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How do 3-dimensional images promote products on the Internet?

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ABSTRACT

The study investigates 3D virtual advertising as it affects the online shopping environment. It examines the vividness of mental imagery as a mediator, and consumers' need for touch and product type as moderators of the effects. An experiment conducted with 207 study participants and two product types, a watch and a jacket, indicates overall that 3D advertising outperforms 2D advertising in effectiveness. The vividness of mental imagery appears to directly influence attitudes and intentions by mediating the effects of 2D versus 3D. As expected, the 3D and 2D formats consistently differed more in their effects for geometric products than for material products. Consumers' NFT affected only intentions to revisit, interacting with product type and site type. For the watch product, 3D advertising is more persuasive for both high and low NFT consumers. Comparatively, for the jacket product, 3D strongly impacts low-NFT consumers only, but has no significant difference for high-NFT study participants.

Introduction

Three-dimensional (3D) images strongly affect virtual experiences (Debbabi, Daassi, & Bail, 2010; Kahrimanovic, Tiest, & Kappers, 2011; Li, Daugherty, & Biocca, 2002; Mollen & Wilson, 2010); that is, psychological states that consumers experience when they interact with 3D product images in computer-mediated environments (Li, Daugherty, & Biocca, 2001). 3D virtual experiences initiate visual mental imagery that positively impacts web advertising (Coyle & Thorson, 2001; Li et al., 2002). Object interactivity makes the message more persuasive by using sensory input such as sight to generate vivid mental images of sensory modalities such as touch, taste, and smell (Schlosser, 2003). Depicting a product more visually vivid can cause mental simulation that enhances purchase intentions: an experiment showed that when a mug was pictured with the handle on the right, it offered more mental simulation and generated higher purchase intention for right-handed viewers as a match than for left-handed viewers as a mismatch (Elder & Krishna, 2012).

Those observations indicate that 3D versus 2D product visualization is a theoretically valid construct that affects virtual experience and deserves further investigation to improve consumers' experiences in online shopping contexts.

Consumers differ in terms of their haptic orientation or their need for touch (NFT), which influences their evaluations of product offerings (Grohmann, Spangenberg, & Sprott, 2007; Krishna & Morrin, 2008; Peck & Childers, 2003a, 2003b). Higher-NFT individuals have been shown to be more confident about their product judgments when they can touch the products they evaluate, and they are more frustrated when they cannot touch the products (Peck & Childers, 2003a). The personal proclivity for touch may also influence persuasion in a virtually simulated 3D environment, and the effect could vary by product type (e.g., Li et al., 2002).

If the virtual product experience incurs more vivid mental imagery and simulates sensory information, the persuasive effects may depend on consumers' personal proclivity for the specific sensory modality; for example, if it appeals to their sense of touch it may depend on their need for touch, whether high or low. However, prior studies have apparently failed to consider virtual experience in conjunction with consumer preferences for certain sensory information. Therefore, we investigate the effects of 3D virtual advertising in the online shopping environment, examining the vividness of mental imagery for its mediating role, and consumers' need for touch and product type as moderators.

This research may contribute to further development of theories regarding consumer responses to virtual shopping experiences. It may also help marketing managers and practitioners as they undertake advertising in new media and online channels such as online shopping malls, social networking sites, and mobile apps.

Theoretical background and hypotheses

3D virtual experience — Development of mental models

Mental models are the cognitive representations of (a) situations in real, hypothetical, or imaginary worlds, including space and time;

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(b) entities found in the situation and the states of those entities; (c) the interrelationships between the various entities and the situation, and (d) events that occur in that situation (Garnham, 1997; Johnson-Laird, 1983; Radvansky & Zacks, 1997; Wyer & Radvansky, 1999; Zwaan & Radvansky, 1998). Mental models are hypothesized to exist in conjunction with the semantic networks or schematic network models of memory (Radvansky & Zacks, 1997; Yang, Roskos-Ewoldsen, & Roskos-Ewoldsen, 2004). Schemas are knowledge structures or cognitive frameworks based on past experiences: individuals dynamically construct mental models from stored schemas and merge them with new episodic information (Kuipers, 1975; Preece et al., 1997). If a given situation lacks perceptual information, individuals will supply it with default assignments based on stereotypic expectations from past experience to make the schema consistent with the mental model (Kuipers, 1975). In response to missing but expected spatial information, individuals will make inferences about the absent elements based on their memories. The integration may be so complete that they cannot distinguish episodic information from the schema's consistent information (Mania, Robinson, & Brandt, 2005).

Following that theory, when users interact with virtual environment stimuli, they develop mental models using default sensory cues stored in memory to cognitively supply missing information. In trying to make inferences or predictions about virtual worlds, they use sensory cues to relate objects, actions, or events to past experiences in the physical world. Thus they experience perceptual illusions.

Vividness of mental imagery

Imagery involves visualizing a concept or relationship (Lutz & Lutz, 1978) to draw stored, long-term memories of sensory information (e.g., hearing, touch, taste, smell, and sight) into working memory (MacInnis & Price, 1987). Individuals can experience sensory stimuli even when the true stimuli are absent because imagery is based on nonverbal, sensory representations of perceptual information in memory (Childers, Houston, & Heckler, 1985). In the same vein, imagery also refers to the quasi-sensory experiences in the absence of stimulus conditions known to produce their genuine sensory counterparts (Richardson, 1969). The crucial difference between imagery and perception is that perception starts with an external stimulus, whereas mental imagery is based on information stored in memory (Cooper, 1995; Rouw, Kosslyn, & Hamel, 1998).

Vividness is considered dominant among factors related to visual imagery (Burns, Biswas, & Babin, 1993; Ellen & Bone, 1991). Vivid information such as concrete words or pictures draw interest and attention, in addition to being sensorially, temporally, and spatially proximate (Nisbett & Ross, 1980). Vivid elements are also memorable because they prime relevant information stored in memory (Sherman, Mackie, & Driscoll, 1990).

Relationship between mental models and vividness of imagery

Vivid elements in virtual environments basically draw attention and activate relevant information in memory (Nisbett & Ross, 1980; Sherman et al., 1990), allowing viewers to fill in the information missing from the sensory stimuli. In this way, vivid stimuli may develop more concrete mental models and more vivid imagery for an object or an artificial environment.

Interactivity also evokes vivid mental images of using products (Schlosser, 2003). Directly manipulating virtual objects stimulates more vivid mental imagery and greater immersion in the virtual world. Considering that object interactivity causes individuals to mentally experience products, sensory input such as sight may allow object interactivity to deliver mental images of sensory modalities such as touch, taste, and smell (Schlosser, 2003). This reasoning infers that consumers become mentally immersed in the virtual world by interacting with virtual objects, which leads to vivid mental imagery tied to sensations. That is, they experience quasi-sensory experience, mostly from memory.

With respect to interactivity, the more that users feel immersed in the virtual environment, the more they will see the experience as being real: they will experience thoughts, emotions, and behaviors similar to those they could experience in a real-life situation, thus creating a more compelling experience (Mantovani & Castelnuovo, 2003). When they form imagery from a mental event involving visualization, immersion in a concrete mental model may lead to more vivid or richer mental imagery.

In the virtual-store setting, when consumers view product information that includes the illusion of actually interacting with the product, the illusion may evoke more vivid imaginations of trying and using the product. By perceiving real information through one sense (e.g., seeing pictures of a product) and also virtually perceiving information through another sense (e.g., having the illusion of touching the product), their quasi-sensory product experience will be more vivid than it will be without the illusion of interacting with a product. Therefore, a virtual product experience with a fuller, more-concrete mental model represented by three dimensions rather than two, may generate more vivid imagery regarding consumption experience.

Persuasive effects of virtual experience and mental imagery

Virtual experiences have well-established persuasive effects. 3D interactions provide virtual experiences that favorably influence attitudes and intentions (Choi, Miracle, & Biocca, 2001; Coyle & Thorson, 2001; Klein, 2003; Li et al., 2002). 3D advertising enhances product knowledge, brand attitudes, and purchase intentions by creating compelling virtual product experiences (Li et al., 2002). Material products require touching for understanding; geometric products require vision for understanding (Klatzky, Lederman, & Matula, 1991). For both material and geometric goods, 3D advertising outperforms 2D advertising for yielding more favorable brand attitudes and better product knowledge (Li et al., 2001): zooming, rotating, and moving products in 3D generate limited haptic sensations (Li et al., 2002). Thus consumers using 3D product images develop vivid mental imagery and construct mental models, which positively affect their attitude toward the brand and their product knowledge.

Imagery beneficially affects persuasion (1) by transforming information stored in long-term memory into working memory; (2) by using prior personal experience to make advertisement seem more relevant, and (3) by providing multisensory experiences that are appealing in their own right (Burns et al., 1993). Given that vivid mental imagery more closely resembles the actual experience of using a product, it is thought to positively influence judgments and intentions (Bone & Ellen, 1992; MacInnis & Price, 1987).

The vividness of the mental image refers to the clarity of the imagined scenario (MacInnis & Price, 1987). Whether a consumer can vividly imagine a particular stimulus or memory depends on the nature of the stimulus and on the availability of working memory resources (Bywaters, Andrade, & Turpin, 2004). Vivid, self-related, and plausible stimuli positively and directly influence attitudes toward advertisements (Bone & Ellen, 1992). Additionally, object interactivity supports vivid mental imagery and mediates interactivity's effect on attitudes and purchase intentions by closely simulating actual product usage (Schlosser, 2003). Imagery's vividness dimension seems to mediate between the stimulus (e.g., concrete wording) and attitudinal and cognitive responses (Burns et al., 1993).

Thus, we expect that 3D advertising will be more persuasive than 2D advertising on attitudes and behavioral intentions, and that the vividness of mental imagery will mediate its persuasive effects. Using the measures of attitudes toward advertising, brand attitude, purchase intention, and intentions to revisit the website to compare advertising effectiveness between conditions, we hypothesize:

H1. 3D advertising will have higher persuasive effects than will 2D advertising.

H2. Mental imagery will mediate the persuasive effects of the 3D versus 2D advertising format.

Moderating role of product type and need for touch

Products may be classified as having either material or geometric properties. Consumers will judge products with material properties such as texture, hardness, temperature, and weight (Klatzky et al., 1991; Peck & Childers, 2003a) by touching them to ascertain material properties such as roughness, stickiness, and elasticity. People will judge products having geometric properties by looking at their appearance, such as their size and shape (Klatzky, 2010). For example, sweaters and tennis rackets have high material salience; their quality or performance depends more on weight, softness, and elasticity. Comparatively, calculators and cordless telephones have medium material salience, and cereal and toothpaste have low material salience because consumers will judge these products more by their appearance, such as shape, size, and color. Consumers can get sufficient information about products that have low material salience without touching them (MaCabe & Nowlis, 2003), but when products have varying material properties, consumers are more likely to use touch for judging their quality (Peck & Childers, 2003a). In general, in judging geometric products, vision or appearance carries the most weight. In judging material products, touch carries the most weight (Klatzky, 2010).

Haptic information may be represented through visual imagery (Klatzky et al., 1991). Visual images usually accompany factual images: for example, when imagining the tactile sensation of exploring a smooth pane of glass, one might mentally observe one's hand touching the glass (Katz, 1989). Similarly, when imagined exploratory processes associate with haptic perception, they may also appear as visual imagery as was shown in a study in which many participants who were judging an object's material properties imagined their hands exploring the object, but the hand-exploration imagery decreased substantially when they judged geometric properties of size and shape (Klatzky et al., 1991). The authors of the study concluded that visual perceptions may convey at least crude haptic information via visible changes in the object and signs of force in the effector. They extended the study and found that for material judgments, visualized touch was more frequent and rapid than the time it took to use vision alone; however, for geometric judgments, touch was rarely used and took about the same time as visual responses (Klatzky, Lederman, & Matula, 1993) The authors see this as evidence supporting a "visual preview model" proposing that the consumer uses vision as a preview (or guidance) to determine whether and when to use touch to select vision or haptic explorations from memory to provide further information (Klatzky et al., 1993).

3D advertising generates more favorable brand attitudes and higher product knowledge for both material and geometric products (Li et al., 2001), consistent with the visual preview model. However, 3D ads have weaker effects for material products than for geometric products (Li et al., 2001). Therefore, 3D advertising should outdo 2D in persuasiveness (Li et al., 2002). 3D should also have higher effects for geometric products than for material products because vision is more strongly associated with the encoding of geometric properties. By contrast, haptics will be more important when encoding information about an object's material properties. 3D interaction will generate more vivid product imagery, but its persuasive effects will be somewhat limited for material goods because they are being touched visually rather than actually handled.

In addition to variance in the product-based sources of salience for haptic information, haptic salience is also likely to depend on the person involved. For example, haptically oriented, high-NFT consumers consider material properties and access haptic information earlier in product evaluation (Peck & Childers, 2003b). High-NFT consumers are more confident and less frustrated about their evaluations when they touch products, whereas low-NFT consumers have stable confidence in their judgments independent of their ability to touch the products (Peck & Childers, 2003a). Consistent with the visual preview model, that study found that written descriptions and visual depictions can partially enhance certain types of touch information. A more recent study shows that tactile input enhances high-NFT consumers' ability to judge quality and generates more favorable evaluations of a material product (e.g., a washcloth) but does not negatively affect evaluations of low-quality products (Grohmann et al., 2007). Similarly, in a study of Internet shopping behavior, tactile need significantly negatively affects the purchase of material products (e.g., clothes) but has no significant effect for geometric products (e.g., books, videos, and compact disks) (Citrin, Stem, Spangenberg, & Clark, 2003). These results indicate that NFT interacts with the product type. For low-NFT consumers, visual information can compensate for haptic exploration; for high-NFT consumers, vision can only partially compensate for touch: visuals may satisfy low-NFT consumers, but high-NFT consumers may desire additional haptic information. For high-NFT consumers, a website's 3D representation might be even more frustrating than an unclear or less-detailed picture in thwarting NFT (Peck & Childers, 2003a). Thus 3D advertising for geometric products may be more effective for low-NFT individuals. Consequently, both product type and the NFT consumer trait should moderate advertising effectiveness of 2D versus 3D formats.

For geometric goods, the visual mental imagery that comes from visually inspecting 3D images may easily evoke the illusion of trying a product because geometric goods are highly associated with visual cues. Therefore, for geometric products, 3D advertising will be more persuasive than will 2D advertising for both high and low-NFT consumers. By contrast, for material goods, haptic information is more important, so visuals may fail to persuade high-NFT consumers who prefer real touch. Therefore, for material products, 3D advertising will have higher persuasive effects only for low-NFT consumers. Thus, we propose the following hypotheses:

H3. 3D advertising will have higher persuasive effects for geometric products than for material products.

H4. For geometric products, 3D advertising will have higher persuasive effects than will 2D advertising for both high- and low-NFT consumers. However, for material products, 3D advertising will have superior effects only for low-NFT consumers.

Method

Research design and subjects

For the experiment, the study employs a 2 (site type: 2-dimensional vs. 3-dimensional) × 2 (product type: geometric — watch vs. material — jacket) × 2 (consumer trait: high vs. low NFT) factorial design. Study participants are 207 undergraduate students (105 males: 50.7%) from a large university in Seoul. All participants use the Internet for an average of 3.5 h daily. Most (93.2%) reported having online shopping experience.

Participants are assigned as follows: 51 for the 2D watch; 56 for the 3D watch; 48 for the 2D jacket; and 52 for the 3D jacket. Their dichotomous NFT level is decided based on a median split (median = 4.60, M = 4.52, *SD* = 1.11) in the composite sum of the NFT scales (Peck & Childers, 2003b).

Pretest for the choice of products

The experiment centers around two products: a watch as a geometric product and a jacket as a material good following prior studies

(Li et al., 2002; MaCabe & Nowlis, 2003). For verification, a pre-test with 54 participants verifies the products' choice. NFT scales measure autotelic and instrumental properties. The autotelic property relates to sensory experience and the hedonic appreciation of a product; instrumental information is more intrinsic to a product and more specific to the goal-directed evaluation of a product's performance (Peck & Childers, 2003b). The participants rate their NFT (instrumental dimension only) for five products: t-shirt, sweater, watch, calculator, and toothpaste. Measuring only instrumental properties is deemed appropriate for the pre-test because this dimension is more intrinsic to a product and its purchase. The six items of the NFT scale, with endpoints of *strongly agree* (7) to *strongly disagree* (1), included: "I place more trust in a jacket that can be touched before purchase. I feel more comfortable purchasing a jacket after physically examining it. I feel more confident making a purchase after touching a jacket. If I can't touch a jacket in the store, I am reluctant to purchase it. The only way to make sure a jacket is worth buying is to actually touch it. I would buy many jackets only if I could handle them before purchase." The same questions were used for the other pre-tested product categories.

The results of the pre-test show that respondents' instrumental NFT is highest for sweaters (M = 5.55), t-shirts (M = 5.38), watch (M = 4.29), calculator (M = 4.16), and toothpaste (M = 2.89). The scores are not significantly different between products within the same category (e.g., t-shirts and sweaters in clothing or watch and calculator in electronics), so the combined scores are compared with other product categories. Clothing (t-shirts and sweater) (M = 5.47) is significantly higher than electronics (M = 4.22; $t = 7.64$, $p < .001$) and toothpaste (M = 2.89; $t = 12.59$, $p < .001$) in instrumental NFT. In choosing the products, the study considered both participants' product involvement and appropriateness of using 3D interaction on the website. Accordingly, toothpaste is dropped because it had low involvement features. Finally, the watch and the jacket appear as the appropriate match for geometric versus material product to be presented for a virtual 3D product experience (e.g., moving the watchhands or bending the watchband, or moving the zipper up and down on the jacket).

Stimuli design, manipulation check, and procedure

The study develops websites with 2D and 3D formats for each product type, all using the same fictitious brand name to prevent confounding effects. The websites include product images to interact with and text-based product descriptions. In the jacket condition, text messages include brand name, size, and color along with product attributes (e.g., soft, light, durable, wearable, ventilated, and moisture-proof). In the watch condition, the text includes brand name and color along with product features (e.g., light, durable, wearable, and water-proof). The websites are advertisements including nonpersonal communications about the products by media-identified sponsors (Arens, Weigold, & Arens, 2009, p. 7).

The 2D images are static product pictures taken from front, back, and side angles. 3D images are aided by interactive features such as zooming, moving, and rotating. Additionally, product specific interactive functions facilitate the illusion of touch, for example moving the watchhands, bending the watchband, or moving the jacket zipper up and down. Jacket rotation is limited to horizontal movement because vertical rotation makes the jacket look too artificial (similar to a can). This limitation may have made the 3D jacket condition less interactive relative to the 3D watch condition. However, participants' perceived interactivity in the 3D jacket (M = 4.30) and 3D watch (M = 4.38) conditions is not significantly different ($t = .48$, $p > .10$), and thus 3D interaction is judged to be equivalent. In the 2D condition, perceived interactivity between the jacket (M = 4.14) and watch (M = 4.43) also shows no significant difference ($t = 1.22$, $p > .10$). Participants' perceived interactivity is measured based on items from Liu (2001) such as "The website puts a great deal of control in its visitors' hands. While surfing the website, my actions decided the kind of experiences I got."

The study tests the equivalence of message content in the experimental websites by product category in terms of the website's informativeness, persuasiveness, and quantity of information (2D watch: M = 3.57, 3.30, 2.33 vs. 2D jacket: M = 3.87, 3.65, 2.77, respectively; 3D watch: M = 4.73, 4.33, 3.89 vs. 3D jacket: M = 4.29, 4.09, 3.60, respectively). No significant differences appear in either the 2D ($t = -1.19$, $p > .10$; $t = -1.30$, $p > .10$; $t = -1.52$, $p > .10$, respectively) or the 3D condition ($t = 1.87$, $p > .05$; $t = 1.08$, $p > .10$; $t = 1.07$, $p > .10$, respectively). Therefore, the result confirms the equivalence of the websites.

The next step is the manipulation of 3D interaction. In an ANOVA test, only the 3D manipulation effects are significant (F = 193.28, $p < .001$) with no main effects of product type (F = 1.85, $p > .10$) or interaction effect (F = .04, $p > .10$). The perception of interaction in the 3D condition is higher than that in the 2D condition for both the watch (M = 5.64 > 3.23) and the jacket (M = 5.37 > 3.03). The result indicates that the manipulation of the 3D interaction is successful. For the 3D conditions, brief navigation instructions explain how to interact with the 3D display before showing the test website. Stimulus materials are developed via design tools including Macromedia Shockwave version 10.1, 3D Studio Max, and Director MX 2004.

The experiment is conducted in a computer lab and students are randomly assigned to a treatment condition. The study instructs participants to thoroughly examine the website to determine how they think and feel about the product. After they browse their target website, they fill out a questionnaire, are debriefed, and dismissed.

Measurement

Items from Chen and Wells (1999) measure attitudes toward the website. Measures drawn from previous research (Bearden, Lichtenstein, & Teel, 1984; Lutz & Belch, 1983; Mitchell & Olson, 1981) are used for attitude toward the brand and purchase intention. Five-point Likert scales measure vividness of mental imagery (Schlosser, 2003). Consumers' need for touch is measured by NFT scales (Peck & Childers, 2003b), which are generally reliable with reliabilities from .83 to .96 (Table 1).

Results

An ANOVA run on site attitude shows significant main effects of site type on site attitude ($M_{3d} = 4.40$ vs. $M_{2d} = 3.31$; $F(1, 197) = 48.62$, $p < .001$), and a significant two-way interaction between site type and product type ($F(1, 197) = 5.70$, $p < .05$). Simple effects tests show significant differences in attitude toward the site between 2D and 3D conditions both in the geometric and the material product. In the watch condition, site attitude in 3D ($M = 4.59$) is higher than in 2D ($M = 3.18$; $F(1, 202) = 46.79$, $p < .001$). Also, in the jacket condition, 3D ($M = 4.20$) results in more favorable site attitude than 2D ($M = 3.44$; $F(1, 202) = 12.77$, $p < .001$). Therefore, the difference of site attitude between 2D and 3D is higher in the geometric product than in the material product.

An ANOVA run on brand attitude shows significant main effects of site type on brand attitude ($M_{3d} = 4.25$ vs. $M_{2d} = 3.88$; $F(1, 198) = 4.57$, $p < .05$), and a significant two-way interaction between site type and product type ($F(1, 198) = 8.08$, $p = .005$). Simple effects tests show no difference in attitude toward the brand between 2D ($M = 3.97$) and 3D in the jacket condition ($M = 3.92$; $F(1, 203) = .56$, $p = n.s.$). In the watch condition, 3D ($M = 4.55$) results in more favorable brand attitude than 2D ($M = 3.79$; $F(1, 203) = 13.73$, $p < .001$). Therefore, superior effect of 3D advertising for brand attitude appears only in the geometric product.

An ANOVA run on intention to purchase shows significant main effects of site type on purchase intention ($M_{3d} = 2.68$ vs. $M_{2d} = 2.18$;

Table 1
Scale items and descriptive statistics.

Variables	Scales	M	SD	α
Site attitude	Not fun/fun	3.91	2.14	.92
	Unexciting/exciting			
	Not cool/cool			
	Imaginative/unimaginative[a]			
	Not flashy/flashy			
	Uninformative/informative			
	Unintelligent/intelligent			
	Knowledgeable/unknowledgeable[a]			
	Useless/useful			
	Unhelpful/helpful			
Brand attitude	Negative/positive	4.07	1.10	.94
	Unfavorable/favorable			
	Bad/good			
	Dislike/like			
PI	Unlikely/likely to purchase	2.44	1.37	.92
	Probably not/probably will purchase			
	Impossible/possible to purchase			
VI	Never/absolutely visit	3.31	1.55	.96
	Improbable/probable to visit			
	Certain not to visit/certain to visit			
	Impossible/possible to visit			
Vividness of imagery	How vivid did you find the product description on the site to be?	2.91	.85	.83
	To what extent did the site provide features to help you imagine using the product?			
	To what extent did the site include features that help you visualize a product trial?			
	To what extent did the site include features to help you imagine touching or manipulating the product?			

[a] Recoded items.

$F(1, 198) = 5.52$, $p < .05$), and a significant two-way interaction between site type and product type ($F(1, 198) = 8.33$, $p < .005$). Simple effects tests show no difference in purchase intention between 2D ($M = 2.30$) and 3D in the jacket condition ($M = 2.29$; $F(1, 203) = .003$, $p = n.s.$). In the watch condition, 3D ($M = 3.04$) results in higher purchase intention than 2D ($M = 2.06$; $F(1, 203) = 14.37$, $p < .001$). Therefore, superior effect of 3D advertising for purchase intention appears only in the geometric product.

Next, an ANOVA run on intention to revisit the site shows significant main effects of site type on revisit intention ($M_{3d} = 3.84$ vs. $M_{2d} = 2.73$; $F(1, 198) = 28$, $p < .001$), a significant two-way interaction between site type and product type ($F(1, 198) = 3.92$, $p < .05$), and a significant three-way interaction between site type, product type, and NFT ($F(1, 198) = 9.98$, $p < .005$). Simple effects tests on two-way interaction show significant differences in the intention to revisit the site between 2D and 3D conditions both in the geometric and material products. In the watch condition, revisit intention in 3D ($M = 4.07$) is higher than in 2D ($M = 2.62$; $F(1, 203) = 26.76$, $p < .001$). Also, in the jacket condition, 3D ($M = 3.60$) results in higher revisit intention than 2D ($M = 2.85$; $F(1, 203) = 6.67$, $p = .01$). Therefore, the difference of revisit intention between 2D and 3D is higher in the geometric product than in the material product. Therefore, H1 and H3 are supported for all dependent measures.

Simple effects tests on the three-way interaction show that, in the geometric product, revisit intention in the 3D condition is significantly higher than in the 2D condition for both high-NFT ($M_{3d} = 4.31$ vs. $M_{2d} = 2.42$; $F(1, 198) = 21.97$, $p < .001$) and low-NFT consumers ($M_{3d} = 3.82$ vs. $M_{2d} = 2.77$; $F(1, 198) = 7.53$, $p < .01$). Comparatively, in the material product, revisit intention is higher in 3D than in 2D only among low-NFT consumers ($M_{3d} = 3.90$ vs. $M_{2d} = 2.38$; $F(1, 198) = 13.51$, $p < .001$) but showing no significant difference in high-NFT consumers ($M_{3d} = 3.38$ vs. $M_{2d} = 3.56$; $F(1, 198) = .20$, $p = n.s.$) (Fig. 1). Thus, H4 is supported for revisit intentions.

Finally, a mediation analysis (Baron & Kenny, 1986) tests H2. To establish mediation, (1) the independent variable should affect the mediator, (2) the independent variable must affect the dependent variable, and (3) the mediator must affect the dependent variable when regressed in conjunction with the dependent variable, and the effect of the independent variable should increase when going from the second step to the third step.

In the analysis of participants' attitudes toward the sites, site type positively affects both site attitude ($\beta = .46$, $t(1, 205) = 7.34$, $p < .001$, $R^2 = .21$) and mental imagery ($\beta = .23$, $t(1, 206) = 3.46$, $p < .005$, $R^2 = .06$). When site type and mental imagery are regressed together for site attitude, the effect of site type diminishes ($\beta = .33$, $t(1, 206) = 6.38$, $p < .001$, $R^2 = .48$). In the analysis for brand attitude,

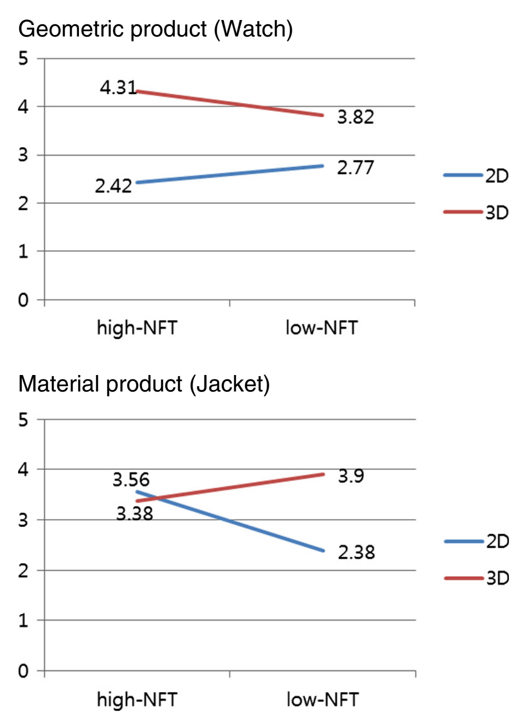

Fig. 1. Three-way interaction for revisit intention (VI) to the website by site type, product type, and NFT.

site type positively affects both brand attitude ($\beta = .17$, $t(1, 206) = 2.46$, $p < .05$, $R^2 = .03$) and mental imagery (vividness). However, when site type and mental imagery are regressed together for brand attitude, the effect of site type is insignificant ($\beta = .05$, $t(1, 206) = .86$, $p = n.s.$, $R^2 = .26$). In the test for purchase intention, site type positively affects both purchase intention ($\beta = .18$, $t(1, 206) = 2.65$, $p < .01$, $R^2 = .03$) and mental imagery. When site type and mental imagery are regressed together for purchase intention, the effect of site type is not significant ($\beta = .07$, $t(1, 206) = 1.14$, $p = n.s.$, $R^2 = .24$). In the test for revisit intention, site type positively affects both revisit intention ($\beta = .36$, $t(1, 206) = 5.50$, $p < .001$, $R^2 = .13$) and mental imagery. When site type and mental imagery are regressed together on revisit intention, the effect of site type diminishes ($\beta = .24$, $t(1, 206) = 4.20$, $p < .001$, $R^2 = .36$).

Next, the Sobel (1982) test further assesses the mediation effects by statistically determining whether the indirect effects in the model are significant. This test is recommended (Preacher & Hayes, 2004) for addressing the limitations of conditions and for enhanced statistical rigor in confirming mediation (Baron and Kenny, 1986). The indirect effects of mental imagery are significant for all dependent measures (site attitude: $Sobel = 3.32$, $SE = .10$, $p < .001$; brand attitude: $Sobel = 3.21$, $SE = .08$, $p < .002$; purchase intention: $Sobel = 3.19$, $SE = .098$, $p < .002$; revisiting intention: $Sobel = 3.27$, $SE = .12$, $p < .002$).

Therefore, the mediating effects of mental imagery are confirmed in all dependent measures, supporting H2. Imagery fully mediates the effects of site type (2D vs. 3D) on brand attitude and purchase intention.

Discussion

The moderating effects of site type, product, and NFT on advertising effectiveness

Overall, the results indicate that 3D advertising outperforms 2D advertising in improving consumers' attitude toward the brand, purchase intention, and intention to revisit the website, which is consistent with results from prior studies (e.g., Debbabi et al., 2010; Li et al., 2002). As expected, the 3D format has different effects by product type: 3D and 2D conditions have consistently higher differences for the geometric product than for the material product. Especially in brand attitude and purchase intention, 3D advertising fails to have superior effects for the material product. Thus, 3D advertising looks more effective for geometric products than for material products. 3D advertising may have had more favorable effects in the watch condition and partially favorable effects in the jacket condition because 3D advertising can enhance visual sensory information, for example by showing different angles, and zooming in and out. This visual information can drive the consumer to create more vivid mental imagery about using the product.

Marketers may find it more appropriate to employ visual devices for promoting geometric products rather than for promoting material products. However, 3D advertising's partially superior effects for the jacket condition indicate that 3D advertising can be effective even for material goods where tactile examination is more important in purchase decisions. Tactile illusion perhaps plays a role in the superior effects, and could be transferred from visual inspection through vivid mental imagery. This is consistent with research suggesting that visual perception may convey haptic information via visible changes in the object (Klatzky et al., 1991). However, as expected, 3D interaction has a weaker effect for the material product, as consumers usually need real touch feedback before purchasing material products, which may explain why 3D advertising in the jacket condition generates more favorable site attitude and higher revisit intention but does not generate favorable brand attitude and purchase intention. Vivid mental imagery built from 3D interaction may have caused study participants to respond more favorably to the website, but it is not enough to fill their need to actually examine the material product.

Consumer traits have rather limited effects. NFT interacts with product type and site type to affect only revisit intention. For the watch, 3D advertising outperforms 2D in persuasive effects for both high- and low-NFT consumers. Comparatively, for the jacket, 3D has a superior impact only for low-NFT consumers; high-NFT consumers show no significant differences. For high-NFT consumers, 3D interaction's positive vivid mental imagery effects may have been countered by frustration that they could not touch the material product. For low-NFT consumers, visual examination may be sufficient to assess haptic properties, but for high-NFT consumers, 3D advertising may compensate only partially for the desired real-touch haptic information (Peck & Childers, 2003a).

For advertisers developing websites for online shopping, geometric products are especially appropriate for 3D advertising, and NFT tendencies are not a major concern because they seem to affect only revisit intentions. For advertising material products, however, advertisers must consider NFT needs more carefully. Although 3D advertising appears to be persuasive, 2D formats are actually more cost-effective for encouraging intentions to revisit when the target audience generally prefers touch feedback.

The relationship between vivid mental imagery and advertising effectiveness

The vividness of mental imagery appears as a key resource for persuading consumers in a virtual environment. Mental imagery directly influences attitudes and intentions by mediating the effects of 2D or 3D site characteristics, reinforcing the idea that imagery powerfully changes consumers' state of mind (Branthwaite, 2002). The visualization of product images in the experiment may have translated an abstract idea into a more concrete and convincing experience, which then generates more favorable brand opinions. This finding vindicates the idea that experiential contact with a product can trigger more concrete mental construal and increase preferences for products that are easy to use over those that are more desirable but difficult to use (Hamilton & Thompson, 2007).

3D interaction, with its vivid product imagery, likely enhances message acceptance by allowing consumers to develop concrete mental models that simulate direct product experience (e.g., product trial). The Transportation Imagery Model (TIM) explains that simulation reduces negative cognitive responses, makes experience more realistic, and generates strong affective responses (Green & Brock, 2000). The research finding aligns with TIM theory in suggesting that the virtual experience associated with a 3D website leads to more vivid and realistic product imagery and more favorable attitudes. Apparently study participants' mental models, developed while interacting with a 3D image, cause illusions or quasi-sensory experiences somewhat akin to direct product experience. Unlike direct experience, virtual experience occurs in the mind's eye to deliver mental images of sensory modalities (Schlosser, 2003). For example, the quasi-sensory experience of tactile illusion can trigger virtual affordance (Li et al., 2002). Shape may significantly affect weight perception, either haptically (Kahrimanovic et al., 2011) or visually (Koseleff, 1957). Following this idea, interacting with the 3D images may have provided the illusion of direct product experience and have prompted product attachment to positively shape perceptions.

If web advertisers seek to attract consumers and keep them on the site longer for browsing and learning about the product, the best strategy is to help visitors vividly imagine using the products. The result encourages site designers to use rich sensory cues and various interactive options to deliver the product concept. For example, adding audio files or using a mouse with touch feedback would enhance site experience. Likewise, a better site design can allow users to choose from various visual, textual, and video presentation formats. Interactivity can enhance product imagery by employing design features such as fast interaction speed, sufficient choices (or menus), and natural predictive mapping of site interaction.

Limitations and suggestions for future study

The study used only two products for the experiment. More effort is required to replicate the findings using other product types such as durables versus convenience goods, high-involvement versus low-involvement products, hedonic versus utilitarian products, or service products. In addition to consumers' need for touch, research design can include other user characteristics such as heuristic versus analytical information processing styles, and intrinsic or situational involvement, because different people can respond differently to the same material. Future research should employ more variables that may possibly affect the building of mental models and product imagery, such as the breadth and depth of sensory modality, interactivity, and people's immersion tendencies, to better understand consumers' responses to simulated product experiences in virtual environments.

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