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공공 서비스 기반 모바일 어플리케이션에서 인간 행동의 변화를 촉진하는 디자인 요인의 효과 연구

Public Service-Oriented Mobile Applications in Facilitating Changes in Human Behavior: The Effects of Design Factors

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요 약

스마트폰의 획기적인 사용량 증가에 따라 모바일 앱은 에너지 절감과 같은 공공 영역에서의 인간 행동변화를 가져오는 유력한 방법이 되었다. 이를 위해 앱과 행동 변화 간의 관계성을 인식하는 것은 공공 기관으로 하여금 보다 더 효과적인 공공 커뮤니케이션 전략을 수립하는데 유용한 활동이다. 본 연구는 디자인 과학 접근법을 기반으로 하여 개인화, 접근성, 표현의 풍부성과 같은 공공 서비스 중심의 모바일 앱의 디자인적 요인들이 사용자의 인지적, 감성적 태도에 미치는 영향을 조사하는 것이다. 분석 결과 대부분의 디자인적 요인들이 사용자의 인지적 감성적 태도에 유의한 영향을 주는 것으로 밝혀졌다. 또한, 인지적 태도는 사용자의 행동 변화와 감성적 태도에 영향을 미치며, 한편 감성적 태도는 공공 모바일 앱의 평균 사용시간과 에너지 절감이라고 하는 행동 변화에 긍정적인 작용을 하는 것으로 나타났다.

키워드 : 공공 서비스 기반 모바일 어플리케이션, 디자인 과학, 에너지 절감, 모바일 커뮤니케이션

Ⅰ. Introduction

Various communication channels have been utilized in recent years to earn people's agreement and trust and encourage consensus on various global issues. For more than a decade, governments have advertised the global warming problem and provided information on how to save energy through a variety of mobile information systems in addition to television, books, and newspapers (Gardner and Stern, 2002). As the number of smart phone users has increased dramatically, designers of mobile applications have come to regard them as a promising and effective means to deliver knowledge about energy saving to smart phone users

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(Stafford, 2005). Determining the extent to which mobile applications contribute to actual energy saving outcomes by users is crucial for further development of more effective energy saving strategies.

Intervention strategies have been used to communicate the efficiency of various energy saving methods (Midden *et al*., 2007; Weiss *et al*., 2012). These strategies aim to change energy usage behavior by targeting psychological states such as recognition and attitude (Abrahamse *et al*., 2005). These strategies may include behavioral intervention and contextual intervention.

To evaluate the effectiveness of utilizing a mobile device to communicate information about energy saving, understanding of the unique features of mobile devices is required. In the context of mobile information management, conventional intervention strategies to encourage energy saving may not apply. Moreover, previously used methods of behavior modification or manipulation may not result in intrapersonal changes in individual users, such as recognition, preference, and capability.

In many studies, the relationships between the design characteristics of mobile applications and users' adoption behavior or performance (e.g., energy saving, actual purchase) have been discussed (Cyr *et al*., 2006; Magrath and McCormick, 2013). However, very few empirical studies have examined these relationships. In this empirical study, a theoretical model is proposed to explain the inherent process of recognition of the design features of mobile applications and their contribution to inducing individual users to engage in energy saving behaviors. Both cognitive and affective attitudes are identified as direct paths from information system design to actual performance; indirect paths via adoption intention are not discussed. As a proxy for cognitive and affective factors, perceived knowledge acquisition and perceived enjoyment are considered, respectively. According to the literature on mobile information architecture, the design characteristics of mobile applications pertinent to this empirical research include personalization, accessibility, and representation richness.

This paper is organized as follows. In chapter Ⅱ, related research is described to provide background to the underlying problem and the theory on which the empirical analysis is based. The research model and corresponding hypotheses are described in chapter Ⅲ. Methodology and results are provided in chapters Ⅳ and Ⅴ, respectively. Finally, the main findings, related theory, practical implications, and suggestions for further research are discussed in chapter Ⅵ.

Ⅱ. Research Background

2.1 Energy Conservation Behavior

Several social and environmental psychological studies of energy conservation behavior have proposed various methods to encourage users to reduce energy consumption. These studies have evaluated the effectiveness of intervention strategies to change energy consumption behavior. Many intervention strategies target individual attitudes, perceptions, preferences, and abilities.

Briefly, intervention strategies may be divided into two main categories: behavioral intervention, such as information provision and modeling, and contextual intervention, such as the introduction of regulations or new technologies. The details of each category are as follows.

Behavioral intervention aims at spontaneous changes in users' behavior as a result of changes in their perceptions, preferences, and abilities. One typical behavioral intervention strategy is the provision of information. Information provision enhances users' knowledge about the cause-and-effect aspects of energy problems

and energy saving methods (Steg and Vlek, 2009).

Contextual intervention encourages energy saving behavior by changing contextual elements to induce users to make energy saving decisions. The introduction of regulations and new technologies falls into this category. For example, in exploiting mobile computing and smart technologies, users can receive energy consumption-based feedback information obtained in real time and useful energy saving knowledge at any time, in any place (Weiss *et al*., 2012). Various mobile applications have been developed recently related to energy saving with the growth of the smart phone and mobile internet markets. In addition, interest is increasing in how system design and development may enhance users' energy saving behavior; this approach is superior to simply measuring the effects of mobile application-based intervention strategies (Hondo and Baba, 2010).

The energy diet application is a public service-oriented mobile application designed and developed to encourage energy saving behavior. It could therefore be considered as a technology introduction intervention strategy in that it provides a new technology to users. In addition, because it may also be considered an information provision intervention strategy in that it provides energy saving information, the energy diet could be considered a combination of both contextual and behavioral intervention strategies.

2.2 Design Characteristics of Public Service-oriented Mobile Applications

Many studies have emphasized the importance of system design elements as key factors influencing users' behavior toward mobile systems. In the mobile commerce field, several studies have examined mobile application design and its contribution to product adoption, loyalty, and purchasing activities (Andreou *et al*., 2002; Cyr *et al*., 2006; Oh, 2014). For example, Cyr *et al*. (2006) emphasized that consumers prefer well-designed mobile commerce applications, and that the most successful applications were those designed to appeal to users emotionally through colors, shapes, fonts, and animation, including hedonic elements for users' amusement.

Other studies have examined design elements and their influence on the effectiveness of an intervention strategy for energy saving developed for mobile feedback systems. Jacucci *et al*. (2009) pointed out that many currently available mobile solutions fail to draw the attention of users; the mobile user interface must be designed so as to provide more personalized information in sufficient quantity and quality to encourage energy saving behavior. Despite the high expectations for energy saving-related mobile applications, research into the design characteristics of these applications is lacking. Accordingly, in this study, new design characteristics of energy saving-related public service-oriented mobile applications are defined, and the influence of these design characteristics on users' attitudes and behavior is investigated.

The design characteristics were based on mobile information architecture because public service-oriented mobile applications' main intention was to deliver information to users. In this study, the mobile information architecture of Kim *et al*. (2005) was chosen as a reference framework. They suggest that mobile information architecture is composed of four elements: content, structure, navigation, and representation. Details of these respective elements are as follows.

Content is about providing information suitable to a user's specific context. The personal nature of mobile devices compared to other media affects the content of mobile applications. Thus, designers must take into account personalization of content so that information

provided in public service-oriented mobile applications may be personalized for each user.

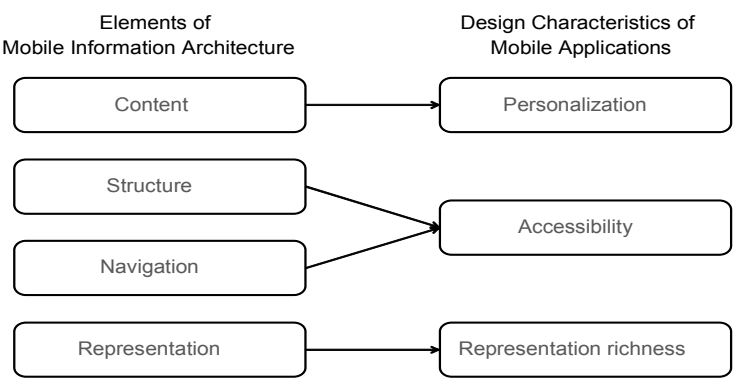
Second, the categorization and labeling of the menu, which provides structure to the mobile information architecture, must allow users to find desired information effectively. Navigation refers to ease of movement between sources of information provided by mobile devices for quick access to desired information. These two elements, structure and navigation, are about easy access to desired information. This design feature may be called accessibility. Public service-oriented mobile applications must be designed with easy access in mind. If these applications are difficult to access, even the personal benefits of mobile devices to users will be outweighed by the inconvenience of excessive time required to find information. Thus, users will be less likely to participate in the energy saving behavior that the mobile application was intended to encourage.

Finally, the fourth element of mobile information architecture suggested by Kim *et al.* (2005), representation, refers to visual presentation of information (Kamba *et al.*, 1996), or how effectively visual content is represented and read on the relatively small screen of a mobile device. This design feature could be described as representation richness. Applications must be designed to represent information richly. Guidebooks or e-mail messages, which are other important means of communicating about energy conservation, provide information primarily in text form; however, when communicating by means of mobile applications, information must be provided more visually due to the limited screen size, even if the same content is provided. Rich representation of information is possible if elements from multiple media are included; the multimedia functions of smart phones for mobile applications are excellent for this purpose.

Based on the framework of Kim *et al.* (2005), three design characteristics of public service-oriented mobile applications were defined in this study <Figure 1> personalization, accessibility, and representation richness.

IS devices developed to provide general information do so with different degrees of effectiveness (Wang and Dai, 2013; Wells *et al.*, 2011). In particular, in the case of mobile devices, with their limited screen size, effectiveness is related to design aspects like readability and convenience of navigation (Chae and Kim, 2004; Chittaro, 2006; Churchill and Hedberg, 2008).

In Korea, various mobile applications have recently



〈Figure 1〉 Mobile Information Architecture-Based Design Characteristics of Public Service-Oriented Mobile Applications

been developed by various government organizations for public relations purposes (Bae *et al*., 2012). These applications inform people about policies and encourage participation in the decision-making process. The energy diet app which is the subject of this study was also developed to provide people with behavioral tips on how to save energy and adjust their lifestyle.

Such public mobile applications are intended to promote government policies and persuade people to act according to these policies (Sim *et al*., 2013). Such applications differ from general commercial mobile applications, which are mainly intended for multiple downloads. However, studies on the effects of design characteristics of mobile applications on users' behaviors in the context of public mobile applications have not considered the characteristics of such public mobile applications.

Hence, in this study, the three design characteristics of mobile applications, personalization, accessibility, and representation richness, are investigated from the perspective of mobile information architecture. In addition, we examine the characteristics of public mobile applications that are mainly intended for public relations and communication about policies, and study their effects on user behavior.

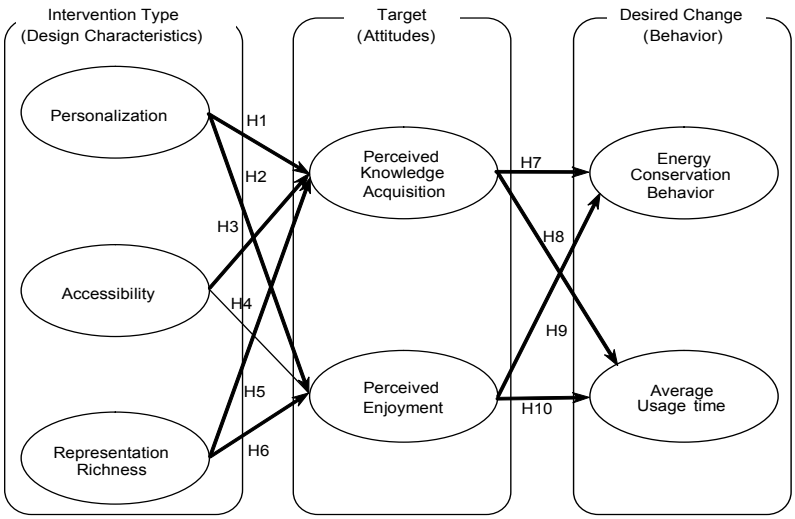
Ⅲ. Research Model and Hypotheses

3.1 Research Model

In this study, in which the causal relations among the design characteristics of public mobile applications are examined, users' attitudes and changes in behavior are the important parameters included in the study model. Variables related to these design characteristics are listed in the research model in <Figure 2> and are discussed below.

3.2 Design Factors: Personalization, Accessibility, and Representation Richness

Personalization refers to the amount of information



〈Figure 2〉 Research Model

provided by an application delivered in a customized form suitable for individual users (Xu, 2006). Personalization attracts the interest of users of mobile devices, fulfilling their desires for personalized information (Kalakota and Robinson, 2001) and advice and delivering information effectively and efficiently (Jacucci *et al*., 2009). Several earlier studies referred to the fact that providing personalized information enhances user knowledge, which ultimately leads to behavioral change (Lehman and Geller, 2004; Steg and Vlek, 2009). In addition, they determined that knowledge acquisition, which may cause behavioral change, requires not only information provision. Rather, it may be acquired only if users are interested in and understand the information provided, especially its greater implications (Shippee, 1980). Thus, the personalization feature, which attracts users' attention and enables useful information to be provided to users, may have a positive effect on users' knowledge acquisition by increasing users' interest and helping them understand the provided information.

Researchers such as Katterbach (2002) found compacted, brief, personalized information to be most likely to draw users' attention. This attention forms the basis for users to enjoy using the device. Chang and Wang (2011) also noted the influence of personalization of mobile applications on users' value recognition. Thus, the personalization level may have a positive effect on perceived enjoyment, which falls into the category of affective values. Hence, we hypothesized that:

Hypothesis 1: The personalization of a mobile application is positively associated with perceived knowledge acquisition.

Hypothesis 2: The personalization of a mobile application is positively associated with perceived enjoyment.

Accessibility refers to how easily and quickly users may access specific information (Volery and Lord, 2000). For mobile applications, the amount of information that may be displayed on a smart phone screen is limited. Therefore, applications must be designed with consideration of information accessibility. According to Park *et al*. (1994), users access information primarily to receive or share it in an information-based, interconnected network or system. They generally make better use of more accessible information. In addition, Midden *et al*. (2007) determined that easily accessible information about environmental issues related to energy saving stimulates and enhances environmental awareness. Therefore, accessibility of energy saving information may have a positive effect on acquisition of energy saving-related knowledge.

Other research has shown that interaction with media such as mobile applications generates positive feelings. When users frequently access interesting and easily accessible information via mobile applications, their attention and interest may increase (Xu, 1996). Ease of use is an attribute of these applications that affects user satisfaction. Existing studies have identified a close relationship between information accessibility and perceived ease of use (Lin and Lu, 2000; Teo *et al*., 2003). Ease of use in turn is positively related to perceived enjoyment (Van der Heijden, 2004). Therefore, accessibility of energy saving information may have a positive effect on users' perceived enjoyment. We therefore hypothesized that:

Hypothesis 3: The information accessibility of a mobile application is positively associated with perceived knowledge acquisition.

Hypothesis 4: The information accessibility of a mobile application is positively associated with perceived enjoyment.

Representation richness refers to the depth of information to be delivered (Jahng *et al*., 2006). Information is represented differently depending on the characteristics of the media and the attributes of the message (Otondo *et al*., 2008). When richly representing information using images or multimedia rather than simple texts, or when providing information by an interactive method, users' knowledge about the content is likely to increase (Jahng *et al*., 2006; Kim *et al*., 2009). Meanwhile, several studies related to representation richness have been conducted on energy saving. Staats *et al*. (1996) found that providing energy saving information through mass media rather than printed text is helpful to enhance users' knowledge, and Midden *et al*. (2007) showed that information experienced through sound or images, such as television advertisements or video clips, is helpful to improve users' awareness of environmental issues. Therefore, representation richness of energy saving information, which enables energy saving information to be provided through rich representation methods, may have a positive effect on users' knowledge acquisition.

Some researchers, including Magrath and McCormick (2013), also found that if information is represented richly and delivered through photographs, graphics, and video, then interaction functions, enjoyment, and entertainment are provided. Therefore, we postulate that representation richness will have a positive effect on users' perceived enjoyment. Thus, we hypothesized that:

Hypothesis 5: The representation richness of a mobile application is positively associated with perceived knowledge acquisition.

Hypothesis 6: The representation richness of a mobile application is positively associated with perceived enjoyment.

3.3 Attitude: Perceived Knowledge Acquisition and Perceived Enjoyment

Perceived knowledge acquisition refers to the acquisition of knowledge that users want to gain (Yli-Renko *et al*., 2001). Several earlier studies found a positive relation between energy saving knowledge and users' energy saving behavior (Brandon and Lewis, 1999). Steg (2008) emphasized that certain knowledge and methods of energy saving are needed for reducing home energy consumption. Staats *et al*. (1996) also identified a positive relation between the energy saving information provided through mass media and the energy saving knowledge level of users by measuring knowledge levels before and after the information was provided. Meanwhile, perceived knowledge acquisition is a cognitive value provided to users and this factor leads users to use information systems continuously (Karahanna *et al*., 1999). Therefore, perceived knowledge acquisition may have a positive effect on the energy saving behavior of users and use of mobile applications.

Perceived enjoyment refers to the interest users feel as an affective and intrinsic value (Davis *et al*., 1992). It has been identified as an important factor affecting mobile service usage (Dickinger *et al*., 2008; Luo *et al*., 2013). Several studies found that it also have a positive effect on energy saving behavior (Gardner and Stern, 2002; Mills and Schleich, 2012). Furthermore, appeals to enjoyment in an educational campaign were effective in inducing energy saving behavior for users with low self-awareness about energy use and environmental problems, or when making difficult decisions about energy saving behavior (Abrahamse *et al*., 2005). Other studies proved that perceived enjoyment is a key intrinsic factor to encourage continuous use of information systems (Hong *et al*., 2008; Kim

and Han, 2009). Therefore, perceived enjoyment may have a positive effect on energy saving behavior of users and use of mobile applications. Thus, we hypothesized that:

Hypothesis 7: Perceived knowledge acquisition in a mobile application is positively associated with energy conservation behavior.

Hypothesis 8: Perceived knowledge acquisition in a mobile application is positively associated with average usage time for the application.

Hypothesis 9: Perceived enjoyment in a mobile application is positively associated with energy conservation behavior.

Hypothesis 10: Perceived enjoyment in a mobile application is positively associated with average usage time for the application.

3.4 Dependent Variable: Energy Conservation Behavior and Average Usage Time

In this study, two dependent variables related to user behavior were measured: energy saving behavior and average mobile application usage time. Users' energy saving may be perceived as a type of performance from public viewpoints; average usage time may be perceived as performance from the viewpoint of information technology.

In this study, electricity saving behavior was measured in a self-reported form. Many studies have analyzed the effects of energy saving-related intervention strategies based on self-reports about energy saving behavior changes (Shippee, 1980; Abrahamse *et al.*, 2005). In many studies, self-reported behavior has been used as a valid indicator of actual behavior (Warriner *et al.*, 1984; Steg and Vlek, 2009). For example, Warriner *et al.* (1984) showed that self-reported behavior reflects actual behavior. They found no significant difference between objectively observed energy saving behavior and the self-reported energy saving behavior of users.

The average usage time was measured as the number of hours per week that the respondent reports using the application. Previous studies related to user behavior in mobile systems also measured usage behavior of users based on the amount of time an application was used per week or the frequency of use (Bianchi and Phillips, 2005, 2008).

Ⅳ. Method

4.1 Data Collection and Samples

Data for the analysis was collected as follows. First, a draft of the questionnaire was created. Korea Research Inc., the specialized research institute that conducted the survey, conducted a pilot test to modify and complement the questionnaire. The target respondents were householders and their spouses who pay electric charges. At the time of the study, respondents to the questionnaire survey were users who were actually using the energy diet app, as evidenced by the fact that they had installed it. Other users were excluded. The survey was conducted over a period of about two months.

In the final survey, 231 of 425 responses were received (response rate: 54.3%). In total, 205 surveys were used for the analysis. Excluded surveys were those with missing values or those with the same answer for all the items. <Table 1> provides demographic information about the responses used in the analysis. Males and females made up 46.3% and 53.7% of respondents, respectively. Most respondents (82.9%) were in their 30s and 40s. Office workers and house-

〈Table 1〉 Characteristics of Subjects

Categories		Number	%
Gender	Male	95	46.3
	Female	110	53.7
Age	19～29	17	8.3
	30～39	113	55.1
	40～49	57	27.8
	Over 50	18	8.8
Education level	High school	24	11.7
	Undergraduate	153	74.6
	Masters' and Doctorate degrees	28	13.7
Occupation	Clerical worker	134	65.4
	Professional	20	9.8
	Housewife	45	22
	Student	3	1.5
	Other	3	1.5
Annual income	Under 3000	51	24.9
	3000～5000	58	28.3
	5000～7000	59	28.8
	Over 7000	37	18.0

wives accounted for 75.2% and 22.0% of respondents, respectively. Finally, income level was comparatively even (between 30 million and 90 million won).

4.2 Measurement

The survey items and references for the variables included in the research model for analyzing the effect of design characteristics of public service-oriented mobile applications on users' behaviors are summarized in <Table 2>. Questions used in this study were selected with consideration of their validity as verified in a previous study, and various survey items were adapted to make them suitable to the context of this study. Measurements were performed as follows. We measured average usage time over the course of one week. High frequency of use was defined as two times for the same participant. Average usage time was measured for six months. Hence, the difference in the two frequencies was considered an indicator of behavioral change.

The public service-oriented mobile application analyzed in this study was the energy diet application. The application was developed by the Ministry of Knowledge Economy in Korea. It was distributed for the purpose of sparking interest and participation in energy saving by promoting and providing simple, customized information based on users' participation. Popular entertainers and familiar characters are featured in this application.

4.3 Validity Testing

In this study, various measurement items were used to verify the empirical model. An exploratory factor analysis and confirmatory factor analysis were conducted to evaluate the validity and reliability of the measurement items with SPSS Statistics 20. Exploratory

〈Table 2〉 Measurement items

Construct	Items	References
Personalization (PER)	PER1. I feel that the mobile application displays providing energy conservation information are personalized for me. PER2. I feel that the energy conservation information in the mobile application is personalized for my usage. PER3. Energy conservation information in the mobile application is personalized. PER4. The mobile application seems to provide information suitable to each person using it.	Xu (2006)
Accessibility (ACC)	ACC1. I feel that energy conservation information in the mobile application is easily accessible. ACC2. I feel that browsing speed is satisfactory. ACC3. I experienced no frustration in accessing energy conservation information. ACC4. I experienced no problems while browsing for energy conservation information.	Volery and Lord (2000)
Representation richness (RR)	RR1. All necessary features/specifications of the energy conservation information were vividly represented. RR2. All necessary features/specifications of the energy conservation information were represented using nonverbal symbols (e.g., images, graph). RR3. I was able to obtain/understand all necessary information about energy conservation. RR4. It was easy to understand/process all the energy conservation information that was presented.	Jahng *et al.* (2006)
Perceived knowledge acquisition (PKA)	PKA1. Because I used the mobile application I was able to obtain knowledge about electricity saving methods when using appliances in everyday life. PKA2. Because I used the mobile application, I was able to obtain knowledge about the obesity index for electricity consumption. PKA3. Because I used the mobile application, I was able to learn about various electricity saving methods. PKA4. Because I used the mobile application, I was able to obtain knowledge about electricity saving. PKA5. In general, I acquired diverse electricity saving knowledge by using the mobile application.	Yli-Renko *et al.* (2001)
Perceived enjoyment (PE)	PE1. I find using the mobile application to be enjoyable. PE2. I have fun using the mobile application. PE3. Using the mobile application provides me with a lot of enjoyment. PE4. I enjoy using the mobile application.	Davis *et al.* (1992); Agarwal and Karahanna (2000)
Energy conservation behavior (ECB)	ECB1. As a result of using the mobile application, I was able to reduce electricity use. ECB2. I was able to practice power saving behavior by using the mobile application. ECB3. The mobile application enabled me to save electricity.	Ek and Söderholm (2010); Nordlund and Garvill (2003)

factor analysis was used to determine whether the initially suggested items should be treated as a single factor or kept separate from those measuring other concepts. Based on this factor analysis, reliability was evaluated using Cronbach's alpha to determine internal consistency among items.

The exploratory factor analysis was conducted using the Varimax method, an orthogonal rotation method. Following the recommendation of Hair *et al.* (1998), factor loadings greater than 0.50 were considered to be very significant. In the results of the analysis, all factor loadings were actually greater than 0.50, and most were above 0.60.

Next, the internal consistency of each construct was tested using Cronbach's alpha and average variance extracted (AVE). If Cronbach's alpha exceeded 0.70 and AVE exceeded 0.50, meaning that the construct met the general standard of conceptual reliability, the

〈Table 3〉 The Results of Validity Testing

Constructs	Items	Factor Loadings	Composite Reliability	Cronbach's Alpha	AVE	PER	RR	ECB	ACC	PKA	PE	AUT
PER	PER1	0.9209	0.9637	0.9498	0.8692	**0.9323**						
	PER2	0.9339										
	PER3	0.9370										
	PER4	0.9371										
RR	RR1	0.9223	0.9571	0.9402	0.8481	0.8558	**0.9209**					
	RR2	0.9092										
	RR3	0.9316										
	RR4	0.9201										
ECB	ECB1	0.9259	0.9596	0.9560	0.8879	0.8053	0.7769	**0.9423**				
	ECB2	0.9440										
	ECB3	0.9566										
ACC	ACC1	0.8932	0.9319	0.9378	0.7744	0.7442	0.7834	0.6415	**0.8800**			
	ACC2	0.9218										
	ACC3	0.9021										
	ACC4	0.7974										
PKA	PKA1	0.9224	0.9682	0.9589	0.8590	0.8639	0.8647	0.8147	0.7915	**0.9268**		
	PKA2	0.9232										
	PKA3	0.9324										
	PKA4	0.9354										
	PKA5	0.9202										
PE	PE1	0.9369	0.9613	0.9461	0.8612	0.7869	0.7631	0.7829	0.5626	0.7537	**0.9280**	
	PE2	0.9528										
	PE3	0.9210										
	PE4	0.9004										
AUT	-	-	1.0000	1.0000	1.0000	0.2246	0.2379	0.2444	0.1549	0.2233	0.2979	**1.0000**

Notes) The recommended levels for the above statistics were as follows: Composite reliability > 0.70, Cronbach's alpha > 0.70, average variance extracted (AVE) > 0.50. AUT indicates Average Usage Time.

construct was presumed to be reliable (Hair *et al*., 1998). As summarized in <Table 3>, the Cronbach's alpha values of all variables exceed 0.70 (0.9378～1.0000). AVE also exceeded 0.50 in all cases (0.7744～1.000). Therefore, the measurement variables were considered to be reliable.

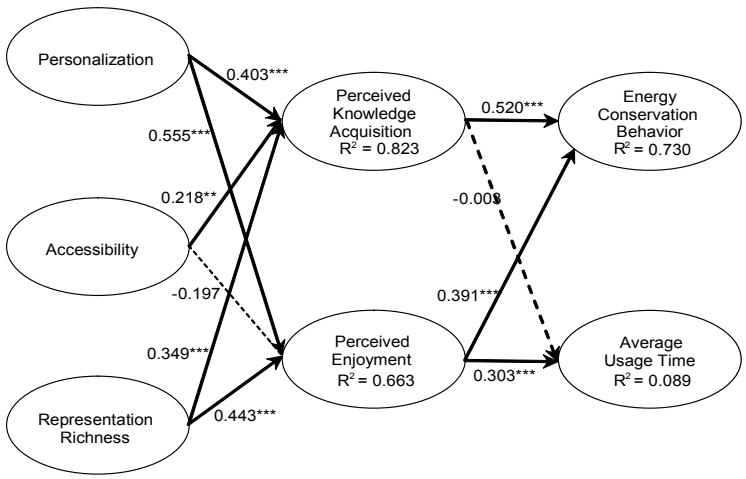
Finally, we examined the relationship between the square root of the AVE and the correlation coefficients, as shown in <Table 3>. The discriminant validity was examined as a 95% confidence interval of the correlation coefficients, showing that the square root of AVE was larger than the correlation coefficient (Fornell and Larcker, 1981).

V. Results

We then examined how the design features of mobile applications influenced users' perceived knowledge acquisition and perceived enjoyment. The full model of the hypothesized relationships was tested using partial least squares analysis. The standardized path coefficients for the research model are shown in <Figure 3>. All hypotheses except H4 and H8 were supportive. The results of hypothesis testing are summarized in <Table 4>.

We then examined how the design features of mobile applications influenced users' perceived knowledge acquisition and perceived enjoyment. The results were as follows.

The degree of personalization of mobile applications influenced users' perceived knowledge acquisition (β = 0.403, $p < 0.01$) and perceived enjoyment (β = 0.554, $p < 0.01$). Therefore, hypothesis 1 and hypothesis 2 were supported. Secondly, the degree of accessibility of information about energy saving on mobile applications influenced users' perceived knowledge acquisition (β = 0.218, $p < 0.05$), supporting hypothesis 3. On the other hand, the degree of accessibility of information about energy saving on mobile applications had no influence on users' perceived enjoyment. Therefore, hypothesis 4 was not supported. Lastly, the richness of representation of information about energy saving on mobile applications influenced users' perceived knowledge acquisition (β = 0.349, $p < 0.01$) and perceived enjoyment (β = 0.443, $p < 0.01$). Therefore, hypotheses 5 and 6 were supported.



Note) * |t| > 1.645, ** |t| > 1.965, *** |t| > 2.580.

〈Figure 3〉 Path Coefficients of the Research Model

〈Table 4〉 Summary of Hypothesis Testing

Hypothesis	Path			Coef.	SD	t-value	Result
H1	Personalization	→	Perceived knowledge acquisition	0.403	0.121	3.340	Supported
H2	Personalization	→	Perceived enjoyment	0.555	0.165	3.355	Supported
H3	Accessibility	→	Perceived knowledge acquisition	0.218	0.103	2.112	Supported
H4	Accessibility	→	Perceived enjoyment	-0.197	0.136	1.451	Not supported
H5	Representation richness	→	Perceived knowledge acquisition	0.349	0.092	3.804	Supported
H6	Representation richness	→	Perceived enjoyment	0.443	0.146	3.033	Supported
H7	Perceived knowledge acquisition	→	Energy conservation behavior	0.520	0.093	5.567	Supported
H8	Perceived knowledge acquisition	→	Average usage time	-0.003	0.109	0.028	Not supported
H9	Perceived enjoyment	→	Energy conservation behavior	0.391	0.093	4.189	Supported
H10	Perceived enjoyment	→	Average usage time	0.300	0.095	3.168	Supported

An analysis of the relationships between dependent variables revealed that users' energy saving knowledge acquisition influenced their energy saving behavior ($\beta = 0.520$, $p < 0.01$), thereby supporting hypothesis 7. However, users' energy saving knowledge acquisition had no influence on the average usage time of the energy diet application. Therefore, hypothesis 8 was not supported. Additionally, users' perceived enjoyment influenced both their energy saving behavior and the average usage time of the energy diet application ($\beta = 0.391$, $p < 0.01$; $\beta = 0.300$, $p < 0.01$). Therefore, hypotheses 9 and 10 were supported.

Ⅵ. Discussion

6.1 Main Findings

The results of this study suggested causality between the design characteristics of public service-oriented mobile applications and changes in user attitude and behavior based on the intervention strategies for saving energy. The study model was verified through a survey. The main findings are as follows.

First, the results of our study revealed that the design aspect of mobile applications has an effect on individual behavior change. This is in accord with existing research, which indicated that design-related aspects such as the user interface, input mechanism, and aesthetics all affect individual performance. For example, design aesthetics which refers to the objective design aspects of a product have a significant influence on user behavior (Sonderegger and Sauer, 2010). Settapat *et al.* (2011) also found that the design elements of 3D input have an effect on users' learning behavior. In this study, new design characteristics of mobile applications were defined related to the information architecture of mobile applications and an influential relationship between these characteristics and user performance was identified.

To be more specific, the personalization of mobile

applications influenced users' perceived knowledge acquisition. Users acquired more energy saving knowledge when the information provided through the energy diet application was more customized to their individual needs and circumstances. This result is similar to that in previous research indicating that personalization in the mobile environment is a distinctive attribute that gains the attention of users (Xu, 2006), which has a positive effect on users' knowledge acquisition because relevant information may be delivered more effectively and efficiently (Jacucci *et al*., 2009). In addition, the degree of personalization of information provided by mobile applications influenced users' perceived enjoyment. This result is similar to that in previous research, where users valued concise, personalized information (Katterbach, 2002). The accessibility of information provided by mobile applications also influenced users' perceived knowledge acquisition. Users acquired more energy saving knowledge when they could access the relevant information provided through the energy diet application easily and quickly. This research finding is similar to the result of Midden *et al.* (2007), who found that providing easily accessible information directly increased awareness of environmental problems related to energy saving, effectively stimulated users' environmental awareness, and enhanced their knowledge. However, the degree of accessibility of information had no significant influence on users' perceived enjoyment. A positive relation between information accessibility and perceived enjoyment is evident primarily in hedonic information systems (Van der Heijden, 2004). Although public organizations developed and distributed the energy diet application to increase awareness and spark interest, users may not have recognized it as a hedonic information system because the information about energy saving is relatively educational and instructive rather than entertaining. The hypothesis therefore may not have been supported because users thought of the energy diet application as a utilitarian rather than a hedonic information system. In the analysis of representation richness, a strong influence on users' perceived knowledge acquisition was found. Several other studies have investigated representation richness in campaigns aimed at energy saving. For example, Midden *et al*. (2007) determined that information visualized through sound or images such as video clips increased users' awareness about the environment. In addition, representation richness in mobile applications also influenced users' perceived enjoyment. Users reported that they enjoyed receiving the energy saving information in various forms offered by the energy diet application. This supports the findings of previous researchers that users enjoy interactive and sensory experiences when receiving information via images, graphics, videos, or other interactive functions (Magrath and McCormick, 2013).

Second, affective and cognitive factors had a combined effect on user performance in this study in various contexts. In other studies, Kim (2007) found that shopping outcomes and service use were both influenced by affective and cognitive factors in online and mobile contexts, respectively. In this study, knowledge acquisition was examined as a cognitive factor, and enjoyment was examined as an affective factor. These two factors had a conjoint effect on user performance.

Users' acquisition of knowledge about energy saving influenced their energy saving behavior. However, no association was found between knowledge acquisition and average usage time of the energy diet application. That is because users' affective reactions to products or services is much more influential for in enhancing commitment which is strongly related to users' usage amount (Park and Kim, 2006). Additionally, users' perceived enjoyment influenced both their energy saving behavior and the average amount of time that they used the energy diet application.

Third, use of mobile applications contributed to energy saving knowledge. In previous energy saving studies, several intervention strategies and their effects on users' behavior have been studied. Regarding the introduction of new technologies, many studies have evaluated the effect of introducing energy saving technologies or mobile devices with feedback about energy consumption (Midden *et al*., 2007; Hondo and Baba, 2010). The results of this study also showed that providing information about energy saving through mobile applications may have a positive effect on users' energy saving behavior.

6.2 Theoretical Implications

The main contribution of this study is its empirical investigation of eco-friendly behavior, which is a very meaningful and timely topic for academic and business purposes. Social responsibility and sustainability are very important in today's world. Prior research focuses on personal traits, such as self-enhancement (Urien and Kilboume, 2011), environmental concerns (Royne *et al*., 2011), positive attitudes toward eco-friendly lifestyles (Pirani and Secondi, 2010), socioeconomic characteristics such as gender and age (Han *et al*., 2009), and cultural differences (Chan and Lau, 2002) as determinants of eco-friendly intentions or environmentally responsible consumption behaviors. They overlooked the roles of mobile applications as mediating devices with the power to change user attitudes and promote environmentally responsible consumption behaviors. Hence, to the best of the authors' knowledge, this study is the first to investigate the design factors of mobile applications empirically.

A design science approach was successfully incorporated into the research model of mobile application success in this study. To identify the impacts of the design characteristics of a public service-oriented mobile application, we defined three design characteristics: personalization, accessibility, and representation richness, based on a mobile information architecture. This choice was based on the fact that public service-oriented mobile applications with information about energy saving are mainly intended as a form of communication. The results showed that the design characteristics influenced individual performance by changing cognitive and affective factors. The cognitive model was extended by the addition of a new path to determine how mobile applications affect consumers and help them to save energy. The results showed that the affective factor examined in this study, perceived enjoyment, significantly affected energy saving outcomes.

This study suggests that a change of direction is necessary in energy saving research toward the contribution of information technologies. Prior energy saving studies about information technologies generally focused on the performance and functions of these technologies and how they support intervention strategies, investigating correlations between technological characteristics and effectiveness of the intervention. However, in this study, the design characteristics of mobile applications were influential in actually inducing behavior change in terms of energy saving. Design characteristics such as personalization, accessibility, and representation richness, which are features of the energy diet mobile application, influenced the intervention strategies, as evaluated on the basis of users' behavior. Therefore, in energy saving research, the quality of information technologies should be improved in order to increase the effectiveness of intervention strategies and to enhance knowledge acquisition and enjoyment of users.

Lastly, the design characteristics of mobile applications used in this study were important in changing users' attitudes or behavior in other studies of mobile systems. However, not all of these factors influenced

users' attitudes and behavior in the current study. For example, the accessibility of information had no significant effect on user satisfaction. This discrepancy between results may have been caused by the fact that most existing studies on the design characteristics of mobile applications were carried out in the context of commerce-related mobile applications (Andreou *et al*., 2002; Lee and Benbasat, 2003; Cyr *et al*., 2006; Magrath and McCormick, 2013). Therefore, to induce changes in users' energy saving behavior effectively, new design characteristics specific to public service-oriented mobile applications should be developed.

6.3 Practical Implications

The findings of this study should encourage public institutions to engage in development of new IT solutions, including mobile applications, to enhance the enactment of public policy. A theoretical model was presented on the design elements of mobile applications and the ripple effects of energy intervention strategies through a review of literature from diverse fields such as mobile systems, energy policy, and system design. Thus, the results may be applicable in a variety of fields. In addition, user performance was measured to determine the effects of a public service-oriented mobile application on energy saving behavior from the public stance. Average usage time was used as a variable to represent the situation from the stance of information technology. Thus, a more extensive method was utilized to analyze the effect of policy communication.

Furthermore, the results suggest that both cognitive and affective factors contribute to increase average usage time, which is one of the crucial attractions of mobile applications from a business perspective. This clearly encourages private companies to build up and maintain public mobile applications. In other words, public mobile applications can be attractive to companies interested in developing private applications if those applications are sufficiently well designed to foster perceived enjoyment. This is an important implication for developers who may focus only on the public value of mobile applications and disregard their hedonic aspects.

Practitioners in public institutions are advised to be careful when developing public communication strategies via digital communication channels such as smart phones with mobile applications. Today's smart phone users are exposed to numerous applications of various kinds. Selection of certain applications and measurement of continued use sufficient to determine the intended effect of the application is not easy. In the case of energy saving behavior, users may be required to accept some inconvenience or to sacrifice currently enjoyed comforts (Ibtissem, 2010). In addition, ensuring users' accurate response in terms of how they use the application is also difficult. Public organizations should develop content and services useful to mobile systems based on the deeper understanding about the characteristics of mobile applications provided in this study. Moreover, public service providers tend to ignore the impact of affective factors related to mobile applications, although these factors may influence use of mobile applications and hence the acceptance of public policy on energy consumption. Thus, public organizations should consider elements of enjoyment or interest when developing and distributing mobile applications for public purposes. Better information must be provided, of course, but the elements of enjoyment and interest are also important.

In addition, project managers should not simply convert information provided in existing e-mails or guide books into mobile applications. Instead, they must consider carefully how such information may be provided to respective users in a customized form

and how they can make good use of multimedia functions such as sound, images, and videos in addition to text to provide information.

6.4 Limitations and Future Research

Our study had several limitations. First, studies based on self-reported behavior may have problems related to reliability. Some researchers have argued that the correlation between self-reported and actual behavior of users is low (Corral-Verdugo, 1997; Steg and Vlek, 2009). Nevertheless, because measurement of users' actual behavior is not always possible, a self-report survey was used in this study.

Using Korean participants only was inevitable just because the application was written in Korean. This might cause a concern of generality. Therefore, researchers and practitioners must be careful to interpret the results of the experiment. To resolve the problem which results from biased sample, future research could consider propensity score method. Furthermore, the findings of this study must be carefully interpreted to generalize them to other public service domains. Although many public service-oriented mobile applications are available, and their usage is increasing, use of mobile applications is strongly influenced by culture (Urbaczewsk *et al*., 2002). Thus, the results of this study should not be generalized universally because they refer only to domestic public service-oriented mobile applications. In the future, the current model may be complemented by similar studies conducted in other countries.

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Public Service-Oriented Mobile Applications in Facilitating Changes in Human Behavior: The Effects of Design Factors

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Abstract

Due to the dramatic increase in usage of smart phones, mobile applications offer a promising public communication channel to effect behavioral change in areas such as energy saving. For this, identifying relationships between applications and behavioral change would be useful for public institutions to formulate more effective public communication strategies. Based on a design science approach, this study examines the effect of design factors of public service-oriented mobile applications such as personalization, accessibility, and representation richness on users' cognitive and affective attitudes. Their effects on behavioral outcome are also investigated. The results of the analysis show that most design factors contribute significantly to the cognitive and affective attitudes of users. In turn, cognitive attitudes affect users' behavioral change in terms of energy saving, while affective attitudes are positively associated with the average usage time of mobile applications and behavioral changes in terms of energy saving.

Keywords: Public Service-Oriented Mobile Application, Design Science, Energy Conservation, Mobile Communication

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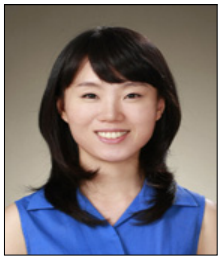
현재 국제개발협력 전문 컨설팅 기관인 GDC 컨설팅의 선임연구원으로 활동하고 있다. 이화여자대학교 경영학과에서 석사, 경희대학교 경영학과에서 박사 학위를 취득하였다. 석사학위 취득 후 4년 간은 금융권과 IT컨설팅 분야에서 IT컨설턴트로 활동하였으며, 지금은 한국국제협력단, 교육부 등의 국제개발 사업에 컨설턴트로 참여하고 있다. 관심 연구분야는 국제개발협력, 정보기술기반 사용자 행태 변화, 사용자 행태 빅데이터 정보 분석 등이다.



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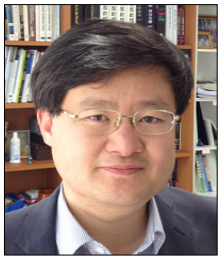
한동대학교 경영경제학 학사, 이화여자대학교 경영학 석사 학위를 취득하였고, 경희대학교에서 MIS 전공으로 경영학박사 과정을 수료하였다. 신한은행 마케팅부, SAS Korea 컨설팅부, 농협 여신부 등에서 CRM 분석 모델, 금융 리스크 관리 모델, 기업신용평가 예측 모델 등 다양한 경영분석 실무 분야의 데이터 애널리틱스 전문가로서 근무한 바 있다. 최근 한국전자거래학회지에 논문을 발표하였으며, 저역서로 “빅데이터 비즈니스 성공 지도,” “데이터 통신과 네트워크 원론,” “B2B 브랜드 마케팅,” “기업은 왜 사회적 책임에 주목하는가” 등이 있다.



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서울대학교 경영대학에서 학사, 한국과학기술원 경영과학과에서 공학 석사, 박사학위를 취득하였다. 한동대학교 경영경제학부 부교수에서 근무한 바 있으며, 현재 경희대학교 경영대학에서 교수로 재직 중인 그는 유비쿼터스 컴퓨팅, 소셜미디어, 데이터분석 등을 주제로 연구해 왔으며 Carnegie Mellon University 방문과학자, San Diego State University 겸임교수로서 국제공동연구도 진행하였다. Journal of Management Information System, International Journal of Information Management, Decision Support Systems 등 국제학술지에 논문을 발표해왔다.

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