Factors affecting the perceived usability of the mobile web portal services: comparing simplicity with consistency

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Abstract Korean IT industry has noticed innovative changes emerging along with the increased popularity of smartphones. Increase of smartphone user has extended the smartphone business arena from simple and personal applications and content to professional software for the purpose of working in- and out of the office. In this regard, developing their services to be mobile-friendly would be important business strategies for Web business companies. The mobile data traffic in Korea had been 11.2 times increased from January 2010 to January 2011 and the average traffic per user in Korea is much higher than other countries. Usage of smartphones also has been steadily increased with the diffusion of smartphones. This may indicate that the dependency level on mobile portal service in Korea would be higher and more important than in other countries. This study analyzes the influences of UI simplicity and UI consistency on user perceptions of mobile portal services using PLS methodology. Simplicity shows a greater effect on usability and credibility than does consistency although consistency also shows a significant effect. In this regard, developing mobile Web services to be simple by following the selection and concentration strategy can be an effective strategic approach. Credibility shows a greater and direct effect on user satisfaction in this study than simplicity. But it does not mean that the perceived credibility should be treated simply as more important to user satisfaction than usability. Credibility of mobile Web services would be concreted more when the perceived usability would be developed with proper UI simplicity and consistency following the suggestion of Mann and Sahni. Also satisfaction significantly turns out to mediate the effect of credibility on loyalty. This study contributes as an earlier study on how and what the mobile Web service providers should design and provide their services.

Keywords Mobile web service · Smartphone · Simplicity · Consistency · Credibility · Usability · Portal service

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1 Introduction

Increase of smartphone user has extended the smartphone business arena from simple and personal applications and content to professional software for the purpose of working in- and out of the office. Consequently, diverse Web business companies are facing business changes and developing mobile-friendly services became important business strategy for Web business companies.

Before the release of the iPhone, smartphones were used by only a few early adopters among the larger body of mobile

service subscribers in Korea [73]. Since late 2009, however, Korean IT industry has noticed innovative changes emerging along with the increased popularity of smartphones. Korea has had a faster penetration of smartphones than was expected, with meaningful growth of mobile application markets and dramatic changes of business environments that are related with the increasing number of smartphone and other smart device users. There were only 470,000 smartphone users at the end of November 2009 in Korea but in March of 2011 that number broke the 10 million mark, and it had reached the 20 million mark in the end of October 2011. The number of mobile phone users in Korea reached 52 million as of the end of August 2011, indicating that four out of 10 Koreans are using smartphones and showing the fastest penetration rates of smartphones in the world [42]. According to the report of KISDI, mobile media's penetration rate has been dramatically increased, so smartphones became the secondly important and effective media for the Internet users following PCs in Korea. The mobile data traffic in Korea had been 11.2 times increased from January 2010 (449 TB) to January 2011 (5,463 TB) and the average traffic per user in Korea (287 MB) is much higher than US (150 MB), Western-Europe (74 MB), and Japan (199 MB). Usage of smartphones in Korea including searching, news, office, and learning has been steadily increased with the diffusion of smartphones. This may indicate that the dependency level on mobile portal service in Korea would be higher and more important than in other countries.

Interestingly, more than 80 % of Korean Internet users have used domestic Web portals such as Naver or Daum because their interface design is more convenient for Korean users while the Google, the world No. 1 Web service, is not [59]. This may demonstrate that Korean Internet users would count for the usability of portal sites more than other factors. In these regards, it can be expected that the usage of the mobile portal services in Korea would be different from other countries.

This study focuses on finding meaningful factors related with the perceived usability of the User Interface (UI) and the perceived credibility of the mobile portal sites in order to affect user satisfaction with and loyalty toward the mobile portals in Korea. This study concentrates on the effects of the simplicity and consistency of mobile portal services on smartphone users' perception of the usability and credibility of portal service providers.

2 Research background

2.1 Internet portal services

Among the diverse Web services, portal services have specific and distinguished features. Most important feature

is, (general) Internet portals have been prime entrance gateways to the Internet [43]. Internet users would use the Internet portals because they want to find out something while the users may use other sites such as e-banking sites because they should use the sites for their purposes. Also Internet users who have loyalties on one portal would move to another portal without any obstacles [50]. The portals would lose their users with several reasons which may not be important or serious for other services such as public library sites, e-banking sites, or others. This may be because the portals commonly serve quite similar and easy-to-copy contents and services. For instance, if some users feel that a portal site does not provide convenient and usable UI (not a content), they may find or move to other similar portals without any hesitate.

2.2 Mobile web evolution

Based on advances in mobile computing and communication technologies, diverse mobile Web services including local information, search engine functions, shopping, and e-mail service are being developed and are common and familiar. Mobile phone users can access and use mobile Web services anytime and anywhere [19]. So, mobile Web service providers have improved their current services including Web portal services to be compatible in mobile environments. According to several academic studies on mobile Web services, browsing-enabled cell phones such as smartphones, high-speed wireless networks, and special tariffs are essential factors for the success of mobile Web services, given the smartphone's fast diffusion [39]. A variety of content, Web pages, and services may feasibly be delivered in mobile environments. Although the mobile Web services extend the fixed Web services into the mobile environment, the mobile Web services are not merely the replications of the fixed Web services. The mobile Web services would be more personalized, developed, and simple [34]. The mobile Web users have difficulty of small view sizes although there are technical advances of mobile hardware and the degree of display resolution. Also the mobile network is still relatively slower than the fixed network.

2.3 Small screen issues in mobile web

Diverse mobile technologies including the Wireless Application Protocol (WAP) have been developed to help diverse organizations to design simple websites for mobile phones [16]. Although current smartphones can provide users "Full-Browsing" mobile browsers with relatively wide display sizes to navigate and to use webpages while moving, still there are several issues related with the small screen size of smartphones. To overcome these small

screen issues, Web service providers such as Web portal sites should select important contents and functions to be displayed on their webpages designed specifically for smartphones [14].

The small screen issue of mobile devices commonly results from the complexity of service provider websites. To solve this problem, service providers must simplify and organize their service structures with efficient trade-offs— Selection and Concentration. Web service companies including the Internet portals operate their mobile services in diverse ways. For instance, several portals focus on extraordinary and specific contents to be displayed on mobile webpages while others try to show as much content as they can and to design their mobile services to be consistent with their services for PCs (fixed webpages). In this study, one key decision for service providers is defined as a choice between 'Simplicity' and 'Consistency.'

Several Korean portal sites are now supporting mobile-friendly webpages (mobile webpages) for smartphone users. These portal sites also provide users access to their fixed webpages via a simple link their mobile webpages and they are developing several smartphone applications that support the users to use of their services without operating the mobile Web browsers in their smartphones.

2.4 Literature review

This study concentrates on the behavioral differences of Korean smartphone users according to the simplicity and the consistency of the mobile portal services and the behavioral differences of smartphone users according to the perceived usability and credibility of mobile portal services.

2.5 Simplicity

There are diverse academic studies on simplicity, especially in Human–Computer-Interface (HCI) studies. Simplicity can be defined as a key factor in designing easy-to-use products which is one of the important factors to develop the usability of information [47, 48, 51, 52, 75]. According to the previous studies, simplicity in the area of HCI represents not only simple page layout but also interface organization, functionality, structure, and work-flow and framework. Based on this definition, diverse studies classify it into four sub-constructs of reduction, organization, integration, and prioritizing [47, 48, 52, 67] (Fig. 1).

2.5.1 Reduction

Maeda and the SAP Design Guide describe "Reduction" as concentrating on the essentials of services to reduce
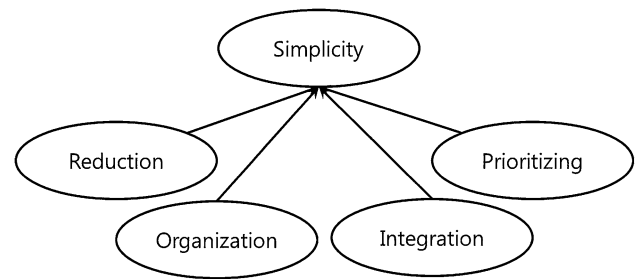

Fig. 1 Simplicity model [48]

functionality and complexity, especially in terms of structure and interface.

2.5.2 Organization

According to the studies of Maeda and Lee et al. "Organization" can be defined as the arrangement of an application's structure, functionality, and navigation. Organizing or structuring an application includes arranging the screens, pages, layout, navigation, and functionality of the application.

2.5.3 Integration

"Integration" means to integrate isolated applications or components into one construct. The SAP Design Guide explains that it is necessary to integrate simple and isolated tasks to make applications more accessible to users.

2.5.4 Prioritizing

Lee et al. introduce that "Prioritizing" means that applications should be composed with essential components to carry out their important tasks rather than attempting to serve diverse goals.

Based on the previous studies, the 'Simplicity' construct used in the present study can be described as formative and the four first-order constructs of 'Reduction,' 'Priority,' 'Integration,' and 'Organization' can be described as reflective (Figs. 2, 3) [38].

3 Consistency

Consistency is one of ten usability heuristics [56] and there are diverse definitions of consistency including consistent user interface, consistent contents, and consistency in terms of other aspects of design [63]. Consistency at the various levels of user interface meaningfully decreases error rates in PC- and Web-based computer tasks [63, 64].

Koohang and Ondracek [46] define the consistency of a digital library as terms, words, and actions being activated throughout a system. Consistency between fixed and mobile
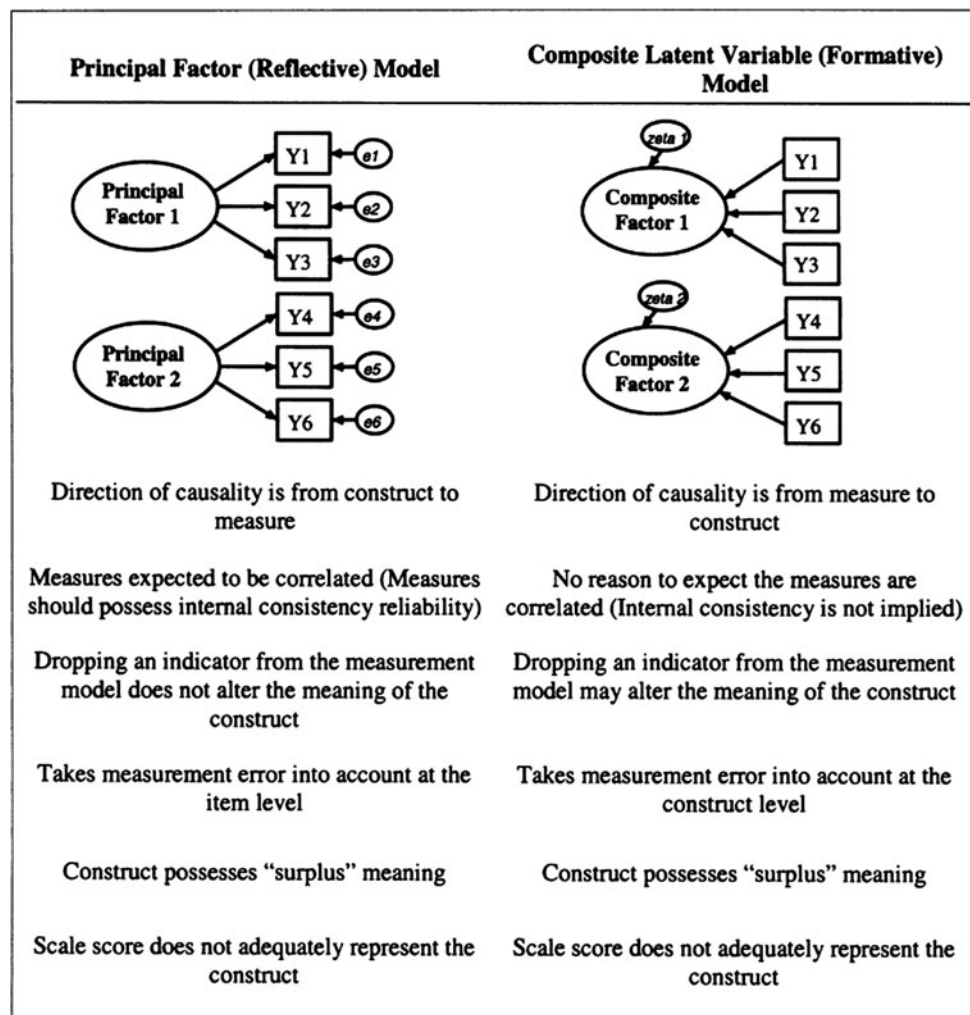
Fig. 2 Reflective and formative factors [38, 48]

Web browsers can be related with usability [41]. Their study investigates whether a Web site should consistently be displayed at all platforms or whether it should be changed and customized according to environmental differences. They suggest considering internal and external consistency when mobile webpages are designed, according to the functionality and usability of the expected user interface. Also they propose that a web browser on a new platform should be used the same way in other environments to achieve external consistency [41]. Grudin explains the differences between internal and external consistency. Internal consistency in an interface design means a consistency of the design itself. Internal consistency within a given platform may be sought in physical and graphical layout, selection techniques, and dialogue forms. External consistency focuses on consistency among diverse platforms [28].

In this study, consistency is defined as external consistency between mobile Web services and fixed Web services in terms of UI.

4 Usability

Usability is identified to consist of ease of use and ease of learning excluding utility, based on the studies of Nielsen and Lee et al. [47, 57]. Interestingly, usability is treated as the most important factor for the Web services in Korea [49]. ISO 9241-11 explains usability as encompassing effectiveness, learnability, flexibility, and efficiency and user satisfaction as one of the subjective attributes of usability. Alonso-Rios et al. and Lee et al. [2, 47] suggest the usability to represent internal and external software quality. Based on these studies, usability can be described with the five attributes of understandability, learnability, operability, attractiveness, and usability compliance. Usability attributes depend upon diverse usability properties including simplicity, readability, navigability, and others [46]. In other studies, usability is defined to be related with an easy-to-use interface to make the product understandable, learnable, easy to use, and attractive [8, 55–58].
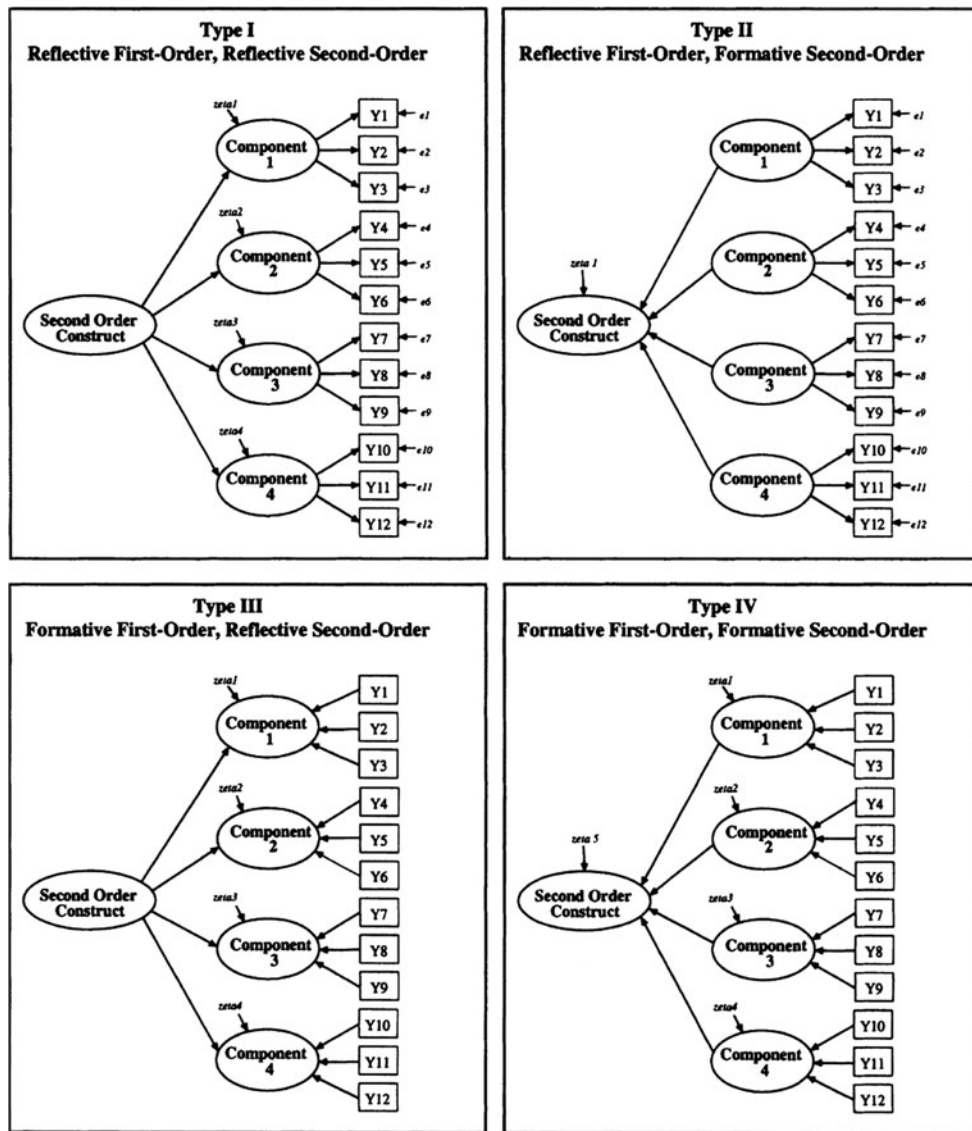
Fig. 3 Four types of second-order factor [38, 48]

Based on these conceptual definitions, usability is defined in this study to explain mobile Web service interfaces as an understandable, ease to use, attractive UI.

5 Credibility

Credibility can be defined as a perceived quality made up of multiple dimensions such as trustworthiness and expertise. In other words, credibility is a kind of perceived believability [22, 76].

Previous academic studies on the internet's credibility have suggested diverse perspectives on the credibility of internet services [40]. Several studies suggest that online information sources such as online news sites are more credible than traditional media to prove the credibility in Web services.

Fogg and Tseng define surface or interface credibility to describe the perceived beliefs of users based on simple inspection and explain that highly credible computer products would have high levels of trustworthiness and expertise [22]. Expertise can be defined as capability and trustworthiness can be defined as believability [35, 72]. In other words, trustworthiness can be defined as being well-intentioned, trustful, unbiased, and so on. Expertise can be defined as knowledge, experience, and competency to capture the perceived knowledge and skill of the source.

Fogg and Tseng expect that people can evaluate four different aspects of a computing product including information services when assessing credibility—*Device Credibility* relates to the physical aspect of a computing product, such as the physical design, density, and button detents of a pocket calculator. *Functional Credibility* relates to what a

computer product does and how it does it. *Information Credibility* refers to the believability of information provided by the computing product. *Interface Credibility* is the notion that the interface of a product can affect the perceived credibility of the product negatively or positively if the interface is far from or close to the user's expectation.

This study concentrates on *Interface Credibility* because device credibility may focus on the smartphone's hardware side. Functional and information credibility also would be neglected in this study because mobile Web services commonly provide diverse information and information searching UI via intuitive and simple structures to navigate between the menus. In this study, credibility for mobile Web services is defined as a believable interface with perceived expertise that encourages user trust in the service.

6 Research design

6.1 Hypotheses

Lee et al. [11, 44–47], Koohang, Koohang and Ondracek, and Carstens and Patterson explain simplicity as an important factor affecting usability.

Chae and Kim note that the small screen size of mobile devices may negatively affect user perceptions of site effectiveness, so simplicity of site design should be considered. Simplicity is expected to exert a positive influence on the perceived ease of use, which is one of the meaningful constructs of usability. Dianne et al. [20] explain that adherence to design simplicity for a mobile Web site will positively affect the perceived usability.

Interface credibility is based on user perceptions from simple inspection. Several studies describe the effects of interface design on perceptions of credibility, such as the influence of interface design features and balanced layout on perceived trustworthiness. For instance, credibility can be affected by the user's impression of the visual design of a simple web site [22].

This study proposes the first and second hypotheses as below:

H1: Simplicity positively affects usability
H2: Simplicity positively affects credibility

Koohang and Ondracek suggest twelve individual factors affecting the usability attributes—Simplicity, Comfort, User friendliness, Control, Readability, Information Adequacy, Navigability, Recognition, Access time, Relevancy, Consistency, and Visual presentation. Carstens and Patterson cite the studies of Nielsen and Shneiderman and Plaisant to explain consistency as one of the usability heuristics affecting perceived usability attributes [11, 56, 70]. Ketola

et al. [41] explain that internal and external consistency should be considered to provide the interface with functionality and usability when mobile services including WAP service are designed.

Credibility can be expected when one can concretely use past actions to predict future behavior [33]. In this regards, consistent and predictable reactions by a site to user choices and actions can promote a user to view a site as credible. Wathern and Burkell suggest that message credibility can be derived from an interaction of source characteristics, message characteristics that include plausibility, consistency, and quality, and receiver characteristics [77]. Clark and Montgomery suggest that high consistency will lead to higher credibility while low consistency will lead to lower credibility [18].

Based on these theoretical backgrounds, this study proposes the third and fourth hypotheses as below:

H3: Consistency positively affects usability
H4: Consistency positively affects credibility

Usability is described in diverse academic studies as significantly affecting user satisfaction. Satisfaction as an affective consumer condition derived from a global evaluation of all the aspects that make up the consumer's relationship with a service or product [47, 54]. Casalo et al. [13] explain that satisfaction is affected by perceived usability and also suggest that loyalty can be affected by satisfaction and usability. Based on the study of Roy et al., Schmidt-Belz explains that the perceived site usability has a positive impact on the perceived trustworthiness [66, 71]. Fogg et al. [23] explain that enhancing the usability of a web site may be related with the site's perceived credibility.

Loyalty is widely accepted to be related with diverse variables known as "Accumulative Inertia." According to Casalo et al. [37], the level of usability may be related with the user's belief on the value—the perceived value—of a website in the same category, and usability may enhance the level of lock-in and loyalty. Loyalty can be measured by attitudinal and behavioral methods. Increased satisfaction also affects user loyalty and behavioral intention [6, 62].

Based on these theoretical backgrounds, this study proposes the fifth, sixth, seventh, and eighth hypotheses as below:

H5: Usability positively affects user satisfaction with mobile Web services
H6: Usability positively affects user loyalty toward mobile Web services
H7: Usability positively affects credibility
H8: Satisfaction positively affects user loyalty toward mobile Web services

Wright empirically proved the existence of significant relationships among perceptions of source credibility,

similarity, and network satisfaction in online support groups [80]. Selnes and Gronhaug explain there is a significant relationship between reliability and satisfaction [68]. Reliability and credibility are defined to have the same meanings as "trust" in the study of Golbeck et al. [27]. Several studies describe that credibility moderates the effects of positive and/or negative feedback signs [5, 65]. Anderson and Narus and Anderson and Sullivan explain that trust can be an antecedent to satisfaction [4, 5]. Abdul-Muhmin [1] explains a significant relationship between credibility and satisfaction.

Brand comes to strengthen credibility only with repeated interactions between customers and firms. High trustworthiness and expertise, which are accepted as essential components of credibility, will affect the user's loyalty commitment. Gustafsson et al. [30, 72] and Sweeney and Swait explain the effect of brand credibility on satisfaction being related with customer retention. Bove and Johnson [10] explain that the perceived credibility of service providers positively affects the customer's loyalty toward the service worker.

In this study, this interpersonal relationship is accepted to explain the effect of credibility on customer loyalty based on the studies of Garbarino and Johnson, Chaudhuri and Holbrook, and Ball et al. [7, 15, 26] (Fig. 4).

H9: Credibility positively affects user satisfaction with mobile Web services

H10: Credibility positively affects user loyalty toward mobile Web services

7 Survey design and analysis results

To analyze the proposed hypotheses and the conceptual research model, an online survey was conducted to gather 285 survey participants. Among the collected survey responses, nine survey responses were eliminated because of their unreliable answers and 276 survey responses were used in this study.
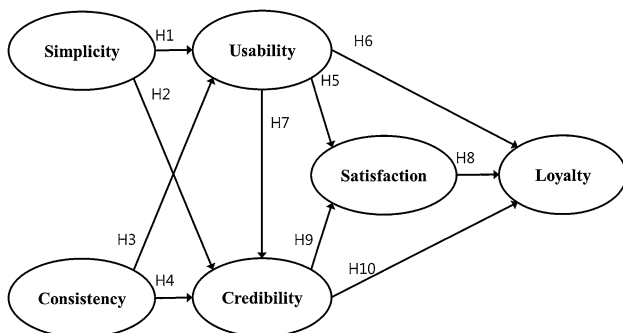

Fig. 4 Proposed conceptual research mode

The partial least squares (PLS) path modeling method which is famously and diversely used by a growing number of researchers studying subjects such as e-business, customer behavior, and marketing theories to analyze the relations among diverse latent variables is also used in this study [29, 32]. Chin suggests to multiply ten to the predictor numbers of the latent variable possessing the most predictors to expect the minimally needed sample sizes [17]. By that standard, the minimum sample size for this study is expected to be 30, so the sample size of this study can be accepted as sufficient.

Four survey items were designed to let participants indicate their favorite portal sites in fixed and mobile network environments and another four survey items were designed to determine the demographic features of the participants. To analyze the research model, forty items were adopted, and two items were used to determine whether there were any common method variances(Table 1). Among all survey participants, 69.20 % were male, and 81.16 % of participants ranged in age from 20 to 39. Approximately 60 % were students or office workers. Other demographic features are described in Table 2.

Factor loading analysis was conducted to certify whether all indicators for the constructs were reliable. Hulland suggests that indicators whose factor loading values are below 0.5 should be eliminated, and Carmines and Zeller [12, 36] suggest that indicators can be accepted as reliable when their loading values do not fall below 0.7. In this regard, indicators of loading values below 0.7 are eliminated. Fornell and Larcker [24] suggest that the average variance extracted (AVE) measuring the among of variance captured by the construct should show values greater than 0.5 to ensure acceptable discriminant validity. Based on these previous studies, 'Cons4', 'Orga1', 'Redu4', 'Loyal4', and 'Loyal5' were eliminated from the analysis.

Several studies suggest that too many indicators per factor may accompany decreases in theoretical reliability and may increase the potential for shared secondary influences to contribute to overall lack of fit of the model [3, 21, 31, 78]. Hall et al. suggest to use three to four indicators per latent variable. Based on these suggestions, each latent variable (construct) in this study should have three to four indicators, so 'Prio1' and 'Prio2' were dropped from the final analysis.

After eliminating these indicators, every AVE value was greater than 0.5 (Table 3). Table 4 shows the correlation values between all latent variables and compares these correlation values with the square roots of AVE values. Every square root value of the AVE is higher than the correlation values between the latent variable and all other latent variables, which proves that each latent variable expresses high discriminant validity, as Fornell and Larcker suggest. In addition, Table 4 shows the composite reliabilities of the latent variables; all composite reliabilities are greater than 0.7, and Nunnally suggests that high

Table 1 Survey items

Construct	Item	Description (Five-point Likert's scale)
Consistency (1)	Cons1	The mobile portal service provides information consistent with that of the fixed Web portal service
	Cons2	The contents of the mobile portal service are consistent with the contents of the fixed Web portal service
	Cons3	The mobile portal service is designed to be the same as the fixed Web portal service in terms of color and content placement
	Cons4	I feel that the mobile portal service is the same service as the fixed Web portal service
Credibility (2)	Cred1	The mobile portal service has a reliable user interface
	Cred2	The mobile portal service seems professional and inspires trust
	Cred3	The mobile portal service provides reliable search results
	Cred4	Information I can receive from the mobile portal service is of higher quality than I expected
Integration for simplicity (3)	Inte1	The mobile portal service integrates its functions according to their relationships
	Inte2	The mobile portal service provides integrated functions that may beused with ease
	Inte3	The mobile portal service provides integrated search results
	Inte4	The mobile portal service provides integrated functions for writing personal posts that may be published to personal media
Organization for simplicity (4)	Orga1	I can make a private menu to gather the necessary functions of the mobile portal service
	Orga2	I can arrange and manage my pictures and posts conveniently in the mobile portal service
	Orga3	The mobile portal service provides functions systemically
	Orga4	The mobile portal service categorizes its articles and posts systemically
Priority for simplicity (5)	Prio1	The mobile portal service displays recent information on the first page
	Prio2	The mobile portal service displays much-used functions on the first page
	Prio3	The mobile portal service provides the important functions on the first page
	Prio4	The mobile portal service displays the important information on the first page
	Prio5	The mobile portal service includes useful functions on the first page
	Prio6	The mobile portal service includes useful contents on the first page
Reduction for simplicity (6)	Redu1	It is hard to search for information via the mobile portal service
	Redu2	It is inconvenient to navigate to the function I want in the mobile portal service
	Redu3	It is inconvenient for me to publish favorite posts from the mobile portal service to other sites
	Redu4	There are many unnecessary functions and menus in the mobile portal service
Satisfaction (7)	Sati1	Using the mobile portal service is a satisfactory experience
	Sati2	On the whole, I am satisfied with the mobile portal service
	Sati3	I am satisfied with the functions of the mobile portal service
	Sati4	I am satisfied with the quality of the contents of the mobile portal service
Usability (8)	Usab1	The mobile portal service provides an easy-to-use interface
	Usab2	On the whole, the mobile portal service provides an easily-understandable user interface
	Usab3	The mobile portal service provides an easy-to-understand user interface
	Usab4	The mobile portal service provides an attractive user interface
Loyalty (9)	Loyal1	When using my smartphone, I use the mobile portal service more than other mobile web services
	Loyal2	When using my smartphone, I prefer the mobile portal service over other mobile web services
	Loyal3	I use the mobile portal service to search for information more than I use the default search function of my smartphone
	Loyal4	I do not use mobile portal services other than my favorite portal service
	Loyal5	I think that I don't need to use mobile portal services other than my favorite portal service

convergent validity is expected when each composite reliability is greater than 0.7 [60]. Every loading value for each latent variable is over 0.7 and is greater than other loading values of the indicators (construct items) for each latent variable (construct) after the seven indicators were eliminated. Thus, it can be accepted that every indicator shows high reliability, as Hulland suggests (Table 5).

To certify whether the four first-order factors of the latent variable of 'Simplicity' are reliable, the hierarchical component approach is used, as it is known as a proper and

Table 2 Demographic features of survey participants

Demographic feature	Category	Numbers	Percentage (%)
Gender	Male	191	69.20
	Female	85	30.80
Age	10–19	8	2.90
	20–29	95	34.42
	30–39	129	46.74
	40–49	44	15.94
Occupation	Students	54	19.57
	Office workers	111	40.22
	Sales workers	17	6.16
	Specialists in law, labor, accounting, and tax	3	1.09
	Researchers	22	7.97
	Owners of private companies	7	2.54
	Service industry workers	17	6.16
	Clergy	2	0.72
	Medical doctors and pharmacists	4	1.45
	Education related workers	4	1.45
	Technical engineers	21	7.61
	Officials	2	0.72
	Art and athletics workers	1	0.36
	Bank and insurance workers	1	0.36
	Others	10	3.62
Education level	Graduated middle high school	5	1.81
	Graduated high school	17	6.16
	Community college student	11	3.99
	Associate's degree	33	11.96
	University student	37	13.41
	Bachelor's degree holder	136	49.28
	Master's degree holder	32	11.59
	Ph.D. degree holder	5	1.81

Table 3 AVE values of the latent variables

Latent variable	AVE	Latent variable	AVE
Consistency (1)	0.632	Credibility (2)	0.649
Integration (3)	0.559	Organization (4)	0.686
Priority (5)	0.652	Reduction (6)	0.689
Satisfaction (7)	0.712	Usability (8)	0.709
Loyalty (9)	0.704		

effective approach to analyze higher-order factors in PLS research models [79]. It can be accepted that those four first-order factors are well-defined based on the result (Fig. 5).

Table 6 shows the R^2 values and Cronbach's alphas of each latent variable.

The R^2 value of the loyalty construct is lower (0.151) than the R^2 values of the usability (0.464), credibility (0.519) and satisfaction (0.550) variables. However, every Cronbach's alpha value is sufficiently greater than 0.7 to prove the unidimensionality of a block or a latent variable, so the values can be accepted as showing meaningful results [74].

According to the analysis result (Fig. 6), every hypothesis excepting H6 and H10 is accepted to be significant. Also, every first-order factor ('Reduction,' 'Integration,' 'Priority,' and 'Organization') is significant for simplicity (the second-order factor), so the simplicity factor can be accepted as a reliable second-order factor. Simplicity affects usability significantly, at 0.1 % significance level with a path coefficient of 0.584, so Hypothesis 1 is accepted. Also, simplicity affects credibility significantly, at 0.1 % significance level with a path coefficient 0.295, so Hypothesis 2 is accepted. Consistency affects both usability and credibility significantly, at 0.1 % significance level with path coefficients of 0.177 and 0.220, so Hypothesis 3 and Hypothesis 4 are accepted. According to this result, it can be understood that simplicity affects usability and credibility more than consistency affects usability and consistency, so the users of a mobile portal service are expected to count on UI simplicity more than UI consistency when they access mobile Web portal services.

Usability positively affects user satisfaction with mobile portal services at 0.1 % significance level and with a path coefficient of 0.354 (Hypothesis 5 is accepted). Nevertheless, usability does not affect user loyalty toward mobile portal services, although the path coefficient is weakly positive (0.040), so hypothesis 6 is rejected. Usability positively and significantly affects the perceived credibility of the service at 0.1 % significance level and with a path coefficient of 0.350, so hypothesis 7 is accepted. Satisfaction with the service affects user loyalty significantly and positively at 1 % significance level and with a path coefficient of 0.242, so hypothesis 8 is accepted. Usability is expected to mediate the relationships between simplicity and credibility and between consistency and credibility partially. When the path between usability and credibility is eliminated, the R^2 value of the credibility construct is reduced(0.453) and the path coefficients between simplicity and credibility (0.499) and between consistency and credibility (0.281) increase. It can be understood that usability mediates the relationships between simplicity and credibility and between consistency and credibility not entirely but partially because still paths between simplicity and credibility and between consistency and credibility are significant without the path between usability and credibility.

The credibility of the service affects satisfaction positively and significantly, with a path coefficient of 0.464 and

Table 4 Latent variable correlations and square root values of AVE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	**0.795**								
(2)	0.550	**0.806**							
(3)	0.371	0.516	**0.748**						
(4)	0.281	0.493	0.624	**0.828**					
(5)	0.392	0.540	0.596	0.545	**0.807**				
(6)	0.272	0.312	0.265	0.306	0.208	**0.830**			
(7)	0.518	0.689	0.592	0.501	0.540	0.33	**0.844**		
(8)	0.431	0.632	0.580	0.489	0.542	0.354	0.645	**0.842**	
(9)	0.240	0.325	0.407	0.191	0.312	0.104	0.356	0.283	**0.839**
Composite reliability	**0.836**	**0.881**	**0.835**	**0.868**	**0.882**	**0.869**	**0.908**	**0.907**	**0.876**

Table 5 Factor loading values of construct items for each latent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cons1	**0.837**	0.416	0.336	0.278	0.341	0.213	0.451	0.369	0.190
Cons2	**0.835**	0.449	0.326	0.313	0.398	0.281	0.476	0.380	0.177
Cons3	**0.705**	0.318	0.212	0.054	0.177	0.146	0.294	0.270	0.212
Cred1	0.449	**0.802**	0.460	0.429	0.460	0.226	0.570	0.591	0.264
Cred2	0.409	**0.858**	0.415	0.368	0.450	0.240	0.560	0.556	0.315
Cred3	0.393	**0.768**	0.396	0.356	0.403	0.287	0.515	0.443	0.260
Cred4	0.360	**0.792**	0.390	0.437	0.428	0.256	0.577	0.441	0.207
Inte1	0.266	0.423	**0.773**	0.501	0.505	0.147	0.439	0.440	0.322
Inte2	0.288	0.356	**0.772**	0.499	0.471	0.245	0.454	0.520	0.280
Inte3	0.264	0.374	**0.724**	0.397	0.388	0.195	0.428	0.398	0.303
Inte4	0.292	0.389	**0.722**	0.467	0.413	0.205	0.451	0.371	0.315
Orga2	0.204	0.309	0.442	**0.776**	0.332	0.193	0.330	0.313	0.088
Orga3	0.207	0.425	0.546	**0.879**	0.502	0.239	0.429	0.453	0.172
Orga4	0.288	0.485	0.560	**0.827**	0.512	0.327	0.482	0.442	0.210
Prio3	0.239	0.397	0.416	0.424	**0.770**	0.154	0.357	0.400	0.198
Prio4	0.301	0.423	0.495	0.468	**0.821**	0.135	0.414	0.416	0.251
Prio5	0.351	0.465	0.519	0.445	**0.842**	0.200	0.490	0.457	0.293
Prio6	0.371	0.459	0.492	0.423	**0.795**	0.181	0.480	0.481	0.264
Redu1	0.351	0.241	0.270	0.271	0.221	**0.785**	0.315	0.303	0.136
Redu2	0.174	0.247	0.245	0.256	0.188	**0.883**	0.266	0.318	0.084
Redu3	0.162	0.291	0.145	0.237	0.111	**0.820**	0.248	0.259	0.041
Sati1	0.408	0.547	0.479	0.429	0.439	0.224	**0.829**	0.549	0.325
Sati2	0.439	0.587	0.526	0.408	0.464	0.340	**0.869**	0.548	0.305
Sati3	0.470	0.577	0.485	0.395	0.444	0.281	**0.851**	0.518	0.294
Sati4	0.432	0.615	0.508	0.461	0.476	0.273	**0.826**	0.562	0.278
Usab1	0.385	0.514	0.524	0.433	0.480	0.302	0.531	**0.858**	0.271
Usab2	0.347	0.536	0.494	0.395	0.422	0.297	0.553	**0.885**	0.243
Usab3	0.349	0.487	0.424	0.321	0.412	0.306	0.506	**0.850**	0.262
Usab4	0.375	0.600	0.516	0.509	0.526	0.287	0.588	**0.771**	0.171
Loya1	0.125	0.192	0.313	0.150	0.242	0.035	0.203	0.171	**0.873**
Loya2	0.219	0.366	0.385	0.213	0.307	0.144	0.339	0.308	**0.904**
Loya3	0.274	0.258	0.327	0.110	0.233	0.081	0.334	0.232	**0.729**
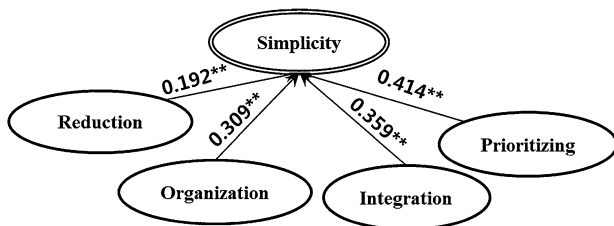
Fig. 5 Result of hierarchical component approach to certify 'simplicity'

Table 6 R^2 values and Cronbach's alphas of the latent variables

Latent variable	No. of item	Cronbach's alpha	R^2
(1)	3	0.702	–
(2)	4	0.819	0.519
(3)	4	0.736	–
(4)	3	0.763	–
(5)	4	0.821	–
(6)	3	0.774	–
(7)	4	0.865	0.550
(8)	4	0.860	0.464
(9)	3	0.784	0.151

at 0.1 % significance level, so hypothesis 9 is accepted. Although the relationship between credibility and loyalty is positive (path coefficient 0.147), the relationship is not significant—thus hypothesis 10 is rejected. Although usability and credibility do not show any significant effects on loyalty directly, it can be expected that user satisfaction mediates the relationships between usability or credibility and loyalty. To certify the mediating effect, four steps of analysis are proposed by Sobel [69]. First, the independent variable (IV) should affect the mediator significantly; second, variable IV should significantly affect the dependent variable (DV). Third, the mediator should significantly affect the DV, and finally, the effect of variable IV

should be reduced after adding the mediator to the model. Based on these four steps, the mediating effect can be analyzed.

In this study, these four steps are followed to certify the mediating effect of user satisfaction. First, the path coefficients between usability/loyalty and the mediator (satisfaction) are significant, as can be seen in Fig. 6, so it is expected that satisfaction will mediate the effects of credibility and usability on satisfaction. Second, when eliminating the relationship between satisfaction and loyalty, the relationship between usability and loyalty is still not significant, although the path coefficient increases slightly (path coefficient: 0.126). The path coefficient between credibility and loyalty also increases and becomes significant (path coefficient: 0.263) at a 1 % significance level. Because the relationship between credibility and loyalty shows significant difference, Sobel's test is used to certify the significance of the mediating effect after connecting satisfaction to loyalty. The unstandardized path coefficients and standard errors of the relationships between credibility and satisfaction (a) and between satisfaction and loyalty (b) are shown in Table 7. Satisfaction turns out to mediate the relationship between credibility and loyalty significantly.

$$\text{z-value} = \frac{a - b}{\sqrt{b^2 \times s_a^2 + a^2 \times s_b^2}} \quad \text{Sobel's Test}$$

a, b: Unstandardized Path Coefficient, s_a, s_b: Standard Errors

Based on the analysis result, it can be understood that the credibility of a mobile portal service can be a more directly effective factor for increasing user satisfaction with a service than is usability. It can also be understood that a user of a mobile portal service will be more satisfied with the service when he/she accepts the service as credible (or trustworthy) with simple UI design being compatible with smartphone display size, even though usability and consistency can also affect his/her satisfaction with the
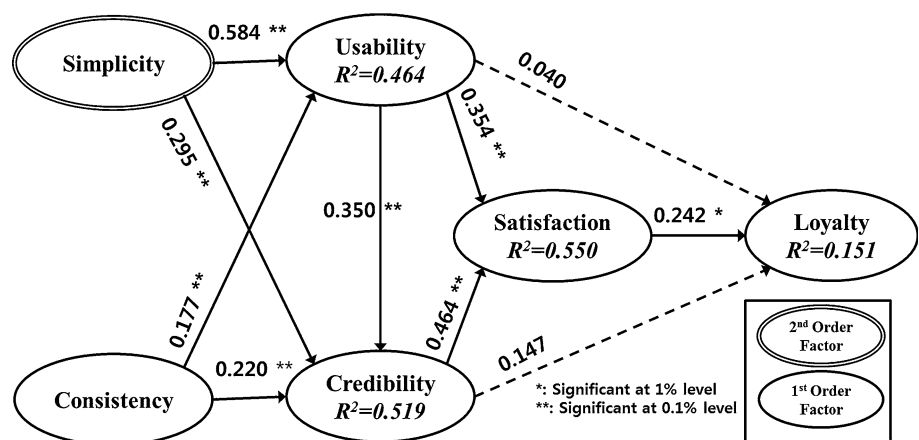

Fig. 6 Result of PLS methodology analysis

Table 7 Unstandardized path coefficients and standard errors of relation (a) and (b)

Path	Path coefficient	Standard error	Sobel's test result
Path (a)	0.462	0.053	Significant at 5 % level
Path (b)	0.248	0.101	

service. Also usability should be treated as an important mediator to enhance the effect of credibility. It is hard for portal services to gather and to keep users if the service companies providing those portal services do not concentrate on credibility-related factors such as simplicity and consistency.

8 Discussion

This study analyzes the factors influencing the behavior and attitudes of Korean users of mobile Web services to concentrate on the influences of UI simplicity and UI consistency on user perceptions of mobile portal services. An online survey targeting users of mobile portal services was conducted and the conceptual research model analyzed by PLS methodology. In the analysis result, simplicity shows a greater effect on usability and credibility than does consistency. Consistency also shows a significant but weaker effect on usability and credibility. Both usability and credibility show significant effects on satisfaction, but there are no direct and significant effects of those two variables on loyalty. Satisfaction shows a significant effect on loyalty. According to the Sobel's test, satisfaction significantly turns out to mediate the effect of credibility on loyalty. Based on these results, this study has several academic and practical findings and implications.

9 Academic and empirical implications

This study suggests several academic and empirical implications for mobile and fixed Web business environments as following.

As reviewed earlier, there are diverse viewpoints on the priority of UI simplicity for mobile Web services. Although mobile Web services are generated by similar Web technologies as are fixed Web services, mobile Web services should be carefully considered and developed because mobile devices such as smartphones and tablet PCs have relatively restricted screen size. Nonetheless, there are opposing views arguing that mobile Web services should prioritize consistency with fixed Web services, especially in terms of UI. Nowadays, internet portal sites commonly develop their mobile services to be simple and compatible with the size of smartphone screens and also

include a page link to move into the UI for their fixed Web environments at their service pages.

There have been diverse debates to compare simplicity with consistency. Gabriel [25] suggested that simplicity including interface simplicity rather than consistency should be counted as the most important factor when designing a system. Gabriel insisted that consistency including the interface consistency can be sacrificed if simplicity would be properly defined. Blair-Early and Zender [9] suggested that consistency may be the most comprehensive principle for good interface design. They emphasized that consistent and rational patterns would help users with average cognitive abilities to recognize their meanings. Obendorf [61] insisted that consistency can serve as a replacement for simplicity and with a new interface consistent with a known design, only new additions have to be learned and mastered. According to the results of this study, both simplicity and consistency should be maintained, but simplicity seems to be more meaningful.

Smartphone users turns out to prioritize simple user interfaces that fit well with mobile screen sizes, although they also may want mobile Web services to be consistent with fixed Web services. Common Web services have much information on the first (main) pages of their fixed Web services, including today's news, recommended posts, and private information. However, the service companies must choose whether to keep the complicated UI of their fixed Web services or to select and display only the most critical of the information from their fixed Web services when they develop new mobile Web services. This study suggests to Web service companies that mobile Web services may benefit from selecting the most popular information and sub-services for their mobile UI rather than offering all functions, information, and other personal favorites from their fixed Web services.

In this regard, developing mobile Web services to be simple by following the selection and concentration strategy can be an effective strategic approach. E-business companies need to offer the most popular services such as Web searching services, e-Mail, and others in their mobile services to build credibility and to foster user satisfaction. However, even though this selection and concentration strategy might eliminate little-used functions and less-important contents which competitors may still include in their mobile Web services, Web service companies do not need to try to keep every service in their mobile Web services. Conversely, companies should be aware of the reason why smartphone users want to visit their sites. To satisfy users with limited screen sizes in relatively slow networks, the company may have to reduce waiting times and focus on the selected mobile services to be more fascinating and usable. Also, because of the current technical and efficiency gaps between mobile and fixed network environments, it would be better to maintain the current dual-interface

Table 8 Top 10 web sites of korean android phone users (left) and PC users (right)

Rank	Domain	UV ratio (%)	Rank	Domain	Reach (%)
1	Naver.com	80	1	Naver.com	96.60
2	Google.com	71	2	Daum.net	89.00
3	Daum.net	64	3	Nate.com	75.10
4	Nate.com	52	4	Cyworld.com	65.70
5	Cyworld.com	28	5	Tistory.com	62.70

Fig. 7 A process chain to achieve the user's loyalty

Simplicity ⟩ Usability ⟩ Credibility ⟩ Satisfaction ⟩ Loyalty
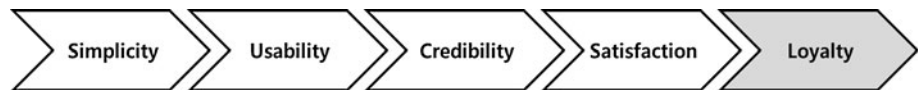
strategy—providing both mobile-optimized simple service and a page link to the fixed Web services.

The Nielsen-KoreanClick reports that the rank list of the favorite mobile web sites of smartphone users differ from that of PC users in Korea (Table 8). According the report, the Google shows a higher rank in the mobile Web than in the fixed Web environment. The second and third rankers in the fixed Web environment are 'daum.net' and 'nate.com'('cyworld.com' is a sub-domain of 'nate.com'). Although the Google's relatively higher rank in the mobile Web environment may be caused by various factors, this study can explain why the second ranker in the mobile Web environment is 'google.com' while 'google.com' is out of the top 10 rankers in the fixed Web environment. The report of the Nielsen-KoreanClick introduces that smartphone users would use their smartphones to access information including searching the news as quickly and use their PCs to keep using SNSs [59]. This report is close to the implication of this study that the mobile users emphasize the simplicity rather than the consistency.

This study also explains the relationship between credibility and usability. Even though credibility and usability may be attributed diverse meanings, this study considers those factors as both being related to user satisfaction with the UI of a site. Usability turns out to be an important and significant factor influencing user satisfaction and also to mediate the effects of simplicity and consistency on credibility partially. Credibility shows a greater and direct effect on user satisfaction in this study than simplicity. But it does not mean that the perceived credibility should be treated simply as more important to user satisfaction than usability. Instead, credibility of mobile Web services would be concreted more when the perceived usability would be developed with proper UI simplicity and consistency. Mann and Sahni explain that web site design factors such as the navigation structure between menus and displayed content are important antecedents affecting the customer's perception of service quality, and that this perceived service quality will affect the customer's satisfaction with and trust of the Web services such as e-banking

services [53]. This study shows that mobile Web service also would follow the suggestion of Mann and Sahni.

Even though diverse academic papers on user behaviors have studied perceived user satisfaction and the intention of users to use services, there are very few studies concentrating on the factors related with the UI of mobile Web services. Also studies on user behaviors comparing the influences of simplicity and consistency on the perceived usability and credibility based on the user's perceived value on a UI are likewise rare. This study was undertaken because there are no clear academic studies to conclude whether mobile Web services should keep the dual-interface strategy or should use a consistent UI regardless of platform. This study also contributes as an earlier study on HCI issues as they relate to user behavioral studies how and what the mobile Web service providers should design and provide their services. This study proposes a process chain to achieve the user's loyalty on the mobile Web services (Fig. 7). This study can be a proper reference to investigate the effects of those factors although there are still diverse academic debates on these effects and factors.

9.1 Limitations and suggestions for the future studies

This study is an early inquiry into issues related with the UI of mobile Web services, and it has several academic limitations.

First, even though simplicity turns out to be a more effective factor than consistency in this study, it should be noted that the mobile-optimized UI (generally a simplified UI) may have rapidly become familiar to smartphone users after the release of the iPhone in Korea. In other words, smartphone users might take the simplicity of the UI of mobile Web services as matter-of-fact because many Web service sites already accept the dual-interface strategy. If this study had been conducted earlier, before widespread familiarization with the simplified mobile UI, the result might have been different.

Second, the effect of user satisfaction on loyalty shows lower R square value than other constructs. It is expected that this lower R square value is because this study concentrates on UI-related factors rather than other well-known factors such as user intention, enjoyment, and other emotional factors which can affect loyalty and user satisfaction.

Third, the mediating effect of satisfaction unexpectedly turned out to be significant only for the case of credibility in this study although the previous studies broadly to prove the mediating effect of customer satisfaction and the customer's perceived value on the loyalty. Yang and Peterson explain the value perceived by a customer (or user) as a fundamental basis for all marketing activity and also explain the perceived costs(or values) of a product or service as including monetary payments and nonmonetary sacrifices of time consumption, energy consumption, and stress, citing the studies of Holbrook and Oliver and DeSarbo's study. This should be studied further also [81].

Based on these limitations and the aforementioned implications of this study, the following suggestions for future related studies may be proposed. This study applies UI factors which are treated in design- and HCI-related studies to the research area of user behavioral features. Nonetheless, there are still diverse HCI-related factors not treated in this study, such as the UI factors of text-alignment, the colors used, the loading speed of a site, and others. Future studies should be aware of more HCI-related factors than are treated in this study. Also, this study collected its data by surveying smartphone users. To assess HCI-related factors more efficiently, more practical studies to encourage users to compare mobile Web services with fixed Web services could be applied.

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