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The Effects of Mental Model on the Variables in the Technology Acceptance Model

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Abstract

Since Smartphones emerged in the market around 2000, the smartphone market has expanded exponentially. Although they are very versatile, smartphones have less overall capabilities in general than their PC counterparts, which make applications difficult to have a usable interface. A usable user interface is critical to any application and plays an important role when users create the mental model of an application. A comprehensive IS literature review found that little empirical research on the mental model of smartphone users has been documented. Specifically, there has been little understanding and evidence about the impact of the mental model of users on their behavioral beliefs and attitude in a smartphone application context. Thus, the main research goals of this study are; 1) to suggest a theoretical model integrating mental model as an antecedent of two user behavioral beliefs and attitude in the Technology Acceptance Model (TAM) and 2) to empirically validate the new model by examining the relationships among the variables in the model. A survey was conducted to collect data. Structural Equation Modeling (SEM) was employed to analyze the data. The results showed that there is an indirect effect of the mental model of users on the intention to use smartphone applications through the variables, perceived usefulness, perceived ease of use, and attitude.

Keywords: *Smartphone, application, mental, model, behavioral, beliefs, attitude, intention, use, TAM*

1. Introduction

Smartphones emerged in the market around 2000. When they were rolled out, they were regarded as supplements to computers [5, 15]. However, it is not too much say that today they are almost portable multimedia computers necessary in our daily lives. After Apple launched the iPhone in 2007, the smartphone market has expanded exponentially. According to a survey by ComScore, 82.2 million people in the U.S. owned smartphones by July 2011 [6]. The rapid penetration rate of smartphone facilitated a wider use of smartphone applications [34]. Application developers have constantly introduced new applications. Now, hundreds of thousands of smartphones are waiting out there to be selected. Smartphone applications can be used in many useful ways for our lives. They can be used to make phone calls, exchange text messages, search the Internet, take photos, listen to music, watch TV and videos, play games, even purchase products and services online, and so on [6, 23, 26].

Although they are very versatile, smartphones still have less overall capabilities in general than their PC counterparts. Especially, smartphones have small display screens and low resolutions compared to PCs. These hardware limitations make applications

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difficult to have a usable interface. If the user interface of an application is less usable, then users may think that the applications are not useful, nor easy to use.

A usable user interface is critical to any application [28, 29]. According to Lauesen [18], users can see, hear, and feel information systems through user interface. Similarly, Moran [21] explained that users use everything in user interface to contact systems – physically, perceptually, and conceptually. Based upon these views, it can be inferred that while users experience systems through user interface, they generate their mental model of the systems. That means, the mental model of systems that users create could be consistent with the user interface of systems.

According to Rouse and Morris [27], a mental model can be defined as a cognitive structure comprised of specific knowledge. Similarly, Johnson-Laird [14] saw it as a kind of internal representation of complicating external reality. Thus, a mental model can be much simpler than the entity it represents. Rouse and Morris [27] also said that people understand and predict their surround world with their mental models. These views imply that smartphone users are also able to not only understand, but also use their applications based upon their mental model of the applications, which is created based on the user interface of the applications. Furthermore, the views also imply that if the user interface of applications is well designed, then the users can easily generate high quality of mental model of the applications.

If the mental model of an application is formed precisely, that is, consistent with the actual ways of using the application, then it could make users to be better able to understand the usage of the application. Consequently, users can perceive the usefulness and ease of use of the application, leading to positive attitude toward using the application and intention to use the application. Meanwhile, the poorly developed mental model of an application makes users confused, which leads to the reluctance of using the application. If users do not use, then they cannot perceive behavioral beliefs, perceived usefulness and ease of use.

Over the past decade, TAM introduced by Davis [8] has been applied to understand the attitude IT users holds about the use of a variety of technologies, which is used to predict the adoption of numerous technologies [19, 32]. Three constructs in TAM, perceived usefulness, perceived ease of use, and attitude toward using the system, explain a user's intention to adopt a new technology. Perceived usefulness and ease of use are behavioral beliefs impacting on attitude which influences intention to use [9]. Nielsen [22] also suggested that with other systems attributes, such as cost, compatibility, and reliability, usefulness leads to practical acceptability of a system. Researchers have validated and extended this model by not only providing a number of empirical tests and model variants, but testing in various information technology contexts. The factors and external variables introduced from related models and literature are demographic characteristics, personality traits, subjective norm, system and service quality, online shopping experience, trust, security, risk, emotions, and so on [1, 4, 7, 10, 12, 16, 17, 20, 25, 30, 31, 33, 35, 36].

Based on these views, it seems possible to infer that the mental model of applications smartphone users hold has an impact on the variables in the TAM including user behavioral beliefs, attitude, and intention to use applications. A comprehensive IS literature review, however found that little empirical research on the mental model of smartphone users has been documented. More specifically, there has been little understanding and evidence about the impact of the mental model of users on their behavioral beliefs, attitude, and intention to use in a smartphone application context. Thus, the main research goals of this study are; 1) to suggest a theoretical model integrating mental model as an antecedent of two user behavioral beliefs and attitude in the Technology Acceptance Model (TAM) and 2) to empirically validate the new model by examining the relationships among the variables in the model. Hypotheses are proposed based on the discussion and the literature review above and the proposed research model is depicted in Figure 1 below.

H1: The mental model of applications that smartphone users hold positively affects perceived usefulness.

H2: The mental model of applications that smartphone users hold positively affects perceived ease of use.

H3: Perceived usefulness positively affects smartphone users' behavioural attitude toward using applications.

H4: Perceived ease of use positively affects smartphone users' behavioural attitude toward using applications.

H5: Smartphone users' behavioural attitude toward using applications positively affects their intention to use the applications.

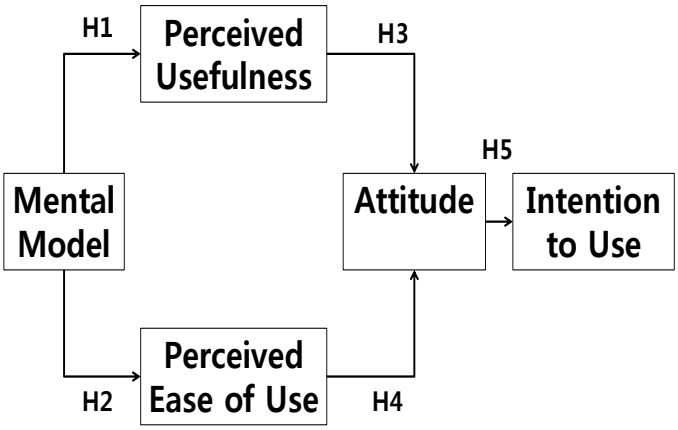

Figure 1. Proposed Research Model

2. Data Analysis and Results

The research aim of this study is to examine the effect of the mental model of smartphone users on their intention to use applications through the variables in the TAM, perceived usefulness, perceived ease of use, and attitude. A survey was conducted to collect data and a total of 236 students and practitioners participated in the survey (see Table 1). Of the respondents, 66.9% were undergraduates and 33.1% were practitioners. Fifty point four percent were male. Eighty point one percent were in their twenties. The students volunteered for the survey were majoring in various academic programs including business administration, economics, and computer science at three universities in Korea.

Table 1. Participant Characteristics

	Characteristics	Frequency	Percent
Gender	Males	119	50.4
	Females	117	49.6
Age	20-29	189	80.1
	30-39	35	14.8
	40 Above	12	5.1
Job	Students	158	66.9
	Practitioners	78	33.1

Since Structural Equation Modeling (SEM) is a traditional approach for analyzing multivariate models, this study employed it with AMOS ver. 18 to test the proposed research model. First of all, the reliability of individual measurement items was examined to test the measurement model. To do so, the loadings of the measurement items on their respective constructs were checked. The loadings should be above 0.6 or ideally, 0.7 [2, 3]. All of the loadings for the measurement items in the model were greater than the recommended level of 0.6, suggesting adequate reliability (see Table 2).

Table 2. Standardized Regression Weights of Observable Variables

Latent Variables	Questions	Est.	Var. C.R.
Mental Model	The way to use the application that I used recently was predictable enough.	.873	7.985
	The application that I used recently worked in the same way as I predicted.	.929	5.471
	The application that I used recently worked in the same way that I know.	.856	8.446
Perceived Usefulness	The application that I used recently helped me achieve my personal goals easily.	.766	8.207
	The application that I used recently was the most efficient way to achieve my personal goals.	.759	8.319
	I think that the application that I used recently was beneficial to me in general.	.801	7.515
Perceived Ease of Use	The way of using the application that I used recently was simple enough.	.918	6.390
	The way of using the application that I used recently was easy enough to understand.	.867	8.308
	The functions in the application that I used recently were easy to use.	.839	8.873
	I think that the application that I used recently was easy to use in general.	.820	9.149
Attitude	Using the application that I used recently was a pleasant experience in general.	.890	7.464
	My attitude toward using the application that I used recently was positive in general.	.898	7.150
	I prefer using the application that I used recently.	.868	8.140
Intention to Use	I have an intention to use the application again in the near future.	.927	4.845
	I will use the application again whenever the chances are given.	.859	7.805
	I will use the application again to complete my specific tasks.	.817	8.798

Next, in order to assess the convergent validity of the constructs in the model, two measurements, composite reliability (CR) and average variance extracted (AVE) of latent variables were examined. Because AMOS ver. 18 does not provide the values of the measurements, they were calculated manually. Two formulas suggested by Fornell and Larcker [11] and Hair *et al*. [13] were used.

$$CR = (\sum \text{Standardized Regression Weights})^2 / ((\sum \text{Standardized Regression Weights})^2 + (\sum \text{Variance})) \quad [11]$$

$$AVE = (\sum \text{Standardized Regression Weights}^2) / N \quad [13]$$

The results found that all constructs had the estimates of CR greater that the recommended tolerance of 0.7. In addition, the results also showed that the values of AVE for all constructs exceeded the recommended cutoff 0.5 (see Table 3). Therefore, these results demonstrated convergent validity was satisfactory.

Table 3. Composit Reliability (CR) and Average Variance Extracted (AVE)

Constructs	C.R.	AVE
Mental Model	.948	.787
Perceived Usefulness	.830	.603
Perceived Ease of Use	.947	.740
Attitude	.936	.783
Intention to Use	.928	.757

After that, the square root of the AVE of any latent variable was compared with the correlation between the particular latent variable and other variables in order to examine the discriminant validity of the constructs in the model. The results showed that the square roots of the AVEs are higher than the construct correlations (see Table 4). These test results exhibit good disrciminant validity.

Table 4. Correlation Coefficient Value between Constructs and AVE

Constructs	AVE	ø²	ø²	ø²	ø²	ø²
Mental Model	.787	.236	.251	.474	.355	1.000
Perceived Usefulness	.603	.499	.540	.473	1.000	
Perceived Ease of Use	.740	.303	.267	1.000		
Attitude	.783	.489	1.000			
Intention to Use	.757	1.000				

Following that, the goodness of fit for the model was checked using the x^2/df, GFI, AGFI, NFI, TLI, CFI, and RMSEA. The statistics are as follow: x^2/df = 2.984, GFI = .865, AGFI = .815, NFI = .908, TLI = .923, CFI = .936, and RMSEA = .092. The overall fit statistics suggested the hypothesized model has a fairly good fit.

Finally, the structural model was analyzed to examine the significance and strength of relationships hypothesized. The results showed that mental model positively influenced perceived usefulness ($\beta = .650$; $p < 0.001$) and perceived ease of use ($\beta = .793$; $p < 0.001$), which support H1 and H2 (see Table 5). Perceived usefulness ($\beta = .719$; $p < 0.001$) and ease of use ($\beta = .124$; $p < 0.05$) also positively influenced attitude respectively, supporting H3 and H4. In addition, attitude positively affected intention to use ($\beta = .792$; $p < 0.001$), supporting H5. The structural model results are presented in Figure 2.

Table 5. Hypothesis Test

	Paths	Coefficient	Standardized Coefficient	S.E.	C.R.	P	Results
H1	Mental Model -> Perceived Usefulness	.650	.621	.078	8.335	***	Accept
H2	Mental Model -> Perceived Ease of Use	.793	.707	.069	11.443	***	Accept
H3	Perceived Usefulness -> Attitude	.719	.695	.081	8.856	***	Accept
H4	Perceived Ease of Use -> Attitude	.124	.129	.059	2.116	.034	Accept
H5	Attitude -> Intention to Use	.792	.726	.065	12.208	***	Accept
R^2 for Intention to Use: .527							

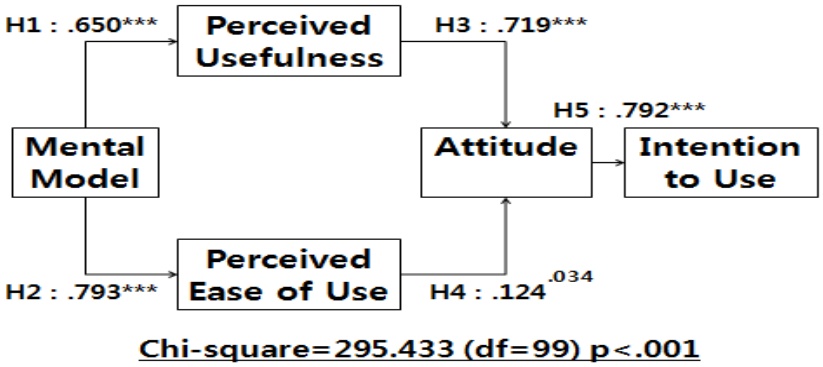

Figure 2. Structural Model Results

3. Discussion

Little empirical evidence and understanding of the effects of the mental model of smartphone users on their behavioral beliefs, attitude, and intention to use applications has been documented in IS literature. Thus, this study empirically examined the relationships between the mental model of users and the variables in the Technology Acceptance Model including perceived usefulness and ease of use, attitude, and intention to use. The results showed strongly significant effects of the mental model of users on their behavioral beliefs, perceived usefulness and ease of use. This means that if the mental model of users complies with the actual ways of using the applications, then the users can perceive that the applications are not only useful, but also easy to use.

Furthermore, this study found that there were significant effects of these two beliefs on users' attitude toward using applications. There was also a significant effect of users' attitude to their intention to use the applications. These results mean that once usefulness and ease of use are perceived, then the users show positive attitude toward using applications, which in turn lead to intention to use the applications. Therefore, the findings of this study mean that the mental model of applications that users hold plays a critical role for user IT adoption in a smartphone context.

This study contributes to the IS literature by providing empirical evidence to validate and extend the Technology Acceptance Model [8, 9] in a smartphone context. According to a comprehensive IS literature review, there are few academic empirical studies on the effect of mental model especially in a smartphone application context. The analyses of

this study showed that the mental model of users as an antecedent of two user beliefs, perceived usefulness and ease of use, affected their behavioral attitude and intention to use applications. These results not only confirm and extend the Technology Acceptance Model, but also can be used to predict user IT acceptance in a smartphone application context.

In addition, the findings of this study suggest that the mental model of users is an important consideration in the design of user interface of smartphone applications. By understanding the effects of the mental model of users on their behavioral beliefs, attitude, and intention to use, the best strategy to attract prospective users can be established. Application designers and developers can develop effective user interface which can help users generate their mental model easily and precisely. Thus, the findings of this study are worthwhile to pay attention for the practitioners in the fields of user interface design and human-computer interaction.

Even though this study found a number of findings which is useful for improving our understanding of the effects of mental model on users' behavioral beliefs and attitude in a smartphone application context, it is subject to the limitations of empirical research. For example, data was collected from a sample of 235 participants and about 67 percent of them were undergraduate students in their twenties. Furthermore, the smartphone applications that the participants used for the survey were not diverse. The influence of all these extraneous variances was not handled properly. Therefore, the findings might not generalize to a broad population. Single empirical study may not be enough to validate the findings. Follow-up research should address the limitations.

4. Conclusion

This study empirically examined the relationships between the mental model of users and the variables in the Technology Acceptance Model. The results showed strongly significant effects of the mental model of users on their behavioral beliefs, attitude, and intention to use. This means that if the mental model of users complies with the actual ways of using the applications, then the users perceive that the applications are not only useful, but also easy to use. In addition, once users perceive usefulness and ease of use, then they will show positive attitude toward using applications, which in turn lead to the intention to use the applications. In sum, the findings of this study mean that the mental model that users hold plays a critical role for user IT adoption in a smartphone application context. This study contributes to the IS literature by providing empirical evidence to validate and extend the Technology Acceptance Model in a smartphone context.

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