence consumer evaluations. Specifically, our tested model confirmed that both interactivity and vividness generate diverse positive consumer evaluations through increased immersion but the part of immersion generated in new innovative media, such as AR is directly associated with the novelty effects. It was more evident as shown in the model comparisons between how AR works versus how the traditional web works. In the web condition, we could not find evidence that interactivity generates significant immersion nor that previous media experience affects media novelty, though these relationships were significant in the AR condition. That is, we see that in comparison with the traditional web, AR benefits more from the media characteristic of interactivity while losing benefits from the possibly soon decayed media novelty in the future as users become more familiar with AR (Sawyer 1981; Tellis 1997). As such, this model confirms that the success of the medium as an information source for persuading consumers can be warranted when the technological features of the medium are able to generate high levels of interactivity and vividness without expecting much influence from the novelty effects.

Another important contribution of this study is the finding that the significant negative impact of previous media experience on media novelty only occurred in the AR condition. This has interesting mixed implications but is consistent with what the habituation–tedium theory (Sawyer 1981) asserts. That is, greater previous media experience has both positive and negative impacts on a sense of immersion in that it reduces novelty, resulting in decreased immersion, but alleviates the potential negative impact of irritation on immersion. Consistent with what the theory asserts, our results revealed that the negative impact caused by a high level of media familiarity is still more critical in reducing the sense of immersion in the AR condition. As for the reason why we could not find this direct path in the web condition, we speculate that this is because, relative to AR, the web platforms that are very familiar to many participants may be limited by a floor effect in generating novelty. In summary, the findings from Study 2 indicated that AR benefits from the mechanical features of interactivity and vividness but if AR loses its newness, innovativeness and uniqueness, the essence of media novelty, its overall effectiveness would be weakened.

Finally, we would like to highlight the unique and important efforts we made to directly listen to consumers' opinions through the text mining technique. In that AR is still unknown to many consumers and little is known about AR from a consumer standpoint, our findings are believed to be important in enriching our understanding about AR. Consistent with the findings in Study 2, many participants were interested in AR and willing to utilize it, but in part because AR is a new, innovative technology that attracted their attention. At the same time, some other participants pointed out technological limitations often found in new, innovative technologies, such as difficulty in installing the related software, lack of computer literacy, and malfunctioning of the AR programs (e.g., slow response speed, cartoony product images). Thus, AR is believed to be at the infant stage, needing more room to improve to be loved and used by more consumers.

Limitations and Future Research

While this current study provides many meaningful findings, it is not immune from limitations. The findings of our two studies should be interpreted with caution because we used a convenience sample of college students. Although they are likely to be within the primary target audience for many AR-based product presentations, college students may be more open to something new and innovative than average consumers thereby causing less generalizable results. This means that because college students may be more likely to adopt new technologies compared to other age groups of consumers, external validity issues may arise. Also, our findings are limited to one particular media environment – personal computers – although many AR applications that have been introduced operate in mobile devices. For example, Snapchat introduced diverse AR-based filters that enable consumers to experience virtual products or places. Therefore, replicating the proposed model using a broader, more representative and truly random sample of subjects along with more diverse media contexts is strongly encouraged for future researchers.

Examining other interesting variables would contribute to the existing literature. For example, timing of purchase would be important, as consumers who are about to purchase certain products may be more highly involved and more likely to employ more extensive and more readily accessible information sources. Constructs such as need for cognition or need for emotion may also be interesting to explore in that some consumers are more dependent on visualized information (i.e., visual learner) than on text-based information. In a similar vein, it would be interesting to compare consumer responses toward small-sized products that can be displayed on consumers' viewing screens (e.g., watches, sunglasses) with those products that are much bigger than their viewing screen sizes (e.g., cars, furniture), because using AR to present sunglasses and watches may generate more realistic product visualizations than could be done for products such as cars or furniture that have much smaller visualizations than actual sizes.

Another ambitious research topic would be to examine whether or not AR is actually linked, directly or indirectly, to increased product sales or improved company or brand images when positioned as high technology. If the primary role of AR is not to generate a direct sales increase, but to stimulate consumers' curiosity or to draw attention of consumers, future researchers are also encouraged to investigate the relationship between confidence about product information and intent to actually visit retail stores to supplement product information. As such, there remain many questions to be answered, since few researchers have addressed the functional benefits of AR in the context of e-business.

Appendix A

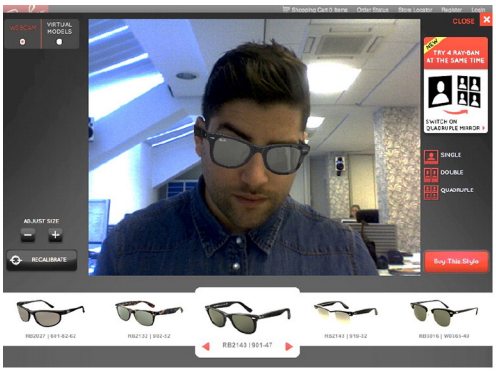
The SEM model measurement items with estimated structural parameters and reliability and validity test statistics.

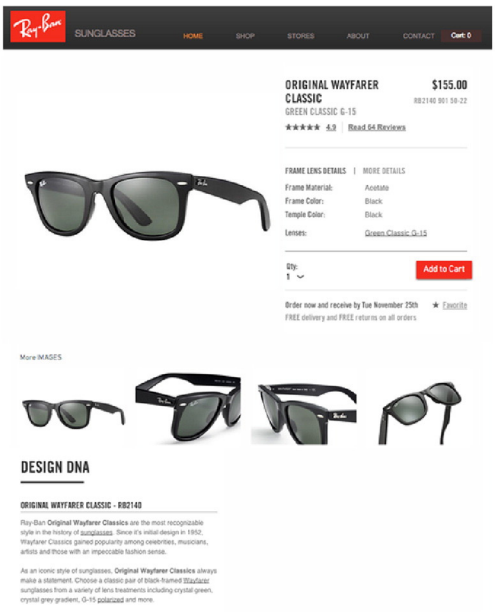
Item	Cronbach's alpha	Composite reliability	Std. loading	AVE	ϕ^2
Interactivity	.87/.80	.88/.81		.62/.51	.00–26/.00–.26
I was in control of my navigation through the augmented reality technology (website).			.85/.76		
I had some control over the content of the augmented reality technology (website) that I wanted to see.			.85/.67		
I was in control over the pace to watch products.			.75/.71		
The augmented reality technology (website) had the ability to respond to my specific needs quickly and efficiently.			.69/.71		
Vividness	.90/.86	.94/.90		.63/.54	.00–.25/.00–36
Clear			.78/.68		
Detailed			.82/.81		
Vague			.41/.55		
Vivid			.82/ 64		
Sharp			.92/.79		
Well-defined			.91/.89		
Previous media experience	.93/.97	.94/.97		.82/.92	.00–04/.00–.03
Unfamiliar–Familiar			.89/.94		
Inexperienced–Experienced			.90/.97		
Not knowledgeable–Knowledgeable			.93/.96		
Media usefulness	.93/.94	.94/.95		.73/.77	.00–33/.00–.52
The augmented reality technology (website) enhances my ability to make product choices more effectively.			.83/.81		
Using the augmented reality technology (website) saves me time.			.80/.88		
Using the augmented reality technology (website) improves the quality of my search for products.			.88/.91		
The augmented reality technology (website) enables me to acquire information more quickly.			.86/.89		
Overall, I find the augmented reality (website) useful in my shopping experience.			.90/.89		
Media enjoyment	.95/.94	.95/.96		.85/.78	.00–38/.00–.47
The augmented reality technology (website) was entertaining.			.90/.85		
The augmented reality technology (website) was enjoyable.			93/.96		
The augmented reality technology (website) was pleasing.			.92/.93		
The augmented reality technology (website) was fun to use.			.88/.79		
Immersion	.90/.88	.89/.89		.71/.68	.00–.28/.00–.45
Not deeply engrossed–Deeply engrossed			.88/.87		
Not absorbed–Absorbed			.88/.90		
My attention was not focused–My attention was focused			.77/.69		
Media novelty	.90/.76	.95/.95		.73/.51	.00–.14/.00–.29
New			.87/.45		
Unique			.94/.74		
Different			.94/.97		
Unusual			.63/.59		
Attitudes toward medium	.96/.97	.95/.97		.83/.87	.00–.33/.00–.52
Unfavorable–Favorable			.90/.93		
Bad–Good			.92/.96		
Unpleasant–Pleasant			.91/.91		
Negative–Positive			.91/.92		
Purchase intention	.93/.94	.96/.97		.77/.81	.00–.32/.00–.25
Uncertain–Certain			.86/.88		
Unlikely–Likely			.95/.96		
Improbable–Probable			.95/.96		
Impossible–Possible			.73/.79		

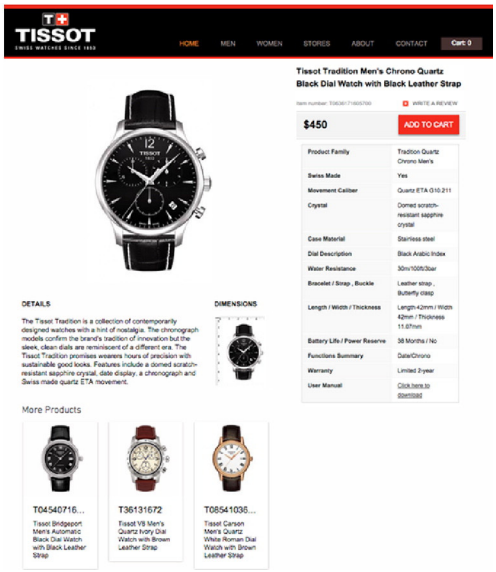
Notes: The former indicates AR, whereas the latter indicates Web. AVE = average variance extracted, ϕ^2 = squared correlation.

Appendix B

Stimuli — AR-based vs. web-based product presentations.







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