Effects of 3D vs 2D interfaces and product-coordination methods

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Abstract

Purpose – The purpose of this paper is to examine the effects of product display based on colour, discount and brand on retail pleasure, arousal, flow, perceived merchandise quality, time spent, satisfaction and patronage intentions in both 3D and 2D interfaces. This study uses the flow theory and stimulus-organism-response framework to understand the effects of product coordination methods and interface dimensions on consumers' emotional, cognitive and behavioural outcomes.

Design/methodology/approach – This study conducted a 2 (interface: 3D and 2D) × 3 (product coordination method: colour, discount and brand) between-subjects experimental design. The coordination of display refers to the way products are arranged based on similar properties, such as similar colour, discount or brand. 3D stores were designed using Mockshop, a 3D virtual retailing software. A total of 144 US female college students from various universities participated in the study.

Findings – The findings showed that the 3D interface produced higher flow, satisfaction, time spent and patronage intention than the 2D interface. Also, among the six display scenarios, participants who were in the colour-coordinated 3D store showed the highest levels of emotional, cognitive and behavioural outcomes except for retail pleasure and arousal.

Originality/value – This study investigates product display based on colour, discount and brand in both 3D and 2D interfaces. Although product coordination methods have been tested in 3D stores in previous studies, they have not been compared with their effects in the 2D interface such as online shopping sites. Therefore, this study fills in this gap in the literature, which can guide retailers in making the right decisions for visuals.

Keywords 2D interface, 3D interface, Mockshop, Product coordination

Paper type Research paper

Introduction

Currently, retailers have taken significant interest in developing three-dimensional (3D) interfaces because of their highly attractive features (Brandon, 2007). Lee and Chen (2011) stated that the realistic layout of a 3D interface accurately parallels the real world physical environment in consumers' mental representation. Consumers could get a tangible brand experience in a 3D interface because it mimics the consumers' engagement in a physical store (Gabisch and Gwebu, 2011). Moreover, a 3D product presentation reduces perceived risk (Shim and Lee, 2011) because consumers could get a better idea about colour, texture and fit when the 3D virtual model is presented instead of the 2D image. Moreover, a 3D product display method allows consumers to examine products from various angles (Khakimdjanova and Park, 2005). Alpcan *et al.* (2007) claimed that we are moving towards a 3D internet. On the other hand, navigation in a 2D environment is difficult because it presents a lot of information in an abstract way.

Furthermore, the product placement in a 3D environment creates brand awareness because it provides consumers virtual experiences with products (Barnes and Mattsson, 2008). Also, a 3D interface gives consumers an immersive brand experience because of its multimedia features. Therefore, it helps consumers to enhance their emotional, practical and logical value towards a brand.

However, one of the disadvantages a 3D interface is the cognitive overload of information (Nah *et al.*, 2011). Using the "distraction conflict theory" they note that rich, dynamic and multi-sensory elements of a 3D environment create cognitive overload and distract consumers' concentration. An orderly arrangement in a 3D environment could reduce the cognitive overload of information (Kotabe *et al.*, 2016). As noted by Kotabe *et al.* (2016),

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disorderly arrangement in a 3D environment leads to the loss of consumers' self-control, which creates fatigue. In addition, environmental disorder is positively associated with social disorder (Kotabe *et al.*, 2016). Interestingly, Reber *et al.* (2004) found that consumers' interest increases if there is an orderly arrangement in a 3D environment or uniformity in variety. The processing fluency theory states that consumers could easily process and understand the complex visual stimuli if those stimuli present symmetry and contrast clarity. Also, Seock and Lee (2013) showed that inspirational co-ordination of items with appealing colours in the home furnishing store increases the frequency of visit. In a recent study, Jang *et al.* (2018) found an interaction effect between visual complexity and order for those consumers who score high in sense making. High sense making consumers most prefer the complex environment when it is highly organised.

Moreover, by designing uniformity in variety, consumers will be less affected by the cognitive overload of information. Although prior studies discuss the importance of uniformity in variety, little empirical research has been done to differentiate which types of uniformity in a 3D environment create a higher level of preference. Using Mockshop, a 3D virtual retailing software, Wu *et al.* (2013) created product display methods based on colour, texture, and style coordination and tested whether this type of uniformity influences consumer response. Their findings indicate that product display methods, especially the colour displays significantly influence consumer response. To build on their study this present study focuses on a different combination of product display methods: colour, discount and brand as both discount and brand are commonly used in retailing as dominance factors in coordinated product displays (Pegler, 2018; Bell and Ternus, 2017). Also, the effects of these three different product display methods are compared between the 3D and 2D interfaces.

The main aim of this study is to investigate if using a 3D vs a 2D interface for three different product display methods based on colour, discount and brand would make a difference in consumers' emotional, cognitive and behavioural responses. This study thus could contribute to the development and design of 3D and 2D shopping environments, especially with regard to product display. Theoretically, this study contributes to the testing of the S-O-R theory and the flow theory in the context of both 3D and 2D retailing.

Literature review

Stimulus-organism-response framework

S-O-R is considered an appropriate framework to understand the relationship between product display methods and consumers' responses. Mehrabian and Russell (1974) stated that environmental stimuli influence consumer behavioural responses primarily through emotional responses: pleasure, arousal and dominance. Subsequently, Donovan and Rossiter (1982) tested this model in the case of retail environment and note that store environment variables (colour, store layouts, or signage) affect our emotional responses, which enhances shopping enjoyment, spending behaviour, willingness to interact with sales personnel and likelihood of returning to the store. In sum, store environment variables serve as stimuli, which influence our emotional responses. These emotional responses mediate the relationship between environmental stimuli and consumer responses.

Stimulus. Eroglu *et al.* (2001) defined stimulus as "the sum total of all the cues that are visible and audible to the online shopper" (p. 179). In the case of online context, Eroglu *et al.* (2001) described two types of online environmental cues that serve the role as stimuli: high task and low task relevant cues. High task relevant cues include descriptions of the merchandise, availability of sampling and navigation aids such as site map and guide bar at the top or bottom of the page. On the other hand, low task relevant cues contain verbal content, colours, borders, background patterns, animation, typestyles, fonts, entertainment, amount of white space, icons, image maps and pictures.

In the case of physical environment, Baker (1986) classified the elements of store environment into three types: social factors, design factors and ambient factors. Social factors include people in the store, both customers and employees. On the other hand, design factors include visual cues such as layout and colour. Ambient cues include non-visual cues such as sounds, smells and lighting.

Organism. Eroglu *et al.* (2001) defined organism as "affective and cognitive intermediary states and processes that intervene the relationship between the stimulus and individual's responses" (p. 180). Cognitive states refer to how consumers understand information through their own mental experiences. Affective states refer to consumers' emotional responses exerted in response to environmental stimuli. Mehrabian and Russell (1974) and Donovan and Rossiter (1982) used the PAD model to explain these emotional responses. Donovan and Rossiter (1982) defined pleasure (P) as "the degree to which the person feels good, joyful, happy or satisfied with the situation" (p. 38); arousal refers to "the degree to which a person feels excited, stimulated, alert, or active in the situation" (p. 38) and dominance means "the degree to which a person feels excited, stimulated, alert, or active in the situation" (p. 38).

Baker *et al.* (1992) showed that consumers' emotional states, pleasure and arousal, significantly influence willingness to buy in the store. Also, pleasure and arousal enhance perceived merchandise quality and variety, leading to unplanned time spent in the store and unplanned purchasing (Donovan *et al.*, 1994). These emotional states are influenced by social, image, design and ambiance cues of the retail environment (Sherman *et al.*, 1997).

Like emotional states, consumers' cognitive states also affect consumers' responses (Eroglu *et al.*, 2001). Eroglu *et al.* (2001) defined cognitive state as "consumers' internal mental processes and states, and include attitudes, beliefs, attention, comprehension, memory and knowledge" (p. 181). For example, Eroglu *et al.* (2003) showed that online environmental cues have significant effects on both affective (pleasure and arousal) and cognitive states, which impacts satisfaction, attitude and approach or avoidance behaviour. Therefore, this study includes both affective and cognitive states as mediators.

Response. Mehrabian and Russell (1974) classified responses into two types: approach or avoidance behaviour. Subsequently, previous literature reviews documented consumer responses as money spent, patronage intentions, willingness to spend more time in the store, satisfaction, purchase intention, store loyalty, impulse buying behaviour and others.

Flow

Nah *et al.* (2011) defined flow as "an optimal state of experience in which one is completely absorbed in an activity that nothing else seems to matter" (p. 734). Novak *et al.* (2000) further defined flow as:

> […] a cognitive state experienced during navigation that is determined by (1) high levels of skill and control; (2) high levels of challenge and arousal; and (3) focused attention; and (4) is enhanced by interactivity and telepresence. Consumers who achieve flow on the web are so acutely involved in the act of online navigation that thoughts and perceptions not relevant to navigation are screened out, and the consumer focuses entirely on the interaction. (p. 22)

Previous studies suggested some important antecedents of consumer flow experience: interactivity, vividness, telepresence, novelty, playfulness, attractiveness, personal innovativeness, ease of use (Hoffman and Novak, 2009), challenge and skills (Mathwick and Rigdon, 2004), focused attention (Novak *et al.*, 2000) and specific goals (Novak *et al.*, 2003). Some of the important outcomes of flow are addictive behaviour, learning, perceived behavioural control, positive subjective experience, purchase intention and exploratory behaviour (Hoffman and Novak, 2009).

In order to highlight the characteristics of 3D virtual worlds (VWs) that affect flow, Park *et al.* (2008) have developed a conceptual model of 3D VWs. These characteristics are control, content and process. Control characteristics deal with the balance of challenge and skills. Content characteristics refer to the interactivity and vividness of 3D interface. And, process characteristics discuss consumers' intrinsic and extrinsic motivation. These three essential characteristics of 3D VWs can provide a high flow experience for consumers, which improve brand value.

Nah *et al.* (2010) presented the importance of control characteristics (skills and challenges) of 3D VWs on flow experience empirically. The balance of power and challenges is essential to enhance consumer flow experience, which in turn improves brand equity and behavioural intention. Subsequently, Nah *et al.* (2011) compared brand equity and behavioural intention between 2D and 3D virtual worlds based on content characteristics (interactivity and vividness). 3D VWs offer immersive and enjoyable virtual product experiences, which heightens telepresence, a specific aspect of flow. Telepresence refers to the state in which a person feels present in the physical world while using software (Steuer, 1992). Both interactivity and vividness enhance increased telepresence. Vividness is associated with the clarity, concreteness and richness of the mediated environment (Steuer, 1992). Previous studies defined telepresence either as a critical component or an antecedent of flow. For example, Hoffman and Novak (1996) stated that telepresence positively affects consumer flow experience, while Skadberg and Kimmel (2004) and Pace (2004) defined telepresence as one of the essential elements of flow.

Product display related to colour

Colour, an atmospheric cue, plays an important role in the retail environment (Bellizzi *et al.*, 1983; Turley and Milliman, 2000). Using the stimulus-organism-response, Eroglu *et al.* (2001) conceptualised how colour impacts both affective and cognitive states, as well as shopping outcomes. Roschk *et al.* (2017) conducted a meta-analysis (from the previous 30 years) to examine the effects of colour on consumers' responses. The results showed that colour type, such as warm or cool colour, influences consumers' pleasure, arousal, satisfaction and behavioural intentions. Furthermore, online environment cues such as colour and layout directly affect shopping enjoyment, shopping involvement and desire to stay at an online store (Kim *et al.*, 2007).

Additionally, colour has also been explained as a component of product display method (Lam and Mukherjee, 2005; Wu *et al.*, 2013). As noted by Lam and Mukherjee (2005), merchandise products that are coordinated based on colour, style, or design may enhance brand image and affect shopping behaviour, shopping experience and shopping outcomes. Subsequently, Wu *et al.* (2013) conducted experimental research to compare among three types of product coordination display methods based on colour, texture and style. Colour-coordinated store showed significantly higher patronage intention and retail pleasure compared to the texture and style coordinated store. Furthermore, the Kim *et al.* (2018) study presented an interesting finding regarding product information, which is displayed based on colour. They showed that product information presented based on colour has significant effects on "compromise effect". If products are presented in different colours, consumers rely on heuristics to process the information. However, it is difficult for them to reach a decision, ultimately choosing the middle option which is called compromise effect. On the other hand, if products are presented in the same type of colour, consumers do not have difficulty in choosing products. From the above studies, it is clear that colour impacts consumers in retail environments.

Product display related to discount

Discount plays an important role in influencing consumers' product evaluation and purchase intention (Grewal *et al.*, 1998; Nusair *et al.*, 2010). As noted by Grewal *et al.* (1998),

when retailers offer a high discount, it reduces consumers' perceived quality of products. Furthermore, price discount significantly influences consumer price perceptions (Nusair *et al.*, 2010). Also, Nusair *et al.* (2010) showed that different discount levels significantly influence the value of the discount, the quality of the service, the purchase intentions, the willingness to engage in the word of mouth advertising and the overall evaluation of the discount. The researchers described two types of discount frame: dollar off and percentage off. The "Dollar off" discount frame enhances the consumers' intent to make a purchase. On the other hand, the "Percentage off" discount frame heightens service quality and intention to spread WOM advertising.

Previous studies also examined discounts as a component of product display method (Kim and Kramer, 2006; Feng *et al.*, 2017). For example, Kim and Kramer (2006) compared two types of discount presentation such as telling consumers they will pay 80 per cent of the total retail price or 20 per cent of the original retail price. By presenting consumers with 80 per cent of pricing of the original, the presented discount increased the perception of savings and purchase likelihood compared to presenting customers with 20 per cent off the original price. As noted by Kim and Kramer (2006), pay 80 per cent is a novel presentation, whereas, take 20 per cent off is a typical presentation. Novel presentation format increases systematic processing of information, which helps consumers to improve the calculation accuracy. Also, Feng *et al.* (2017) showed that consumers take less time to compute the monetary discount when price promotions with discounts are presented vertically rather than horizontally. Vertical presentation format refers to when the regular price of products is presented vertically, while horizontal presentation format means when the regular price of products is placed from the left to right or vice-versa. Horizontal presentation format induces complexity in information processing and exerts math anxiety because it only relies on verbal memory resources. On the other hand, vertical presentation format relies on visual-spatial resources, which increases the ease of information processing.

Product display related to Brand

A synopsis of prior research suggests that the image of the retail environment influences consumers' perceptions of brands (Dolbec and Chebat, 2013; Damminga *et al.*, 2012; Foster and Mclelland, 2015). For example, Dolbec and Chebat (2013) showed that flagship stores create a better brand experience than brand stores for the same brand. Flagship stores provide highly interactive, emotional and sensory elements than brand stores. Foster and Mclelland (2015) stated that retailers need to present theme-dictated display over merchandise-focused display to enhance brand differentiation, brand loyalty and shopping enjoyment.

Furthermore, brand has also been examined as a component of product display method (Pullig *et al.*, 2006; Berger *et al.*, 2007). As noted by Pullig *et al.* (2006), when a newly introduced brand is displayed with existing brands, this mix significantly influences consumers' responses. For example, if the new brand's attributes in a category are dissimilar to the existing brands, this dilutes the brand. On the other hand, the brand is not diluted if the new brand and existing brand show similar attributes. Also, brand variety plays an important role in influencing consumers' brand evaluations and choices (Berger *et al.*, 2007). As stated by Berger *et al.* (2007), a variety of brands serves as a quality cue. Using six experimental studies, they show that consumers' brand evaluations and brand choices are higher when brands are presented with the large number of competing brands.

In addition to this, brand influences the perception of status (Nelissen and Meijers, 2011). By using an experimental study, Nelissen and Meijers (2011) compared a luxury label with a no label product and found that when a person wears a shirt with a luxury label, it increases their status. Based on costly signalling theory (Miller, 2009), wearing a luxury label is considered a signal of wealth, which enhances preferable social interactions with other consumers.

Characteristics of 3D vs 2D interfaces

One of the fundamental differences between 3D and 2D interface is telepresence (Nah *et al.*, 2011). As noted by Nah *et al.* (2011, p. 735), "users who perceive a sense of telepresence are focused on virtual or mediated environment to the extent that their stimulus field is limited to just that environment, while the physical environment is disregarded". 3D environments contain dynamic and multisensory elements. These dynamic and multisensory elements evoke a sense of being a presence in the environment, which enhances telepresence. Goel *et al.* (2011) stated that the visual and dynamic elements in 3D environments help consumers to create social, task and location awareness. These awareness states contribute to the formation of place attachment within 3D environment. Moreover, these three awareness states heighten cognitive absorption (deep involvement with the software), which influences the desire to return to the virtual world.

Bulu (2012) stated that 3D environments produce a spatial distribution of information regarding product, texture, motion and other details. These spatial distributions of information increase consumers' sense of presence in those environments. More recently, Vonkeman *et al.* (2017) discussed how the sense of presence influences consumers' impulsive buying behaviour. They compared the difference between a virtual mirror and a static image. As noted by, Vonkeman *et al.* (2017), the 3D virtual mirror provides the possibility for consumers to try on their chosen products, which reduces their psychological distance. On the other hand, one of the important problems of 2D static images is that consumers are not able to have the sense of touching a product. Therefore, 3D virtual mirrors exert higher local presence and product affect than 2D static images, and this influences consumers' impulsive buying behaviour. Park *et al.* (2005) stated that 3D product movement increases consumers' confidence to reduce their perceived risk. Also, it increases consumers' intentions to purchase a product. Besides, 3D rotation, multisensory channels, richness and multimedia features help consumers to engage in systematic information processing (Jiang and Benbasat, 2007).

Another significant advantage of using 3D interfaces is their visualisation features (Ives and Junglas, 2008). 3D interfaces allow consumers to create their own virtual environments (Nah *et al.*, 2010). Wu *et al.*'s (2015) study introduced three important facets of 3D virtual environment: merchandise presentation (fixturing, product density, manner of presentation and product adjacency), in-store environment (layout and interior), and in-store promotion (signage).

Based on the above review of the S-O-R framework, flow theory, product display methods and 3D vs 2D interfaces, we hypothesise:

H1. The effects of 3D and 2D interfaces on subjects' (a) flow, (b) pleasure, (c) arousal, (d) perceived merchandise quality, (e) satisfaction, (f) time spent and (g) patronage intentions are significantly different.

H2. The effects of product display methods based on colour, discount and brand on subjects' (a) flow, (b) pleasure, (c) arousal, (d) perceived merchandise quality, (e) satisfaction, (f) time spent and (g) patronage intentions are significantly different.

H3. The effects of the 2 × 3 experimental design (resulting in six display scenarios: 3D Colour, 2D Colour, 3D Brand, 2D Brand, 3D Discount and 2D Discount) is significant on subjects' (a) flow, (b) pleasure, (c) arousal, (d) perceived merchandise quality, (e) satisfaction, (f) time spent and (g) patronage intentions.

H4. Subjects' (a) flow, (b) pleasure, (c) arousal, (d) perceived merchandise quality mediate the relationships between the six display scenarios and subjects' (e) satisfaction, (f) time spent and (g) patronage intentions.

Thus, the stimuli variables in our study include the six display scenarios; the organism variables are flow, pleasure, arousal and perceived merchandise quality; and response variables include satisfaction, time spent and patronage intentions.

Methodology

Experimental design

This research conducted a 2 (Interface: 2D vs 3D) × 3(product display: colour, discount and brand) between-subjects experimental design. Six stimuli were developed, including 3D colour store, 2D colour store, 3D brand store, 2D brand store, 3D discount store and 2D discount store.

Experimental stimuli

The Mockshop software was used to develop the 3D interface of three different product display methods based on colour, discount and brand (see Figures 1–3). Mockshop is a 3D virtual retailing software that is designed for the fashion industry to create 3D merchandising directives and immersive stores in a virtual environment. One can take a virtual walk and check the information on any of the 3D products that simulate a real shopping experience. On the other hand, a 2D interface of three different product display methods based on colour, discount and brand were designed based on actual online retailing websites such as GAP or Forever 21.

Figure 1.
Product display based on color in the 3D interface

Figure 2.
Product display based on brand in the 3D interface

Figure 3.
Product display based on discount in the 3D interface

To develop both 3D and 2D product display methods, the following guidelines were implemented:

(1) None of the six product display methods contained any real brand information.

(2) The 3D colour, 3D brand and 3D discount product display methods were used in three 3D stores with the same size (35 inch × 30 inch × 15 inch). Also, 2D colour, 2D brand and 2D discount product display methods were also used in three 2D websites with the same size (35 inch × 30 inch). The brightness level, fixtures, background colour, floor materials and other variables were kept constant for the 3D colour, 3D brand and 3D discount display methods. Both 3D and 2D interfaces contained the same type and similar number of apparel items.

(3) To develop the 3D and 2D colour display methods, apparel items were coordinated based on warmness, coolness, neutral and a mix of warmness and coolness of colours. For the 3D colour display method, warm colour apparel items were arranged on the left side of the store; cool colour apparel items were coordinated on the right side of the store; mixed colour (warm and cool) apparel items occupied the back space of the store. Finally, neutral colour apparel items were displayed in the front of the store. For the 2D colour display method, warm colour apparel items were first grouped side by side. Subsequently, cool, mixed and neutral coloured apparel items were grouped side by side.

(4) Apparel items were coordinated based on brands A, B, C and D to develop the 3D and 2D brand display methods. Like the 3D and 2D colour display methods, the same procedure was followed to design the 3D and 2D brand display methods.

(5) Apparel items were coordinated based on new arrivals, 10 per cent off, 30 per cent off and 50 per cent off to develop the 3D and 2D discount display methods. Like the 3D and 2D colour display methods, the same procedure was also followed to design the 3D and 2D discount display methods.

Data collection procedure and sample

This study focused on only female consumers because only female apparel items were chosen. A total of 144 US female college student consumers participated in this study. Among them, 60 female undergraduate students from a mid-Western university evaluated 3D product display methods based on colour, discount and brand. They attended a computer lab with the Mockshop software installed. After their arrival, the researcher provided them with some basic training on how to navigate the Mockshop and review product information. All participants confirmed that they knew how to use this software

before moving forward. After their confirmation, participants were randomly assigned to one of the three 3D stimuli. First, they provided their informed consent, and then they were instructed to observe the assigned visual store. They were asked to shop and buy apparel items for themselves or for a friend who was a college woman. Also, they tracked the start and end times of their shopping in the visual store. After finishing the virtual shopping, they filled out the online questionnaire. This process took approximately 15 min including the practice session. For their participation, participants were awarded extra credit for a design course.

The remaining 84 undergraduate female students from various US universities were recruited through Amazon M-Turk to evaluate 2D product display methods based on discount, colour and brand. After providing their informed consent, participants were asked to indicate their education level. The screening process confirmed that only college women participated in this study. They were randomly assigned to each stimulus. After reviewing the 2D displays, they filled out an online questionnaire. Each participant was awarded $1 for their participation.

Though the two sample groups are not randomly selected out of a homogenous pool of participants we consider this sampling method valid because of the specificity of our topic in comparing 2D online shopping with 3D virtual reality shopping. Both are powered by technology, for which geographic boundaries are not an issue. All our participants are college students within the USA, which offers some level of control on age and education. Five graduate students were recruited to test the questionnaire and experimental stimuli. Minor adjustments were made to improve the clarity of the questions based on their suggestions.

Instrumentation

Pleasure. The pleasure instrument was adopted from the Donovan and Rossiter (1982) study. This instrument included seven items such as contended-depressed, happy–unhappy, satisfied–unsatisfied, pleased–annoyed, relaxed–bored, free–restricted and hopeful–despairing. The reported Cronbach's α was 0.87.

Arousal. The arousal instrument was also derived from the Donovan and Rossiter (1982) study. This instrument included seven items, with a Cronbach's α of 0.87, such as stimulated–relaxed, excited–calm, jittery–dull and wide awake–sleepy.

Flow. The consumer flow experience was measured by adopting an instrument from the Novak *et al.* (2000) study. This instrument comprised of three items: "When carrying the virtual tour, I experienced flow at some point," "I felt I was in flow during some parts of the virtual tour," and "I did not experience any flow during my virtual tour". The reported Cronbach's α was 0.90.

Satisfaction. The satisfaction instrument was adopted from the Mägi (2003) study. This instrument comprised of two items: "How satisfied are you with your primary grocery store (very dissatisfied–very satisfied)?" and "How well does your primary grocery store match your expectations (not at all-completely)?" The reported Cronbach's α was 0.80.

Patronage intentions. The patronage intention instrument was adopted from the Baker *et al.* (2002) study. It included three items with a Cronbach's α of 0.84–0.88. They were "The likelihood that I would shop in this store is high," and "I would be willing to buy gifts at this store".

Perceived merchandise quality. The perceived merchandise quality instrument was adopted from the Baker *et al.* (2002) study. This instrument comprised of two items: "This store offers high-quality gifts," and "The products in this store have high workmanship". The reported Cronbach's α was 0.73.

All items were measured using a seven-point Likert scale (strongly disagree to agree strongly).

Manipulation check. Three single items were used for the manipulation check: this visual product display was coordinated based on the brand of the apparel products; this visual product display was coordinated based on price discount of the apparel products; and this visual product display was coordinated based on the colour of the apparel products.

Results

Sample characteristics

This study included a total of 144 US undergraduate female consumers (age ranging from 18 to 23). Many of the participants' majors were Retail Merchandising (46 per cent), followed by business, communications and advertising (26 per cent) and apparel design (18 per cent).

Preliminary data analysis

Cronbach's α was used to measure the reliability of all measurement scales. The accepted value for Cronbach's α is 0.7 (Kline, 1999). All items showed high reliability and the Cronbach's α value was above 0.8. The Cronbach's α value for pleasure, arousal, flow, perceived merchandise quality, satisfaction and patronage intention instruments was 0.93, 0.87, 0.93, 0.88, 0.92 and 0.96, respectively.

Manipulation check

Three single items were used for the manipulation check. Multivariate analysis (MANOVA) confirmed that there were significant differences in subjects perceptions of colour (3D interface) ($F = 26.72$, $p < 0.001$), discount (3D interface) ($F = 22.63$, $p < 0.001$), brand (3D interface) ($F = 23.47$, $p < 0.001$), colour (2D interface) ($F = 32.34$, $p < 0.001$), discount (2D interface) ($F = 18.87$, $p < 0.001$) and brand (2D interface) ($F = 21.34$, $p < 0.001$).

Homogeneity assumption test

The assumption of homogeneous expression – an important feature of Levene's test – for all dependent variables with respect to six different product display methods met ($p > 0.05$) except pleasure and arousal. Therefore, we employed Pillai's trace instead to investigate the results of the test (Field, 2009). A MANOVA was conducted to understand the effects of the six different display scenarios on all dependent variables. Results from Pillai's trace showed that the six different product display scenarios had significant effects on all dependent variables ($v = 0.402$, $F = 1.697$, $p < 0.05$).

Hypothesis testing

H1 predicted that the 3D and 2D interfaces showed significant differences on all dependent variables. The MANOVA analysis confirmed that the 3D and 2D interfaces demonstrated significant differences on: flow ($F = 6.66$, $p < 0.05$, partial $\eta^2 = 0.05$), satisfaction ($F = 7.63$, $p < 0.05$, partial $\eta^2 = 0.05$), time spent ($F = 10.02$, $p < 0.05$, partial $\eta^2 = 0.07$) and patronage intentions ($F = 7.07$, $p < 0.05$, partial $\eta^2 = 0.05$) except pleasure, arousal and perceived merchandise quality. Therefore, *H1* were partially supported.

Fitted regression models showed that flow (coefficient = 0.06*, $p < 0.05$), time spent (co-efficient = 0.07**, $p < 0.05$), satisfaction (coefficient = 0.07**, $p < 0.05$) and patronage intentions (co-efficient = 0.07**, $p < 0.05$) were higher for the 3D interface than the 2D interface.

H2 predicted that colour, discount and brand coordination product display methods showed significant differences on all dependent variables. The results showed that product display methods based on colour, discount and brand showed significant differences on flow ($F = 4.27$, $p < 0.05$, partial $\eta^2 = 0.06$), time spent ($F = 4.49$, $p < 0.05$, partial $\eta^2 = 0.05$) and patronage intention ($F = 3.49$, $p < 0.05$, partial $\eta^2 = 0.05$).

Post hoc Dunett *t* (two-tailed) test showed significant differences between colour and discount product display methods on flow, satisfaction, time spent and patronage intentions, but showed no significant differences between colour vs brand, and brand vs discount product display methods. Flow (MD = 1.07, $p < 0.05$), satisfaction (MD = 0.74, $p < 0.05$), time spent (MD = 1.06, $p < 0.05$), and patronage intentions (MD = 0.88, $p < 0.05$) were higher for the colour display method compared to the discount display method.

H3 predicted that the six different product display scenarios showed significant effects on all variables. MANOVA analysis showed that there were significant differences of six product display methods on flow ($F = 3.75$, $p < 0.05$, partial $\eta^2 = 0.05$), satisfaction ($F = 2.83$, $p < 0.05$, partial $\eta^2 = 0.05$), time spent ($F = 4.42$, $p < 0.05$, partial $\eta^2 = 0.06$), and patronage intentions ($F = 359$, $p < 0.05$, partial $\eta^2 = 0.05$).

Post hoc Dunett *t* (two-tailed) test demonstrated that 3D colour creates higher flow than 2D brand, 2D discount and 2D colour; and 3D discount, 3D brand and 2D colour also shows higher flow than 2D discount. And 3D colour, 2D colour and 3D brand also shows higher satisfaction than 2D discount. Also, participants spent more time in 3D colour and 2D colour than in 2D brand and 2D discount, respectively. Moreover, participants perceived higher patronage intention in 2D colour, 3D colour, 3D discount, 3D brand than in 2D discount. Also, 3D colour showed higher arousal than 2D discount. Finally, 3D colour and 3D brand create higher perceived merchandise quality than 2D discount (see Table I).

Response variables	MD	*p*
Flow		
3D Colour/2D Brand	1.64	$p < 0.05$
3D Colour/2D Colour	2.17	$p < 0.05$
3D Colour/2D Discount	2.04	$p < 0.05$
3D Discount/2D Discount	1.38	$p < 0.05$
3D Brand/2D Discount	1.58	$p < 0.05$
2D Colour/2D Discount	1.36	$p = 0.056$
Satisfaction		
3D Colour/2D Discount	1.44	$p < 0.05$
2DColor/2D Discount	0.93	$p < 0.05$
3D Brand/2DDiscount	1.29	$p < 0.05$
Time spent		
3D Colour/2D Brand	1.36	$p < 0.05$
2D Colour/2D Discount	1.40	$p < 0.05$
Patronage intentions		
2D Colour/ 2D Discount	1.24	$p < 0.05$
3D Colour/2D Discount	1.51	$p < 0.05$
3D Discount/2D Discount	1.12	$p < 0.05$
3D Brand/2D Discount	1.38	$p < 0.05$
Pleasure		
Product display		$p > 0.05$
Arousal		
3D Colour/2D Discount	0.87	$p < 0.05$
Perceived merchandise quality		
3D Colour/2D Discount	1.63	$p < 0.05$
3D Brand/2D Discount	1.13	$p < 0.05$
3D Colour/2D Brand	1.09	$p = 0.053$

Table I.
Comparison among six different product display methods on response variables

H4 predicted that pleasure, arousal and perceived merchandise quality mediate the relationship between the six product display scenarios and satisfaction, time spent and patronage intention. Sobel test (1982) was used to analyse the mediating roles of flow and perceived merchandise quality. The results showed that flow ($z = -2.35$, $p < 0.05$) and perceived merchandise quality ($z = -2.85$, $p < 0.05$) mediated the relations between the six product display scenarios and satisfaction, time spent and patronage intentions. The mediation was partial because there were also direct effects of the six product display scenarios on satisfaction, time spent and patronage intention.

Discussion and conclusion

The results showed that this study partially supported the S-O-R and flow theories. For example, 3D and 2D interfaces showed significant differences on flow, perceived merchandise quality, satisfaction, time spent and patronage intentions. Also, product display methods based on colour, discount and brand in both 3D and 2D interfaces had significant influences on most outcome variables. However, they did not have significant differences on consumers' emotional states: pleasure and arousal (in most cases). This finding is contrary to the Wu *et al.* (2013) study because the authors found that product display methods based on colour, style and texture had significant differences on consumers' emotional states. We reasoned that perhaps colour, brand and discounts are more commonly used display approaches in the retail industry than style coordination and texture and thus the differences among them are not as noticeable. Though the 3D interface contains richer multi-sensory elements than the 2D interface, it failed to provide consumers with significantly more impactful emotional experience than the 2D interface. This might be because consumer might concentrate more on examining apparel items rather than focusing on the rich, sensory attributes of the 3D interface since this experiment is a task given to the subjects.

This study makes a unique theoretically contribution in that it tested the S-O-R framework for its applicability for a three-dimensional virtual retail environment. The Sobel mediation test confirmed the hypothesised mediation of some "organism" variables, e.g. flow and perceived merchandise quality, of the effects of the six product display scenarios, i.e. stimuli, on the response variables, such as satisfaction, time spent and patronage intention.

Findings from our study showed that the 3D interface created higher flow, perceived merchandise quality, satisfaction, time spent and patronage intentions compared to the 2D interface. The 3D interface allows consumers to "walk" around the store. They can examine an apparel item closer and from multiple angles, which thus provides them with a richer, sensory experience. On the other hand, the 2D interface presents static images of apparel items. Therefore, the information provided about a product is limited compared to the 3D interface. This finding aligns with Park *et al.*'s (2005) claim: 3D product movement allows consumers to carefully examine the product, which reduces perceived risk.

Our study implies that retailers could benefit from using a 3D interface instead of a 2D interface. Retailers could implement the 3D interface with coordinated displays in their shopping site. Furthermore, retailers could also present 3D features such as virtual try on, virtual mirror, 3D rotation, 3D videos and spatial distribution of information, haptic feedback and avatar in their existing 2D websites.

Additionally, our study investigated the effects of product coordination display methods based on colour, discount and brand. It provides retailers with a better understanding of how they can arrange products in an apparel store. The findings showed that the colour-coordinated display created higher flow, satisfaction, time spent, purchase intentions and perceived merchandise quality than the discount-coordinated display. Also, the colour-coordinated display marginally showed better perceived merchandise quality

than the brand-coordinated display. These findings confirmed the findings of the Wu *et al.* (2013) study, which also found that consumers preferred colour-coordinated display over style- and texture-coordinated display. Moreover, the importance of the colour-coordinated display is also illustrated in the Kim *et al.* (2018) study. As noted by Kim *et al.* (2018), colour presents additional information when consumers make their decisions. They argue that it is difficult for consumers to make their decisions when products are presented with different colours. The colour-coordinated display can help consumers to attenuate the "compromise effect". Also, colour-coordinated display helps consumers to deeply absorb information because it creates higher flow when compared to discount-coordinated display method.

The implication of this finding is that online retailers could present information based on similar colours, so that consumers can find visual harmony, which influences their flow experience, perceived merchandise quality, satisfaction, time spent and patronage intentions. Such colour coordinated displays could emphasise the colour attribute of the products and group products based on their similarity in the colour hues. For example, warm, cool or neutral colours could be grouped together; Or monochromatic, analogous, or contrasting colour schemes could be intentionally used to feature products. Our finding showed that the 3D interface creates better consumer response compared to the 2D interface. Therefore, the colour-coordinated display in a 3D interface can provide consumers with richer information, which in turn helps them to make informed decisions. Also, along with the product presentation based on colour, online retailers could provide virtualization technology, interactive medium and zooming technology to magnify the colour effect and thus enhance consumers' cognitive and behavioural outcomes.

The least preferable display method is product coordination display based on discount in the 2D interface. This finding showed that consumers might not respond to discount-based displays as intended. Therefore, retailers should take caution when implementing discount-based displays. This finding aligns with Blattberg and Neslin (1990) and Grewal *et al.*'s (1998) studies. As noted by Grewal *et al.* (1998), "perceptions of quality can be explained using self-perception theory, one type of attribution theory which describes how consumers explain events. If a consumer purchases a product on discount they often 'attribute' " the fact that it was on discount because it is a poorer quality product" (Dodson *et al.*, 1978, p. 7).

Limitations and future research

One of the limitations of this study is that the 2D interface is not as interactive as the real online shopping sites. For example, real online retailers such as GAP or Forever 21 provide many navigation options online to view and select apparel items such as online pathfinding assistance, search engine, site map and guide bar at the top or bottom of the page. Therefore, future research could develop a more interactive 2D interface to compare it with 3D interface. Another limitation of this study is that the subjects were given a shopping task, which differs from a real shopping task with a budget and perhaps a shopping list in mind. Also, though all our participants are college students in the USA, they came from methods of recruitment, which could potentially skew our results. Further, there are many extraneous variables that we cannot control, such as the environment that participants were in when responding to the 2D scenarios, participants' prior knowledge about online or 3D shopping, etc. These are shared limitations for experiments involving self-selected online participants.

Also, this research only investigated the effects of product display methods on unidimensional flow. Future research could measure the effects of product display methods on multidimensional flow. The multidimensional flow consists of enjoyment, concentration, control and challenge (Hausman and Siekpe, 2009).

Moreover, future research could focus on consumers' responses such as impulsive buying behaviour, which might be better suited to a lab setting shopping requirement. Sharma *et al.* (2010) define impulse buying "as a sudden, hedonically complex purchase behaviour in which the rapidity of the impulse purchase precludes any thoughtful, deliberate consideration of alternative or future implications" (p. 277). Future research can be conducted to understand which product display methods would stimulate higher impulsive buying behaviour.

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