3D Product Authenticity Model for Online Retail: An Invariance Analysis.

Raed Algharabat
Brunel Business School, Marketing Department, Brunel University, U.K.
Phone: +44 (0) 1895 266251, Fax: +44 (0) 1895 269775
Raed.Algharabat@brunel.ac.uk

Charles Dennis
Brunel Business School, Marketing Department, Brunel University, U.K.
Phone: +44 (0) 1895 265242, Fax: +44 (0) 1895 269775
Charles.Dennis@brunel.ac.uk

Raed Algharabat is a Ph.D. researcher at Brunel University, London, U.K. He has won numerous research awards including Best Papers Award at the *Academy of Marketing* Conference in 2009 and Brunel Business School Symposium 2009. Raed's research area is e-retailing, particularly, 3D virtual models and their impact on consumers' behaviour within the online retailer context.

Charles Dennis is a Senior Lecturer at Brunel University, London, UK. His teaching and research area is (e-) retail and consumer behaviour – the vital final link of the Marketing process – satisfying the end consumer. Charles is a Chartered Marketer and has been elected as a Fellow of the Chartered Institute of Marketing for work helping to modernise the teaching of the discipline. Charles was awarded the Vice Chancellor's Award for Teaching Excellence for improving the interactive student learning experience. Charles's publications include *Marketing the e-Business,* (1st & 2nd editions) (joint-authored with Dr Lisa Harris), the research-based *e-Retailing* (joint-authored with Professor Bill Merrilees and Dr Tino Fenech) and research monograph *Objects of Desire: Consumer Behaviour in Shopping Centre Choice*. His research into shopping styles has received extensive coverage in the popular media.

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Abstract

This study investigates the effects of different levels of invariance analysis on three dimensional (3D) product authenticity model (3DPAM) constructs in the e- retailing context. A hypothetical retailer Web site presents a variety of laptops using 3D product visualisations. The proposed conceptual model achieves acceptable fit and the hypothesised paths are all valid. We empirically investigate the invariance across the subgroups to validate the results of our 3DPAM. We concluded that the 3D product authenticity model construct was invariant for our sample across different gender, level of education and study backgrounds. These findings suggested that all our subgroups conceptualised the 3DPAM similarly. Also the results show some non-invariance results for the structural and latent mean models. The gender group posits a non-invariance latent mean model. Study backgrounds group reveals a non-invariance result for the structural model. These findings allowed us to understand the 3DPAMs validity in the e-retail context. Managerial implications are explained.

Keywords: 3D product authenticity, control, animated colours, value, behavioural intention, invariance analyses.

1. Introduction

Scholars (e.g., Li et al., 2001, 2002, 2003) classify experiences, based on the interaction between a product or an environment and an individual, into three types. First, direct experience permits consumers to interact (e.g., physically) directly with a product. Second, indirect experience often allows consumers to interact with second-hand source such as static visual pictures. Third, virtual experience allows consumers to interact with three dimensional (3D) virtual models. According to Steuer (1992, p.78) virtual reality (VR) is "*a real or simulated environment in which a perceiver experiences telepresence*". In contrast, virtual experience (VE) derives from VR and can be defined as "*psychological and emotional states that consumers undergo while interacting with a 3D environment*" (Li et al. 2001, p. 14). A 3D presentation enables

consumers to interact with products, enriches their learning processes, and creates a sense of being in a simulated real world. Furthermore, direct and virtual experiences combine within VR, such that the latter enhances and enriches the overall experience because consumers use almost all of their senses when interacting with a 3D product visualisation (Klein, 2003; Li et al., 2001, 2002, 2003). Despite widespread discussions and various definitions of VE, we notice that previous scholars, within the online retail context, consider the notions of 3D telepresence as virtual substitutes for actual experience with the products. However, the telepresence and presence constructs are not necessarily wholly appropriate concepts for marketers since they represent a process of being mentally transported into other areas or being immersed into an illusion environment. Such notions may not be particularly helpful for marketers and website designers who are concerned with 3D product visualisation of real products. Instead, we propose the 3D product authenticity construct, which refers to simulating a real product authentically online. We therefore first discuss the notions of telepresence or presence in the immersive virtual reality (IVR) environment then proceed to explain applications of non-immersive virtual realties (NIVR i.e., an online retailer context). We also offer a new definition and measurement scale for the construct of authenticity. Furthermore, we introduce the 3D product authenticity model to replace the telepresence model in the virtual reality environment. To validate our findings of the 3D product authenticity model, we investigate the effects of different levels of invariance analysis, across gender, levels of education and study backgrounds subgroups.

2. Theoretical Background

2.1. 3D Product Visualisation in the Immersive and Non-Immersive VR

VR terminologies enter the vocabulary with the emergence of IVR devices, such as head-mounted display, which allow users to interact with virtual environments and to visualise different objects (Suh and Lee, 2005). As a result, the notions of telepresence or presence emerge. Notwithstanding, previous literature in the IVR area has provided readers with different classifications and conceptualisations of VR. For example, Steuer's (1992, p. 76) definition of VR focuses on human experience, not technological hardware, and differentiates between presence and telepresence. Whereas presence refers to "*the experience of one's physical environment; it refers*

not to one's surroundings as they exist in the physical world, but to the perception of those surroundings as mediated by both automatic and controlled mental processes", telepresence is "*the experience of presence in an environment by means of a communication medium*". In turn, Sheridan (1992) distinguishes between virtual presence and telepresence, such that presence relates to the sense of being in a computer-mediated environment, whereas telepresence indicates a sense of being in any real remote location. To that end, Bioccca and Delaney (1995) argue that the definition of VR depends on technological hardware and software. The authors define VR as perceptual immersion presence. This type of presence depends on sensory immersion in virtual environments. To extend prior literature, Lombard and Ditton (1997) identify six taxonomies of VR presence: social richness, realism, transportation, immersion, social actor within medium and medium as social actor. Notwithstanding Lombard and Ditton's (1997) classification, two types of presence are identified in the NIVR area, concerning users interaction with e-retailers' websites and products using desktop or laptop computers (Suh and Lee, 2005). The first is telepresence, or the illusion of being in a place far from the physical body (Biocca, 1997; Heeter, 1992). This conceptualisation of telepresence relates to transporting a user, self, or place, to another place. The second form is telepresence in a social sense, such that other beings exist in the VR world with whom users can interact (e.g., avatars). Authors such as Heeter (1992) and Lombard and Ditton (1997) empirically test this concept, and McGoldrick and colleagues (2008) emphasise the avatar's role in enhancing virtual personal shopper capabilities. We notice that previous scholars, within the online retail context, use the notions of 3D telepresence and presence to surpass actual experience with the products. However, telepresence or presence constructs are not the proper terminologies that marketers should use since they represent a process of being mentally transported into other areas or being immersed into an illusion environment. Moreover, such notions may not help marketers and website designers to deal with 3D product visualisation as a real product. Instead, using the 3D product authenticity construct to simulate a real authentic product that a consumer can experience when engaging with an online retailer might be better. We felt that it is important to measure how consumers, within the online retail context, could imagine that 3D presented products. Particularly, we introduced our new construct, namely, 3D product authenticity to reflect customers' virtual experience, where customers can feel the authenticity of the 3D products.

2.2. 3D Product Authenticity (3DPA) Construct

None of the previous definitions of telepresence or presence that use 3D virtual models realistically taps consumers' virtual experiences. A 3D virtual experience should be an authentic representation of the direct (offline) experience. We therefore propose a new notion that relates to the simulation of online products and virtual experience, namely, the authenticity of the product visualisation. Telepresence and presence are not particularly well suited to the online retail context, because they reflect illusion and transportation to other places. In contrast, the concept of 3D authenticity of the product visualisation implies the ability to simulate the product experience in bricks-and-clicks contexts. We propose the following definition of perceived 3D product authenticity in a computer-mediated environment: 3D Product Authenticity (3DPA) is a *psychological state in which virtual objects presented in 3D in a computer-mediated environment are perceived as actual objects in a sensory way*.

2.3. 3D Product Authenticity Antecedents and Definitions

We use the control construct to represent interactivity in an online retail context. Ariely's (2000) definition of control refers to users' abilities to customise and choose Web site contents to achieve their goals. We focus more on consumers' ability to control and easily interact with the 3D virtual model. Therefore, we define control as *users' abilities to customise and choose the contents of the virtual model (i.e., 3D product visualisation), rotate, and zoom in or out on the product in the virtual model and the ability of the virtual model (3D) to respond to participants' orders properly.*

Furthermore, 3D vividness should facilitate virtual experience by providing more sensory depth and breadth (Li et al., 2002, 2003). High-quality online animations enhance perceived telepresence (e.g., Fortin and Dholakia, 2005; Klein, 2003; Shih, 1998). Specifically, we consider vividness of the visual imagery, such that consumers can see online products with different colours (skins) just as they would see them in person. Media richness may lead to telepresence, according to research on online

shopping (Klein, 2003; Schlosser, 2003). Moreover, consumers' ability to change the animation (colours) of the 3D product might help them sense control over the product.

2.4. Effects of 3D products Authenticity on Utilitarian Value

Scholars (e.g., Fiore and Jin, 2003; Fiore et al., 2005a; Kim et al., 2007; Klein, 2003; Li et al., 2001, 2002, 2003; Suh and Chang 2006) explain the importance of using 3D product visualisations in enhancing consumers' understanding of product attributes, features and characteristics. 3D visualisation increases consumers' involvement and encourages them to seek more information about the products (Fiore et al., 2005a). Suh and Lee (2005) posit a positive relationship between higher levels of 3D product visualisation and seeking more information about the products' characteristics and features. Suh and Chang's (2006) empirical research of the influence of 3D product visualisation and product knowledge reveals a positive relationship between 3D and perceived product knowledge. Using 3D product visualisation helps consumers to imagine how a product may look and it gives them more details about the products' characteristics (Fortin and Dholakia, 2005; Klein, 2003; Shih, 1998).

2.5. Effects of 3D Products Authenticity on Hedonic Value

Scholars (Fiore et al., 2005b; Kim and Forsythe, 2007; Lee et al., 2006; Schlosser, 2003) report the importance of 3D product visualisation in enhancing the experiential aspects of a virtual shopping. The above researchers find that the ability of 3D product visualisation to produce hedonic values for shoppers is greater than its ability to produce utilitarian values. Fiore et al. (2005b) assert that image interactivity technology produces hedonic value, which is highly correlated with consumers' emotional pleasure and arousal variables. Fiore et al. (2005a) posit the importance of virtual models in boosting hedonic value (enjoyment). Fiore et al. (2005a) also report the importance of a high level of image interactivity technology in comparison to a low level of image interactivity technology (in the low level conditions, consumers could only enlarge the static picture of clothing) in producing more hedonic value. Many scholars in the communication field (e.g., Heeter, 1992; Lombard and Ditton, 1997; Song et al., 2007) report the importance of enjoyment as a consequence of

using 3D. Consumers use 3D product visualisation to have more fun, enjoyment and entertainment (Kim and Forsythe, 2007). Such sources of fun or enjoyment come from consumers' ability to rotate, and zoom in or out on the product (Fiore et al., 2005a), seeing different animated coloured pictorial images that may enhance their mental pleasure when using 3D sites.

2.6. Effects of 3D Product Authenticity, Utilitarian and Hedonic Value on Behavioural Intention

The role of 3D product visualisation in enhancing behavioural intentions appears well supported; 3D utilitarian and hedonic values improve willingness to purchase from an online retailer (Fiore et al., 2005a, 2005b), intention to buy (Schlosser, 2003) and purchase intentions (Li et al., 2001; 2003). Moreover, 3D realism improves users' beliefs and attitudes towards an online store (Klein, 2003)

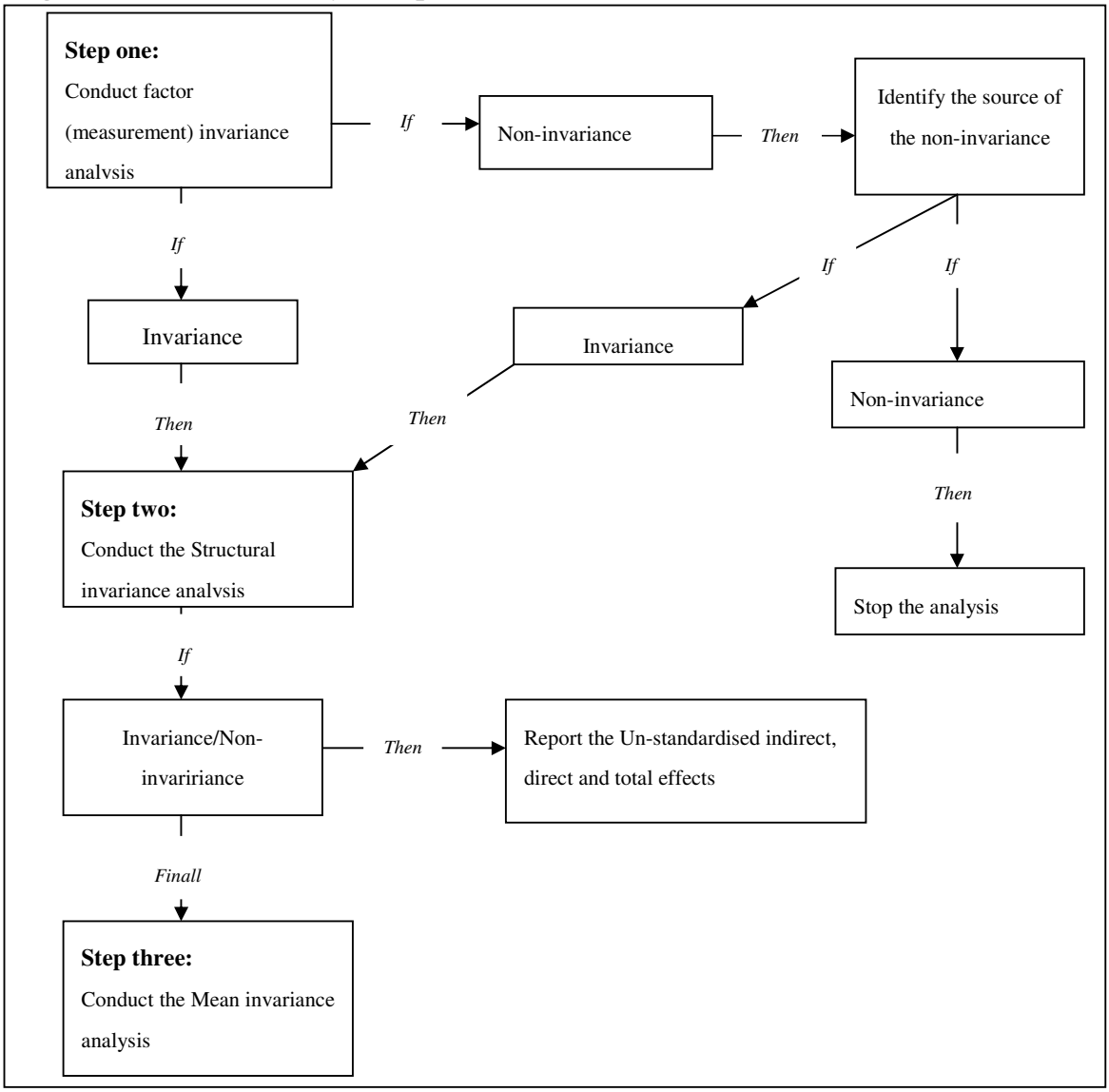
3. Invariance Analysis

We use the invariance analyses to determine the effects of gender, education levels and study backgrounds and their relationships in our conceptual framework. Figure 1 explains the steps used in our invariance analyses. We start with conducting a measurement invariance analysis (measurement weight) for gender, education levels and study backgrounds to determine whether, for example, the males and females groups would use the same pattern in measuring the observed items. If the result is invariant, then the data of each group is suitable for further analysis (i.e., structural invariance analysis). However, if the two groups understood the items in different ways (i.e., non-invariance), then, we identify the source of the non-invariance. To do so, we identify the observed item(s) that caused the non-invariance. If the result of the measurement model is invariance, then, we go to the next step. However, if the results still non-invariant, then, we stop the analysis.

Secondly, after having the insignificant results in the measurement model, we conduct the invariance structural model analysis to determine if gender, education levels and study background groups have invariance or non-invariance results in perceiving the relationships between the unobserved constructs. In conducting this analysis, we

follow two steps (i) if the members of any group (e.g., the males and females groups) perceive the relationships between the constructs similarly (i.e., invariance), then, we move to the third step (i.e., latent mean invariance analysis), (ii) however, if the members of any group perceive the relationships between the constructs differently (i.e., non-invariance), then we determine the source of the non-invariance. Moreover, regardless whether the structural model analyses are variance or non-invariance we calculate the un-standardised direct, indirect and total effects. Thirdly, we conduct the latent mean invariance analyses among latent constructs to determine if the groups have perceived each construct similarly (invariance) or differently (non-invariance). In all the three previous steps, we report $\Delta\chi^2$ and Δdf and fit indices (TLI, CFI and RAMSE) models for the comparison purposes.

Figure 1. Invariance analysis steps

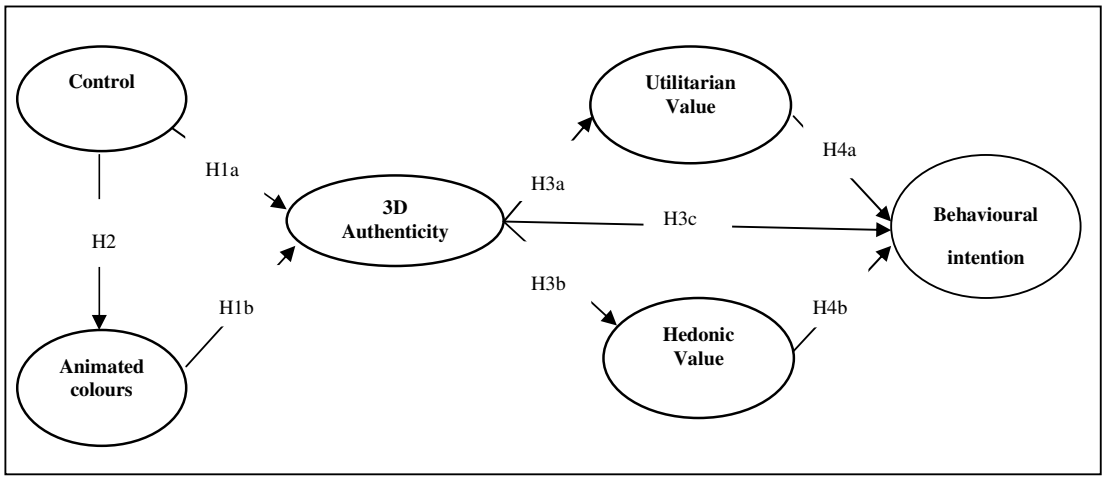


Source: the authors.

4. Research Model

We demonstrate our research model in Figure 2. Our model is testing the relationships between control, animated colours, 3D product authenticity, hedonic and utilitarian value and behavioural intention. As the objective of our study is 3D product authenticity model's measurement equivalence, the focus of our model is concentrated on whether gender, education levels and study backgrounds affect participants' responses to our 3D product authenticity model.

Figure 2: conceptual framework (source: the authors).



5. METHODS

5.1. Design and Participants

We designed a retailer website with one stimulus. The stimulus allowed participants to view a laptop's attributes, functions and characteristics; they also can zoom in or out, rotate it and see it with different colours. Moreover, unlike previous studies that focused on perceived product knowledge, our design enhances consumers' actual product knowledge (see Appendix A). The website that we created for this study was not previously known to users, nor did users have any knowledge of the fictitious brands on the site. Thus, we eliminated any impact of previous experiences or attitudes (Fiore *et al*., 2005a). The site offers a wide variety of laptops, similar to

those that many college-aged women and men currently buy and use. We used a sample of 312 students to perform this experiment. The sample was gender balanced, consisting of 48% women and 52% men, and 90% of the sample ranged from 18 to 30 years of age. Approximately 90% reported having had prior online shopping experience.

5.2. Instrument

Participants were informed that this study pertained to consumers' evaluations of an electrical retailer's Web site. The questionnaire contained five-point Likert-type scales, anchored by "strongly disagree" and "strongly agree".

To measure the control construct, we developed a five-item scale that centres on users' ability to rotate and zoom in or out the virtual model based on Liu and Shrum's (2002); McMillan and Hwang's (2002) and Song and Zinkhan's (2008) studies. To measure animated colours, we developed a four-item animated colour scale based on Fiore and colleagues (2005a), Klein's (2003), Steuer's (1992) studies. The items tap how closely the simulated sensory information reflects the real product. We could not find an existing scale to measure 3D product authenticity so we developed a new five-item scale. We submitted the items to evaluations by academics (lecturers in online retailing and Ph.D. students); these respondents considered the items relevant for measuring the authenticity construct. We followed Churchill's (1979) procedures for developing a marketing construct scale and adopted Christodoulides and colleagues (2006) procedures for developing a scale for the online context. Each item began with "After surfing the 3D sites", and then obtained responses to the following: "3D creates a product experience similar to the one I would have when shopping in a store", "3D let me feel like if I am holding a real laptop and rotating it" (i.e. virtual affordance), "3D let me feel like I am dealing with a salesman who is responding to my orders", "3D let me see the laptop as if it was a real one", and "Being able to zoom in/out and rotate the laptop let me visualise how the laptop might look in an offline retailer".

To measure hedonic values, we adopted a modified version of Babin and colleagues (1994) scale. We based the study on 4 of the 11 items. To measure utilitarian values, we adopted a modified version of Fiore and colleagues (2005a) scale. To measure

Behavioural intention, we used a modified version of Fiore and colleagues (2005a) scale (see Table).

6. RESULTS

6.1. Respondent's Profile

Table 5.4 shows the demographics of the respondents including age, levels of education and educational backgrounds. Table (5.4) shows a gender balance, male (53.2%) to female (47.8%). In regard to level of education, 58.7% of the sample are undergraduate students and 41.3% are postgraduate students. In terms of the study backgrounds, the sample represents two main subjects as follows; Business and Social Science (55.1%) and Maths-IT and engineering Science (44.9%).

Table 1: Demographic Items

Demographic profile	Number of respondent N= 312	Valid percentage
Gender		
Male	162	53.2
Female	149	47.8
Level of education		
Under graduate	183	58.7
Post graduate	129	41.3
Study background.		
Business school and Social science school.	172	55.1
Maths and IT school and Engineering school	140	44.9

6.2. Measurement Model for the 3D Product Authenticity Model

We evaluated the measurement and structural equation models using AMOS 16. The measurement model includes 23 indicators, and we provide its results in Table 2, including the standardised factor loading, standard error (S.E), critical ratios (C.R), composite reliability, squared multiple correlation and average variance extracted (AVE) for each construct. The standardised factor loadings (λ) are all greater than .61. The composite reliabilities for control (.80), animated colours, (.782), 3D authenticity

(.86), utilitarian (.85), hedonic (.86) and behavioural intention (.88) are acceptable (Hair *et al.,* 2006). Moreover, average variance extracted by each construct exceeds the minimum value recommended by Hair *et al.* (2006), (i.e., exceeds .5).

Table 2. Measurement model results for hypothetical 3DPAM.

Construct Indicator	Standardized factor loading (λ)	S.E.	C.R.	Average Variance extracted	Squared multiple correlation	Composite reliability
η1 (control)				0.50		0.80
- I felt that I could choose freely what I wanted to see	.78	-			0.602	
- I felt that I had a lot of control over the content of the laptop's options (i.e. angles and information)	.71	0.077	12.097		0.508	
- I felt it was easy to rotate the laptop the way I wanted.	.71	0.076	10.009		0.503	
- I felt I could control the laptop movements.	.61	0.071	8.916		0.369	
η2 (animated colours)				.502		0.78
-There are lots of colours on 3D laptop websites.	.79	-			0.631	
- Colours brightness of the 3D laptop let me visualize how the real laptop might look.	.71	0.067	11.391		0.499	
- The laptop illustrated by 3D was very colourful	.61	0.064	10.099		0.375	
η3 (Authenticity)				.608		0.86
- 3D Creates a product experience similar to the one I would have when shopping in a store.	.77	-			0.598	
- 3D Let me feel like if I am holding a real laptop and rotating it (i.e. virtual affordance)	.79	0.078	14.093		0.628	
- 3D Let me feel like I am dealing with a salesman who is responding to my orders.	.81	0.078	14.581		0.656	
- 3D let me see the laptop as if it was a real one.	.74	0.076	13.293		0.550	
η4 (hedonic value)				0.59		.86
- Would be like an escape.	.64	-			0.411	
- Would be truly enjoyable	.77	0.105	12.752		0.589	
- Would be enjoyable for its own sake, not just for the items I may have purchase.	.88	0.128	11.987		0.722	
- Would let me enjoy being immersed in an existing new product.	.79	0.144	11.123		0.618	
η5(utilitarian value)				.582		0.85
- Help me make a better decision about the product.	.80	-			0.637	
- help me buy the right product.	.92	0.079	16.179		0.844	
- Aid me in evaluating the laptop items.	.69	0.067	12.481		0.475	
- Help me in finding what I am looking for	.61	0.066	11.002		0.375	
η6 (Behavioural intention)				0.631		.88
- After seeing the web site, how likely is it that you would buy a laptop from this online store.	.81	-				
- I would be willing to purchase a laptop through this online store.	.82	0.061	16.151			
- I intend to buy a laptop from this online store.	.82	0.075	15.323			
- I would be willing to recommend this	.72	0.059	13.160			

online retailer to my friends.						

6.3. Structural Equation Model for the 3D Product Authenticity Model

The hypothesised model achieves a chi-square of 350.225 (df = 219), with a goodness-of-fit index (GFI) of .911, comparative fit index (CFI) of .965, root mean square residual (RMR) of .038 and root mean square error of approximation (RMSEA) of .044, normed fit index (NFI) of .912, relative fit index (RFI) of .9, incremental fit index (IFI) of .965, and χ^2/df = 1.599. These results indicate a good fit of the data to the model (Byrne, 2001; Hair et al., 2006). Furthermore, the structural equation model confirms that control and animated colours have significant positive effects on authenticity (H_{1a} t = 2.098; H_{1b} t = 7.951). Moreover, animated colour exhibits a significant positive effect on control (H_2 t = 7.888). Finally, as we hypothesized, authenticity, hedonic and utilitarian values have positive effects on behavioural intention (H_{3c}: 2.465, $H4_a$: t = 2.216, H_{4b}: t= 2.454). Table 3 reports estimates, standardised estimates, and critical ratio for each hypothesized path. All the hypothesized paths are supported ($p < .05$).

Table 3. Summary of results of structural model estimation

Standardised regression paths (β)		Estimate	S.E.	C.R.	P	hypothesis
H_1	Animated colours → Control	.539	.068	7.888	***	Supported
H_{2a}	Control →Authenticity	.165	.079	2.098	.036	Supported
H_{2b}	Animated colours →Authenticity	.672	.085	7.951	***	Supported
H_{3a}	Authenticity → Utilitarian	.470	.055	8.567	***	Supported
H_{3b}	Authenticity → Behavioural intention	.229	.093	2.465	.014	Supported
H_{3c}	Authenticity → Hedonic	.483	.054	8.875	***	Supported
H_{4a}	Utilitarian → Behavioural intention	.211	.086	2.454	.014	Supported
H_{4b}	Hedonic → Behavioural intention	..274	.124	2.216	.027	Supported

6.4. Invariance Analysis Results

The invariance analyses provide a better understanding of our conceptual model and its constructs invariance validity. Following a series of invariance analyses, we could conclude that our conceptual framework was invariant of measurement loading, structural loading and latent mean across gender, education level and study background. The following explains the invariance analysis and it reports the non-invariance models.

6.4.1. Gender

We classify the participants into two groups according to their gender (i.e., males or females). The measurement model results (Table 4) reveal insignificant differences between the males and females groups in understanding the questions of each latent construct. In other words, both groups have understood the questions similarly. The second step is to check the structural invariance.

Table 4: Results of factorial invariance analysis for gender: assuming model unconstrained to be correct.

Gender (n= 312)	P	χ^2	df	$\Delta\chi^2$	Δdf	CFI	RAMSE
Measurement model	**.404**	635.786	455	17.761	17	.952	0.036

The structural model results (Table 5) reveal insignificant differences between the males and females groups in determining the relationships between the proposed constructs. In other words, both groups have perceived the importance of the relationships between the constructs similarly. The latent mean model results (tables 6 and 7) reveal that the behavioural intention construct has a non-invariance difference between the males and females groups. The females group is higher (.179) than the males group in perceiving the behavioural intention construct.

Table 5: Results of structural invariance analysis assuming model measurement weight to be correct:

Gender (n = 312)	P	χ^2	df	$\Delta\chi^2$	Δdf	CFI	RAMSE
Structural model	**.082**	649.793	463	14.007	8	.952	0.036

Table 6: Mean: (Male-Unconstrained): assuming model measurement weight to be correct:

Gender (n = 312)	P	χ^2	df	$\Delta \chi^2$	Δdf	TLI	CFI	RAMSE
Structural mean model	**.019**	650.619	464	15.136	6	.946	.950	0.036

Table 7: Means: (male-Measurement weight)

Construct (gender mean 312)	Estimate	S.E	C.R	P
Control	-.138	.088	-1.562	.118
Animation	.069	.069	.994	.320
Authenticity	.016	.097	.168	.867
Hedonic	.071	.065	1.092	.275
Utilitarian	.048	.055	.875	.382
Behavioural intention	**.179**	.069	2.581	**.010**

Table 8 shows the results of un-standardised indirect, direct and total effects-estimates for the females and meals groups. The females group perceives the total effects of the 3D product authenticity construct on behavioural intention more (.479) than the males group (.402) does. Moreover, the females group perceives the total effects of the animated colours construct (.366) more than the males group does (.316), also the females group perceives the total effects of the hedonic values on behavioural intention (.366) more than the males group does. However, the males group perceives the total effects of the utilitarian values on behavioural intention (.282) more than the females group does (.135).

The females group perceives the total effects of the hedonic values (.366) on behavioural intention more than the total effects of the utilitarian values (.135). In turn, the males group perceives the total effects of the utilitarian values (.282) on behavioural intention more than the total effects of hedonic values (.152). The animated colours construct has the strongest indirect effect (females = .366, males = 316) in both groups. Finally, the females group perceives the indirect effect of the

control construct on behavioural intention (.190) more than the males group (.003) does.

Table 8: Results of un-standardised indirect, direct and total effects- estimates

Direct, indirect and total effects-estimates Males.

Predictor variables	Behavioural intention toward the online retailer		
	Indirect effects	Direct effects	Total effects
Animated colours	.366	------	.366
Control	0.190	------	.190
Authenticity	.262	.217	.479
Utilitarian value	------	.135	.135
Hedonic value	------	.366	.366
R^2		.36	

Direct, indirect and total effects-estimates Females.

Predictor variables	Behavioural intention toward the online retailer		
	Indirect effects	Direct effects	Total effects
Animated colours	.316	------	.316
Control	0.003	------	.003
Authenticity	.185	.217	.402
Utilitarian value	------	.282	.282
Hedonic value	------	.152	.152
R^2		.36	

Un-standardised indirect, direct and total effects- estimates

6.4.2. Education Level

The second invariance analysis classifies participants into two groups according to the participants' educational levels (undergraduates and postgraduates groups). The measurement model results (Table 9) reveal invariance differences (i.e., insignificant differences) between the undergraduates and postgraduates groups in understanding the questions of each latent construct. In other words, both groups have perceived the questions similarly.

Table 9: Results of factorial invariance analysis for education: assuming model unconstrained to be correct.

education level (n = 312)	P	χ^2	df	$\Delta\chi^2$	Δdf	CFI	RAMSE
	.562	649.828	455	15.466	17	.949	0.37

Measurement model							

The structural model results (Table 10) reveal invariance (insignificant) differences between the undergraduates and the postgraduates groups in determining the relationships between the proposed constructs. In other words, both groups have perceived the importance of the relationships among the constructs similarly.

Table 10: Results of structural invariance analysis assuming model measurement weight to be correct:

education level	P	χ^2	df	$\Delta\chi^2$	Δdf	TLI	CFI	RAMSE
(n = 312) Structural model	**.240**	660.190	463	10.363	8	.943	.948	.037

The latent mean model results (Tables 11 and 12) reveal invariance differences between the undergraduates and the postgraduates groups. In other words, both groups perceive the latent constructs similarly.

Table 11: Mean: (undergraduate -Unconstrained): assuming model measurement weight to be correct:

education level	P	χ^2	df	$\Delta\chi^2$	Δdf	TLI	CFI	RAMSE
(n = 312) Structural mean model	**.072**	**656.679**	**464**	**11.575**	**6**	**.945**	**.949**	**0.037**

Table 12: Mean: (undergraduate –Measurement weight)

Construct (education level mean 312)	Estimate	S.E	C.R	P
Control	**.178**	**.091**	**1.957**	**.050**
Animation	**.125**	**.071**	**1.775**	**.076**
Authenticity	**.001**	**.096**	**.010**	**.992**
Hedonic	**-.029**	**.066**	**-.447**	**.655**
Utilitarian	**.016**	**.056**	**.291**	**.771**
Behavioural intention	**.080**	**.069**	**1.167**	**.243**

Table 13 shows the results of un-standardised indirect, direct and total effects-estimates for the undergraduate students group and the postgraduate students group. The undergraduate students group perceives the total effects of the 3D product

authenticity construct on behavioural intention more (.489) than the postgraduate students (.404) group does. In turn, the postgraduate group perceives the total effects of the utilitarian and hedonic values on behavioural intention more than the undergraduate students group does. The undergraduate group perceives the direct effect of the utilitarian values on behavioural intention more (.163) than the direct effect of the hedonic values (.148). In contrast to the undergraduate students, the postgraduate students perceive the direct effect of the hedonic values on behavioural intention more (.478) than the utilitarian values (.243). The animated colour has the strongest indirect effect (The undergraduate group = .361, postgraduate group = .338) in both groups. However, the indirect effect of the control construct in the undergraduate group (.133) is greater than the indirect effect of the postgraduate group (.001).

Table 13: Results of un-standardised indirect, direct and total effects- estimates

Direct, indirect and total effects-estimates
Undergraduates

Predictor variables	Behavioural intention toward the online retailer		
	Indirect effects	**Direct effects**	**Total effects**
Animated colours	**.361**	**------**	**.361**
Control	**.133**	**------**	**.133**
Authenticity	**.161**	**.329**	**.489**
Utilitarian value	**------**	**.163**	**.163**
Hedonic value	**------**	**.148**	**.148**
R^2	.37		

Direct, indirect and total effects-estimates
Postgraduates

Predictor variables	Behavioural intention toward the online retailer		
	Indirect effects	**Direct effects**	**Total effects**
Animated colours	**.338**	**------**	**.338**
Control	**.001**	**------**	**.001**
Authenticity	**.317**	**.087**	**.404**
Utilitarian value	**------**	**.243**	**.243**
Hedonic value	**------**	**.478**	**.478**
R^2	.37		

Un-standardised indirect, direct and total effects- estimates

6.4.3. Participants' Study Backgrounds

The third invariance analysis classifies the participants into two groups according to the participants' study backgrounds (Business-Social and Maths-IT-Engendering groups). The measurement model results (Table 14) reveal insignificant differences between the Business-Social studies and the Maths-IT-Engendering studies backgrounds in understanding the questions. In other words, both groups have perceived the questions similarly. The second step is to check the structural invariance.

Table 14: Results of factorial invariance analysis for background: assuming model unconstrained to be correct

Background	P	χ^2	df	$\Delta\chi^2$	Δdf	CFI	RAMSE
(n= 312) Measurement model	**.221**	675.953	455	21.115	17	.943	0.040

Structural model results (Table 15) reveal non-invariance (significant) differences between the Business-Social studies and the Maths-IT-Engendering studies groups in determining the relationships between the proposed constructs. The following section explains the source of the non-invariance in the structural model.

Table 15: Results of structural invariance analysis assuming model measurement weight to be correct

Background	P	χ^2	df	$\Delta\chi^2$	Δdf	TLI	CFI	RAMSE
(n = 312) Structural model	**.010**	696.033	463	20.080	8	.934	.939	0.040

The structural model results (Table 16) reveal significant differences between the Business-Social studies and the Maths-IT-Engendering studies groups. The relationships between 3D product authenticity→ hedonic, and hedonic → behavioural intention are the source of this non-invariance. In other words, both groups perceive the importance of the hedonic values differently.

Table 16: Results of path coefficient invariance analysis for study background.

Model	P	χ^2	df	$\Delta\chi^2$	Δ df	TLI	CFI	RAMSE
Animation →Authenticity	.221	654.963	439	.125	1	.935	.944	.040
Control→ Authenticity	.589	655.131	439	.292	1	.935	.944	.040
Authenticity→ Hedonic	.002**	664.788	439	9.950	1	.932	.941	.041
Authenticity →Utilitarian	.128	657.156	439	2.317	1	.935	.943	.040
Utilitarian →BI	.295	655.934	439	1.096	1	.935	.944	.040
Hedonic → BI	.048*	658.745	439	3.906	1	.934	.943	.040
Animation →Control	.326	655.804	439	.966	1	.935	.944	.040
AU→BI	.419	655.493	441	.654	1	.935	.944	.040

p < 0.05; ** p <0.01.

Table 17 shows the results of un-standardised indirect, direct and total effects-estimates for the Maths-IT-Engendering studies background group and the Business-Social studies background group. The Maths-IT-Engendering group perceives the total effects of the 3D product authenticity construct on the behavioural intention more (.574) than the Business-Social studies group (.306) does. However, the Business-Social studies group perceives the total effects of the utilitarian values (.169) on the behavioural intention more than the Maths-IT-Engendering group does. On the other hand, the Maths-IT-Engendering group perceives the total effects of the hedonic values (.225) on the behavioural intention more than the Business-Social studies group (.029) does. In contrast to the Maths-IT-Engendering group who perceives the direct effect of the hedonic values (.225) on the behavioural intention more than the utilitarian values (.069), the Business-Social studies group perceives the direct effect of the utilitarian values on the behavioural intention more (.169) than the hedonic

values (.029). The animated colour has the strongest indirect effect (.221, 433 respectively) in both groups. However, the indirect effect of the control construct in the Maths-IT-Engineering group (.244) is greater than the indirect effect of the control on the Business-Social studies group (.029). Finally, in both groups the 3D product authenticity construct has the strongest direct effect and total effects.

Table 17: Results of un-standardised indirect, direct and total effects- estimates

Direct, indirect and total effects-estimates Human-science group.

Predictor variables	Behavioural intention toward the online retailer		
	Indirect effects	**Direct effects**	**Total effects**
Animation colours	**.221**	**------**	**.221**
Control	**0.029**	**------**	**.029**
Authenticity	**.075**	**.230**	**.306**
Utilitarian value	**------**	**.169**	**.169**
Hedonic value	**------**	**.029**	**.029**
R^2	.34		

Direct, indirect and total effects-estimates Maths-IT-Engendering group.

Predictor variables	Behavioural intention toward the online retailer		
	Indirect effects	**Direct effects**	**Total effects**
Animated colours	**.433**	**------**	**.433**
Control	**0.224**	**------**	**.224**
Authenticity	**.156**	**.419**	**.574**
Utilitarian value	**------**	**.069**	**.069**
Hedonic value	**------**	**.225**	**.225**
R^2	.34		

Un-standardised indirect, direct and total effects- estimates

The latent mean model results (Tables 18 and 19) reveal invariance differences between the Business-Social studies and the Maths-IT-Engendering studies. In other words, both groups perceive the latent constructs similarly. The latent mean model results reveal that both groups have invariance differences

Table 18: Mean: (Human-studies-Unconstrained): assuming model measurement weight to be correct:

Background	P	χ^2	df	$\Delta\chi^2$	Δdf	TLI	CFI	RAMSE
(n= 312)	**.664**	681.002	464	4.094	6	.938	.944	0.039

Structural mean model								

Table 19: Mean: (human-studies- Measurement weight)

Construct (Background mean 312)	Estimate	S.E	C.R	P
Control	**.080**	**.092**	**.873**	**.382**
Animation	**.036**	**.068**	**.530**	**.596**
Authenticity	**.084**	**.097**	**.871**	**.384**
Hedonic	**.045**	**.065**	**.698**	**.485**
Utilitarian	**0.068**	**.056**	**1.214**	**.225**
Behavioural intention	**.127**	**.068**	**1.873**	**.061**

7. Discussion

7.1. Genders

Following a series of invariance analyses, it can be concluded that our 3D product authenticity model is invariant in respect of measurement model and structural model across gender. The un-standardised effects show that females group perceives the total effects of the animated colours (.366) on the behavioural intention more than the males group does (.316). This finding could be interpreted by using the media richness theory, which Dennis et al. (1999) apply on the computer-mediated environment and find that females' ability to understand and use nonverbal cues are better than males. The females group perceives the total effects of the 3D authenticity construct on the behavioural intention more (.479) than the males group (.402) does. This result supports Tversky and Morrison's (2002) findings regarding the ability of the animated graphics to increase females' comprehension and learning. In support of previous scholarly literature (e.g., Dennis and McCall, 2005; Carpenter and Moore, 2009; Chang et al., 2005; Overby and Lee, 2006), this study finds that the females group perceives the total effects of the hedonic values on behavioural intention (.366) more than the males group does. However, the males group perceives the total effects of the utilitarian values on behavioural intention (.282) more than the females group does (.135). Moreover, this result supports the findings of Dennis and King (2009)

and Dholakia and Chiang (2003) regarding the Empathising and Systemising nature of shopping styles in males and females. The difference (non-invariance) in the latent mean between males and females groups suggests that females tend to accept the idea of buying from our fictitious e-retailer more than the males group does.

7.2. Educational levels

The invariance analysis across educational levels shows similarity in measurement model, structural model, and latent mean model. The un-standardised effects show that undergraduate students perceive the total effects of the 3D authenticity construct on behavioural intention (.489) more than the postgraduate students (.404) do. Undergraduate students perceive the direct effect of utilitarian values on behavioural intention (.163) more than the direct effect of the hedonic values (.148). In contrast to the undergraduate students, postgraduate students perceive the direct effect of the hedonic values on behavioural intention (.478) more than the utilitarian values (.243). The above results support Raijas' (2002) findings that highly educated people may have the experience that they need to buy a laptop and they know the characteristics that they seek. To ensure this result, we go back to the participants' demographic variables and find that the postgraduate students bought on average two laptops online, whereas undergraduate students bought on average one laptop online. This result indicates that highly educated people enjoyed the 3D for the sake of enjoyment.

7.3. Study backgrounds

The invariance analysis results reveal similarity in measurement and latent mean models. However, the non-invariance (significant) differences between Business-Social group and Maths-IT-Engendering groups clearly come in the relationships between the proposed constructs (i.e., the structural model). The authenticity→ hedonic and the hedonic→ behavioural intention relationships are the source of the coefficients non-invariance. In other words, both groups perceive the importance of the hedonic values and the behavioural intention differently. That is, Maths-IT-Engendering group tend to accept that the 3D authenticity and the novelty of the 3D flash increases the level of fun and entertainment. On the other hand, Maths-IT-Engendering group does not accept that the high level of entrainment may end with a positive behavioural intention towards the online retailer. In regards to the un-

standardised effects, students with the Maths-IT-Engendering backgrounds perceive the total effects of the 3D authenticity construct on the behavioural intention (.574) more than the Business-Social backgrounds (.306) do. This could be justified due to the Maths-IT- Engineering group ability to understand and criticize the novelty of the 3D more than the Business-Social backgrounds. However, the Business-Social background group perceives the total effects of the utilitarian values (.169) on behavioural intention more than the Maths-IT-Engendering group does. On the other hand, the Maths-IT- Engineering group perceives the total effects of the hedonic values (.225) on behavioural intention more than the human-studies group (.029) does. In contrast to the Maths-IT-Engendering group who perceives the direct effect of the hedonic values (.225) on behavioural intention more than utilitarian values (.069), the Business-Social studies group perceives the direct effect of the utilitarian values on behavioural intention (.169) more than the hedonic values (.029). These results could be explained as follows. First, Raijas (2002) finds that the experienced people know what they are looking for. Moreover, these results support the findings of Dennis and King (2009) and Dholakia and Chiang (2003) regarding shopping styles. In other words, when shopping for technical and expensive products shoppers who are Empathisers turn to become Systemisers and vise verse. Second, in comparison to the Business-Social group, the Maths-IT- Engineering group bought on average more laptops online ($M_{\text{Maths-IT-Engendering}} = 1.33$, $M_{\text{human-studies}} = 1.3$) than the Business-Social group did. The Business-Social group are more interested in a laptop features and characteristics than entertainment features. The animation construct had the strongest indirect effect (.221, 433 respectively) in both groups. However, the indirect effect of the control construct in the Maths-IT- Engineering group (.244) is greater than the indirect effect of control on the Business-Social studies group (.029). Finally, in both groups, the 3D authenticity construct has the strongest direct effect and total effects.

8. Conclusion

Our invariance analyses highlight the importance of 3DPAMs applicability in e-retailing and its construct invariance validity. Following a series of invariance analyses, it can be concluded that our 3DPAM is invariant in respect of measurement model and latent mean model across gender, education level and study background.

Of the nine invariance tests conducted, three were found to be non-invariant. This conclusion posits that females and males, undergraduates and postgraduates, Business-Social and Mathes-IT- Engineering groups, overall, conceptualise the 3DPAMs constructs and its variables: animated colours, control, authenticity, utilitarian, hedonic and behavioural intention similarly. These results confirm the applicability of our model in the e-retailing area, unaffected by bias of gender, education level and study background (Lai and Li, 2005).

9. Managerial Implications

E-retailers should pay more attention to 3D product authenticity antecedents, i.e., control and animated colour when designing their 3D virtual models. Including real colours and flashes that consumers can control easily will lead to more authentic online experiences. The direct and indirect effects of animated colours and control constructs reveal the importance of these constructs within the 3D e-retail context. Any 3D flash should include the essential information that consumers seek rather than just a pretty picture. For example, consumers should be able to click on any part of the 3D flash to get access to information about it. Web site developers should take advantage of technological advancements to develop and update online retailers' 3D flashes. Pechtl (2003) asserts a positive relationship between perceived innovation attributes and online adoption behaviour. Algharabat and Dennis (2009a) posit the importance of authentic 3D product to enhance users' hedonic and utilitarian values. Managers and Web sites designers should work together to ensure that the 3D product visualisation provides customers with the complete and accurate information they need. In addition, marketers should decide what information (or knowledge) to focus on before developing 3D flashes. It should be accepted that developing 3D flashes is not a money-free issue. Nevertheless, many companies have already claimed to have improved their sales as a result of designing and using 3D flashes. For example, J.C. Penny, eBags and Wal-Mart claimed that their online sales have increased 10% to 50% after using rich media such as 3D flashes (Demery, 2003). Moreover, Demery (2006) posits that the numbers of companies who are investing in 3D virtual models is increasing steadily because these companies are seeing the potential of the technology for selling more products. Nantel (2004) asserts that consumers shopping online for clothing are 26% more likely to purchase from the sites that have 3D virtual model

than from sites that have not. Moreover, Fiore (2008) posits that media richness is an important way to differentiate retailers. Wagner (2000) asserts that online retailers with 3D product visualisations may reap benefits that extend beyond sales. For example, 3D increases site stickiness: users will spend more time on the online retailer, which leads to more opportunities to learn more about the products, interact with them, build trust and confidence. Finally, according to the Social Issues Research Centre (SIRC, as cited in Herrod, 2007) study it is expected that "by 2020 virtual commerce (v-commerce) will replace e-commerce" and the development of 3D virtual models (such as 3D virtual shopping malls) will be leading the whole industry by 2020.

10. Limitations and Further Studies

Although the generalisability of the results is limited by the student sample, and cannot be generalised to all online consumer groups, we argue that students represent the shoppers of tomorrow (Algharabat and Dennis, 2009b; Balabanis and Reynolds, 2001) and the research thus has prescient value. Second, since this study has focused only on laptops, which we consider to be products that are associated with more search or experience, it is unclear to what extent the results can be generalised and applied to other online products. On the bases of our results, we recommend that Web site developers should pay more attention to simulating 3D animation colours to reflect the real products more authentically. Moreover, they should work to create an environment in which consumers sense that they can feel the online products when they navigate the site. We recommend research efforts to extend the generalisability of our findings to other contexts (e.g., clothing) and to non-student samples. Further research may add and test other stimuli, for example by simulating real sounds to investigate how auditory vividness may influence 3DPAM.

11. References

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Appendix A