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ABSTRACT

The rapid spread of technological innovations like mobile data services (MDS) has made ubiquitous computing a fact of everyday life for many people. We need therefore to understand the contribution of ubiquitous computing to overall quality of life. This study proposes a theoretical model that connects user satisfaction (a traditional outcome variable of IT) with contributions to quality of life (a new outcome variable for ubiquitous computing) in the domain of MDS. The reliability of the outcome variables and the validity of the proposed model were tested through three empirical studies in Korea. Study results indicate that user satisfaction with MDS affected the contribution of MDS to quality of life in eleven subordinate domains, and these contributions in turn influenced the overall contribution of MDS to quality of life. The paper ends with a discussion of the implications and limitations of the study results.

Keywords

Ubiquitous Computing, quality of life, mobile data service, life domain

INTRODUCTION

As information technology (IT) develops rapidly and IT products permeate the marketplace, interest in ubiquitous computing continues to grow as well. The term ubiquitous computing implies that the most profound technologies are those that weave themselves into the fabric of everyday life until they are indistinguishable from the life itself (Weiser, 1993). A ubiquitous computing environment comprised of multiple small devices, such as PDAs and mobile phones, provides users with information that suits their needs anywhere and at any time.

Mobile data services (MDS) are one of the most widely dispersed components of ubiquitous computing because most people already carry a mobile phone as an everyday necessity. MDS is defined here as wireless access to the World Wide Web, allowing users to obtain digitized contents and services from the Internet via handheld mobile devices. MDS user numbers passed the 1.5 billion mark in the first week of June 2004, and it is forecasted that more than two billion people will use MDS by July 2006 (EMC, 2004). Study of MDS reveals that people in ubiquitous computing environments exhibit radically different usage patterns than those using traditional information systems. The latter are used mostly at a certain place and time for specific purposes. For example, ERP systems are used mainly for managing and allocating corporate resources in business organizations, digital TV systems mostly for entertainment purposes in domestic environments. In contrast, ubiquitous systems are used for diverse purposes in every place and at every time. MDS users can manage their business affairs from home, maintain relationships with friends and family on the subway, and enjoy mobile games on the street. While a traditional information system focuses on the specific tasks it supports, MDS engages a user at multiple and diverse points. It is, in other words, ubiquitous.

The ubiquity of MDS requires us to consider a new outcome variable, one appropriate to a new kind of information system. Because traditional information systems (IS) are dedicated for the most part to specific tasks, studies of them have usually measured how useful and easy a system is in achieving its specific purposes, and how satisfactory users find the experience of using it (Oliver and Desarbo, 1988). In other words, the outcome variables in studies of traditional IS pertain to systems and tasks. Such narrowly focused variables are inadequate, however, for studying the impact of a ubiquitous computing environment, which affects not just specific, well defined tasks, but various interrelated facets of everyday life. In other words, because information systems in a ubiquitous computing environment are diffuse, pervasive, and in some sense indistinguishable from life itself, we require a new outcome variable that addresses not isolated traits of specific tasks or processes, but an environment's impact on overall quality of life.

The goal of this study was to explore how one instance of ubiquitous computing, mobile data services, contributes to overall quality of life. We have designated "contribution to quality of life" as an outcome variable for MDS, constructed a theoretical model linking a traditional outcome variable (user satisfaction) to the new outcome variable, and verified the outcome variable and research model through three consecutive empirical studies in Korea.

THEORETICAL BACKGROUND

Quality of life

Quality of life (QoL) is a conceptualization of happiness or subjective well-being (Diener et al. 1985) that involves judgments about the fulfillment of one's needs, goals, and wishes (Campbell et al., 1976). QoL is a measure of how happy people are, or, to put it another way, how fulfilled they are in terms of their various wants and needs.

Studies of QoL have been conducted in diverse areas, including marketing, health, and education. For example, QoL is an evolving philosophy in marketing, with studies focusing on tools and techniques that enhance the well-being of consumers (Lee and Sirgy, 1995). However, little research has been conducted in the area of IS, even though information technologies, MDS included, have a substantial effect on overall quality of life.

Individual life domains

Because, as a general concept, *life* is complex and abstract, QoL researchers have identified a number of distinct life domains that encompass the various places, things, activities, roles, and relationships in which a person typically finds himself or herself involved (Andrews and Withey, 1976; Campbell et al., 1976). They propose that people actually experience and store the various events of their life in distinct domains, including leisure life, family life, friend life, cultural life, work life, educational life, community life, consumer life, financial life, spiritual life, social life, health and safety life, neighborhood life, and self life. Most prior QoL studies have focused on a few specific life domains relevant to their interests. For example, marketing researchers have been interested mainly in the consumer life domain, while researchers in public welfare have focused on the health and safety domain to study the quality of life of medical patients and the elderly. However, because MDS has the potential to affect many life domains, and because we do not know yet which domains are most relevant to MDS, our study needed to investigate most of the life domains established in the literature.

Bottom-up spillover theory

The bottom-up spillover theory (Andrews and Withey, 1976; Campbell et al., 1976; Diener, 1984) is a model of the relationship between individual life domains and quality of overall life. The theory indicates that quality of life in individual domains has spillover effects on overall quality of life. In other words, happiness in subordinate individual life domains can spill over to produce superordinate overall happiness (Andrews and Withey, 1976; Campbell et al., 1976; Diener, 1984). The bottom-up spillover theory has been concretized into the satisfaction hierarchy model (Lee and Sirgy, 1995). The premise of this model is that overall life satisfaction is functionally related to satisfaction within each of the individual life domains, which is in turn affected by satisfaction with specific events in each life domain (Sirgy, 2002). For example, Sirgy and Cornwell (2001) have found that the quality of community life is a direct function of satisfaction with three types of individual services: satisfaction with government services, with business services, and with nonprofit services. The bottom-up spillover theory and the satisfaction hierarchy model have been supported by many prior studies (Andrews and Withey, 1976). However, few studies have applied the theory to the contribution of IT to QoL. That contribution is the focus of this paper.

THEORETICAL MODEL AND HYPOTHESES

Drawing from the bottom-up spillover theory and the satisfaction hierarchy model, summarized in the left-hand triangle in Figure 1, we propose our theoretical model, similarly represented on the right side of Figure 1 as a triangle with three layers. The main difference between our model and the satisfaction hierarchy model is that we focus on the *contribution* of MDS to QoL, not on QoL *per se*. In other words, we are more interested in how MDS contributes to quality of life than in how generally satisfied people are with their lives. This research focus has been implemented in each of the three layers in our research model. First, the bottom layer of the satisfaction hierarchy model represents a person's satisfaction with diverse life experiences in the corresponding individual life domains. The corresponding layer in our model represents the satisfaction of MDS users when using MDS services (henceforth, *Experience Satisfaction*) in the corresponding life domain. For example, our model asks how satisfied MDS users are when they download mobile games while they are waiting for their friends. Thus we have limited the scope of life experience to MDS-use experience. Second, the middle layer of the satisfaction hierarchy model represents quality of life in individual life domains, while the middle layer of our model represents the contribution of MDS to quality of life in those domains (henceforth, *Individual Contribution*).

For example, the middle layer might include the contribution of MDS to leisure life and consumer life. Individual Contribution within a given domain is the difference in satisfaction between life before and life after the use of MDS services in that domain. The survey questions attempt to determine whether users feel their life in a specific domain is better or worse after using the mobile Internet than it was before. In other words, the items measure not how full the glass of well-being is, but whether the level is rising or falling. Finally, the top layer of the satisfaction hierarchy model represents overall

quality of life, while the corresponding layer in our model represents the specific contribution of MDS to overall quality of life (henceforth, *Overall Contribution*). Like Individual Contribution, Overall Contribution is conceptualized as the difference in a user's overall satisfaction with his or her life before and after using MDS.

We propose two groups of hypotheses based on the theoretical model presented in Figure 1. The first group concerns the relationship between the bottom and middle layers of the right-hand triangle. According to the satisfaction hierarchy model, satisfaction in a given life domain is influenced directly by satisfaction with particular events within that domain (Sirgy, Hansen, and Littlefield, 1994). In our research model, we propose that positive experiences with MDS in a given life domain will increase the perceived contribution of MDS in that domain. In other words, if a user has positive experiences using MDS (Experience Satisfaction) in a life domain, the quality of life in that domain will be higher after using

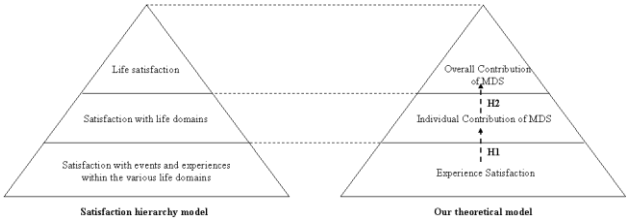

Figure 1. Theoretical model and hypotheses

MDS than it was before (Individual Contribution). The contribution of MDS to that domain will be the difference in QoL in the domain before and after use. Thus we hypothesize:

Hypothesis 1: Experience Satisfaction with MDS in a life domain will increase the Individual Contribution of MDS in that domain.

The second group of hypotheses concerns the relationship between the middle and top layers of the right-hand triangle in Figure 1. The basic premise of the bottom-up spillover theory is that satisfaction levels within individual life domains affect the overall level of life satisfaction (Sirgy, 2002). In this study, we propose that contributions of MDS to QoL within individual domains (Individual Contribution) affect the contribution of MDS to overall QoL (Overall Contribution). Thus, while the traditional bottom-up theory concerns spillover of QoL *per se*, our theory concerns spillover of *contribution* to QoL by a specific factor, namely, MDS. We derive our hypotheses from the satisfaction hierarchy model by the following reasoning. According to the bottom-up spillover theory, overall QoL before using MDS will be positively affected by the QoL in individual domains before use. Similarly, overall QoL after using MDS will be positively affected by the QoL in individual domains after use. If there is a positive difference of QoL in individual domains before and after using MDS, there will also be a positive difference in terms of overall QoL. In other words, if MDS improves QoL within individual domains, it will also improve QoL overall. We refer to this improvement as Overall Contribution and hypothesize:

Hypothesis 2: A positive Individual Contribution of MDS will increase the Overall Contribution of MDS to quality of life.

RESEARCH METHOD

Our research took place in three stages. In the first stage, we conducted focus group interviews to identify common experiences of using MDS and major life domains affected by MDS. In the second stage, we conducted mall-intercept interviews to test the validity of measures for Individual Contribution and Overall Contribution, and also to identify use experiences and life domains not captured in the first stage. In the third stage, we conducted a large-scale online survey to verify our research model, using a questionnaire shaped by our findings in the first and second stages. Space limitations require us to provide only brief explanations of the first two stages and to focus on the third stage. Detailed information about the first two stages is available on request.

Stage 1 – Focus Group Interview

Stratified samples of five MDS user groups were selected according to age and occupation: a group of six middle school students, a group of five high school students, a group of five college students, a group of seven adults, and a group of seven MDS experts. The focus group interview (FGI) sessions consisted of two open-ended questions: "What mobile data services do you use frequently and in what context?" and "In what areas of your life do you use mobile data services frequently?' All FGI sessions were videotaped and all responses transcribed verbatim. Two independent reviewers coded each sentence of the resulting transcript into use experiences and corresponding life domains. The inter-coder reliability was 0.809, above the threshold value of 0.7 (Holsti, 1969). A total of 11 life domains were identified: cultural life, leisure life, work life, educational life, health and safety life, financial life, consumer life, family life, friend life, social life, and self life. All have been identified in prior QoL studies, as explained in section 2.2.

Stage 2 – Mall Intercept Interview

We conducted mall-intercept interviews to test the validity and reliability of questions for the three constructs in our research model: Experience Satisfaction, Individual Contribution, and Overall Contribution.

Questions measuring Experience Satisfaction in the 11 life domains were based on the MDS use experiences mentioned frequently in the focus group interviews. We chose to use the formative indicators elicited in stage one in order to reflect concrete user experiences with MDS and thereby to make it easier to elicit practical implications.

Subjects were asked to rate how each experience of MDS was on an eight-point Likert scale, ranging from 0 for "have never experienced," 1 for "very dissatisfied," 4 for "neutral," and 7 for "very satisfied." Individual Contribution in each of the 11 domains was measured by a single item based on the 'D-T Question', a metric frequently used in QoL studies (Andrews and Withey, 1976). We chose the single question metric because the question had to be asked repeatedly, once for each of the 11 life domains. For example, the question measuring Individual Contribution in the domain of leisure life was, "How has the quality of your leisure life changed since you started using mobile data services, compared to the time before you ever used it? (1 = have become very dissatisfied, 7 = have become very satisfied)." Questions measuring Overall Contribution were constructed as reflective indicators based on the Satisfaction with Life Scale (SWLS). The SWLS is one of the most widely used scales in QoL research and has exhibited high internal consistency and test-retest reliability (Pavot and Diener, 1993). Four questions were phrased to elicit the contribution of MDS to overall quality of life on 7-point Lickert scale, ranging from 1 for strongly disagree to 7 for strongly agree.

In stage two of the study, the questions for Experience Satisfaction, Individual Contribution and Overall Contribution were pilot-tested by means of the mall-intercept method to ensure validity and reliability.

Visitors to a multiplex movie theater were randomly solicited with monetary compensation equivalent to USD $7. A total of 249 subjects participated. All had used MDS at least once during the past week. They were asked 1) to review the formative questions for Experience Satisfaction and to add any further MDS use experiences they could think of; 2) to explain to the researcher how they understood the single item for Individual Contribution; and 3) to answer the four questions adapted from SWLS to check their reliability. The questions were modified according to the pre-test results. Detailed information about survey questions is available on request because of space limitations.

Stage 3 – Survey

Using the questions developed in stage two, we conducted a large-scale online survey in Korea to test the research model. To draw from diverse MDS user groups with different educational and economic profiles, we solicited participants via banner advertisements on several popular portals. A total of 6,481 people participated in the survey. Their telephone numbers were handed to telecommunication companies to verify their past use experience of MDS. Only those who had used MDS at least once before completing the survey were retained. The final number of effective participants was 6,431. Among the final effective respondents, 68.9% were in their twenties.

RESULTS

The research model was tested using Partial Least Squares (PLS), a method well suited to highly complex predictive models (Joreskog & Wold, 1982). PLS is appropriate for this study, which includes both formative indicators (for Experience Satisfaction) and reflective indicators (for Overall Contribution) and analyzes the strengths and directions of the relationships among the variables (Chin, 1998).

Because reflective and formative indicators must be treated differently (Barbara, 2001), we tested them using different methods. We first checked the reliability measure for Overall Contribution, the reflective construct, and found it to be 0.923, well above the threshold value 0.7 (Fornell and Lacker, 1981). We also found that the Overall Contribution has convergent validity because it has

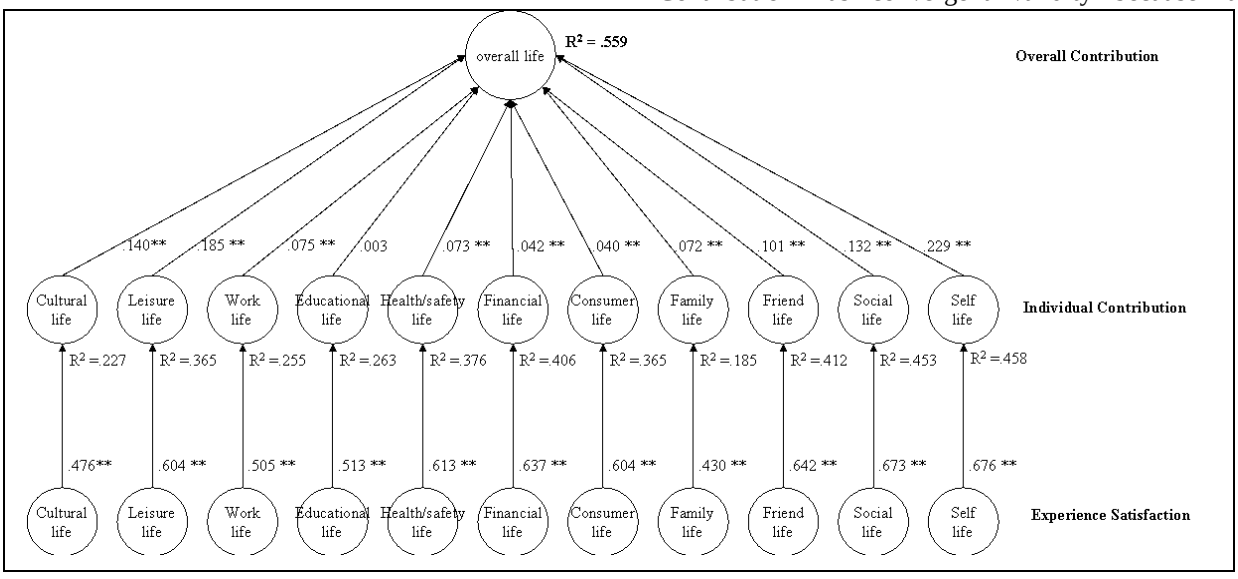

Figure 2. PLS results for research model verification

significant loadings and t-statistics, well above the threshold value (Wixom and Watson, 2001). We then examined the item weights for Experience Satisfaction, the formative measurement. All but three of the formative indicators were found to bear significantly on Experience Satisfaction within the corresponding life domains.

We went on to test our hypotheses using PLS Graph Version 3.0 and the bootstrap re-sampling method. As shown in the figure 2, Experience Satisfaction was found to affect Individual Contribution positively in all 11 life domains. Therefore, the first hypothesis (H1) was supported in all domains. More specifically, Experience Satisfaction influenced Individual Contribution most heavily in the self domain (R^2 = 0.458, β = 0.676). Individual Contribution was in turn found to affect Overall Contribution positively in all life domains except educational life. Taken together, Individual Contribution explains 55.9% of Overall Contribution. Therefore, our second hypothesis was supported in 10 of the 11 life domains. More specifically, Individual Contribution from the self domain affected Overall Contribution most heavily (β = 0.229).

CONCLUSIONS

Results from the three consecutive studies clearly indicate two things about the contribution of MDS to quality of life. First, as people felt more satisfied with their MDS use experience in a given domain, they perceived a stronger contribution of MDS to the quality of their lives in that domain. Second, as they perceived a stronger contribution of MDS in individual domains, they also perceived a stronger contribution of MDS to their overall quality of life. Two other findings deserve mention. First, of all the life domains, the self domain had the greatest impact on both Individual Contribution and Overall Contribution. This may be related to the pervasiveness in Korea of MDS services such as photo-mail and ring-tone downloads. These features offer Korean MDS users a wide variety of ways establish an identity and present it to others, and they seem to enjoy doing so in mobile Internet spaces. Multinational MDS studies have arrived at similar results (mGain, 2003). Second, Individual Contribution from the educational domain did not affect Overall Contribution. This may be a result of the low usability and limited bandwidth that constrain mobile devices. Online education usually requires users to participate actively in a learning process by engaging with multimedia broadcasting facilities. The low usability of mobile devices inhibits active participation, and the limited bandwidth precludes effective use of multimedia broadcasting. It is not surprising, then, that the contribution of MDS to educational life had no significant effect on its contribution to overall quality of life. This study provides a theoretical as well as an empirical basis for considering ubiquitous computing as an important contributor to the quality of its users' lives.

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