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Understanding the behavior of mobile data services consumers

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Abstract Due to rapid advances in the Internet and wireless technologies, a ubiquitous computing world is becoming a reality in the form of mobile computing. At the center of this phenomenon is mobile data services which arise from the convergence of advanced mobile communication technologies with data services. Despite the rapid growth in mobile data services, research into consumers' usage behavior is scarce. This study attempts to identify and empirically assess the factors that drive consumers' acceptance of mobile data services. A research model based on the decomposed theory of planned behavior and incorporating factors that represent personal needs and motivations in using mobile data services is presented. The model is tested via an online survey of 811 consumers of four categories of mobile data services (i.e., communications, information content, entertainment, and commercial transactions) associated with different usage contexts. We found that attitude, social influence, media influence, perceived mobility, and perceived monetary value influence consumers' intention to continue usage of mobile data services. In addition, perceived ease of use, perceived usefulness, and perceived enjoyment influence attitude toward continued usage of mobile data services. Finally, separate analysis of the different categories of mobile data services highlights the influence of individual usage context on consumers' behavior.

Keywords Consumer behavior · Mobile data services · Mobile phones · Decomposed theory of planned behavior · Technology acceptance · Online survey

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1 Introduction

> *The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it* (Weiser 1991).

Weiser (1991) has predicted that technology will become ubiquitous such that society will take new technology for granted as being inseparable from everyday life. In such an environment, individuals can enjoy abundant computing and communications capabilities and services based on diverse sets of information in a transparent, integrated, convenient, and adaptive manner (Kleinrock 2001). Thanks to rapid advances in the Internet and wireless technologies, this prediction is becoming a reality in the form of mobile computing where communications and computer networks are embedded in daily experience such that individuals can interact with various digital services anytime and anywhere.

At the center of the mobile computing phenomenon is a new array of mobile data services. Mobile data services

refer to the convergence of mobile communication technologies with information and data communication services (ITU 2002). In this study, mobile data services are defined as an assortment of data communication services that can be accessed using a mobile phone over a wide geographic area via mobile telephone networks. Some of the mobile data services that consumers can enjoy include exchanging short text messages, e-mails, and photographs; checking stock market information; booking movie tickets; and playing mobile games. These services have received an enthusiastic response in countries with high mobile phone penetration rates, such as South Korea, Japan, Hong Kong, and the Scandinavian countries.

The main focus of prior research on mobile data service has been on the technical issues of hardware/software development (Imielinski and Badrinath 1994) and the potential business applications (Varshney and Vetter 2001). Despite the rapid growth in mobile data services and their significance in contributing to the development of a ubiquitous computing society, scant academic research is available on consumers' acceptance of mobile data services. An important research question is: What are the factors that drive the use of mobile data services? A perennial objective of technology adoption research is to provide product developers and marketers with insights into why a new technology is not widely accepted by consumers and advice on where their efforts should be focused to increase usage of the technology (Davis et al. 1989). Thus, identifying the factors that drive the usage behavior of consumers will shed light on what can be done to meet consumers' needs, and ultimately make mobile data services a successful innovation. Further, in view of the astronomical investment in billions of US dollars by the telecommunications industry to build the technical infrastructure and to acquire licenses for the third generation (3G) mobile data services, understanding the usage intention of mobile data services consumers is critical for the survival of the whole mobile telecommunications industry.

Unfortunately, there is little research that attempts to understand the perceived value of mobile data services and how the value impacts consumers' adoption and usage decisions (Pedersen et al. 2002). One notable exception is Hong and Tam's (2006) study which examined the factors that drive potential consumers' intention to adopt mobile data services. While their study has contributed to understanding the adoption behavior of potential consumers, there is still a need for studies of the usage intention of existing consumers in order to develop a more complete understanding of the behavior of mobile data services consumers. In view of the rapid progress of mobile data services in many developed countries, this study focuses on the usage intention of existing consumers. For example, the penetration rates of such services in countries like Hong Kong and South Korea are very high (ITU 2006). Given the maturity of the market, understanding the behavior of existing consumers will be more relevant than that of potential consumers. For many business-to-consumer e-commerce firms, the continued usage decision or consumer retention is much more critical than the pre-adoption decision for the long-term profitability of these firms (Bhattacherjee 2001; Reichheld and Schefter 2000). From this perspective, identifying the factors that influence existing customers' sustained usage is important for the long-term viability of the telecommunications operators and content developers of mobile data services. Theoretically, post-adoption perceptions are more salient than pre-adoption perceptions in determining the ultimate success of an information technology innovation (Bhattacherjee 2001). Karahanna et al. (1999) also found that the antecedents of continued information technology usage can be quite different from the antecedents of initial adoption. Thus, the current study focuses on existing consumers because they have more vivid perceptions about various dimensions of mobile data services from their direct usage experiences.

This study represents an effort to understand consumers' acceptance of this new type of technology—mobile data services; more specifically, to identify and empirically assess the factors that drive consumers' intention to continue usage of mobile data services by drawing on the decomposed theory of planned behavior as the theoretical lens. As these services penetrate all aspects of consumer life, the ways that consumers use them and the reasons behind the usage will vary depending on the many different contexts of daily life. For example, some consumers may use mobile data services for communication activities, such as short message service (SMS) and multimedia message service (MMS), while others focus on fun activities, such as games, ring-tones and music downloads. Consumers can also choose different services depending on everyday life situations. In addressing such complex and context-adaptive interactions between consumers and mobile data services, this study echoes Benbasat and Zmud's (2003) perspective that the technology artifact—the unique and specific characteristics and usage contexts of the technology being studied—should play a central role in technology adoption and usage research to better understand the complex relationships between the technology and the contexts in which it is used. Examining the interactions between a specific technology innovation and consumers through incorporation of its particular usage purposes as well as distinct capabilities and features is necessary, as no single conceptual snapshot of technology can capture all usage contexts (Orlikowski and Iacono 2001). In line with this reasoning, the research model in this study takes the unique aspects of mobile data services into account.

Further, considering the context-specificity of mobile data services, this study concentrates on the factors affecting consumers' perceptions and continued usage intention in personal settings, where mobile data services are used for personal purposes. Examining the factors that drive consumers' continued usage intention in personal settings is an appropriate starting point to understand consumers' behavior in the mobile communications industry, as the consumer market for personal use rather than the corporate market is the driving force of rapid industry growth (The Economist 2001).

2 Mobile data services

In general, mobile data services can be classified into four categories: communications services, information content services, entertainment services, and commercial transaction services (ITU 2002; Sadeh 2002). Mobile communications services, which are currently the most widely used form of mobile data services, include SMS, MMS, e-mails, and mobile chatting (ITU 2002). On the other hand, entertainment services are rapidly becoming popular among consumers (ITU 2002). Examples of mobile entertainment services include ring-tones, digital characters, horoscope, mobile gaming, mobile video, mobile music, etc. Information content services deliver information content, such as news headlines, weather news, sports news, maps, location-based information, traffic information, etc. Finally, commercial transaction services enable consumers to purchase movie/concert tickets, conduct financial transactions (e.g., buying and selling stocks, transferring funds between bank accounts, paying bills), and shop for goods and services (Sadeh 2002).

Conceptually, mobile data services may be more than an extension of the wired Internet due to unique features that differentiate them from their wired counterparts (Dholakia and Dholakia 2004; Kannan et al. 2001). The unique features include mobility, wide scope of usage, being personal, and usage costs. In turn, these unique features will have an impact on the resulting mobile data services acceptance model, and may not coincide with existing technology acceptance models.

2.1 Mobility

First of all, mobile data services are unique because of their mobility. Consumers can access mobile data services anywhere, anytime. This implies that the extent to which mobile data services can maintain instant connectivity on the road is an important consideration for consumers. Indeed, previous technology innovation studies that tend to examine consumers' adoption of software packages (e.g., Microsoft Word, Windows operating system, Excel), training systems, Web sites, digital libraries, and others do not address the notion of mobility.

2.2 Wide scope of usage

Compared to many other information technology innovations, the scope of mobile data services is much more comprehensive. When combined with the mobility characteristic, mobile data services allow consumers to engage in various activities ranging from leisure (e.g., games and music download) to information acquisition (e.g., weather, news and stock market information) to communications (e.g., SMS and mobile chatting) and to conducting commercial transactions (e.g., booking movie tickets) in many different social contexts whenever or wherever needed. In addition, while the typical information technology innovations in prior research by design support only restricted use by a specific group of users within a particular organizational setting, mobile data services serve a wider audience catering to consumers with a variety of unique needs and expectations.

2.3 Being personal

Mobile data services are closely associated with the consumer. These services are delivered through mobile phones which are in the personal possession of consumers almost all the time. Consumers have exclusive access to their mobile phones, and they are unlikely to share their phones with others. Like other personal possessions and accessories, consumers use the phones in ways that suit their particular needs. For example, they will customize their mobile phones with entertaining icons, ring-tones, and interface preferences to access mobile data services. As such, the personal relationship between consumers and their mobile phones sets the adoption of mobile data services apart from the adoption of technology innovations studied in the past that are typically productivity tools for job-related functions.

2.4 Usage costs

Finally, the use of mobile data services incurs monetary costs, whereas many services received through the fixed-line Internet are free. The mechanism by which mobile data service providers charge their consumers at present is implemented over the wireless network. Consumers recognize that using mobile data services costs money and are prepared to pay a premium to do things anywhere and anytime (The Economist 2001). Prior information technology adoption research seldom acknowledges the impact of cost on consumers' behavior.

3 Development of the research model

While the academic literature advances a variety of theoretical perspectives to address individual usage of information technology, the focus of these perspectives is on performance-oriented technology innovations within organizational settings. In comparison, mobile data services can be used for many different purposes in the daily personal life of individual consumers. Thus, the direct application of prior perspectives developed for performance-oriented information technology innovations for workplaces to mobile data services usage contexts may not be appropriate, especially when the focus is on usage behavior in personal contexts, where mobile data services are used to fulfill consumers' personal needs.

In recognition of the potential limitation of prior information technology adoption perspectives, the current study identifies factors that are relevant to the usage behavior of mobile data services from different streams of literature, including psychology and consumer behavior, and combines these factors with an existing technology usage framework. Several previous studies of technology adoption/usage behavior have used this approach in enhancing the explanatory power of their models (e.g., Taylor and Todd 1995; Venkatesh and Brown 2001; Venkatesh and Morris 2000). Following the above approach, the current study uses the decomposed theory of planned behavior as the base framework to develop a research model for continued usage intention of mobile data services among existing consumers. Figure 1 presents our proposed model.

The decomposed theory of planned behavior is especially appropriate for the current study, as it has been used to study individuals' intention to use an information technology (Mathieson 1991) and can flexibly incorporate a large number of factors that may influence usage decisions; thus providing a more complete understanding of technology usage relative to other parsimonious models (Taylor and Todd 1995). This framework shares Benbasat and Zmud's (2003) view that emphasizes the role of specific technology artifacts by including additional factors relevant to the specific target behavior here, i.e., usage of mobile data services. Indeed, the decomposed theory of planned behavior can explain information technology usage behavior across a variety of settings (Mathieson 1991; Taylor and Todd 1995), including technology usage at homes, which is also a non-work setting like ours (Venkatesh and Brown 2001).

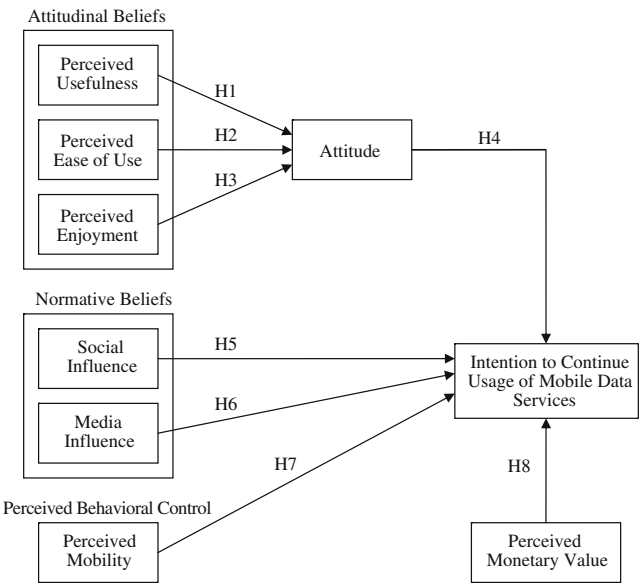

Fig. 1 Research model

The decomposed theory of planned behavior is rooted in Ajzen's (1991) theory of planned behavior, which explains human intention and behavior with three categories of belief—attitudinal belief toward target behavior, normative belief, and perceived behavioral control. The decomposed theory extends the original theory of planned behavior by decomposing each belief category (i.e., attitudinal belief, normative belief, and perceived behavioral control) into more specific belief constructs representing a variety of dimensions that are related to the target behavior. In the decomposed theory of planned behavior, the attitudinal belief category typically consists of behavioral beliefs based on the likely consequences of the behavior (Venkatesh and Brown 2001). These specific beliefs determine the attitude toward using a technology, which in turn affects usage intention. Similarly, the specific beliefs under the normative belief category and the perceived behavioral control category exert influences on usage intention. In the context of information technology adoption and usage, the decomposition can help designers and managers understand which specific factors should be manipulated to affect consumers' behavior (Mathieson 1991).

3.1 Attitudinal beliefs

The attitudinal belief category typically draws upon constructs from the innovation characteristics literature (Taylor and Todd 1995) and other adoption perspectives such as the technology acceptance model (Davis et al. 1989). A review of eight widely used adoption models finds that two factors have been consistently prominent in explaining consumer behavior in a variety of adoption models and studies: perceived usefulness and perceived ease of use (Venkatesh et al. 2003a). In the current study where consumers' usage contexts are personal, these two perceptions may affect consumers' attitude toward continued usage of mobile data services because they are instrumental in enhancing consumers' effectiveness or convenience in daily activities (Karahanna et al. 1999).

H1: *Perceived usefulness has a positive influence on consumers' attitude toward continued usage of mobile data services.*

H2: *Perceived ease of use has a positive influence on consumers' attitude toward continued usage of mobile data services.*

In addition, the model includes another perception about continuing to use mobile data services: perceived enjoyment. Perceived enjoyment is the extent to which the activity of using a certain technology is perceived as being enjoyable (Davis et al. 1992). Previous studies (Bruner and Kumar 2005; Davis et al. 1992) find that perceived enjoyment or fun is an important factor driving technology adoption. A recent study of mobile advertising via SMS also finds that consumers are more likely to accept the mobile advertising when the campaign is interesting (Trappey and Woodside 2005). These findings indicate that creating a fun and enjoyable situation may help to create favorable consumer perceptions conducive to the usage of innovative technologies, especially for personalized services like mobile data services. Those consumers who have experienced enjoyment from using mobile data services are more likely to develop positive attitude toward continued usage of such services.

H3: *Perceived enjoyment has a positive influence on consumers' attitude toward continued usage of mobile data services.*

As theorized in previous studies on the theory of planned behavior (Ajzen 1991, 2002), an individual having more positive attitude toward a behavior is more likely to develop an intention to carry out that behavior. Similarly, in the current study, consumers' attitude toward continued usage of mobile data services may positively affect their intention to continue using mobile data services. The attitude in this context is based on direct experience of consumers that enables them to evaluate mobile data services more clearly and confidently (Fazio and Zanna 1981). Hence, we hypothesize that:

H4: *Consumers' attitude has a positive influence on their intention to continue usage of mobile data services.*

3.2 Normative beliefs

Prior studies suggest the decomposition of the normative belief structure into relevant referent sources (Burnkrant and Page 1988; Taylor and Todd 1995), because of the possible divergence of opinions among the different referent sources. Referent sources range from individuals with whom the consumer has close relationships (e.g., peers, family members, superiors, colleagues) to popular mass media (e.g., newspapers, magazines, television, commercials). Of these referent sources, this study includes the people who are perceived to be important to the consumer (Fishbein and Ajzen 1975) and the mass media (Venkatesh and Brown 2001).

In this study, social influence refers to the perceived pressure from the people who the consumer thinks important. An extensive range of research in social psychology concerns this concept and the theory of planned behavior incorporates social influence as an independent predictor of behavioral intention. To be socially recognized in a group, others must perceive an individual as a member, meaning that the person should act in ways consistent with the group norms. Social influence from consumers' peers and superiors regarding technology use is an important antecedent of consumer behavior in information technology adoption contexts (Mathieson 1991; Taylor and Todd 1995; Venkatesh et al. 2003a). The phenomenal success of mobile services among youngsters in many countries is a case in point. Teenagers rush to subscribe to SMS in order to be connected to their peers, which is a necessary condition for obtaining membership in a group (Ling and Yttri 2001). Similarly, those who adopt the mobile data services du jour popular with group members can maintain and secure their group membership by continuing to use the services. Hence, consumers' intention to continue usage of mobile data services may increase in response to social influence.

H5: *Social influence has a positive influence on consumers' intention to continue usage of mobile data services.*

Mobile service providers commonly organize a variety of marketing promotion events for their services, especially when the market is at an early stage or is very competitive. In general, the mobile data service markets in most countries are either at an early stage or becoming very competitive with many players competing against each other (e.g., mobile network operators, mobile content providers and mobile virtual network operators). Industry players conduct their marketing campaigns through the mass media, such as television, radio, newspapers, and magazines. The consumer behavior literature recognizes the influence of such media as an important factor that affects consumer purchasing decisions (Campbell and Keller 2003; Moschis and Moore 1982). Prior technology adoption research with its primary focus on technology adoption among workers within a specific organization, does not examine such media influence on consumers' adoption decisions. However, Venkatesh and Brown's (2001) work on personal computer adoption decisions in households finds that information from secondary sources such as television news and newspapers (i.e., media influence) significantly affects consumer behavior. By the same token, the providers of mobile data services expend huge effort to

maintain their customer base through media campaigns, as the retention of existing customers is critical for long-term business profitability (Reichheld and Schefter 2000). Thus, media influence may positively affect consumers' intention to continue usage of mobile data services.

H6: *Media influence has a positive influence on consumers' intention to continue usage of mobile data services.*

3.3 Perceived behavioral control

The construct of perceived behavioral control attempts to deal with situations where a person may not have complete control over the behavior of interest due to the presence of obstacles (Ajzen 2002). The current study includes this notion of perceived behavioral control associated with an external constraint in the mobile data services environment (i.e., perceived mobility) in the research model for mobile data services adoption.

In principle, mobile data services enable a consumer to access information and maintain communication anywhere, anytime. However, such ubiquitous information access may not necessarily be guaranteed in reality, because the geographical coverage of mobile data services is not complete in every area. The technical difficulty in implementing universal roaming is another barrier to the ubiquitous availability of mobile data services (Islam and Fayad 2003). Thus, the extent of mobility across geographical regions is not under the control of consumers. Perceived mobility in this study is the extent to which mobile data services are perceived as being able to provide pervasive and timely connections. This factor may impede or facilitate usage of mobile data services. Ajzen (1991, 2002) theorizes that such a factor is likely to affect the formulation of behavioral intention. Prior information technology adoption research studies find that perceived behavioral control associated with external or environmental constraints exerts significant positive influence on usage intention (Mathieson 1991; Taylor and Todd 1995). We believe that the same reasoning applies to the continued usage context. Therefore, the current study hypothesizes that perceived mobility may have a positive relationship with consumers' intention to continue usage of mobile data services.

H7: *Perceived mobility has a positive influence on consumers' intention to continue usage of mobile data services.*

3.4 Perceived monetary value

In addition to the main constructs theorized in the decomposed theory of planned behavior, the proposed model incorporates a construct that may affect mobile data services' usage behavior—perceived monetary value. Similar to other goods and services in the market, the cost of using mobile data services (i.e., subscription fee and charge for usage) will be a very important consideration for consumers in deciding whether to use them or not. The marketing literature suggests that most consumers cognitively encode prices in ways meaningful to them such as expensive or cheap (e.g., Jacoby and Olson 1977). These subjective perceived prices can be both an indicator of the amount of sacrifice associated with the purchase of a product as well as an indicator of product quality (Monroe and Krishnan 1985). Consumer perception of monetary value of goods or services is a result of a mental accounting process of their perceptions of quality and sacrifice (Dodds et al. 1991; Suri et al. 2003). The perceived monetary value is positive when perceptions of quality are greater than perceptions of sacrifice (Monroe 1990). In turn, this perceived monetary value affects consumers' intention to use a product (Cronin et al. 2000; Dodds et al. 1991; Zeithaml 1988). In the continued usage context, such a mental accounting process for the perception of monetary value can be clearer through the direct experience with the services/products. Consistent with this perspective, greater perceived monetary value from use of mobile data services may increase the consumers' willingness to continue usage of mobile data services.

H8: *Perceived monetary value from the use of mobile data services has a positive influence on consumers' intention to continue usage of mobile data services.*

3.5 Distinction between service categories

The scope of mobile services can be very broad, even within the personal usage context. For example, some consumers mainly use mobile data services in the form of SMS for communicating with their friends; some prefer to use mobile data services to download news and stock quotations; others consider mobile data services to be a portable entertainment service. Different categories of mobile service are useful in different contexts and appeal to different consumers. Hence, the process by which the constructs in the proposed model influence mobile data services can vary between service categories. The study of Kraut et al. (1999) on Internet usage in homes makes a distinction between communication services and information/entertainment services. The rationale behind this distinction is that consumers' preference for information/entertainment and interpersonal communication are sufficiently independent of each other. In consumer behavior research, Venkatraman (1991) suggests that the types of products being adopted influence consumers' adoption

decisions, as desired quality levels may vary depending on the consumer and product. Therefore, the types of mobile data services may affect consumers' perceptions and create different usage decision patterns. The practical implication of including the types of mobile data services into the research framework is that their operators and designers can gain insights into which consumer perceptions and service features become important with regard to different categories of mobile data services.

To address the different usage decision processes among consumers of different categories of mobile data services, the research model is tested on four different mobile data services: communication, information content, entertainment, and commercial transactions. The International Telecommunications Union applies a similar categorization scheme (ITU 2002).

4 Research methodology

4.1 Context of study

The empirical test of the research model used data collected from an online survey in Hong Kong. Hong Kong is a suitable context for a study on the adoption of mobile data services because its mobile communications infrastructure is the most advanced in the world and its Internet penetration rate is very high (ITU 2002). Hong Kong ranked first in the 2002 ITU mobile/Internet index, which measures how developed each economy is in terms of mobile/Internet infrastructure, usage, and market development, while also capturing how well that economy takes advantage of future information and communication technology advances. Thus, consumer exposure to mobile data services in Hong Kong is very high.

4.2 Questionnaire

We selected items from previous studies for the model's constructs and rephrased them to suit the context of the current study (see Appendix). Our items were adapted from Davis et al. (1989) perceived usefulness, perceived ease of use, and behavioral intention measures, the perceived enjoyment measure of Davis et al. (1992), the social influence measure of Mathieson (1991), and the perceived monetary value of Dodds et al. (1991). Media influence was measured by two items from Pedersen and Nysveen (2003) and a newly developed third item. The attitude measure used three items from Bhattacherjee (2001) and a newly developed fourth item. Items for perceived mobility were developed specifically for this study. Finally, we included four control variables: age, gender, education level, and experience with mobile data services.

The questionnaire was administered in Chinese, which is the predominant language in Hong Kong. To obtain a good level of translation equivalence, two bilingual research assistants and two professional translators independently translated the English questionnaire into Chinese and then back to English (Brislin 1970). They discussed any differences in their respective translations and reached consensus on a final version of the Chinese questionnaire.

4.3 Data collection procedure

A banner advertising the online survey was placed on a Web site run by the Hong Kong government. This Web site provides Hong Kong residents with various government services electronically, such as filing tax returns and renewing driving licenses. To encourage participation in the online survey, respondents were entered into a lucky draw to win mobile phones and MP3 players. The duration for the online survey was 3 weeks.

As mobile data services encompass a wide variety of different services, they will give rise to different perceptions and have distinct appeal for individual consumers. To address this issue, respondents were presented at the start of the survey with a description of four categories of mobile data services: communication services, information content services, entertainment services, and commercial transaction services (see Section 2 earlier for the descriptions). The respondents were required to choose the category that they used most frequently. Next, they indicated the usage purpose of the selected service category using a five-point scale: (1) entirely personal, (2) mainly personal, (3) half personal, half business, (4) mainly business, and (5) entirely business. The survey also asked respondents to indicate who paid the bill for the service usage: (1) myself, (2) parents or family, and (3) employer. As the objective of this study is to investigate the factors that may affect consumers' intention to continue usage of mobile data services in personal usage contexts, only the responses from those who were using mobile data services for personal purposes (i.e., entirely personal, mainly personal, and half personal, half business) *and* whose bills were paid by either themselves or their parents/family were included in the analysis. We included respondents who did not have economic independence from their family (e.g., students and elderly people) because they are a significant part of the mobile data services' consumer population. Further, only mobile phone consumers could participate in the study. To reduce the possibility that an individual participated in the survey more than once, the survey required respondents to provide their mobile phone number. Later, the mobile phone numbers were used to filter out multiple responses from the same individual.

5 Results

5.1 Descriptive statistics

The survey received 1,183 responses in total, of which 811 were existing consumers of mobile data services for personal purposes and whose bills were paid by either themselves or their parents/family. As the study focused on post-adoption perceptions, the data analysis was based on these 811 existing consumers, of which 46% were female and 54% were male. Their age ranged from 16 to 60 years old, with a mean age of 30 years. In terms of education, 45.9% of the respondents were educated up to high school level with the rest having a college education, including associate, bachelor, and master degrees. Table 1 shows that the distribution of categories of mobile data services between male and female was quite balanced, except for information content where male consumers had a stronger desire for information content.

5.2 Instrument validation

The study used partial least squares (PLS), a structural equation modeling technique that overcomes the limitations of traditional multiple regression analysis, to analyze the data. PLS allows simultaneous evaluations of both the measurement and structural models, which take measurement errors into account (Chin 1998; Fornell and Larcker 1981). The empirical test used the software PLS-Graph Version 3.00 and modeled all variables as reflective constructs. The model test used bootstrapping to calculate the *T*-statistics for all hypothesis testing.

Table 2 presents the analysis of the psychometric properties of the variables. All factor loadings were greater than 0.70, all composite reliability measures were greater than 0.80, and all average variance extracted (AVE) measures were above 0.50 (Fornell and Larcker 1981). Hence, the variables were reliable and demonstrated good convergent validity. A comparison of the square root of a variable's average variance extracted (AVE) and its correlations with other variables provided the means to evaluate the discriminant validity of the variables. From Table 3, the square root of each variable's AVE was greater than the correlations with other variables indicating that all the variables in the model demonstrated discriminant validity.

Table 4 presents the path coefficients and *T*-statistics for significance testing of all the hypotheses. Data analysis was conducted on the four categories of mobile data services separately and also with all mobile data services combined. The percentages of variance explained (R^2) were all very high, ranging from 56.18% to 72.21% for intention to continue usage of mobile data services, and ranging from 40.74% to 61.55% for attitude toward continued usage of mobile data services, indicating a satisfactory and substantive model.

When analyzing the combined mobile data services, all variables significantly predicted either consumers' continued usage intention or attitude toward continued usage of mobile data services. However, the significant predictors of consumers' continued usage intention and attitude toward continued usage of mobile data services were notably different across service categories. For communication services, all variables had significant effects. For the other three services, there were variations in the significant predictors. However, attitude was the common predictor of consumers' continued usage intention while ease of use was the common predictor of attitude for three categories of mobile data services. Among the control variables included in the model, length of experience with mobile data services had a significant positive effect on consumers' attitude toward continued usage of entertainment services, and education level had a significant positive effect on consumers' intention to continue usage of entertainment services. While experience had statistically significant effects on all services combined and communication services separately, the effects were practically insignificant due to the small effects (i.e., standardized path coefficients <0.10). As for the commercial transaction service category, its findings might not be stable due to the small sample size (N=51). Hence, this paper does not discuss the commercial transaction service category further.

Table 1 Distribution of categories of mobile data services by gender

Category of mobile data services	Gender		Total
	Female, *n* (%)	Male, *n* (%)	
Communication	248 (48.8)	260 (51.2)	508
Information content	29 (30.5)	66 (69.5)	95
Entertainment	74 (47.1)	83 (52.9)	157
Commercial transactions	22 (43.1)	29 (56.9)	51
Total	373 (46.0)	438 (54.0)	811

6 Discussion

Anytime and anywhere computing, exemplified by mobile data services, has the potential to intrude into personal space and time (Davis 2002). Given the potential of mobile data services to affect all members of society, it is important to understand the factors that drive consumers' continued usage of mobile data services. This study has attempted to identify the relevant factors and has surfaced some important findings which are discussed next.

Table 2 Reliability and convergent validity

Variables	Mean	Standard deviation	Factor loadings	Composite reliability	Average variance extracted (AVE)
Continued usage intention				0.98	0.93
INT1	4.8	1.30	0.97		
INT2	4.9	1.29	0.98		
INT3	4.8	1.34	0.95		
Perceived monetary value				0.95	0.86
PMV1	3.6	1.34	0.91		
PMV2	3.7	1.29	0.94		
PMV3	3.5	1.33	0.94		
Perceived mobility				0.96	0.84
PM1	5.0	1.52	0.89		
PM2	4.8	1.49	0.91		
PM3	4.8	1.51	0.95		
PM4	4.6	1.54	0.93		
Media influence				0.93	0.81
MI1	4.9	1.30	0.90		
MI2	4.7	1.29	0.90		
MI3	4.7	1.30	0.91		
Social influence				0.96	0.90
SI1	4.1	1.43	0.96		
SI2	4.1	1.41	0.96		
SI3	3.9	1.37	0.92		
Attitude				0.97	0.87
ATT1	5.2	1.18	0.94		
ATT2	5.1	1.16	0.94		
ATT3	5.1	1.14	0.94		
ATT4	5.1	1.15	0.92		
Perceived usefulness				0.93	0.77
PU1	5.0	1.42	0.86		
PU2	4.5	1.48	0.90		
PU3	4.1	1.49	0.84		
PU4	4.6	1.41	0.90		
Perceived ease of use				0.95	0.83
PEOU1	4.9	1.37	0.91		
PEOU2	4.5	1.41	0.88		
PEOU3	5.0	1.35	0.94		
PEOU4	5.0	1.37	0.93		
Perceived enjoyment				0.96	0.86
PENJ1	4.7	1.38	0.89		
PENJ2	4.5	1.36	0.93		
PENJ3	4.8	1.36	0.95		
PENJ4	4.8	1.34	0.93		

6.1 Attitude: Common predictor of continued usage intention for all categories of mobile data services

Overall, all the identified constructs have impact on the intention to continue usage of mobile data services to varying degrees. Among the constructs, consumers' attitude toward continued usage of mobile data services is consistently the most critical factor that influences consumers' intention across all categories of service. Given the critical role of attitude in developing consumers' intention to continue usage of mobile data services, understanding the antecedents of consumers' attitude will be important to increase knowledge about how to encourage continued usage of mobile data services. An imperative for mobile operators and content designers is to devise ways to develop favorable attitude among the consumers.

6.2 Ease of use: Common predictor of attitude for three categories of mobile data services

Among the three hypothesized antecedents of attitude, perceived ease of use is the most important driving force

Table 3 Correlations between variables

	Perceived monetary value	Attitude	Social influence	Perceived usefulness	Perceived ease of use	Perceived enjoyment	Media influence	Perceived mobility	Continued usage intention
Perceived monetary value	*0.93*								
Attitude	0.30	*0.94*							
Social influence	0.45	0.44	*0.95*						
Perceived usefulness	0.30	0.50	0.59	*0.88*					
Perceived ease of use	0.32	0.55	0.41	0.41	*0.91*				
Perceived enjoyment	0.32	0.52	0.52	0.59	0.50	*0.93*			
Media influence	0.33	0.44	0.42	0.38	0.42	0.39	*0.90*		
Perceived mobility	0.26	0.44	0.32	0.29	0.58	0.34	0.43	*0.92*	
Continued usage intention	0.41	0.69	0.50	0.50	0.58	0.52	0.47	0.46	*0.97*

Figures on diagonal are the square root of average variance extracted (AVE). All correlations are significant at $p<0.001$; $n=811$

in forming a positive attitude toward continued usage of mobile data services. The prior technology adoption literature, especially the Technology Acceptance Model, tends to underestimate the effect of ease of use compared to the effect of perceived usefulness (e.g., Davis et al. 1989). However, the results of the current study imply that the prominence of perceived usefulness over perceived ease of use may not hold in the context of continued usage of personal information technology, as in the case of mobile data services. Depending on the technology innovations and their usage contexts, perceived ease of use can be as important as or even more important than perceived usefulness in determining continued usage intention. A study of hedonic system adoption reports similar results (Van der Heijden 2004), where perceived ease of use was found to be a stronger determinant of intention than perceived usefulness. The mobile experience is largely about saving time, varying location, and convenience (Venkatesh et al. 2003b). If consumers face difficulty in using a particular mobile data service while waiting for the bus, they will simply pursue other alternatives to fill their time. Compared to information technology usage in organizations where consumers have little flexibility in choosing an alternative technology to perform their duties, consumers of mobile data services in similar circumstances do have a broad array of alternatives (e.g., read newspapers

Table 4 Hypotheses testing

	Mobile data service categories				
	All services ($n=811$)	Communication ($n=508$)	Information ($n=95$)	Entertainment ($n=157$)	Commercial ($n=51$)
Continued usage intention	$R^2=57.49\%$	$R^2=56.18\%$	$R^2=57.27\%$	$R^2=62.57\%$	$R^2=72.21\%$
Attitude	0.49 ($T=15.07$)	0.46 ($T=10.82$)	0.47 ($T=5.11$)	0.50 ($T=7.38$)	0.69 ($T=5.40$)
Social influence	0.13 ($T=3.85$)	0.14 ($T=3.26$)	−0.01 ($T=0.11$)	0.24 ($T=4.11$)	0.04 ($T=0.36$)
Media influence	0.10 ($T=2.75$)	0.11 ($T=2.81$)	−0.09 ($T=0.82$)	0.07 ($T=0.87$)	0.09 ($T=0.62$)
Perceived monetary value	0.14 ($T=4.61$)	0.17 ($T=4.22$)	0.29 ($T=2.47$)	0.09 ($T=1.57$)	0.08 ($T=0.87$)
Perceived mobility	0.11 ($T=3.41$)	0.12 ($T=2.54$)	0.29 ($T=2.25$)	0.08 ($T=1.47$)	0.10 ($T=0.95$)
Age	−0.03 ($T=1.23$)	−0.04 ($T=1.29$)	−0.08 ($T=0.98$)	0.01 ($T=0.13$)	0.09 ($T=0.95$)
Gender	−0.00 ($T=0.13$)	0.01 ($T=0.38$)	0.11 ($T=1.28$)	−0.07 ($T=1.23$)	−0.01 ($T=0.13$)
Education level	0.04 ($T=1.83$)	0.04 ($T=1.43$)	−0.04 ($T=0.57$)	0.14 ($T=2.42$)	−0.04 ($T=0.41$)
Experience	0.05 ($T=2.24$)	0.08 ($T=2.58$)	−0.05 ($T=0.86$)	0.03 ($T=0.52$)	0.05 ($T=0.52$)
Attitude	$R^2=42.37\%$	$R^2=41.86\%$	$R^2=45.33\%$	$R^2=40.74\%$	$R^2=61.55\%$
Perceived usefulness	0.23 ($T=6.16$)	0.24 ($T=5.05$)	0.09 ($T=0.76$)	0.17 ($T=1.85$)	0.50 ($T=3.70$)
Perceived ease of use	0.34 ($T=10.23$)	0.34 ($T=8.11$)	0.44 ($T=3.87$)	0.31 ($T=3.91$)	0.21 ($T=1.43$)
Perceived enjoyment	0.22 ($T=5.54$)	0.23 ($T=5.11$)	0.26 ($T=2.19$)	0.26 ($T=2.11$)	0.18 ($T=1.36$)
Age	0.02 ($T=0.65$)	0.05 ($T=1.29$)	0.04 ($T=0.54$)	−0.03 ($T=0.45$)	−0.03 ($T=0.32$)
Gender	0.05 ($T=1.86$)	0.05 ($T=1.48$)	0.01 ($T=0.14$)	0.08 ($T=1.19$)	0.03 ($T=0.28$)
Education level	0.02 ($T=0.92$)	−0.02 ($T=0.54$)	0.05 ($T=0.63$)	0.08 ($T=1.35$)	0.10 ($T=0.96$)
Experience	0.04 ($T=1.43$	0.02 ($T=0.55$)	−0.02 ($T=0.19$)	0.15 ($T=2.61$)	0.03 ($T=0.32$)

or magazines; listen to radio or walkman). In addition, due to the constraints unique to mobile phones, such as small screen size and tiny keypads, ease of use should be a central issue for consumers of mobile data services (Venkatesh et al. 2003b). Similarly, market surveys of consumers of mobile data services have indicated that the consumers' biggest frustration comes from usability (Forrester Research 2002; Yankee Group Research 2002).

6.3 Perceived enjoyment: Common predictor of attitude for three categories of mobile data services

The effect of perceived enjoyment is consistent with the hypotheses. Noticeably, perceived enjoyment has a consistently important effect on building consumers' affection toward continuing to use three types of mobile data services. In the context of such a personal innovation, the results suggest that perceptions of pleasure and enjoyment are critical to consumers' usage behavior. Indeed, prior studies suggest the saliency of perceived enjoyment in predicting information technology adoption (Davis et al. 1992; Venkatesh 1999), especially of hedonic systems (Van der Heijden 2004). Given the nature of mobile data services, which can be used for personal hedonic desire, the results of the current study validate Van der Heijden's (2004) finding. Seeking pleasure and joyful experiences is an intrinsic human need (Davis et al. 1992). A growing number of information and entertainment services attempt to fulfill such enjoyment needs. The ITU (2002) predicts that mobile entertainment and information services will represent a significant portion of mobile revenues in the near future. The results imply that understanding, creating, and maintaining the perceptions of enjoyment involved in using mobile data services will be crucial to the success of service operators.

6.4 Variation in significant factors across categories of mobile data services

An interesting finding is that the pattern and the magnitude of the effects of factors on mobile data services' usage decisions can vary among different categories of services. This finding implies that the category of mobile data services can be an important boundary condition in explaining consumer behavior. For instance, the effect of social influence on consumers' intention was salient in the communication service category and entertainment service category, but not in the information content service category. This discrepancy may be related to the nature of the service categories. The information content services (e.g., weather, dictionary, map, financial market information) are more appropriate for individual-centric purposes. In contrast, consumers may use communication services (e.g., SMS and MMS) and entertainment services (e.g., mobile games, movie and music downloads) to reinforce their social links and their feelings of group affiliation. A survey of young people finds that those who do not use mobile communication services appear to struggle to maintain their social relationships (Carroll et al. 2002). The stronger effect of perceived enjoyment on consumers' attitude relative to that of perceived usefulness in the entertainment service category is similarly intuitive. By the very nature of entertainment services, consumers should consider enjoyable services to be more important.

The more salient association between perceived mobility and continued usage intention in the information content category than in the communication service category may be similarly explained. Given that downloading information is quite sensitive to bandwidth and data rate, and geographic location (e.g., in tunnels or a fast moving train), perceived mobility would likely have a stronger effect on intention in information content applications. In contrast, the insignificant impact of perceived mobility on consumers' intention in the entertainment service sector may reflect the development stage of the industry. Despite the huge potential of mobile entertainment services, due to the limited entertainment content repertoire and the constraints of mobile handsets, many mobile entertainment services depend on pre-installed games or simple downloads, which cannot be strictly labeled mobile entertainment (ITU 2002). Consumers with such limited mobile entertainment experience may find it difficult to associate perceived mobility with usage intention. However, as wireless technology and mobile devices advance, consumers' experience with mobile entertainment may become more sophisticated. The recent development of third generation-based audio/video streaming or digital multimedia broadcasting services in South Korea and Japan will help consumers enjoy true mobile entertainment, thus possibly evoking the importance of perceived mobility—perception that mobile data services can provide pervasive and timely connections—in using such services.

6.5 Implications for research and practice

In terms of research contribution, this study improves on prior research effort to understand consumer behavior regarding mobile technology. First, the current study attempts to understand mobile data services' consumer behavior from more realistic perspectives by incorporating two unique variables into the research model: perceived mobility and perceived monetary value. These two variables are subsequently found to be important antecedents of consumers' intention to continue usage of mobile data services. Second, this study has demonstrated the utility of using the decomposed theory of planned behavior as a

framework to investigate consumers' post-adoption behavior toward mobile data services. Our results highlight the importance of attitude and normative beliefs (i.e., social influence and media influence). Third, this study echoes the importance of considering post-adoption beliefs as compared to pre-adoption beliefs (Bhattacherjee 2001; Hong et al. 2006; Thong et al. 2006). By surveying existing consumers of mobile data services, the findings can reflect consumers' perception more accurately. Fourth, this study provides empirical evidence for Benbasat and Zmud's (2003) call to focus on the unique characteristics of the information technology artifact. In the case of mobile data services, which have features for a wide scope of usage context, the antecedents of usage behavior can vary across service categories, thus validating the role of service (or task) type on consumers' adoption behavior (Venkatraman 1991). Finally, the impact of perceived ease of use was stronger than that of perceived usefulness on consumers' intention to continue usage of mobile data services, when compared to the traditional information technology used in organizations or work settings. This finding calls for research into the relative importance of the two major perceptions in different information technology usage contexts.

In terms of practical implications, the findings provide mobile operators and content developers with various strategies to sustain the usage of mobile data services. First of all, mobile operators and content developers should look into ways to inculcate favorable attitude among consumers, design appropriate pricing mechanisms for the mobile data services, develop the technical infrastructure to support true mobility, and make appropriate use of the media to influence consumers and their social network. Second, mobile operators and content developers should look into improving the ease of use and usability of mobile phones and their data service offerings, and develop useful and enjoyable mobile data services. Third, the different patterns of usage intention development across different service categories suggest that mobile operators should design their products and marketing activities based on the nature of service categories. For instance, media influence is an important factor in shaping continued usage intention of communications services, but not of entertainment and information content services. This finding implies that when service providers launch a marketing plan, the allocation of advertisement budget and outlets should vary across different categories of service. Perhaps for entertainment services, generating positive word-of-mouth among consumers through promotional service-trial events for small target groups can be more effective than spending millions of dollars advertising campaigns on television channels and newspapers targeting the general public. In this regard, mobile operators can promote specific campaigns to different segments of consumers. This segmentation method has been used successfully in South Korea, where a mobile operator introduced various campaigns targeted at segmented consumer groups (e.g., the brand name *Na* for college students, *Bigi* for teenagers, and *Drama* for young, high-income career women). Finally, the inconsistent effect of perceived monetary value on continued usage intention—salient in both communication service and information content service, but not in entertainment service—can provide mobile operators and content providers with insights to design effective pricing strategies which take advantage of consumers' price sensitivity toward different services.

6.6 Future research

The results of this study suggest several possibilities for future research regarding consumers' post-adoption behavior with mobile data services. The finding that the predictors of consumers' intention to continue usage can vary across different categories of services implies that different service categories can be driven by different motivations or beliefs. Indeed, as more and more new information technology-based services become available, consumers' perceptions and beliefs toward those emerging services may evolve. By incorporating the peculiar attributes of different service/technology types into the models of consumer behavior, research into consumers' acceptance of information technology will be enriched.

Another possible future research direction is to explore the moderators of the drivers of mobile data services usage behavior. As implied by the results with regard to the impact of some control variables included in the model (e.g., education level and usage experience), there are various factors that can potentially play a moderator role in influencing consumer behavior. The study of moderators, such as demographics/socio-economic factors, may help us better understand consumers' mobile data services usage behavior.

There have also been several attempts to build new models with a comprehensive perspective about technology usage behavior, such as the Unified Theory of Acceptance and Use of Technology (Venkatesh et al. 2003a) and the expectation-confirmation model of IS continuance (Bhattacherjee 2001), or to understand technology usage behavior beyond the work settings, such as the model of adoption of technology in households (Brown and Venkatesh 2005), the model of adoption of information appliances (Hong and Tam 2006), and expanded expectation-confirmation models of IS continuance (Hong et al. 2006; Thong et al. 2006). The versatile usage contexts of mobile data services naturally call for tests of the utility of such models in predicting consumers' technology usage behavior. As today's technology usage is

no longer limited to enhancing productivity within organizational work settings, extending the explanatory power of the research models to encompass different usage scenarios is very much needed.

7 Conclusion

Mobile data services are a technological breakthrough that permeates the personal lives of individual consumers. This study has investigated how to entice consumers' continued usage of mobile data services in the context of personal usage. We have empirically validated a research model based on the decomposed theory of planned behavior and incorporated factors that represent personal needs and motivations in continuing to use mobile data services. Further, by testing the research model with different categories of mobile data services associated with different usage contexts, the influence of service category on existing consumers' usage decisions is highlighted. The findings of this study can provide a foundation for further research into the behavior of mobile data services' consumers, which can contribute to meeting the vision of a ubiquitous computing world.

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Appendix

Table 5 Questionnaire items

Variables	Items
Perceived usefulness	
PU1	I find MDS useful in my daily life.
PU2	Using MDS helps me accomplish things more quickly.
PU3	Using MDS increases my productivity.
PU4	Using MDS helps me perform many things more conveniently
Perceived ease of use	
PEOU1	Learning how to use MDS is easy for me.
PEOU2	My interaction with MDS is clear and understandable.
PEOU3	I find MDS easy to use.
PEOU4	It is easy for me to become skillful at using MDS.
Perceived enjoyment	
PENJ1	Using MDS is enjoyable.
PENJ2	Using MDS is pleasurable.
PENJ3	I have fun with using MDS.
PENJ4	I find using MDS to be interesting.
Social influence	
SI1	People who are important to me think that I should use MDS.
SI2	People who influence my behavior think that I should use MDS.
SI3	People whose opinions that I value prefer that I use MDS.
Media influence	
MI1	Media and advertising consistently recommend using MDS.
MI2	News articles, reviews, vendor promotion and advertising suggest using MDS to be a good idea.
MI3	Media is full of reports, articles and advertisements suggesting MDS to be worth using.
Perceived monetary value	
PMV1	MDS are reasonably priced.
PMV2	MDS offer a good value for the money.
PMV3	At the current price, MDS provide a good value.
Perceived mobility	
PM1	I am able to use MDS anytime and anywhere.
PM2	I find MDS easily accessible and portable.
PM3	MDS are available to use whenever I need it.
PM4	In general, I have control over using MDS anytime and anywhere.
Attitude	
ATT1	All things considered, using MDS is a (bad idea–good idea).
ATT2	All things considered, using MDS was a (foolish move–wise move).
ATT3	All things considered, using MDS would be a (negative step–positive step).
ATT4	My attitude toward MDS use is (extremely negative–extremely positive).
Continued usage intention	
INT1	I intend to continue using MDS in the future.
INT2	I will always try to use MDS in my daily life.
INT3	I will keep using MDS as regularly as I do now.

MDS stands for mobile data services

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