THE EXAMINATION OF TWO WEB SITE USABILITY INSTRUMENTS FOR USE IN B2C E-COMMERCE ORGANIZATIONS[1]

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ABSTRACT

This study used a B2C e-commerce simulation in an effort to validate two Web site usability instruments. The results of the confirmatory factor analysis found the first instrument exhibited moderately acceptable measurement properties, while the second instrument displayed poor validity for the suggested dimensions. Attempted validation of these instruments and the subsequent development of a more comprehensive measure of Web site usability should facilitate an organization's understanding of the strengths and weakness of their B2C Web sites in an increasingly competitive environment.

Keywords: Web site usability, B2C e-commerce, Confirmatory factor analysis, Instrument validation

INTRODUCTION

The evolving strategies for e-commerce deployment make the evaluation of Web site capabilities a necessity. Businesses look for new and unique strategies to increase profits while creating e-commerce environments that exude a sense of trustworthiness, and increase the likelihood that the consumer will complete the transaction. The human-computer interaction that occurs when the consumer visits an e-commerce site is an important part of the online shopping experience. In fact, empirical work by Lohse and Spiller [29] suggests that interface features, such as those assessed during usability testing, explain a substantial amount of the variance (61%) in sales for online stores. Additional studies [10, 53] have found that web design, or the appropriate use in interface features, can impact organizational performance through improved reach to customers and greater loyalty from customers.

One interface feature in particular, Web site usability, has recently garnered a greater emphasis in the MIS literature [39]. Straub, Hoffman, Weber, and Steinfield [52] suggested the need for unique metrics for Web site usability, noting the Web's underlying many-to-many communication model makes traditional metrics ineffective. This human-computer interaction between the consumer and Web site interface allows "an unprecedented level of choice in an environment that approaches full information and shifts the balance of market power toward the end consumer" [60; p. 117].

Developing a standardized instrument is important as this facilitates direct comparisons between individuals, time periods, industries, cultures, or geographic regions [12]. The research cycle for developing a standardized instrument involves two steps: (1) exploratory studies that put forward hypothesized measurement model(s) via the analysis of empirical data from a referent population; and (2) confirmatory studies that test the hypothesized measurement model(s) against new data gathered from a similar referent population. The end user computing satisfaction instrument [17] is an example of the replication of a research instrument in different settings to further validate that instrument. Several studies have shown the importance of validating instruments in this way through confirmatory factor analysis [14, 15, 16].

This paper examines two Web site usability instruments that have been suggested as appropriate for understanding how to improve performance and effectiveness of an organization's B2C Web site. Both Palmer [41] and Agarwal and Venkatesh [3] developed instruments to measure Web site usability. Their work completed the first exploratory step in the instrument development cycle. The current research moves the process into the second step by gathering new data to test the validity and reliability of both the Palmer and the Agarwal and Venkatesh instruments. The paper is organized as follows: a literature review of usability and specifically of website usability. This is followed by a discussion of the two website usability instruments of interest to this study i.e. the Palmer instrument and the Agarwal and Venkatesh instrument. The paper concludes with a presentation of the results, a discussion of implications, and finally potential limitations of this study.

LITERATURE REVIEW

Human Computer Interaction

Several definitions have been developed for the field of human computer interaction (HCI). The Association for Computing Machinery's Special Interest Group in Computer Human Interaction (SIGCHI) (http://sigchi.org/cdg/cdg2.html), the leading professional organization for HCI, defined HCI as "concerned with the design, evaluation, and implementation of interactive computing systems for human use and the study of major phenomena surrounding them." Carroll [11] defines HCI as "the study and practice of usability. It is about understanding and creating software and other technology that people will want to use, will be able to use, and will find effective when used." HCI combines the theories and practices from cognitive and behavioral psychology, ergonomics, anthropology, sociology, computer science, engineering, graphic design, and MIS, among others [28, 46].

The focus of HCI research shifted from the psychology of human information processing in the 1970's and 1980's to the era of the PC, which brought with it a focus on usability of single-user computer systems, multi-user workstations, multimedia,

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hypertext, virtual reality, and a recognition of the importance of group work, integration, use in home and society [44]. The commercial importance of HCI has become increasingly apparent with the development of the Internet, World Wide Web, and associated e-business activities. Others have recognized that applications and interfaces make up the non-commodity value of computer products and services and that there is a clear return on investment in HCI [33].

Usability

Technology usability and design receives considerable attention in the human computer interaction (HCI) literature. Usability of information systems has been shown to include five key elements: consistency of the interface, response time, mapping and metaphors, interaction styles, and multimedia and audiovisual [39]. Nielsen's work extends specifically to Web design when he addresses the problem of rapid growth in the number of Web sites along with the slower growth of Internet developers for these sites. The vast number of Web sites makes it obvious that user interface (UI) professionals will not be employed for each one. According to Nielsen, the possible solution to this would be to (1) make it possible to design usable sites without having UI expertise, (2) train more people in good Web design, and/or (3) live with poorly designed sites that are hard to use [40]. The need to examine the usability of information systems is evident, thus this topic should be of interest to organizations due to the increasing demand by consumers to provide a multitude of products, services, and support in an online format.

According to Smith, Newman, and Parks [48; p. 68], "In order to assess the usability of an artifact, it is necessary to ask what it is being used for and by whom." The HCI literature has focused on several facets of Web site usability, while generally overlooking the need to provide an explicit definition that includes all relevant dimensions. Usability means different things in different settings to different people, but it is important to bring about a consensus to allow for a valid examination of usability. These broad attempts make the underlying dimensions too abstract to provide much value.

Although the HCI literature has examined several aspects of Web site usability [10, 18, 36, 53, 54, 55], it has only been recently that information systems literature began to examine Web site usability in the context of understanding success in B2C e-commerce. The development of instruments to measure Web site usability allows managers to make comparisons, benchmark performance, and plan improvements. Usability is increasingly important as organizations compete in the always changing, hypercompetitive online markets [6, 10, 30, 65]. Therefore, having valid and reliable instruments to measure Web site usability is important for both business and research.

Both Palmer [41] and Agarwal and Venkatesh [3] provided some of the first attempts to better define the underlying dimensions of Web site usability through the empirical development of specific research instruments. The Palmer usability study defined usability based on the five dimensions derived from usability and media richness literature. The Agarwal and Venkatesh study defined usability using the ISO definition of usability—"the extent to which a product (i.e. Web sites) can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [p. 170]. By attempting to develop instruments that provided nomological validity, Palmer [41] and Agarwal and Venkatesh [3] provide a foundation upon which further validation studies can be performed. This paper is an attempted validation of the Palmer and the Agarwal and Venkatesh instruments of Web site usability in consumer-focused Web sites.

Web Site Usability Models

Confirmatory factor analysis was used to evaluate the two research models of interest. Confirmatory factor analysis involves the specification and estimation of models based on their factor structure, each of which proposes a set of latent variables (factors) that account for covariances among a set of observed variables. The analysis in this study used previous studies and goodness-of-fit indexes to validate each instruments' underlying first-order factor structure.

Palmer Instrument (2002)

Palmer [41] developed a measure of Web site usability that found significant associations between Web site design and Web site performance with the constructs demonstrating good nomological validity. Five factors are included in the Palmer instrument. *Download delay* is the initial request for access to the page and then each subsequent request for changing pages with the site [45]. Web site designers can choose not to include slow loading elements, thus length of wait is important. *Navigability* is a measure that is defined as the sequencing of pages, well organized layout, and consistency of navigation protocols. *Content* includes the amount and variety of content as well as the use of text, graphics, and multimedia. *Interactivity* includes the ability to customize the site's look, feel, and content as well as provide interaction with the user. Berry [5] suggests that some of the most valued metrics revolve around customer reaction to the site. *Responsiveness* is defined as the presence of feedback to users and the availability of response from the site managers.

Agarwal and Venkatesh Instrument (2002)

Agarwal and Venkatesh [3] utilized categories and subcategories comprising the Microsoft Usability Guidelines (MUG), when developing an instrument that operationalizes Web site usability. Their findings suggested that the evaluation procedure, the instrument, as well as the usability metric exhibited good evaluation properties. In another study, Ventatesh and Ramesh [59] utilized this instrument within a different environment (Finland) and context (web and wireless) to test its robustness and generalizability. They suggested that the instrument outperformed the widely employed technology acceptance model (TAM) in terms of richness and variance explained.

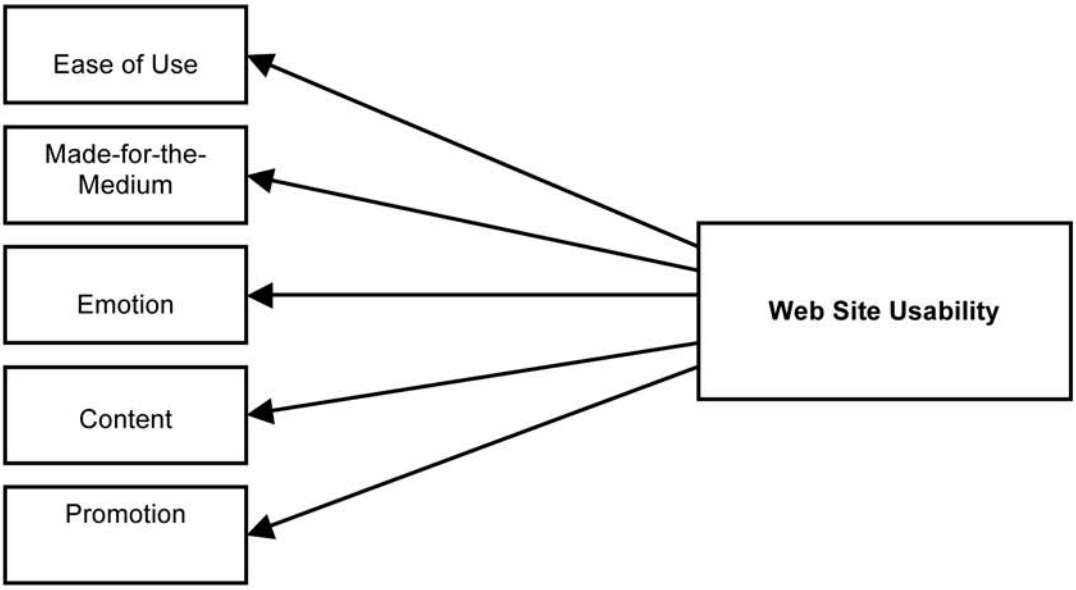
Ease of use describes the cognitive effort required in using a Web site. MIS research has widely accepted this measure as an antecedent to various technology acceptance outcomes [10, 13, 49, 53, 62, 63]. *Made-for-the-medium* relates to tailoring a Web site to fit a particular user's needs. Peppers and Rogers [43] suggest contemporary marketing strategies require Web sites with dynamic content tailored to specific user needs. *Emotion* taps into affective reactions invoked by a Web site. Agarwal and Venkatesh [3] note that affective responses have shown to be important in computer use situations [1, 28, 57, 58, 59]. *Content* assesses the informational and transactional capabilities of a Web site. The content construct similar to the technology acceptance constructs of perceived usefulness and relative advantage [2, 37]. In the

study, *promotion* was defined as the extent to which the Web site is promoted on the Web and other media.

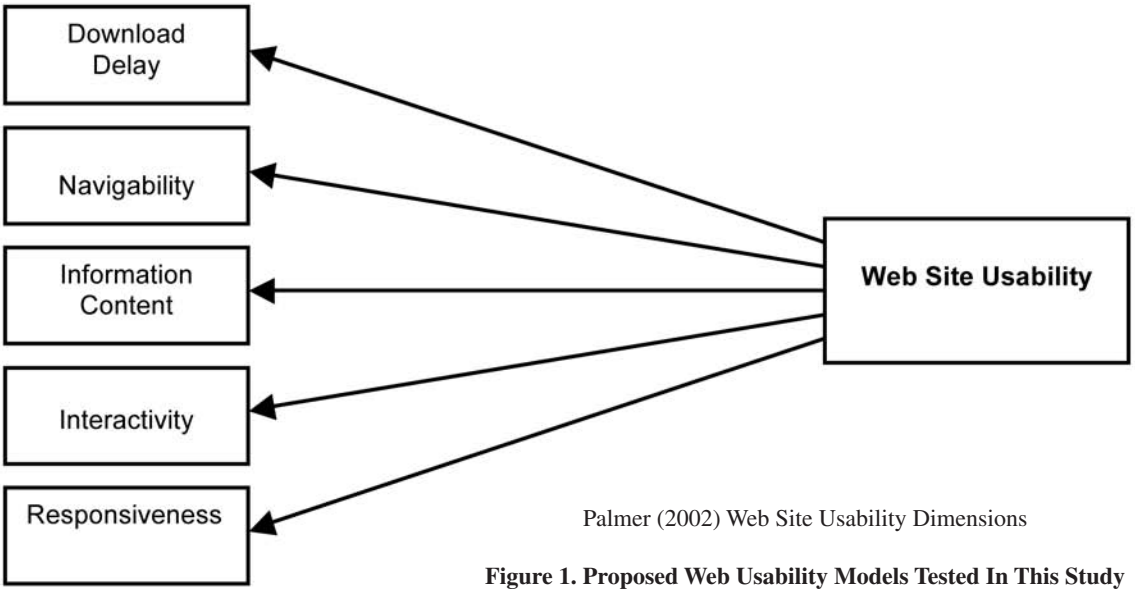
The current research is attempting to identify valid measures of Web site usability. Examination of the *promotion* variable demonstrated a lack of face validity, due to no underlying connection to the definition of usability as well as its lack of relationship with the design of a Web site, thus promotion was dropped for this validation study. The four remaining factors identified in the Agarwal and Venkatesh instrument are directly related to the Web site's design, providing face validity to the underlying concept of Web site usability as defined by Nielsen [40]. Figure 1 and Table 1 provides details about the constructs and definitions for both the Palmer and the Agarwal and Venkatesh Web site usability instruments.

RESEARCH METHODS

Straub [51] offered several guidelines for the validation of IS research instruments. One of the guidelines indicates that researchers should use previously validated instruments wherever possible, being careful not to make significant alterations without revalidating instrument content, constructs, and reliability. Boudreau, Gefen, and Straub [8] reemphasized the importance of validating instruments, noting the need to strive for validity in all research. The research instruments of interest have followed the scientific research cycle as proposed by Mackenzie and House [32] and McGrath [35], by conducting exploratory research. Confirmatory research and conceptual refinements are the next step in the research cycle.



Agarwal & Venkatesh (2002) Web Site Dimensions



Palmer (2002) Web Site Usability Dimensions

Figure 1. Proposed Web Usability Models Tested In This Study

Confirmatory Sample

Although Web site usability is important to several target populations, this study focused on the online consumer in accordance with the Palmer [41] and Agarwal and Venkatesh [3] studies. University students are considered an appropriate surrogate in consumer research that examines products the students are likely to purchase on a regular basis [31], thus music and bookstore sites were chosen due to their ability to provide appropriate external validity. Ten doctoral level information systems students helped identify five B2C web sites that sold cds and books. Based on this initial list of vendors, a separate group of twenty upper level undergraduate business students were asked to rank order these five web sites based on their perceived usability. Based on these rankings, three sites were selected that included the highest, middle, and lowest ranked web sites. These web sites were selected to ensure variability of the usability measures tested in this study. The study's participants were 160 undergraduate business students from a large mid-western university. A large percentage of the participants (84.5%) stated that they had made online purchases in the past year, helping demonstrate the validity of the participants as a sample of online shoppers.

Each scenario involved the process of searching, selecting, and inquiring about a product of their choice that was available from an assigned Web retailer. Research has shown that consumers perform three sub-processes during the transaction process [23, 24] (see Figure 2). The 20-minute activity (time estimate established based on pilot test utilizing 20 undergraduate students) emulated the consumer online transaction process.

Table 1. Constructs, Items and Definitions for Two Web Site Usability Instruments

Instrument	Construct	Items	Definition
Palmer (2002)	Download Delay	DD1 DD2	The initial request for access to the page and then each subsequent request for changing pages with the site.
	Navigability	NAV1 NAV2 NAV3 NAV4 NAV5	The sequencing of pages, well organized layout, and consistency of of navigation protocols
	Information Content	IC1 IC2 IC3	The amount and variety of content as well as the use of text, graphics, and multimedia.
	Interactivity	INT1 INT2	The ability to customize the site's look, feel, and content as well as provide interaction with the user.
	Responsiveness	RES1 RES2	The presence of feedback to users and the availability of response from the site managers.
Agarwal and Venkatesh (2002)	Ease of Use	EOU1 EOU2 EOU3 EOU4 EOU5 EOU6	The cognitive effort required in using a Web site.
	Made-for-the-Medium	MFM1 MFM2 MFM3 MFM4 MFM5	Tailoring a Web site to fit a particular user's needs.
	Emotion	EMO1 EMO2 EMO3 EMO4	Taps into affective reactions invoked by a Web site.
	Content	CON1 CON2 CON3 CON4	The informational and transactional capabilities of a Web site.

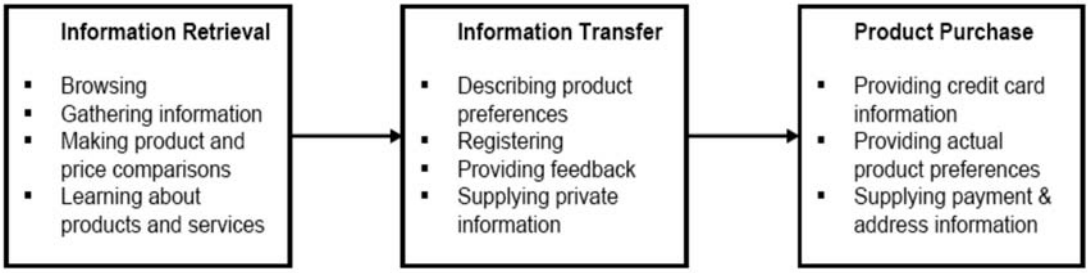


Figure 2. The Consumer Online Transaction Process.

The participants did not actually purchase any products during the experiment. The participants provided their perceptions of the Web site and their intention to make a transaction. Following the exercise, a questionnaire was administered that focused on the Web retailer they visited, containing both usability instruments under study. The student participants were given extra credit points for their participation in the study. Participants who completed the experiment in less than one half the expected completion time were removed from further analysis. This rule was established to ensure that participants took the experiment seriously and carefully read the instructions and questions of the questionnaire. This rule resulted in four individuals being removed from the analysis. Demographic information about the participants is shown in Table 2.

Table 2. Participant Demographics (n = 160)

Variable		Percent		
Gender	Male	56.87		
	Female	43.13		
Age	Under 19	1.1		
	20-29	84.3		
	30-39	7.4		
	Over 39	4.2		
Had Previously Visited the Web Site			Yes	23.2
		No	76.8	
Had Previously Purchased from the Web Site		Yes	17.9	
		No	82.1	

DATA ANALYSIS

Confirmatory Factor Analysis

Confirmatory factor analysis (CFA), using LISREL 8.52, was appropriate in this study due to the Web site usability instruments' empirical foundation, allowing the researchers to specify the exact factor model in advance as opposed to exploratory factor analysis which seeks an undetermined structure for a set of variables [50]. Bentler and Chou [4] suggest that a ratio of 5 participants per variable would be necessary for normal distributions when the latent variables have multiple indicators, supporting the sample size in this study as adequate for both the Palmer [41] and the Agarwal and Venkatesh [3] instruments.

Goodness of Fit Indices

Doll, Xia, and Torkzadeh [14] note the lack of one universally accepted index of model adequacy in a confirmatory factor analysis; therefore there was an expectation that convergence upon multiple indexes would define an appropriate model. In other words, a good instrument should exhibit adequate numbers across multiple indexes, not just one, for the model to be considered robust; therefore, three types of overall fit measures were utilized in this study: absolute fit measures, incremental fit measures, and parsimonious fit measures.

Absolute Fit Measures

An absolute fit index was used to evaluate how well the proposed theoretical models fit the sample data. Absolute indices, including chi-square, goodness-of-fit (GFI), and root mean square residual (RMSR) were used to evaluate each model. Finding significance in a chi-square means the given model's covariance structure is significantly different from the observed covariance matrix, therefore non-significance is desired ($p>.05$). Scores of .90 or higher are considered evidence of good fit for GFI, although many researchers also interpret a score of .80-.89 as representing reasonable fit [16]. The closer the root mean square residual (RMSR) is to 0, the better the model fit. RMSR values with scores below .05 are considered as having good fit [9, 25].

Incremental Fit Measures

Incremental fit indices are based on the comparison of the fit of a substantive model to that of a null model. The normed fit index (NFI) varies from 0 to 1, with 1 equaling perfect fit. NFI values below .90 indicate a need to respecify the model. Measures of .90 or higher are considered evidence of good for AGFI, although many researchers also interpret a score of .80-.89 as representing reasonable fit [17]. The comparative fit index (CFI) is another incremental fit measure that asses the relative improvement in fit of the model compared with a baseline or null model, which assumed zero population covariances among the observed variables. The rule of thumb for CFI is also .90 for reasonably good fit [22].

Parsimonious Fit Measures

Parsimonious fit measures evaluate the fit of the model versus the number of estimated coefficients needed to achieve that level of fit. The normed chi-square (χ^2/df) should have a ratio less than 5 to indicate good fit [34]. Root mean square error of approximation

is a parsimony-adjusted index in that its formula includes a built-in correction for model complexity. Hu and Bentler [22] have suggested .06 or below as the desirable measure for RMSEA.

Validity and Reliability

Factor loadings are viewed as regression coefficients in confirmatory factor analysis. The larger the factor loadings or coefficients as compared with their standard errors the stronger the evidence that the measured variables represent the underlying constructs [7, 38]. The reliability of items, factors, and the overall instrument can also be evaluated with confirmatory factor analysis. The proportion of variance in the observed variables that is accounted for by the latent variables that influence them is used to estimate the reliability of the items. The overall reliability of an instrument is found in the total coefficient of determination for observed variables.

RESULTS

The estimates for each model were examined and found not to have any offending estimates (loadings greater than 1.0). Each model was first assessed for fitness, which is the degree to which the specified indicators represent the hypothesized constructs, then assessed for construct validity. The estimates for the absolute, incremental, and parsimonious fit measures are listed in Table 3. The correlation matrices can be seen in Appendix A and B.

Table 3. Confirmatory Factor Analysis (CFA) Results

Fit Measure	Recommended Value	Palmer Instrument	Agarwal & Venkatesh Instrument
χ^2	>0.05	0.000	0.000
GFI	>0.90	0.900	0.750
RMSR	<0.05	0.047	0.098
NFI	>0.90	0.960	0.910
AGFI	>0.90	0.850	0.670
CFI	>.90	0.976	0.940
χ^2/df	<5.00	1.760	0.000
RMSEA	<.06	0.083	0.120

Goodness of Fit – Palmer Instrument

The chi-square statistic for the Palmer instrument (χ^2= 118.21, 67 d.f.) has a statistical significance level of $p < .00011$, which is not acceptable at the .05 level. Again, non-significance is desired with the chi-square, and we do not want to reject the null hypothesis that the proposed model is correctly identified. In this case, that hypothesis is rejected at the .05 level. For the Palmer instrument, the goodness-of-fit index (GFI) has an acceptable value of 0.90. Another measure, the root mean square residual (RMSR), indicates that the average residual correlation is .047, which is acceptable given the fairly strong correlations in the original correlation matrix. The GFI and RMSR appear acceptable, but the chi-square statistic is not acceptable.

The next goodness-of-fit measure assesses the incremental fit of the model compared to a null model. The NFI yields .96 for the Palmer instrument surpassing the recommended level of .90, supporting the proposed model. The adjusted goodness-of-fit index (AGFI) is .85 for the Palmer instrument and is fairly close to the recommended level of .90, thus marginal acceptance can be given on this measure. The CFI is .976, meeting the acceptable threshold of .90. Again, both the NFI and CFI were acceptable, but the AGFI did not meet the cutoff level.

Parsimonious fit measures evaluate the fit of the model versus the number of estimated coefficients needed to achieve that level of fit. The parsimonious fit indices for the Palmer instrument offered mixed results. The normed chi-square (χ^2/df) for the Palmer instrument has a value of 1.76, falling below the recommended levels of 5.0 while the RMSEA is .0839, larger than desired cutoff of .06.

Goodness of Fit – Agarwal and Venkatesh Instrument

The Agarwal and Venkatesh instrument (χ^2= 499.92, 146 d.f) also demonstrated a lack of support for the fit. In contrast to the Palmer model, the Agarwal and Venkatesh instrument has a GFI of .75 and RMSR of .098, both failing to meet the acceptable threshold for fit.

Two of the three incremental fit indices for the Agarwal and Venkatesh instrument met the necessary criteria. The Normed Fit Index (NFI) is .91, surpassing the recommended level of .90, thus supporting the proposed model. The CFI was also acceptable at .94. However, the Agarwal and Venkatesh instrument has an AGFI of .67, far below the recommended level of .90 for incremental fit.

The parsimonious fit measures for the Agarwal and Venkatesh instrument also provided mixed results. The normed chi-square of 0 is acceptable, well below the accepted upper value of 5 for parsimonious fit. The RMSEA was .12, above the desired .06 threshold. Both the Palmer and Agarwal and Venkatesh instruments demonstrated weaknesses within the multiple fit indices. The lack of conclusive support in the fit indices raises questions about the adequacy of each model.

Validity and Reliability

Although both instruments demonstrated weak to moderate fit indices, the constructs in each of the instruments were evaluated separately based on the statistical significance of the loadings and the construct's reliability and variance extracted. For the Palmer instrument, each item t-value associated with its factor loading exceeded the .05 significance level, thus showing that all items are significantly related to their specified constructs. The same was true for the Agarwal and Venkatesh instrument. The proportion of variances, or R-square, in the observed variables that is accounted for by it corresponding latent variable is used as an indicator of each item's common factor reliability. R-square values ranges from .44 to.83 for the Palmer instrument (see Table 4), and .33 to .76 for the Agarwal and Venkatesh instrument (see Table 5), indicating moderate reliability for all items. These values provide limited support of the hypothesized relationships of the observed items with the overall latent constructs.

Based on the CFA results, both the Palmer and the Agarwal and Venkatesh models displayed acceptable levels of fit on selected measures. The CFA found that all five constructs in the Palmer model and the four constructs in the Agarwal and Venkatesh models loaded as expected and had reasonable levels of reliability.

Residuals & Modification

The standardized residuals represent the differences between the observed and estimated correlation matrices. Residual values greater than +/- 2.58 (the standard for assessing "significant" residuals with LISREL) are considered to be statistically significant at the .05 level. Of the Palmer items, only three correlations from the original input matrix had statistically significant residuals (see Table 6). This falls within the acceptable range of one in twenty residuals exceeding +/- 2.58 strictly by chance, suggesting that the observed values did not differ significantly from expected values. The Agarwal and Venkatesh model resulted in thirty-nine significant residuals (see Table 7), suggesting the observed values differ greatly from the expected values.

Table 4. Standardized Parameter Estimates and t-values for the Palmer Instrument (n=160)

Observed Variables			Latent Variables	
	Factor Loading	R-Square (Reliability)		Cronbach's Alpha
DD1	0.87	0.76	Download	0.884
DD2	0.91	0.83	Delay	
NAV1	0.71	0.50		
NAV2	0.71	0.50		
NAV3	0.83	0.69	Navigability	0.863
NAV4	0.69	0.48		
NAV5	0.83	0.69		
IC1	0.75	0.56		
IC2	0.66	0.44	Information	0.758
IC3	0.76	0.58	Content	
INT1	0.69	0.58	Interactivity	0.735
INT2	0.84	0.71		
RES1	0.66	.44	Responsiveness	0.634
RES2	0.70	0.49		

Table 5. Standardized Parameter Estimates and t-values for the Agarwal and Venkatesh Instrument (n=160)

Observed Variables			Latent Variables	
	Factor Loading	R-Square (Reliability)		Cronbach's Alpha
CON1	0.76	0.57		
CON2	0.71	0.50	Content	0.841
CON3	0.70	0.49		
CON4	0.84	0.71		
EOU1	0.57	0.33		
EOU2	0.67	0.45		
EOU3	0.87	0.76	Ease of Use	0.886
EOU4	0.86	0.74		
EOU5	0.83	0.69		
EOU6	0.73	0.53		
MFM1	0.53	0.28		
MFM2	0.58	0.34	Made-For-	
MFM3	0.73	0.53	The Medium	0.797
MFM4	0.73	0.53		
MFM5	0.74	0.55		
EMO1	0.49	0.24		
EMO2	0.68	0.46	Emotion	0.695
EMO3	0.73	0.53		
EMO4	0.56	0.32		

Table 6. Standardized Residuals (Palmer Instrument)

	DD1	DD2	NAV1	NAV2	NAV3	NAV4	NAV5	IC1	IC2	IC3	INT1	INT2	RES1	RES2
DD1	--													
DD2	--	--												
NAV1	0.29	-0.70	--											
NAV2	0.59	0.64	-.045	--										
NAV3	-0.52	0.89	-1.15	-0.02	--									
NAV4	1.80	1.49	-0.92	-2.18	2.32	--								
NAV5	-0.73	-2.35	2.84	0.81	0.04	-2.22	--							
IC1	-2.31	-1.29	-0.28	2.29	-1.10	-1.09	1.24	--						
IC2	-0.48	-0.39	0.71	-1.98	0.51	2.18	-0.38	0.90	--					
IC3	1.74	2.22	-1.27	-0.20	-0.93	2.68	-1.16	1.21	-2.19	--				
INT1	1.22	0.17	0.17	0.87	-0.97	-1.14	0.84	-0.55	-0.45	-1.62	--			
INT2	-0.45	-0.49	-0.14	1.34	0.36	1.43	-2.16	0.93	0.02	0.58	--	--		
RES1	0.52	-0.62	-0.26	-0.64	-2.89	0.28	-2.58	-1.42	0.50	-0.29	0.58	0.06	--	
RES2	0.01	0.24	0.41	0.49	2.28	4.57	-0.46	-0.20	1.18	0.42	-0.06	-0.42	--	--

Table 7. Standardized Residuals (Agarwal & Venkatesh Instrument)

	CON1	CON2	CON3	CON4	EOU1	EOU2	EOU3	EOU4	EOU5	EOU6	MFM1	MFM2	MFM3	MFM4	MFM5	EMO1	EMO2	EMO3
CON1	--																	
CON2	1.25	--																
CON3	1.03	-0.62	--															
CON4	-0.28	-3.51	2.37	--														
EOU1	1.18	1.92	-0.67	1.03	--													
EOU2	-0.34	3.47	-1.26	1.01	6.22	--												
EOU3	-2.25	1.38	-0.43	-2.63	-1.72	-1.59	--											
EOU4	-2.12	1.87	-1.15	-1.42	-1.89	-1.83	7.92	--										
EOU5	0.57	0.97	-0.01	0.30	-1.91	-1.63	-0.67	-0.60	--									
EOU6	2.44	1.87	-0.02	1.70	-1.69	-0.17	-2.63	-3.83	4.15	--								
MFM1	-2.57	-0.74	-2.42	-1.97	1.65	0.07	-0.86	-0.73	-2.17	-0.01	--							
MFM2	-2.49	-1.04	-0.57	-1.54	2.32	0.07	-2.93	-2.66	-1.78	-0.69	2.42	--						
MFM3	1.00	1.45	-0.21	-0.33	2.27	1.98	-1.06	-1.10	0.62	3.29	-0.98	1.01	--					
MFM4	-0.17	-0.19	-1.02	0.96	2.23	2.43	-2.48	-1.69	-0.47	1.25	0.57	-0.23	-2.04	--				
MFM5	0.87	-0.33	-0.88	5.17	2.97	1.44	0.61	1.09	0.95	3.18	-0.96	-1.90	2.99	-0.34	--			
EMO1	-3.73	-1.13	-2.63	-3.22	0.35	0.02	-3.36	-2.64	-3.29	-0.64	2.35	2.23	-2.84	-2.32	-2.41	--		
EMO2	-2.50	0.10	-0.41	-1.80	1.77	0.28	-0.99	-0.89	-2.14	-0.73	3.06	3.75	-3.53	-0.54	-2.95	5.27	--	
EMO3	0.01	1.37	-1.06	-1.37	2.31	1.57	-2.14	-3.20	-3.20	1.49	2.13	1.21	-0.64	3.30	-3.99	-0.27	1.41	--
EMO4	3.98	3.65	3.93	6.08	1.53	2.97	3.63	4.10	4.10	6.26	-0.79	-1.12	3.59	2.20	1.63	-1.77	-3.94	-0.75

In modification indices for the Palmer model, five of the indicators (NAV4, NAV5, IC3, RES1, & RES2) have indicators above the suggested level (3.84) for possible model respecification, indicating that these variables might be indicators on another construct as well as the intended constructs (see Table 8). The Agarwal and Venkatesh instrument exhibited an even higher need for model respecification with twelve of the indicators above the suggested level of 3.84 (CON2, EOU1, EOU2, EOU3, EOU4, MFM1, MFM2, MFM3, MFM5, EMO1, EMO2, EMO4) (see Table 9).

Although both models exhibited somewhat acceptable measures on fit indices, the high modification indicators indicate potential problem areas. Garson [19] explains that one can have good fit in a mis-specified model, and an important indicator of this is if there are high modification indexes in spite of good fit. High modification indices indicate multicollinearity in the model and/or correlated error. In this study, the results of the residuals and modification indices indicate that both models are poorly specified.

It should be noted that confirmatory factor analysis results should be interpreted with caution. Even though the Palmer model fits the current sample, it does not mean that it is the "best" solution for a Web site usability research instrument. The next step in the instrument development process is to improve or respecify the instrument(s) as a valid measure of Web site usability. The modification indices demonstrated the need for respecification of some indicators. A combination of both instruments may provide a more robust model for determining Web site usability.

COMPREHENSIVE WEB SITE USABILITY MODEL

Exploratory Factor Analysis

Respecification calls for a reexamination of the proposed variables. An additional exploratory factor analysis was conducted to derive dimensions of usability that can be used in regression analysis. Inspection of the correlation matrix that included items from *both* the Palmer and the Agarwal and Venkatesh instruments found significant relationships between items, supporting the use of factor analysis. In addition, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO MSA) and the Bartlett test of sphericity were used to determine the appropriateness of factor analysis on the entire correlation matrix. The KMO MSA,

ranging from 0 to 1 with 1 being the most appropriate for factor analysis, yielded 0.937 [25, 26]. The Bartlett test of sphericity also examines the presence of correlations among the variables. For the present data, the Bartlett test of sphericity was highly significant, χ^2= 3585.420, p<.000, with 528 d.f., suggesting that the sample is appropriate for factor analysis.

Deriving Factors and Assessing Overall Fit

Extraction and retention of the factors is the next step in the exploratory factor analysis. A principal component analysis was used. Five factors were retained based on the Latent Root Criteria (Eigenvalues > 1). Eigenvalues are the proportion of total variance accounted for by each factor; 64.12% of the variance was explained by the five factors.

Table 8. Palmer CFA- Modification Indices for Lambda-X

	Download	Navigability	Information Content	Interactivity	Responsiveness
DD1	--	0.11	0.10	0.39	0.08
DD2	--	0.11	0.10	0.39	0.08
NAV1	0.12	--	0.18	0.00	0.04
NAV2	0.50	--	0.25	1.21	1.18
NAV3	0.10	--	0.56	0.08	0.23
NAV4	**3.86**	**--**	**12.83**	**3.98**	**6.98**
NAV5	**4.12**	**--**	**4.24**	**4.20**	**4.93**
IC1	3.84	0.64	--	0.00	0.04
IC2	0.21	0.00	--	0.10	0.01
IC3	**5.42**	**0.66**	**--**	**0.07**	**0.01**
INT1	0.36	0.13	0.84	--	1.01
INT2	0.36	0.13	0.84	--	1.01
RES1	**0.13**	**6.95**	**4.94**	**1.54**	**--**
RES2	**0.13**	**6.95**	**4.94**	**1.54**	**--**

Table 9. Agarwal and Venkatesh CFA – Modification Indices for Lambda-X

	Content	Ease of Use	Made-for-the-Medium	Emotion
CON1	--	1.17	0.85	1.34
CON2	**--**	**12.58**	**0.50**	**3.66**
CON3	--	1.04	1.53	0.87
CON4	--	1.23	1.46	0.05
EOU1	**5.85**	**--**	**17.16**	**12.09**
EOU2	**2.92**	**--**	**7.84**	**5.94**
EOU3	**9.21**	**--**	**11.66**	**5.13**
EOU4	**3.85**	**--**	**6.61**	**4.28**
EOU5	0.29	--	0.26	0.79
MFM1	**9.81**	**--**	**14.80**	**8.80**
MFM2	**10.65**	**1.78**	**--**	**12.65**
MFM3	**10.61**	**6.90**	**--**	**7.39**
MFM4	1.39	0.64	--	2.36
MFM5	**16.15**	**7.33**	**--**	**16.22**
EMO1	**18.10**	**12.81**	**15.31**	**--**
EMO2	**5.11**	**2.57**	**5.53**	**--**
EMO3	1.05	2.92	0.06	--
EMO4	**57.29**	**50.44**	**40.67**	**--**

Interpreting the Factors

Rotation of the factor structure is used to interpret the factors in the order of importance. Since it was anticipated that correlation existed between the constructs tested in this study, an OBLIMIN rotation was used to develop theoretically meaningful factors for Web site usability [20]. A conservative cutoff of +0.55 was used for retaining items. It is also important to examine the communalities, which represent the amount of variance in an individual item that is accounted for by the factor solution. Each of the communalities for the sample were above 0.5, the acceptable threshold for explained variance. Although the communalities were acceptable, items with low factor loadings, and items that loaded on multiple factors were candidates for deletion. Several items were removed (CON1, CON3, CON4, INT1, INT2, IC1, IC3, EOU6, NAV4, MFM3, MFM4, MFM5, RES1, RES2). The removal of items was anticipated, due to the initial examination of the face validity of the factors contained in the two instruments. Several original factors were not convergent and contained overlap in the two instruments, thus resulting in the need for deletion of several items at this point.

The second OBLIMIN rotation, without the questionable items, resulted in the retention of four factors. The four factor solution contained in items with factor loadings greater than 0.55 with a very clean structure, voiding the need to delete other items and rerun the analysis. The constructs were tested for convergent

Table 10. Factor Loadings

	Ease of Navigation	Customization	Download Delay	Content
Eigenvalue	8.559	2.083	1.254	1.001
Variance Explained	45.046	10.966	6.602	5.269
Standardized Alpha	.942	.799	.859	.827
EOU4	.848			
EOU3	.792			
NAV1	.773			
NAV5	.762			
NAV2	.702			
EOU5	.700			
NAV3	.671			
EMO2		.901		
EMO1		.772		
MFM2		.674		
MFM1		.668		
EMO3		.567		
DD2			.927	
DD1			.870	
EMO4			.638	
EOU2				.857
IC2				.723
EOU1				.714
CON2				.619

and discriminant validity to examine whether the constructs were adequate for predicting Web site success. Reliability, convergent validity, and discriminant validity were satisfactory (see Table 10).

All the factor loadings were positive due to the construction of variable questions as positive statements on a Likert-type scale. The items followed a logical factor structure when examined more closely. Appropriate labels for each factor are presented in Table 11.

The reproduced correlation matrix computes the correlation between the observed and the reproduced correlations. There are 45 (26%) nonredundant residuals with absolute values greater than 0.05. The 26% is acceptable as it is below the acceptable level of 50%. Thus, we can conclude that there was not a significantly large difference in the residuals between the observed and reproduced correlations, supporting the appropriateness of continuing analysis with this data.

Regression

Multiple regression was performed to demonstrate the instrument's nomological validity. As shown in Table 12, ease of navigation, customization, and download delay were found to be significant predictors of intention to return to the Web site in the near future [47]. The comprehensive Web site usability instrument explained 45.2% of the variance of the dependent variable. Table 13 shows that ease of navigation was a significant predictor of satisfaction with the Web site in the regression model, another important evaluation of the consumer's experience with an e-commerce Web site [64]. The Web site usability instrument explained 62.0% of the variance of satisfaction to the Web site.

The revised Web site usability instrument provides significant predictive validity for both intention to return (ITR) and

Table 11. Web Site Usability Dimensions

Old Variable Label	New Variable Label	Question Wording (1-SD – 7-SA)	Factor Name
EOU4	EON1	The site was well organized	East of Navigation (EON)
EOU3	EON2	The site was well structured	
NAV1	EON3	The site w as effectively organized	
NAV5	EON4	The layout of pages made tasks easier	
NAV2	EON5	It was easy to get Web site to do what want it to do	
EOU5	EON6	The site provides clear results regarding my progress	
NAV3	EON7	The sequence of obtaining information was clear	
EMO2	CUS1	The site provides an interesting story line	Customization (CUS)
EMO1	CUS2	The site offers an element of challenge	
MFM2	CUS3	The site treats me as a unique person	
MFM1	CUS4	The site offers me the opportunity to be part of an online group	
EMO3	CUS5	The site ties to individuals within and outside the organization who have credibility	
DD2	DD1	The rate at which the information was displayed was fast enough	Download Delay (DD)
DD1	DD2	The speed in which the computer provided information was fast enough	
EMO4	DD3	The site allows me to control the pace at which I react with information	
EOU2	CON1	The site offers understandable goals	Content (CON)
IC2	CON2	The site presents a variety of products	
EOU1	CON3	The site offers clear goals	
CON2	CON4	The site uses media appropriately to communicate the content	

Table 12.
Regression results on predicting intention to return (ITR)

Independent Variables	Dependent Variables: Intention to Return (ITR) Composite	
	β_s [a]	P-value
EON	.604***	.000
CUS	.385***	.000
DD	-.160*	.033
CON	.097	.083
Adjusted R^2	0.452***	

[a] Standardized β coefficient
**0.01 significance level
*0.05 significance level
***0.001 significance level

Table 13.
Regression results on predicting satisfaction (SAT)

Independent Variables	Dependent Variables: Intention to Return (ITR) Composite	
	β_s [a]	P-value
EON	.819***	.000
CUS	.006	.938
DD	.049	.458
CON	.152	.098
Adjusted R^2	0.620***	

[a] Standardized β coefficient
**0.01 significance level
*0.05 significance level
***0.001 significance level

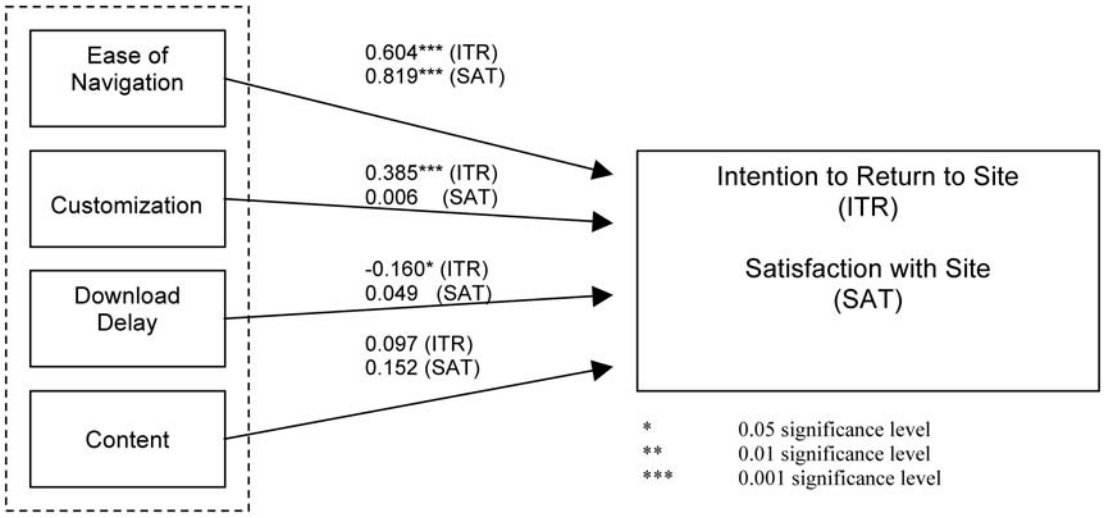


Figure 3. Regression Model Results

satisfaction with the Web site (SAT), demonstrating nomological, or explanatory validity, giving practical use for the measure along with the statistical validation needed for rigorous research (see Figure 3).

It is interesting to note the lack of significant findings for content in predicting satisfaction with the site. The lack of significance for content may indicate that there was not much variation among the retail sites being examined. Content may also be considered a necessary requisite for Web sites before other factors come into play. Also interesting was the lack of significance customization had in predicting satisfaction with the web sites. This would suggest that customization is not considered an important component in web site satisfaction. This supports the findings of Pearson and Pearson who, using a multi-criteria decision approach, found that customization of a web site was the least important criteria in determining web usability [42]. Interestingly, customization was significant in predicting a participant's intention to return to a web site. This makes sense as customization allows the user to change the structure of the web site to fit their personal preferences. The web site thus becomes familiar to the user and increases the probability that they would return to that site.

DISCUSSION AND IMPLICATIONS

This research attempted to validate two proposed web usability instruments for use in examining an organization's B2C Web site as well as in e-commerce research. Although both the Palmer [41] and the Agarwal and Venkatesh [3] Web site usability instruments displayed moderate nomological validity, neither instrument achieved adequate validation and specification of dimensions when examined in an e-commerce setting. This suggests that the underlying theoretical constructs suggested by these instruments may not be sufficient to adequately measure Web site usability in an e-commerce setting. By investigating the validity (or non-validity) of both the Palmer Web site usability instrument and the Agarwal and Venkatesh Web site usability instrument, we were able to complete the suggested second step of the research cycle proposed by Cook and Cambell [12]. This type of confirmatory research is a necessary component in establishing the legitimacy of information systems (IS) research. It is only through the development of standardized instruments that are both valid and reliable that direct comparisons between individuals, time periods, organizations, industries, and cultures can be made. Unfortunately, this type of research typically has not

been completed on many of the instruments that are frequently utilized in IS research.

A new instrument measuring four distinct dimensions (Ease of Use, Customization, Download Delay, and Content) of Web site usability was drawn from the items that were included in the prior instruments. This new, respecified instrument provides a more robust and parsimonious instrument with which to measure Web site usability. The proposed instrument also explained a significant amount of variance in two important variables of e-commerce success, intention to return to the Web site (45.2%) and satisfaction with the Web site (62.0%). These findings suggest that the proposed, respecified Web usability instrument would have application in the e-commerce environment. B2C organizations should utilize this instrument to determine how their customers feel about these four dimensions and make the necessary modifications to their Web sites to overcome any identified deficiencies. We suggest that even though Content was not a statistically significant predictor of intention to return to the Web site or satisfaction with the Web site, it should not be ignored. Web sites that do not deliver current and/or useful content will not be utilized by customers; it is therefore, we believe, a necessary condition for Web site success although it may not be fully captured by the existing items. The unexplained variance indicates that other variables not related to usability of the site are also important factors for Web site success. Other important variables may include aesthetics, product pricing, promotions offered, discounts, or type of payment/checkout.

RESEARCH LIMITATIONS

Although this study advances the understanding of Web site usability, it contains limitations, offering multiple opportunities for additional research. The study examined Web site usability in the realm of e-commerce Web sites rather than information-providing Web sites, limiting the external validity of the instrument to the same type of e-commerce setting. Also, the current study also utilized students, which can be considered a limitation. Although generally considered acceptable for e-commerce research, it is important to test the instrument using other samples using a mall intercept or other method to capture customers making an actual purchase.

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Appendix A

LISREL Standardized Correlation Matrix (Palmer, 2002)

	DD1	DD2	NAV1	NAV2	NAV3	NAV4	NAV5	IC1	IC2	IC3	INT1	INT2	RES1	RES2
DD1	1	0.792	0.409	0.422	0.442	0.462	0.435	0.386	0.386	0.523	0.399	0.413	0.389	0.395
DD2	0.792	1	0.389	0.444	0.510	0.465	0.412	0.447	0.413	0.558	0.372	0.437	0.366	0.423
NAV1	0.409	0.389	1	0.494	0.561	0.456	0.658	0.475	0.457	0.445	0.364	0.430	0.314	0.370
NAV2	0.422	0.444	0.494	1	0.589	0.412	0.609	0.572	0.342	0.485	0.399	0.490	0.295	0.374
NAV3	0.442	0.510	0.561	0.589	1	0.626	0.682	0.530	0.511	0.543	0.372	0.515	0.255	0.495
NAV4	0.462	0.465	0.456	0.412	0.626	1	0.508	0.424	0.507	0.576	0.284	0.479	0.329	0.565
NAV5	0.435	0.412	0.658	0.609	0.682	0.508	1	0.598	0.480	0.536	0.446	0.438	0.268	0.387
IC1	0.386	0.447	0.475	0.572	0.530	0.424	0.598	1	0.518	0.592	0.381	0.524	0.372	0.450
IC2	0.386	0.413	0.457	0.342	0.511	0.507	0.480	0.518	1	0.429	0.333	0.435	0.398	0.452
IC3	0.523	0.558	0.445	0.485	0.543	0.576	0.536	0.592	0.429	1	0.343	0.519	0.422	0.478
INT1	0.399	0.372	0.364	0.399	0.372	0.284	0.446	0.381	0.333	0.343	1	0.582	0.461	0.470
INT2	0.413	0.437	0.430	0.490	0.515	0.479	0.438	0.524	0.435	0.519	0.582	1	0.541	0.570
RES1	0.389	0.366	0.314	0.295	0.255	0.329	0.268	0.372	0.398	0.422	0.461	0.541	1	0.464
RES2	0.395	0.423	0.370	0.374	0.495	0.565	0.387	0.450	0.452	0.478	0.470	0.570	0.464	1

Appendix B

LISREL Standardized Correlation Matrix (Agarwal & Venkatesh, 2002)

	CON1	CON2	CON3	CON4	EOU1	EOU2	EOU3	EOU4	EOU5	EOU6	MFM1	MFM2	MFM3	MFM4	MFM5	EMO1	EMO2	EMO3	EMO4
CON1	1	0.574	0.564	0.635	0.437	0.434	0.518	0.511	0.573	0.582	0.224	0.264	0.515	0.471	0.518	0.016	0.205	0.353	0.494
CON2	0.574	1	0.474	0.519	0.452	0.577	0.587	0.597	0.551	0.532	0.286	0.302	0.505	0.437	0.438	0.150	0.312	0.397	0.467
CON3	0.564	0.474	1	0.646	0.319	0.357	0.526	0.494	0.513	0.448	0.197	0.323	0.432	0.399	0.412	0.056	0.283	0.273	0.483
CON4	0.635	0.519	0.646	1	0.467	0.537	0.589	0.606	0.626	0.598	0.306	0.362	0.520	0.563	0.702	0.088	0.289	0.339	0.610
EOU1	0.437	0.452	0.319	0.467	1	0.668	0.452	0.437	0.412	0.343	0.339	0.398	0.446	0.445	0.488	0.213	0.370	0.416	0.317
EOU2	0.434	0.577	0.357	0.537	0.668	1	0.549	0.532	0.511	0.481	0.282	0.307	0.479	0.502	0.458	0.225	0.328	0.417	0.435
EOU3	0.518	0.587	0.526	0.589	0.452	0.549	1	0.853	0.714	0.578	0.322	0.265	0.456	0.406	0.525	0.121	0.367	0.357	0.508
EOU4	0.511	0.597	0.494	0.606	0.437	0.532	0.853	1	0.704	0.538	0.322	0.269	0.446	0.426	0.536	0.151	0.364	0.308	0.529
EOU5	0.573	0.551	0.513	0.626	0.412	0.511	0.714	0.704	1	0.709	0.237	0.291	0.495	0.453	0.516	0.101	0.293	0.353	0.626
EOU6	0.582	0.532	0.448	0.598	0.343	0.481	0.578	0.538	0.709	1	0.300	0.291	0.565	0.471	0.565	0.204	0.301	0.435	0.633
MFM1	0.224	0.286	0.197	0.306	0.339	0.282	0.322	0.322	0.237	0.300	1	0.432	0.345	0.410	0.354	0.365	0.470	0.438	0.214
MFM2	0.264	0.302	0.323	0.362	0.398	0.307	0.265	0.269	0.291	0.291	0.432	1	0.460	0.413	0.356	0.373	0.525	0.421	0.221
MFM3	0.515	0.505	0.432	0.520	0.446	0.479	0.456	0.446	0.495	0.565	0.345	0.460	1	0.468	0.624	0.166	0.286	0.434	0.519
MFM4	0.471	0.437	0.399	0.563	0.445	0.502	0.406	0.426	0.453	0.471	0.410	0.413	0.468	1	0.529	0.193	0.407	0.581	0.456
MFM5	0.518	0.438	0.412	0.702	0.488	0.458	0.525	0.536	0.516	0.565	0.354	0.356	0.624	0.529	1	0.195	0.320	0.322	0.434
EMO1	0.016	0.150	0.056	0.088	0.213	0.225	0.121	0.151	0.101	0.204	0.365	0.373	0.166	0.193	0.195	1	0.555	0.343	0.182
EMO2	0.205	0.312	0.283	0.289	0.370	0.328	0.367	0.364	0.293	0.301	0.470	0.525	0.286	0.407	0.320	0.555	1	0.529	0.230
EMO3	0.353	0.397	0.273	0.339	0.416	0.417	0.357	0.308	0.353	0.435	0.438	0.421	0.434	0.581	0.322	0.343	0.529	1	0.385
EMO4	0.494	0.467	0.483	0.610	0.317	0.435	0.508	0.529	0.626	0.633	0.214	0.221	0.519	0.456	0.434	0.182	0.230	0.385	1