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Mobile appointment reminders in patient-centered care: Design and evaluation

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MOBILE APPOINTMENT REMINDERS IN PATIENT-CENTERED CARE:

DESIGN AND EVALUATION

A Dissertation

by

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ABSTRACT

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Reminder systems have great potential to enhance healthcare outcome if they can facilitate collaborative appointment management with accessible mobile communication technology in patient-centered care. Yet, current appointment reminder systems are effective but not optimal (McLean, et al. 2016). Following the design science process delineated by Peffers et al. (2007) and other requirements, this study proposes a design of reciprocal reminder system that automates the process of appointment rescheduling for healthcare providers and patients in addition to confirmation and cancellation. Based on the premises of media synchronicity theory, media naturalness theory and stakeholder theory as kernel theories, this study develops a design theory that covers platform design, communication design and service design. Design principles of new mobile appointment reminders are proposed to cater to the different requirements of provider and patient users. Situation adaptivity and privacy sensitivity are identified as the major design features that need to strike a balance between different user requirements. An experiment investigates how the variation in design may influence user behavior, and the findings suggest that situation adaptivity and privacy sensitivity have positive effects on users' system experiences in terms of performance expectancy, effort expectancy and subjective consonance.

Further survey results on the final design confirm that the reciprocal reminder system adaptive to patient situations and sensitive to privacy concerns has the expected effects on user behavior.

DEDICATION

This dissertation is lovingly dedicated to my mother, Zhifang Li. Her constant love, support and encouragement have sustained me throughout my life.

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CHAPTER I

INTRODUCTION

1.1 Background

The high population penetration of cell phones and the power of ubiquitous computing has enabled the use of mobile technology in healthcare to increasingly gain momentum (Ajami & Torabian, 2013; Istepanian, Laxminarayan, & Pattichis, 2006). As of January 2014, 90% of American adults have cell phones (Smith, 2015). According to the findings released in February 2015 from the 5th Annual Makovsky/Kelton "Pulse of Online Health" Survey, about two-thirds (66%) of Americans would use mobile systems to manage health-related issues (Pennic, 2015).

Mobile health (mHealth) refers to the use of mobile and wireless devices to improve health outcomes, healthcare services and health research (Health & Services, 2013). Mobile health can reduce the cost of healthcare while enhancing its quality by offering dramatic innovation and wide accessibility (Cooper & Unit, 2012). The high penetration of mobile phones presents an unprecedented opportunity to improve the health of people at large. For traditionally underserved populations in particular (e.g., rural communities, low-income groups, and ethnic minorities), mHealth helps bridge the digital divide in healthcare as most patients have cellphones but not necessarily PC and Internet access (Kahn, Yang, & Kahn, 2010; NORC, 2010). mHealth helps remove geographic and economic barriers that prevent disadvantaged people from accessing healthcare services.

The advances in wireless and handheld technologies stimulate the development of new mHealth systems (Akter & Ray, 2010). Such emerging systems have huge potentials to provide informational support for medical interventions and improve disease-related health outcomes (Krishna, Boren, & Balas, 2009). Through wireless networks, seamless connections can be established between provider-side systems and patient-side devices.

It is found that mHealth systems are particularly helpful for enhancing healthcare effectiveness by supporting patient self-management (De Jongh, Gurol-Urganci, Vodopivec-Jamsek, Car, & Atun, 2012). For example, a wireless emergency service system allows a patient to monitor the physiological conditions with a wearable sensor, and sends alerts to patients and providers when something goes wrong (Patel, Park, Bonato, Chan, & Rodgers, 2012; Sun, 2005). Another example is mobile reminder that automatically reminds patients of upcoming medications, tests, appointments and other medical interventions through their cell phones. By displaying reminders on personal devices, such systems are able to reinforce patient compliance in a more cost-effective way than mail, email, and phone reminders (Car, Ng, Atun, & Card, 2008; Leong et al., 2006).

Most mHealth systems are based on wireless communication technology, which is considered critical for solving health challenges in the coming era (Ajami & Torabian, 2013). The communication between patients and providers in mobile health can be carried out in various ways, such as email, chat, texting and data streaming (e.g. video). In 2013, there were an estimated 95,000 mHealth systems in the world and over 200 million people had accessed them (Kolley, 2013). Many mHealth systems require the use of high-end mobile devices such as smart phones and tablet computers, which excludes one third of the mobile users who use regular cellphones that do not support such systems (Elliott, 2013). The emergence of smart-phones (e.g.

iPhone) has the great potential to enhance user interaction with mHealth systems, but the cost of wireless data subscription can still be a burden to many patients, especially those in the underserved regions. Also, a large proportion of the people in the USA still do not have sufficient skills to use Internet-based systems due to factors such as age and education (Fox & Duggan, 2012). This contributes to the new form of digital divide in mobile health, which is contradictory to the basic premise of patient-centered care that every patient should at least have access to healthcare services (Sun, Wang, & Rodriguez, 2013).

On the other hand, Short Message Service (SMS), "a one-size-fits-all solution for anybody with a mobile number" (Tolentino, 2015, p. 1), has great potentials for mHealth systems as literally all mobile phones are SMS enabled (Déglise, Suggs, & Odermatt, 2012). As long as an individual has a mobile phone and service plan, the person is able to receive and send SMS. Wide-spread, affordable and easy to use, SMS still maintains the highest engagement rate in comparison to emails and over-the-top messaging systems such as WhatsApp, Facebook Messenger, Viber and WeChat (Tolentino, 2015). Also, SMS has less restriction regarding computers and Internet access, and allows users to receive and respond to messages in a timely manner. According to the Conversational Advertising Report (MobileSquared, 2010, p. 8), "About 90 percent of all text messages are read within 3 minutes of their delivery." In under-developing regions which lack of wired network and Internet infrastructures, affordable wireless services especially SMS have the ubiquitous power needed to improve health outcomes (Kaplan, 2006).

Therefore, SMS is regarded as an indispensable infrastructure to support underserved patients with chronic and other conditions (Moore et al., 2014). The accessibility of SMS to the majority of population makes it one of the preferred means of telecommunication for the

development of mHealth systems in the patient-centered care era (Barton, 2010; Free et al., 2013). In addition to the population-wide accessibility, SMS is a powerful communication tool that allows message customization to meet individual needs in healthcare (CDC, 2014). Researchers found that personalized reminder messages enhance patient adherence to scheduled medical activities such as immunization and chronic disease treatment (Hardy et al., 2011; Stockwell et al., 2012).

1.2 Statement of the Problem

The basic premise of patient-centered care is that allowing patients to play a more active role in their own health and medical care is conducive to better healthcare quality and outcome at a lower cost (Hibbard, Stockard, Mahoney, & Tusler, 2004). The current SMS-based mHealth systems, however, are limited in terms of taking patient preference into account (Finkelstein, Liu, Jani, Rosenthal, & Poghosyan, 2013). A systematic review reveals that existing SMS-based mobile reminder systems can handle scheduled activities (e.g. medication, testing and appointment) but do not allow patients to manage the schedules based on their own needs and situations (Gurol-Urganci, de Jongh, Vodopivec-Jamsek, Atun, & Car, 2013). In this sense, such systems do not truly meet the requirement of patient-centered care as patients have little control.

Take a medical appointment for instance, a patient usually schedules it a few weeks or months ahead of time, but may not be able to make it due to unexpected event that creates schedule conflict. When the person receives a one-way reminder under this circumstance, he/she can do little with it. Rather, reminder systems should be designed to give the patient rescheduling options. The patient is likely to choose an available slot, and avoid the total skipping of the

appointment. Providing a "safe net" in schedule management, therefore, may enhance patient adherence.

Therefore, there is a gap between patient need for self-management of health-related services and the limitation of current SMS-based mHealth systems. This is largely attributed to the mentality in the traditional physician-centered healthcare in which patients are supposed to follow scheduled activities. Thus, the design of existing mobile reminder systems rarely takes patients' flexibility needs into account. In a review of studies on mHealth reminder systems, Riley et al. (2011) found that only one out of the eight SMS appointment systems allowed two-way communication, which is merely for the purpose of confirming or canceling appointments.

In addition to the tradition in practice, there is a lack of guidelines to ground the development of mobile health systems on theoretical foundations (Fiordelli, Diviani, & Schulz, 2013; Riley et al., 2011). In Fiordelli et al. (2013)'s review of mHealth research, only one out of 100 articles published between 2007 and 2011 was uniquely theory-based, 74 were evidence-based, 10 were based on both theory and evidence, and 15 just provided general descriptions. For SMS-based reminder systems in particular, none of the eight studies in the aforementioned review reported theoretical basis for system design and development (Riley et al., 2011). It might be true that a reminder system can be relatively simple if it only involves one-way communication (i.e., message pushing) or limited two-way communication (e.g. confirmation). However, a system taking user flexibility into account based on patient needs and situations is much more complex in terms of system interactivity and user behavior (Aakhus & Harrison, 2015). For system developers to take full advantage of the mobile technology, therefore, they need to base the designs on health behavior models that "guide not only tailored adjustments at

intervention initiation but also the dynamic process of frequent iterative intervention adjustments during the course of intervention" (Riley et al., 2011, p. 54).

In the design of existing mobile reminder systems, another consideration that is largely absent besides interactivity is privacy, which is critical in the use of mobile technology for personal health (Avancha, Baxi, & Kotz, 2012). Many systems identified in previous studies reveal appointment time, place and/or purpose (Downer, Meara, Da Costa, & Sethuraman, 2006; Koshy, Car, & Majeed, 2008; Nelson, Berg, Bell, Leggott, & Seminario, 2011). Yet the information contained in these reminder messages is regarded as personal health information (PHI) as defined by the Health Insurance Portability and Accountability Act (HIPAA) (CDC, 2003). The disclosure of such information may raise privacy concerns, yet few studies have addressed this issue in the theoretical discourse of mobile reminder system design. This resulted in inconsistent empirical findings. A survey study shows that most respondents felt that SMS messages were more private than normal call, because treating phones and messages as confidential is a widely accepted, unwritten rule in life (Häkkilä & Chatfield, 2005). In another pilot study, however, participants indicated the need not to disclose sensitive appointment information in reminder messages (Dowshen, Kuhns, Johnson, Holoyda, & Garofalo, 2012). Additional investigation is needed to reconcile the contradictory findings regarding user privacy in mHealth system design.

1.3 Research Questions

To fill the gaps in the literature, the overall research question that this study aims to investigate is: what are the design features of SMS-based mobile appointment reminder systems that may enhance patient-centered care? The premise of this study is that such systems need to

be designed to cater for the requirements and needs of both physician and patient users in terms of process efficiency and flexibility as well as outcome effectiveness. The overall research question can be divided into three related sub questions:

1. What are the design principles for mobile appointment reminder systems in patient-centered care? (addressed in Chapter 3)
2. How receptive are patient users to personal systems like mobile reminder systems? (addressed in Chapter 4)
3. What are the relationships between mobile reminder designs and patient user adoption? (addressed in Chapter 5)

1.4 Objectives of This Study

Corresponding to the overall research question, the main purpose of this study is to develop and validate a design theory of mobile appointment reminder systems that patients and providers can to use for better healthcare outcomes. This study claims that such systems need to enable "automated reciprocity" between patients and providers in patient-centered care. Following the design theory approach, specific design principles are to be established based on sound foundations (Hevner, March, Park, & Ram, 2004).

Researchers found that the adoption of information systems by organizations or individuals does not necessarily lead to continuous usage (Limayem & Cheung, 2008). User resistance due to improper implementation of healthcare systems are the main reason for their failure (Bhattacherjee & Hikmet, 2007). A well-developed design theory may provide some guidelines for researchers and practitioners to design, develop, and deploy mHealth systems that

people are likely to use. To achieve this goal, there are multiple related objectives that need to be accomplished.

The first objective is to develop a design theory to guide the development of mobile appointment reminder systems based on a good understanding of user behavior from both provider and patient sides. Compared with traditional healthcare systems that providers use, mHealth systems target patients as the direct users and providers as the indirect users. Thus, a new perspective of user behavior is needed to appreciate the unique challenge in system design. This study will take the perspective from the recent trend of patient-centered care in terms of its premise that patient involvement in the collaborative effort with providers will enhance healthcare outcomes (Barry & Edgman-Levitan, 2012; Rathert, Wyrwich, & Boren, 2013). Based on such an understanding, a design theory can be developed to translate user requirement into design principles.

Compared with organizational systems that have been the main focus of IS research, mobile reminder systems are personal systems and they have different implications on user behavior. One distinction is on the influence of normative beliefs. For organizational systems, researchers found the salient effect of subjective norm, or an individual's perception that important others think that the person should use a system or not (Venkatesh & Davis, 2000). This external source of normative beliefs, however, may not be entirely applicable to mHealth systems for personal use. Rather, the internally oriented normative beliefs, or personal norms, may play a more important role (Parker, Manstead, & Stradling, 1995). The second objective of this study, therefore, is to propose a new construct "subjective consonance" to capture such internal normative beliefs, and develop its conceptual and operational definitions.

The third objective is to test a behavioral research model with empirical observations collected from a laboratory experiment. The research model includes key design factors and delineates their hypothesized relationships with behavioral constructs in questions. To test the relationships in the research model, observations are collected from participants exposed to different treatments. The experiment treatments demonstrate the variations of mobile reminder designs to participants.

1.5 Significance of the Research

In theory, this study contributes to the literature on mHeatlh system design from several aspects. First, it develops the understanding of mHealth user behavior in patient-centered care based on behavioral theories. Health interventions can be delivered in timely and frequent manners and tailored to individual needs in context, yet system designs have not been well grounded in behavioral theories (Riley et al., 2011). As an effort, this study adopts theoretical lenses from various fields including media synchronicity theory and stakeholder theory to understand mHealth user behavior in context of patient-centered care.

Based on such an understanding, this study proposes a design theory on mobile reminder systems. The current literature oversimplifies existing mobile reminder as a one-way or limited two-way communication system (Fiordelli et al., 2013). SMS technology has the potential to support in-depth interactivity and personalization, yet at the same time, may raise concerns like privacy and security (Dennison, Morrison, Conway, & Yardley, 2013; Pal, 2003). To take full advantage of technological capabilities and control user concerns, a design theory grounded on behavioral theories (kernel theories) is needed. This study proposes a design theory of mobile reminder systems that handles the main design issues like interactivity and personalization.

This study also contributes to user behavior research by developing and testing a theoretical model. The model describes the relationships between design features and behavioral constructs. Compared with other commonly used models in IS research, such as technology acceptance model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT), the model includes the characteristics of IT artifacts in addition to psychological variables. The development and testing of such a model help validate the design theory. In addition, the modeling explicitly includes the IT artifact in question, which has been largely absent or black-boxed in the models of previous IS research (Orlikowski & Iacono, 2001).

Compared with most IS behavioral research, this study does not just passively observe the new socio-technical phenomenon, but makes a difference in practice by providing some guidance on actual system design with detailed design principles. To validate the design theory, this study compares the effects of different designs on user behavior in an experiment. The empirical observations gathered are used to evaluate the design and test the research model.

Such an approach of mobile reminder system design is likely to enhance healthcare management for both patients and providers. The design enables patients to actively coordinate and collaborate with providers in managing schedules beyond just receiving messages. Providers benefit from the adoption of such system as well. First of all, it may reduce no-show surprises that cause waste in terms of time and material set aside. Given other options, a patient is more likely to indicate the inability to come to an appointment rather than turning away from a reminder. Based on more accurate information of who are coming and who are not, providers can make better preparations for the upcoming appointments. Also, the integration of scheduling and reminder systems may significantly release the burden for providers to manually communicate with patients and rearrange appointments.

1.6 Multi-Method Research Approach

To accomplish the research objectives, this study needs to employ more than a single method. Researchers have recognized the complexity of IS-related phenomenon and propose the multi-method approach (Mingers, 2001). The main premise is that an IS artifact typically involves multiple dimensions (e.g. technical, organizational, social etc.) of factors and impacts, and a method that is strong in dealing with one dimension may be weak to address the others (Mingers, 2003).

For the first objective, that is the design of mobile reminder systems, the most appropriate method is the design science approach. Design science is about the systematic way of developing guidance on IS artifact design, specification and evaluation based on sound theoretical development (Pries-Heje & Baskerville, 2008). First, this study follows Walls, Widmeyer, and El Sawy (1992) information system design theory (ISDT) and Gregor and Jones' (2007) design theory approach to develop a design theory in terms of design principles based on the understanding of user behavior.

This study adopts psychometric method for the second objective to develop a new construct, subjective consonance, to capture the internally-oriented normative beliefs involved in the use of personal systems like mobile reminder systems. The commonly-used subjective norm in IS research, on the other hand, is a single-dimension construct to capture the external influence of important others on the collective use of organizational systems (Venkatesh & Davis, 2000). Rather than such social pressure, individual behavior like the use of mobile appointment systems may invoke multiple aspects of personal norms related to one's value systems (Thøgersen, 2002). Using the psychometric method, this study identifies the sub-

constructs of subjective consonance, and develops their measures for collecting empirical observations of such behavior.

For the third objective of validating the design theory with empirical observations, this study adopts the experiment method. With such a method, it is possible to expose participants to different designs of mobile reminder systems, and test their hypothesized effects on user behavior. Controlled for error and extraneous variances, the experimentation is able to establish the causal relationship between treatments and outcome variables (Kerlinger & Lee, 1999).

1.7 Organization of the Dissertation

Following the design science process delineated by Peffers et al. (2007) and other requirements, this study proposes and evaluates a design of reciprocal reminder system. This study comprises six chapters. Following this introduction, the rest is to be organized as shown in Figure 1.1:

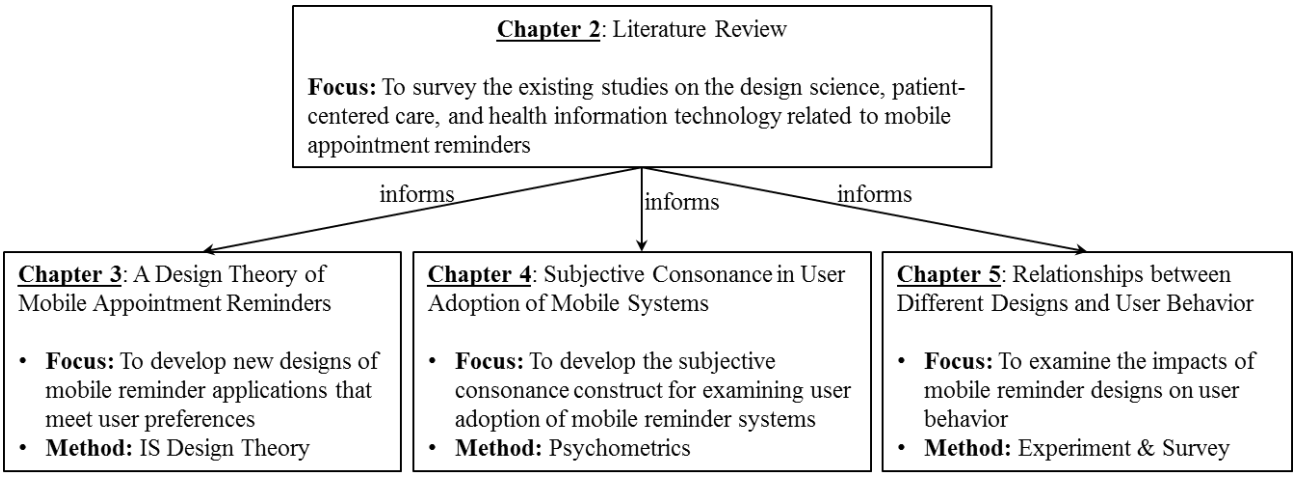


Figure 1.1 A Brief Summary of Dissertation Research

Chapter II consists of a literature review on user requirement in mobile health from multiple perspectives. First it reviews design science methodology. Next, it discusses patient-

centered care and its implications on user behavior that involves both patients and providers. Then, it surveys the current status of mobile reminder systems and related health information technology.

Chapter III conceptualizes a design theory on mobile reminder systems. First, it gives a brief introduction to design science in terms of its origin and existing streams of thoughts. Then, this chapter identifies media synchronicity theory, media naturalness theory and stakeholder theory as the kernel theories that lay the foundation for design theory development. The specific design principles are identified in terms of design constructs and features. Finally, this chapter illustrates the design artifacts of a mobile reminder system that incorporate the design principles.

Chapter IV develops and validates the construct and measurement of subjective consonance to capture intrinsic normative beliefs in the use of personal systems like mobile reminder systems. Based on the literature on technology acceptance and organizational justice, a nomological network depicting the relationships between subjective consonance and other constructs is developed. With the responses from users of mobile reminder systems, measurement validity in terms of reliability, convergent validity, discriminant validity and predictive validity are assessed.

Chapter V evaluates different designs of mobile reminder systems from user perspective with an experiment. It proposes research hypotheses, collects observations with questionnaires, and statistically tests the hypotheses with the observations. Compared with the common survey method used in behavioral IS research, such as technology acceptance model (TAM) and related studies (Venkatesh, Morris, Davis, & Davis, 2003), the experimentation uses different design treatments as exogenous variables. The analysis not only examines the relationships among psychological constructs but also tests the causal effects of different designs on user behavior.

Chapter VI concludes the study. It addresses both the contributions and limitations of the study. Also, some recommendations are made for future research.

CHAPTER II

LITERATURE REVIEW

To design mobile health reminder systems that meet user requirement of both physicians and patients, the current system designs in the literature need to be reviewed. In addition, user requirement needs to be examined under the context of patient-centered care movement. The understanding of the gaps motivates new designs of mobile health reminder systems, which has to be substantiated with the rigor of system design and development. A review of design science research literature may provide formal guidelines in terms of theories and methods. Following a top-down approach, this chapter first reviews the literature on design science research as a paradigmatic framework, and then the patient-centered care research as the research context, followed by existing mobile health reminder system designs as a foundation to build upon.

2.1 Design Science Research

The design and development of IT artifacts play an indispensable role in the information systems (IS) discipline, just like building design to the field of architecture (Lee & Lai, 1991; Walls et al., 1992). Thus system design has been an important research stream in the IS discipline since its inception in the 1970s (Goes, 2014). Many studies before the 1990's focused on IS development approaches and methodologies, representing early system design research (Iivari, 2007; Walls et al., 1992). Those studies were labeled differently such as software

engineering research, constructive research, prototyping, and system development (Gregor, 2006).

Design science research once lost its primary position to behavioral research in IS mainstream research. March and Smith proposed a framework for classifying IS research output. This framework was used to review publications in the IS field around the new millennium (1998-2002) by Andoh-Baidoo, Baker, Susarapu, and Kasper (2007) who found that design-related research received very little attention in contrast to the large number of behavioral studies. One main reason is that design science has practical relevance but is not perceived as rigorous as behavioral science that pays more attention to the impact of IT artifacts than their design and development (Benbasat & Zmud, 1999; Hevner & Chatterjee, 2010). In IS research before 2000, IT artifacts were largely black-boxed as many researchers believed that system design and development belong to the domain of more technical disciplines such as computer science and engineering (Hevner & Chatterjee, 2010; Orlikowski & Iacono, 2001).

Design science research regained attention as several design science seminal papers appeared in the top journals in the 1990s' and later (Hevner et al., 2004; March & Smith, 1995; Nunamaker, Chen, & Purdin, 1991; Nunamaker, Dennis, Valacich, & Vogel, 1991; Walls et al., 1992). The seminal work of Walls et al. (1992), March and Smith (1995) and Hevner et al. (2004), in particular, contributed to design science becoming the umbrella term of a strong research stream that covers different types of system design and development studies as aforementioned.

Since Benbasat and Zmud (1999) raised the concern of the lack of practical relevance in IS research, more and more researchers have paid attention to design science as a legitimate research stream for the "disciplined, rigorous and transparent building of IT artifacts" (Iivari,

2007, p. 41). Despite the fact that behavioral research is still dominant in current IS literature, design science research is increasingly advocated as an "equal companion" (Hevner, 2007, p. 87). In fact more recently Lee and Hubona (2009) demonstrated how both design and behavior research can be conducted to achieve both rigor and relevance.

2.1.1 Relevance and Rigor

In IS research, the practical relevance of result should be valued equally with the rigor of means to obtain the result (Hevner & Chatterjee, 2010). The relevance of IS research to practice is best manifested through its applicability in design that is implementable based on the synthesis of existing literature (Benbasat & Zmud, 1999). Design science is intrinsically strong in research relevance as the successful development of IT artifacts largely depends on valid designs (Glass, 1999; Winograd, Bennett, De Young, & Hartfield, 1996).

Hevner et al. (2004) argued that behavioral science and design science are the two fundamental paradigms that characterize the IS discipline: "The behavioral science paradigm seeks to develop and verify theories that explain or predict human or organizational behavior. The design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts. Both paradigms are foundational to the IS discipline, positioned as it is at the confluence of people, organizations, and technology" (p. 75).

In contrast to behavioral science aimed at developing and testing theories to explain human behavior, design science is concerned with the design, specification and evaluation of technological artifacts that are created to serve human needs (Hevner et al., 2004; March & Smith, 1995; Pries-Heje & Baskerville, 2008). In an effort to pursue rigor, behavioral IS research often suffers the pitfall of lowering its relevance to practice (Lee, 1999). On the other hand,

design science research presents an opportunity to enhance the relevance of IS research given the artificial nature of information systems (Nunamaker, Dennis, Valacich, Vogel, & George, 1991; Venable, 2006).

Hevner (2007) identified three design science research cycles namely relevance cycle, design cycle and rigor cycle. Whereas the design cycle pertains to the building and evaluation of IT artifacts, the relevance cycle addresses the problems and opportunities in the application domain and the rigor cycle grounds the design on and contributes to the knowledge base (Hevner, 2007). In particular, the assurance of rigor in design science research is anchored upon three types of knowledge base foundations: scientific theories and engineering methods that guide system design and development, experiences and expertise that define the state-of-the-art in the application domain of the research, and the existing artifacts and processes in the application domain (Hevner, 2007, p. 89). Thus, the rigor of design science research, compared with behavioral science research, has an extra source in practice in addition to theories and methods, which strikes a natural balance with relevance.

Therefore, application domains, such as healthcare, e-commerce and biology, play a key role in design science research to improve domain-specific systems and processes (Hevner & Chatterjee, 2010). The design of health IT systems is an extremely important issue as a good design may reduce the cost and enhance the quality of healthcare services (Romanow, Cho, & Straub, 2012). However, many systems even the certified electronic health record (EHR) systems are poorly designed in terms of user-friendliness and the ability to improve quality and efficiency in the healthcare system (Blumenthal, 2009). For the emerging mHealth systems, few researchers have followed rigorous approaches to develop and evaluate the designs (Fiordelli et al., 2013; Riley et al., 2011). This presents a niche for IS researchers to apply the rigorous design science

approaches in the IS field to this important cross-disciplinary area of developing health IT systems.

2.1.2 Research Approaches

During the last few decades, design science research has evolved from its infancy to the current plethora. For better design of mobile reminder systems, it is necessary to adopt an appropriate design science approach. This section attempts to obtain a big picture of existing approaches by reviewing relevant publications. The understanding of state of the art provides insights on which approach fits best to the context of this study. This study holds a broad view of design science theorization as a knowledge building process (Gregor & Jones, 2007; Knorr-Cetina, 2013).

Based on how design science research is formulated, there are three general ways to construct a theory: deductive theorizing, inductive theorizing and abductive theorizing (Lee, Pries-Heje, & Baskerville, 2011). Deductive theorizing derives a conclusion from a known theory to a specific instance, leading to knowledge growth by intention; whereas inductive theorizing draws conclusions from specific instances, leading to knowledge growth by extension (Kaplan, 1973). In addition to the two contrasting *mechanistic* ways, theorizing for applied fields is usually intuitive and creative thinking process in rigor, or *disciplined imagination* (Weick, 1989). Abductive theorizing makes sense of a phenomenon by drawing inference to the best explanation from alternatives following a certain process (Brown, 2008; Martin, 2009).

Inductive theorizing is common in design science research, especially at the early stage in form of action research, but is often criticized for the lack of theoretical abstraction; on the other hand, deductive theorizing is often criticized for the lack of practical relevance (Gregor & Jones,

2007; Hevner et al., 2004). Rather, design science researchers proposed rigorous methodology to develop design theories through a comprehensive solution-seeking process (Hevner & Chatterjee, 2010; Holmström, Ketokivi, & Hameri, 2009). This is consistent with the argument that it is more meaningful to focus on the quality of the process of theorizing than evaluating the quality of the theory itself (Weick, 1995). Therefore, this section classifies the different approaches that researchers have adopted into the following categories: actionist approach, methodologist approach, and theorist approach, as shown in Table 2.1.

Table 2.1 General Approaches of Design Science Research

Approach	Focus	Premise	Nature
Actionist	Prototyping & testing	Artifact development is pivotal	Descriptive
Methodologist	Procedure & schema	Rigor relies on method	Prescriptive
Theorist	Theory & principle	Theory guides design	Proactive

Being the oldest among the three approaches, the actionist approach as represented by action research was proposed and adopted by IS researchers in the 1970's based on software development and engineering literature (Gibson, 1975). Its premise is that artifact development is central to design science research, which is supposed to focus on system prototyping and testing (Järvinen, 2007). The main role of researchers is to record the process of artifact creation and modification in terms of the actions taken and their effects, and thus such studies are mainly descriptive in nature (Baskerville & Wood-Harper, 1998). This is in line with Hooker (2004)'s argument that design is "a passage from a functional description to a physical description of an artifact" (p. 76).

Later, many researchers raised the concern on the lack of rigor in action research, as it does not give formal guidelines on how to conduct design science research (Cole, Purao, Rossi, & Sein, 2005; Hevner et al., 2004). Based on the assumption that a rigorous process leads to

quality research, researchers proposed various procedures and schema design science research can follow to enhance its rigor (Gregor & Hevner, 2013; Hevner et al., 2004). Such a methodologist approach is prescriptive in nature as it addresses what needs to be done in order to meet the requirement of research rigor.

The theorist approach claims that a sound theory is needed to guide the design and development of IT artifact in today's dynamic environment where problems are increasingly complex and diversified (Gregory & Muntermann, 2014; Markus, Majchrzak, & Gasser, 2002; Walls et al., 1992). The major components of a design theory include a design product and a design process that specify hypotheses and principles for designers to evaluate the IT artifact in question and its development process (Walls et al., 1992). Both design theory components are built upon theories in natural/behavioral and social sciences known as kernel theories (Walls, Widermeyer, & El Sawy, 2004). The importance of kernel theories has been recognized by design science researchers who follow the theorist approach, though they use other terms such as "micro theories" (Simon, 1996) and "justificatory knowledge" (Gregor & Jones, 2007). Such theory-based design science research approach is proactive in nature as it provides the principles for the design of a category of information systems (Gregory & Muntermann, 2014; Walls et al., 2004).

Table 2.2 lists the seminal works of each approach and their main contributions along the years. It suggests that different approaches have not evolved separately but in an intertwined manner. Since the beginning, the primary focus of actionist approach has been mainly prototyping based on means-ends rationality (Archer, 1984; Janson & Smith, 1985; Simon, 1969). Yet later studies also attempted to enhance research rigor by providing some guidelines for conducting this type of design science research, such as iterative system development and

evaluation (Baskerville, Pries-Heje, & Venable, 2009; Gregg, Kulkarni, & Vinzé, 2001; March & Smith, 1995). Cole et al. (2005) and Järvinen (2007) established the connections between action research and design science research by locating the similarities and parallels between the two. Later, Sein, Henfridsson, Purao, Rossi, and Lindgren (2011) proposed "action design research" as a design science research method for considering organizational context in system building.

Table 2.2 Seminal Works of Design Science Research Approaches

Approach	**Author (Year)**	**Title**	**Main Contributions**
Actionist	Simon (1969)	The sciences of the artificial	1) The first to identify the need for DSR; 2) Deliberation of "science of the artificial" that involves means–ends rationality
	Archer (1984)	Systematic method for designers	Decomposed DSR into six steps: 1) objective establishment; 2) data collection and analysis; 3) synthesis of objectives and analysis results; 4) design proposal development; 5) prototyping; 6) documentation.
	Janson & Smith (1985)	Prototyping for systems development: A critical appraisal	Recognized the importance of prototyping in DSR
	Gregg et al.(2001)	Understanding the philosophical underpinnings of software engineering research in information systems	Proposed a framework for software engineering research methodology (SERM)
	Cole et al. (2005)	Being proactive: where action research meets design research	Revealed parallels between action research and DSR, leading to the recommendation of cross-fertilization between two.
	Järvinen (2007)	Action research is similar to design science	Related action research to DSR
	Baskerville et al. (2009)	Soft design science methodology	Proposed a soft systems approach that combines common DSR process with iterative system development.

Approach	Author (Year)	Title	Main Contributions
	Sein et al. (2011)	Action design research	Considered organizational context in building systems and learning from intervention.
Method-ologist	Takeda et al. (1990)	Modeling design process	Presented three design process models: descriptive, cognitive, and computable.
	Eekels and Roozenburg (1991)	A methodological comparison of the structures of scientific research and engineering design: their similarities and differences	Compared scientific research and engineering design in six dimensions: 1) truth seeking vs. value-preference problems; 2) observation vs. analysis; 3) induction vs. synthesis; 4) deduction vs, simulation; 5) testing vs. evaluation; 6) evaluation vs. decision.
	Nunamaker & Chen (1991)	Systems development in information systems research	Proposed 5-step process: 1) conceptual framework; 2) architecture; 3) design; 4) development; 5) experimentation, observation and evaluation
	March & Smith (1995)	Design and natural science research on information technology	Identified two design processes (build & evaluate) and four design artifacts (constructs, models, methods, & instantiations)
	Zelkowitz & Wallace (1998)	Experimental models for validating technology	Described 12 techniques to validate IT artifact design
	Hevner et al. (2004)	Design science in information systems research	Proposed 7 DSR guidelines and 5 evaluation methods
	Peffers et al. (2007)	A design science research methodology for information systems research	Proposed 6 DSR process elements (problem, objectives, design/development, demonstration, evaluation, & communication)
	Hevner (2007)	A three cycle view of design science research	Prescribed DSR as an embodiment of three activities: relevance cycle related to context, rigor cycle related to knowledge base, and design cycle related to artifact building and evaluation.

Approach	Author (Year)	Title	Main Contributions
	Gregor & Hevner (2013)	Positioning and presenting design science research for maximum impact	Proposed a 2-dimension DSR knowledge contribution framework (problem domain & solution domain) and a DSR communication schema (Introduction, Literature, Method, Artifact, Evaluation, Discussion)
Theorist	Walls et al. (1992)	Building an information system design theory for vigilant EIS	Specified product component and development process component of ISDT based on kernel theories.
	Love (2000)	Philosophy of design: a meta-theoretical structure for design theory	Suggested a meta-theoretical method for the critical analysis, comparison and formulation of design theories and concepts.
	Purao (2002)	Design research in the technology of information systems: Truth or dare	Proposed design theories as knowledge created in form of operational principles to guide the development of artifacts as situated instantiations.
	Goldkuhl (2004)	Design theories in information systems-a need for multi-grounding	Proposed multiple grounding (empirical, theoretical and internal) processes in relation to design theory.
	Venable (2006)	The role of theory and theorising in design science research	Claimed that theory should be the primary output of DSR, and proposed standards for theories in DSR
	Gregor & Jones (2007)	The anatomy of a design theory	Delineated 6 core components (purpose/scope, constructs, principles of form and function, artifact mutability, testable propositions, justificatory knowledge) and 2 optional components (principles of implementation, material instantiation) of design theories.
	Kuechler & Vaishnavi (2008)	Theory development in design science research: Anatomy of a research project	Created design theories by binding kernel theory testing and refinement with artifact development and evaluation
	Baskerville & Pries-Heje (2010)	Explanatory design theory	Suggested that a design theory includes two parts: design practice theory (how to design)

Approach	Author (Year)	Title	Main Contributions
			and explanatory design theory (what are requirements and components)
	Kuechler & Vaishnavi (2012)	A framework for theory development in design science research: multiple perspectives	Developed a hierarchical framework to support ISDT development with the inclusion of design-relevant explanatory/predictive theories (DREPTs).
	Gregory & Muntermann (2014)	Heuristic theorizing: Proactively generating design theories	Generated design theories through heuristic search, heuristic synthesis, and concurrent evaluation.

Note: DSR – design science research; ISDT – information system design theory.

Methodologist approach is built upon engineering design methodology to guide the design and development process (Eekels & Roozenburg, 1991; Takeda, Veerkamp, & Yoshikawa, 1990). Like the actionist approach, it also includes artifact building and evaluation but provides formal frameworks for enhancing the rigor of design science research and the communication of research outcomes (Gregor & Hevner, 2013; Hevner et al., 2004; Nunamaker, Chen, et al., 1991; Zelkowitz & Wallace, 1998). Compared with the artifact-centered actionist approach, the methodologist approach emphasizes knowledge generation and distribution following certain procedures and schemas (Hevner, 2007; March & Smith, 1995; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007).

In addition to the methodological guidance, the theorist approach moves further to seek theoretical guidance in the design and development of IT artifact (Walls et al., 1992). In particular, Walls et al. (1992) required the use of kernel theories from natural/behavioral and social sciences as the foundation of design theory development. Similar to the methodologist approach, the theorist approach stresses the importance of research rigor as well as knowledge generation and distribution (Gregor & Jones, 2007; Purao, 2002). The main outcomes of design

science research for the theorists, however, are design theories and principles that can be generalized to a class of systems (Venable, 2006; Walls et al., 2004). Despite its theoretical focus, the theorist approach is grounded on artifact building and evaluation, which connects it to the actionist approach (Goldkuhl, 2004; Kuechler & Vaishnavi, 2008).

The latest work by Gregory and Muntermann (2014) suggested heuristic theorizing as an iterative process of heuristic search and heuristic synthesis on problem-structuring heuristics and artifact design heuristics with concurrent evaluation. Problem-structuring heuristics consist of problem decomposition, problem class identification, and problem reformulation, and artifact design heuristics can be drawn upon analogical design, ideation and prototyping, playing with kernel theories, and modeling (Gregory & Muntermann, 2014). In particular, it is suggested that researchers "play" with kernel theories to find solutions for generating new knowledge (Kilduff, Mehra, & Dunn, 2011). Compared with the design theory frameworks by Walls et al. (1992) and Gregor and Jones (2007), heuristic theorizing emphasizes theory development process rather than the elements or components of a design theory. Thus researchers may adopt the heuristic approach to develop and refine the design theories that meet the requirement of Walls et al. (1992)'s and Gregor and Jones (2007)'s frameworks.

2.1.3 Design Theory Studies

To guide the designs of mobile reminder systems in the emerging patient-centered care era, it is necessary to develop a design theory based on the sound understanding of user behavior in the new context. Among the aforementioned approaches, the theorist approach is most appropriate for the following two reasons (Gregor & Iivari, 2007). First, theorizing design knowledge provides a sound foundation for the rigor of design science research. Second,

building design theories avoids re-invention of design artifacts and methods but leads to the accumulation of formal knowledge.

Yet the designs of most existing mobile health interventions are not built upon behavioral theories and models (Riley et al., 2011). There may be two reasons: on one hand, many researchers hold the conception that design science is practical in nature and does not need to be explicitly tied to theories (Goes, 2014); on the other hand, the diverse theories adopted from behavioral and social sciences are weakly linked to IT artifact design (Iivari, 2007). Therefore, there is a need to develop a design theory to bridge the gap between behavioral theories and artifact design for effective mobile health intervention.

Diverse researchers have different understanding of what exactly a design theory is. In a broad sense, information system design theory (ISDT) could refer to general systems theory involving the relationships among developers, artifacts, users and environment. More specifically, Walls et al. (1992) defined ISDT as "a prescriptive theory which integrate normative and descriptive theories into design paths intended to produce more effective information systems" (p 36). Kernel theories adopted from natural/behavioral and social sciences are parts of design theories as they provide the descriptive knowledge for the development of prescriptive design theory (Walls et al., 1992).

Compared with other types of theories, design theories are unique in the ways they are developed and tested. Many theories for design and actions, such as systems development life cycle (SDLC), are not always recognized as theories by design science researchers despite their significant impacts (Gregor & Jones, 2007). The seminal work of March and Smith (1995) did not include theory as a part of design science products (i.e., constructs, models, methods, and

implementations) and process (i.e., building and evaluation). These authors and other researchers alike preserve the term "theory" for natural/behavioral science research.

This study holds the position that a design theory is needed for the development of mobile reminder systems as it provides the theory-based design guidance to a class of systems rather than a particular artifact (Markus et al., 2002). In particular, the design theory needs to be drawn upon sound behavioral theories to understand user behavior in patient-centered care. Most atheoretical design science studies, on the other hand, are driven by technology push rather than demand pull (Eierman, Niederman, & Adams, 1995). The proposed mobile reminder systems accessible to most patients are based on SMS technology, which is relatively matured. The development of design theory is driven by emerging user needs in the new healthcare context. Thus theory development is needed for the design of mobile reminder systems. A review of existing design science research following the theorist approach for other types of systems, as summarized in Table 2.3, would be helpful.

Table 2.3 Examples that follow Design Theory Approaches

Author (Year)	**Artifact**	**Research Approach**	**Kernel Theory**
Codd (1970; 1982)	A relational model of database	Fit Gregor and Jones (2007)'s frame of design theory	1) Set theory; 2) Human cognitive processes
Ow and Smith (1987)	Design principles for knowledge-based job-shop scheduling system	Theory grounding	None
Stein and Zwass (1995)	ISDT for an Organizational Memory Information System (OMIS)	Walls et al.(1992)'s ISDT for design product	1) Competing values model; 2) Information processing model of memory
Kasper (1996)	ISDT for decision support system	Walls et al.(1992)'s ISDT for design product	1) mental representation of problem; 2) symbolic representation of problem

Author (Year)	Artifact	Research Approach	Kernel Theory
Markus et al. (2002)	ISDT for EKP support systems	Walls et al.(1992)'s ISDT for design product	Characteristics of emergent knowledge processes (from practical knowledge)
Hall et al.(2003)	ISDT for Learning-Oriented Knowledge Management Systems (LOKMS)	Walls et al.(1992)'s ISDT for design product and portions of the design process.	Intelligence-design-choice model
Jones et al. (2003)	ISDT for web-based education (WBE)	Walls et al.(1992)'s ISDT	1) Hypermedia templates; 2) Design patterns; 3) Diffusion theory; 4) Adopter-based development methodologies; 5) Emergent development
Chiang and Mookerjee (2004)	Software development project management policy	Gregor and Jones (2007)'s frame of design theory	1) Group coordination processes; 2) Team cognition; 3) Software development productivity; 4) Fault growth models
Iversen et al. (2004)	Risk management methods in software process improvement	Gregor and Jones (2007)'s frame of design theory	Risk management approaches (from other design theories)
Kasper and Andoh-Baidoo (2006)	ISDT extenstion of DSS design theory for user calibration	Walls et al.(1992)'s ISDT	1) Decision-making process; 2) mental representation of problem; 3) symbolic representation of problem
Pries-Heje and Baskerville (2008)	Design theory nexus	Van Aken(2005)'s approach	Multiple theories of organizational change
Moody (2009)	A design theory called the Physics of Notations for constructing visual notations in software engineering	Gregor and Jones (2007)'s frame of design theory	1) Visual representations of knowledge; 2) Dual channel theory

Author (Year)	Artifact	Research Approach	Kernel Theory
Arazy et al. (2010)	Design Framework for Social Recommender Systems	Theory-driven design approach in which "applied behavioral theory" was introduced to enhance Walls et al.'s (1992) ISDT	1) Interpersonal attraction theory; 2) Reinforcement theories; 3) Word-of-mouth influence theories; 4) Weak ties theory; 5) Social influence theories
Hanseth and Lyytinen (2010)	ISDT for dynamic complexity in information infrastructures	Walls et al.(1992)'s ISDT	Complex adaptive systems (CAS) theory

One of the earliest information systems design theory studies was conducted by Ow and Smith (1987), who incorporated two design principles, domain-specific knowledge and hierarchical organization structure, in the design framework of a knowledge-based job-shop scheduling system. In the terminology by Goldkuhl (2004), this theory building approach reconstructs practical knowledge and its background knowledge as "internal grounding", in contrast to the "theoretical grounding" recommended by Walls et al. (1992) to use kernel theories from natural/behavioral sciences as the basis of design theory building.

All the studies that followed Walls et al. (1992) ISDT approach explicitly include kernel theories. As recommended, most of the kernel theories were adopted from previous research in natural/behavioral fields. In particular, Hall, Paradice, and Courtney (2003) and Hanseth and Lyytinen (2010) included a single kernel theory in each of their studies, Kasper (1996) and Stein and Zwass (1995) included two kernel theories, Kasper and Andoh-Baidoo (2006) included three, and Jones, Gregor, and Lynch (2003) and Arazy, Kumar, and Shapira (2010) included five or more theories. The only exception is Markus et al. (2002) who took the practical knowledge instead of scientific knowledge previously validated.

Iivari (2007) argued that it is not always possible to find formal kernel theories that are well fit to meta-artifacts. Thus, Gregor and Jones (2007) recommended the use of "justificatory knowledge" as a broader term rather than "kernel theory" to include any knowledge that informs design research, such as practical knowledge. They suggested that it is unnecessary to separate justificatory knowledge for design product and design process, unlike two sets of kernel theories as required by Walls et al. (1992). In addition, Gregor and Jones (2007) extended Walls et al. (1992)'s framework by including the additional components of constructs and artifact mutability. Table 2.4 compares the two design theory frameworks.

Table 2.4 Comparison between Two Design Theory Frameworks

Framework	**Walls et al.(1992)**	**Gregor and Jones (2007)**
Scope	Meta-requirements	Purpose and scope
Construct		Constructs
Principle	Meta-description	Principle of form and function
Context		Artifact mutability
Hypothesis	Testable product hypotheses; Testable process hypotheses	Testable propositions
Knowledge	Product kernel theories; Process kernel theories	Justificatory knowledge
Process	Design method	Principles of implementation*
Instantiation		Expository instantiation*

Note: * - optional.

Constructs are the basic building blocks of a design theory that capture physical phenomena or abstract theoretical terms (Gregor & Jones, 2007), such as "fault threshold" in software development (Chiang & Mookerjee, 2004) and "one-to-many relationships" in database design (Codd, 1970, 1982). Artifact mutability accommodates the fact that an artifact is in constant state of change during its development and maintenance by proposing the "evolutionary trajectory" rather than a static design (O'Hear, 1989, p. 220). In this sense, a design theory needs

to address how a system may evolve over time and adapt to different task and organizational contexts (Gregor & Jones, 2007).

In the review of studies that adopt the ISDT framework over the 10-year period after its publication, Walls et al. (2004) found that few studies include all the components in the framework. Due to the difficulty to explicitly follow their guideline, Gregor and Jones (2007) put principles of implementation and expository instantiation as optional components of a design theory study. Whereas principles of implementation correspond to design method in Walls et al. (1992)'s framework, expository instantiation is included as well so that researchers may better communicate design principles in a theory with the development and use of an actual artifact (Gregor & Jones, 2007). Therefore, Gregor and Jones (2007)'s framework allows design science researchers to present design theories in a more conventional manner that IS field has published design-type work.

To address the question of how a design theory bridge the gap between human and technology, Baskerville and Pries-Heje (2010) suggested that a design theory include two parts: a design practice theory that explains how to design an IT artifact and an explanatory design theory that identifies the general requirements and corresponding general components. On the other hand, Kuechler and Vaishnavi (2012) included design-relevant explanatory/predictive theories (DREPTs) as an intermediate level that may contribute to the development of ISDT in a hierarchical design theory framework.

2.2 Patient-Centered Care

Compared to traditional provider-centered medicine, the emerging patient-centered care reflects the trend to consider patient needs and preferences in delivering healthcare services at

present time (Davis, Schoenbaum, & Audet, 2005). For underserved populations, patient-centered care is particularly relevant as it may provide potential solution to the lack of access to medical services (Silow-Carroll, Alteras, & Stepnick, 2006). As shown in Table 2.5, underserved populations are commonly defined as vulnerable populations with access barriers to primary medical care services due to socio-economic, cultural and/or linguistic factors.

Table 2.5 Characteristics and Definitions of Underserved Populations

Characteristics	Definition	Source
Vulnerability	Disadvantages of certain populations due to various factors related to income, race/ethnicity, health condition, healthcare accessibility, medical insurance, gender, age, education and so on.	AJMC (2006)
Access barriers	Population groups requested for Medically Underserved Populations (MUP) designation should be those with economic barriers (low-income or Medicaid-eligible populations), or cultural and/or linguistic access barriers to primary medical care services.	DHHS (2013)

Among the various definitions of patient-centered care, Berwick (2009)'s is probably the most comprehensive: "The experience (to the extent the informed, individual patient desires it) of transparency, individualization, recognition, respect, dignity, and choice in all matters, without exception, related to one's person, circumstances, and relationships in health care" (p. w560). This definition points out key issues related to patient needs in use of medical appointment reminder system in the environment of patient-centered care.

Unlike the traditional appointment reminder systems, new interactive systems used in patient-centered care should be oriented toward enhancing patient experiences. The design of such systems must take transparency, individualization, recognition, respect, dignity and choice into account in order to enhance patient experiences (Goodman, 2004). Patients should not just receive reminders in a passive manner, but be able to actively manage their own medical

appointments. Active appointment management involves more than unidirectional communication from a provider to a patient, but two-way coordination between them to match their availability.

In addition, system accessibility is a key issue for medical appointment reminder systems. The definition of patient-centered care stresses the importance of service accessibility with the term “without exception”. Medical appointment reminder systems can be implemented with different technologies, which vary in their accessibility. To receive telephone and email reminders, patients have to subscribe to landline and/or Internet services. However, a large proportion of people do not have telephones and computers at home due to various factors such as income, age and skill (Chinn & Fairlie, 2006). On the other hand, the population penetration of mobile telecommunication technology is much higher, and above 90% of adults in USA have cell phones as of January 2014 (Brenner, 2013). Compared to expensive and sophisticated smartphones, even basic cellphones can use short message service (SMS), making it an ideal mobile technology in healthcare to enhance digital inclusion in the era of patient-centered care (Krishna et al., 2009; Roblin, Houston, Allison, Joski, & Becker, 2009). Thus, SMS is preferred in the development of medical appointment reminder systems accessible to most patients.

In the investigation of the relationship between patient-centered care readiness and health digital inclusion, researchers suggested that the health information technology used in patient-centered care has to cater to three basic needs of patient users: health information access, communication and coordination, and choice and empowerment (Sun et al., 2013). In the case of appointment reminder systems, health information access pertains to the personalized reminder messages sent through the channel most accessible and convenient to patients. Compared with telephone, postal and email channels, users can receive SMS messages instantly without much

physical constraints (e.g. close to a computer) and social interruptions (e.g. taking a call in a meeting).

However, the current SMS-based mobile appointment reminder systems only allow unidirectional information access. That is, patients can only receive reminders of existing appointments and cannot access other related scheduling information. Even though some systems allow patients to confirm or disconfirm appointments, their ability to communicate and coordinate with the clinics on appointment scheduling and management is very limited. Users are not given any more choices in the process, and they are far away from getting empowered.

A review of patient-centered care literature may provide some useful insights on the design requirement of mobile reminder systems. This study sampled the most cited publications using the keyword "patient-centered care" on Google Scholar. Then the full text was analyzed based on the main dimensions of patient-centered care. Based on the interview and survey with more than 8000 patient subjects, Gerteis (1993) identified eight dimensions of patient-centered care: 1) respect for patients' preferences, their values and self-expressed needs; 2) physical comfort; 3) emotional needs; 4) communication, information, education and explanation; 5) access to healthcare services; 6) continuity of care and follow-up; 7) involvement of the patients' family and friends in the care process and decision-making; and 8) coordination and integration of healthcare services. From the perspective of healthcare service, researchers also identified other closely related dimensions, including access, choice, shared decision, empowerment, quality, relationship, emotional support, and cost (Berwick, 2009; Reid et al., 2009; Reynolds, 2009).

Using the above-mentioned keywords, the articles in the pool were examined, as summarized in Table 2.6. Key words just mentioned by one or two articles were excluded, such

as physical comfort. The remaining keywords were reorganized into the 10 dimensions of patient-centered care: six related to service delivery (i.e., Information Transparency; Shared Decision; Choice and Preference; Patient Autonomy and Active Involvement; Emotional Support; Coordination and Integration of Care) and four related to the outcome (Quality of Care; Satisfaction; Patient-Provider Relationship; Cost).

Table 2.6 Patient-Centered Care Characteristics

Author (Year)	**IT**	**SD**	**CP**	**AA**	**ES**	**CI**	**Q**	**S**	**R**	**C**
Audet et al. (2006)	X	X		X		X	X			
Bardes (2012)	X	X	X							
Barry and Edgman-Levitan (2012)	X	X	X							
Bechel et al. (2000)	X	X					X			X
Bell (2014)	X									
Bergeson and Dean (2006)	X		X	X						
Bernabeo and Holmboe (2013)	X	X		X						
Bertakis and Azari (2011)	X								X	X
Berwick (2009)	X	X	X							
Charmel and Frampton (2008)	X			X	X		X	X		X
Cooper et al. (2003)	X	X	X					X		
Davidson et al. (2007)	X	X	X	X	X		X	X		
Davis et al. (2005)	X	X		X		X	X	X		
Epstein and Street (2007)	X	X		X	X				X	
Epstein (2000)	X	X	X				X		X	
Epstein et al. (2010)	X	X	X			X	X		X	
Epstein and Street (2011)	X	X	X	X			X		X	
Fiscella et al. (2004)									X	
Gerteis (1993)			X		X	X				
Hibbard (2004)		X		X						
Hibbard et al. (2004)		X		X						
Hobbs (2009)	X	X	X	X	X			X		
Hudon et al. (2011)	X	X		X	X		X			
Ignatavicius and Workman (2013)	X	X	X	X			X	X		
Jahng et al. (2005)		X		X			X	X		
Keirns and Goold (2009)		X	X				X			
Krumholz (2010)	X	X	X							
Laine and Davidoff (1996)	X		X				X			
Lambert et al. (1997)	X									
Maizes et al. (2009)		X	X	X		X				
Mallinger et al. (2005)	X							X		

Author (Year)	IT	SD	CP	AA	ES	CI	Q	S	R	C
Miles and Mezzich (2011)	X	X	X	X	X	X				
Oates et al. (2000)	X	X	X					X		
Physicians (2008)	X					X	X			
Piette et al. (2000)	X		X	X			X	X		
Ponte et al. (2003)		X	X	X			X	X		
Quill and Brody (1996)	X	X	X	X						
Rathert et al. (2013)	X		X	X	X	X	X	X		
Reid et al. (2009)			X		X	X	X	X	X	X
Reynolds (2009)	X	X	X	X	X		X	X	X	X
Robinson et al. (2008)	X	X	X	X			X	X	X	X
Roter (2000)	X	X	X	X	X		X	X	X	
Sacristán (2013)	X	X	X	X			X		X	X
Sepucha et al. (2004)	X	X	X				X	X		X
Shaller and Fund (2007)	X	X	X	X			X	X		X
Shanafelt (2009)							X		X	
Snyder and Neubauer (2007)	X		X			X	X		X	
Street and Haidet (2011)		X	X				X		X	
Sun et al. (2013)	X	X	X							
Wolf et al. (2008)							X	X		
Zolnierek and DiMatteo (2009)	X	X	X		X					
Total	**39**	**35**	**33**	**25**	**12**	**10**	**28**	**19**	**14**	**9**

Note: IT-Information Transparency; SD-Shared Decision; CP-Choice and Preference; AA-Patient Autonomy and Active Involvement; ES-Emotional Support; CI-Coordination and Integration of Care; Q-Quality of Care; S-Satisfaction; R-Relationship; C-Cost.

Half or more publications addressed information transparency, shared decision, choice and preference, patient autonomy and active involvement. Around one fifth of them covered emotional support, and coordination and integration of care. The most mentioned outcome variable is quality of care (55%), followed by satisfaction (37%), relationship (28%), and cost (18%). The design and validation of mobile reminder systems has to take such dimensions of patient-centered care service delivery and outcome into account.

2.3 Health Information Technology and Mobile Reminder Systems

Researchers found that health information technology is a critical contributor to the improvement of clinical outcomes (Garg et al., 2005) and the lowering of healthcare costs

(Hillestad et al., 2005). However, the development and diffusion of new health information technologies encounter tremendous difficulties, especially the resistance from users to adopt the systems, especially when developers do not take their needs and perspectives into account (Jha et al., 2009).

Health information technology is expected to enhance patient-centered care by facilitating patient-physician collaboration and personalized care (Burstin, 2000). Thus health information technology and patient-centered care are recognized as the two most important advents that have the potential to greatly improve healthcare service quality (Ventres & Frankel, 2010). In this era, the developers of new heath IT systems must incorporate user requirements from both patients and providers in system design and development.

In physician-centered care, most systems have been developed for use by healthcare professionals only. For example, the picture archiving and communication system (PACS) provides economical storage of and convenient access to medical images such as X-rays (Choplin, Boehme II, & Maynard, 1992), and computerized physician order entry (CPOE) allows physicians to use computers to enter medical orders for the treatment of their patients (Kuperman & Gibson, 2003; Sittig & Stead, 1994). They are systems used to facilitate the work flow of healthcare providers, rather than enhancing the experiences of users, especially patients.

Traditionally, health information technology is not a major focus in the field of information systems (Chiasson & Davidson, 2004). However, the end users of more and more health IT systems involve patients, and their needs and experiences must be addressed. This is the niche where the information systems field may play a bigger role as one of its major focuses is on user behavioral research. The researchers of the field call for the attention and support from

the community on the vibrant area of health information technology research (Romanow et al., 2012).

As one type of health information technology, mobile health reminder systems are by nature born for patient-centered care. Not only handhelds like cellphones are largely personal devices, but also mobile computing and wireless communication provide them ubiquitous capability for anywhere and anytime service delivery (Mihailidis & Bardram, 2006). For its convenience and accessibility, SMS is a common health information technology used for mobile reminder systems (Patrick, Griswold, Raab, & Intille, 2008). Researchers have examined the characteristics of mobile reminder systems from different aspects of such a technology, as shown in Table 2.7 and Table 2.8.

Table 2.7 Comparison of Media Characteristics for Appointment Reminder Systems

Characteristic	**Explanation**	**Literature Support**			
		SMS	Phone Call	Postal	Email
Immediacy	Message transmission in seconds	Coomes et al., (2011); Atun & Sittampalam (2006); da Costa et al. (2012); Lim et al. (2008); Gurol-Urganci et al. (2013)	High Atun & Sittampalam (2006)	Approximately 1-3 days Clark et al. (2011)	Dombkowski et al. (2014)
Storage/ Retrieval	Messages automatically stored for reading later	Coomes et al. (2011); Kaplan (2006); Atun & Sittampalam (2006)			Car & Sheikh (2004)
Privacy & Confidentiality	Only the recipient can view a message	Atun & Sittampalam (2006)	Low for fixed line and high for mobile phone Atun & Sittampalam (2006)		
Delivery Confirmation	Sender is sure that a message has been sent	Atun & Sittampalam (2006)		A confirmation may be required by the sender Clark et al. (2011)	Dombkowski et al. (2014)
Multiple Recipients Simultaneously	One message can be sent to multiple recipients at the same time	Coomes et al. (2011); Atun & Sittampalam (2006); Downer et al. (2005); da Costa et al. (2012)			
Mobility	Sending and receiving messages anywhere	Coomes et al., (2011); Atun & Sittampalam (2006); da Costa et al. (2012); Gurol-			

Characteristic	Explanation	Literature Support			
		SMS	Phone Call	Postal	Email
		Urganci et al. (2013)			
Cost	Low cost for sending a message	Booth (2005); Kaplan (2006); Atun & Sittampalam (2006); Downer et al. (2006); da Costa et al. (2012); Lim et al. (2008); Gurol-Urganci et al. (2013)	Low for fixed line and Moderate for mobile phone Atun & Sittampalam（2006)		Car & Sheikh (2004); Dombkowski et al. (2014)
Two-Way Communication	The recipient of a message can reply to the sender	Coomes et al. (2011); Booth (2005);			Car & Sheikh (2004); Clark et al. (2011)
Tailorable	Content of a message can be customized	Coomes et al. (2011); Atun & Sittampalam (2006); Downer et al. (2005); da Costa et al. (2012);			
Less Obtrusiveness	Recipients may choose to view a message later at a more convenient time	Kaplan (2006); Atun & Sittampalam (2006); Geraghty et al. (2008); Gurol-Urganci et al. (2013)			Car & Sheikh (2004)
Ubiquity	Wide population coverage	Coomes et al. (2011); Booth (2005); Kaplan (2006); Atun & Sittampalam (2006); Downer et al. (2005); da Costa et al. (2012); Lim et al. (2008); Kharbanda et al. (2009); Gurol-Urganci et al. (2013)			Hughes et al. (2011); Dombkowski et al. (2014)

Characteristic	Explanation	Literature Support			
		SMS	Phone Call	Postal	Email
Personal device	Cellphones are connected to individuals directly	Coomes et al. (2011); Booth (2005); Atun & Sittampalam (2006); Gurol-Urganci et al. (2013)			
Limited Text	Messages limited in length (160 characters)	Da Costa et al. (2012)			No limited in the length and format of email Car & Sheikh (2004)
Staff-intensive	Manual processing of messages from patients required	Downer et al. (2005); Downer et al. (2006)			
Low requirement for phone	Almost all cellphones can use the service	Atun & Sittampalam (2006); Downer et al. (2005); da Costa et al. (2012)			
Contact Stability	The contact address/ number is relatively stable				Car & Sheikh (2004)

Table 2.8 Advantages and Disadvantages of Different Appointment Reminder Systems

	Immediacy		**Store & Retrieve**	**Privacy & Confidentiality**	**Delivery Confirmation**	**Multiple Recipients Simultaneously**	**Mobility**	**Cost**	**Obtrusive-ness**	**Ubiquity**	**Automation**	**Low requirement for phone**
Postal Letter	Slow 1-3 days		Yes	Moderate To mailing address	Yes But at significant expense	Yes	Low	Moderate	Low	High	Less likely	N/A
Email	Moderate It depends on how often the email is checked		Yes	High Email address is more personal	Yes	Yes	Moderate Depend on how the person access their email.	Low	Low	Moderate	Possible	No
Phone Call	Fixed line	Immediate-Moderate Immediate-if picked up Moderate - if message left	No, unless a voice message is left.	Low Fixed phone number is pertained to a place	Uncertain Yes, if call answered. No if message left	No	Low	Low	Moderate	High	No	Yes
	Call to Mobile	Immediate-Moderate Immediate-if picked up Moderate - if message left	No, unless a voice message is left.	High Mobile phone is more personal	Uncertain Yes, if call answered. No if message left	No	High	Moderate	High	Moderate	No	Yes
Auto Phone Call	Call to Fixed line	Immediate-Moderate Immediate-if picked up Moderate - if message left	No, unless a voice message is left.	Low Fixed phone number is pertained to a place	No	No	Low	Low	Moderate	High	Yes	Yes
	Call to Mobile	Immediate-Moderate Immediate-if picked up Moderate - if message left	No, unless a voice message is left.	High Mobile phone is more personal	No	Yes	High	Moderate	High	Moderate	Yes	Yes

	Immediacy	**Store & Retrieve**	**Privacy & Confidentiality**	**Delivery Confirmation**	**Multiple Recipients Simultaneously**	**Mobility**	**Cost**	**Obtrusive-ness**	**Ubiquity**	**Automation**	**Low requirement for phone**
SMS	Immediate	Yes	High	Yes	Yes	High	Low	Low	Moderate	Yes	Yes
			Mobile phone is more personal device								
Face-to-Face (with a reminder card)	Immediate	Yes	High	Yes	No	Low	Low	N/A	N/A	No	N/A
			Direct to person								
Web System	N/A	Yes	High								
			Need login	Yes	Yes	Moderate	Low	Low	Moderate	Yes	No
Stand-alone Mobile System	Immediate	Yes	High								
			Need login	No	N/A	High	Low	Low	Moderate	N/A	No

Many characteristics of the health information technology used for mobile reminder systems pertain to user requirements in patient-centered care, such as accessibility, tailorability, cost, quality (i.e., promoting attendance and compliance), ubiquity, person-oriented, and privacy/confidentiality. Others are closely related to the characteristics of the particular media, such as immediacy, storage/retrieval, two-way communication, and unobtrusiveness. Thus the design theory of mobile appointment reminders in patient-centered care needs to be based upon the kernel theories from different fields, as discussed in the next chapter.

CHAPTER III

A DESIGN THEORY OF MOBILE APPOINTMENT REMINDERS

Reminders are widely used in modern societies to reduce no-shows, missed deadlines to prior agreed appointments for events in an individual's personal, work and social lives. In healthcare, appointment reminder is important to reduce the high rate of non-attendance to healthcare appointments (Koshy et al., 2008; Kunigiri, Gajebasia, & Sallah, 2014; Sharp & Hamilton, 2001). Appointment no-shows prevent patients from getting needed treatments and disrupt the operations of clinics and practices, leading to serious economic and public health consequences (Balikci et al., 2013; George & Rubin, 2003; Moore, Wilson-Witherspoon, & Probst, 2001).

There are different types of appointment reminder systems in healthcare which are marked by the communication media used. Reminders are delivered traditionally with postal mails and telephone calls, but email and cellular messaging have become popular means nowadays (Wei, Hollin, & Kachnowski, 2011). With reminder systems based on such electronic channels, providers set up medical appointments with patients and send out emails and/or text messages to patients in advance to remind them of the upcoming appointments (Car, Gurol-Urganci, de Jongh, Vodopivec-Jamsek, & Atun, 2012).

Electronic reminder systems are as effective as telephone reminders in reducing no-shows to medical appointments compared to no reminders, but are more cost-effective (Koshy et al., 2008; Leong et al., 2006). However, current reminder systems are designed as unidirectional

message delivery or have very limited user interactivity. In the evaluation existing appointment reminder systems in healthcare, researchers found that most systems send out reminder messages like the following: "You have an appointment with [clinic] on [date] at [time]. Please call [telephone number] ONLY if you cannot attend" (Downer, Meara, & Da Costa, 2005; Foley & O'Neill, 2009). Some reminder systems may allow users to reply to the reminder messages with confirmation, but users cannot go beyond such low interactivity. When there is a schedule conflict, a user has to call the office to reschedule an appointment. Therefore, the current reminder systems are limited in their capabilities to cater for users' needs.

Rather than just receiving reminders passively, many contemporary patients want to play a more active role. If a user cannot make a scheduled visit, for instance, the person may reschedule it by interacting with a reminder system without calling the office. This makes appointment management more cost effective for healthcare providers, as well as more convenient and flexible for patient users. This study proposes a design theory to guide the development of reminder systems that facilitate reciprocal process of appointment negotiation, including reminding, confirmation, cancellation, option giving and choice.

Why should researchers in information system (IS) field be interested in design of reminder systems that allow users to actively manage their appointments with healthcare providers? First, there are disturbing statistics that in 2011, healthcare spending in most of the 34 Organization for Economic Co-operation and Development (OECD) nations reached about 9.3% of GDP with the United States in particular recording about 17.7 % of GDP that equates to $8,508 per capita compared to an average of $3,322 for OECD nations (De La Maisonneuve & Martins, 2013). Second, IS scholars recommend that healthcare-related research should incorporate healthcare domain-specific contextual considerations to improve the impact of such

research beyond the IS discipline (Cho & Mathiassen, 2007; Klein, 2007). Romanow et al. (2012) noted that prior health information technology (HIT) studies that attract most attentions are those that directly incorporate healthcare contextual influences to extend IS theories and inform empirical analyses.

In addition to the potential of enhancing healthcare efficiency and effectiveness in practice, the development of a sound and applicable design may also contribute to design science research (DSR) with an effort to integrate behavioral theories, technical artifacts and practical contexts. Scholars suggest that design science research (DSR) can be as rigorous as behavioral research, and they provide guidelines for ensuring the rigor of DSR and strategies for increasing its impact (Gregor & Hevner, 2013; Hevner et al., 2004). This study follows these guidelines to enhance the rigor and impact of proposed reminder system design.

3.1 Research Background

3.1.1 Patient-Centered Care

Patient-centered care poses both a challenge and an opportunity for mobile reminder systems. As its definition by Berwick (2009) implies, the new trend of healthcare requires the considerations of transparency, individualization, recognition, respect, dignity, and choice in system design. Existing information systems (e.g. email-based) used for appointment reminding simply push messages to patients who at most have the options to reply with either confirmation or cancellation (Can, Macfarlane, & O'Brien, 2003; Chen, Sharman, Chakravarti, Rao, & Upadhyaya, 2008; Jibaja-Weiss, Volk, Smith, Holcomb, & Kingery, 2005; Roberts, Meade, & Partridge, 2007; Thomas, 2004). New systems need to give patients more control for enhancing their participation and experience in patient-centered care. This study proposes a design of

reciprocal reminder systems that consider patient empowerment. Rather than receiving reminders in a passive manner, patients are able to actively manage their own medical appointments through two-way negotiation with their providers.

In patient-centered care, service accessibility cannot be overemphasized, as the term "without exception" in Berwick (2009)'s definition indicates. Thus, the design of reciprocal reminder systems is not supposed to exclude certain patients. On one hand, the population penetration of mobile telecommunication technology is relatively high: for instance, over 90% of adults in the USA have cell phones (PEW, 2014). On the other hand, some reminder systems require the installation of applets on expensive and sophisticated smartphones (e.g. Clienttel Smartphone Reminder Applet), but not everyone has a smartphone. However, basic cellphones support short message service (SMS), making it an ideal mobile technology in healthcare to enhance digital inclusion in the era of patient-centered care (Krishna et al., 2009). Thus, SMS is preferred in the development of personal health records systems like appointment reminder systems that are accessible to most patients (Roblin et al., 2009).

Reciprocal reminder systems address the needs of patients in terms of access, coordination and choice by enabling two-way negotiation with providers on appointment management. For such a new class of systems, a sound design theory can provide essential guidelines on their implementation. Yet such a theory does not exist for reciprocal reminder systems, and there is a need to develop one based on the review of design science research.

3.1.2 Design Theory Approach

As the literature review in Chapter 2 indicates, one of the most important approaches of design science research is the development of design theories. Walls et al. (2004) divided design theory into two major components: a design product and a design process. Both of them are built

upon kernel theories and specify hypotheses and principles for designers to evaluate the IT artifact in question and its development process (Walls et al., 2004; Walls et al., 1992). The use of relevant IS theories is preferred, if possible, for the goals of IS serving as a reference discipline for others (Baskerville & Myers, 2002) and IS theories contributing to HIT research (Romanow et al., 2012).

The development of a design theory focuses on the specification of general system requirements based on the understanding of the relationships among developers, clients and users (Churchman, 1979). In the case of reciprocal reminder systems, the clients are healthcare providers who operate the systems, but the direct end-users are patients. The understanding of the provider-patient relationship is the key to a well-specified design theory.

3.2 Kernel Theories

As the literature review in Chapter 2 suggests, many design theories are based on multiple kernel theories to strengthen different design aspects from various perspectives. The design of mobile appointment reminders in patient-centered care requires the specification of electronic platform, communication process, and function provision. For each aspect of design, this study adopts a kernel theory, media synchronicity theory, media naturalness theory and stakeholder theory respectively, as shown in Figure 3.1. Media synchronicity theory facilitates the comparison of different electronic platforms to identify the optimal choice for mobile appointment reminders. Once the platform is determined, media naturalness theory can be used to guide the design of general communication process. The ultimate function design is based on stakeholder theory that provides a lens to examine different user requirements from patients and providers in patient-centered care.

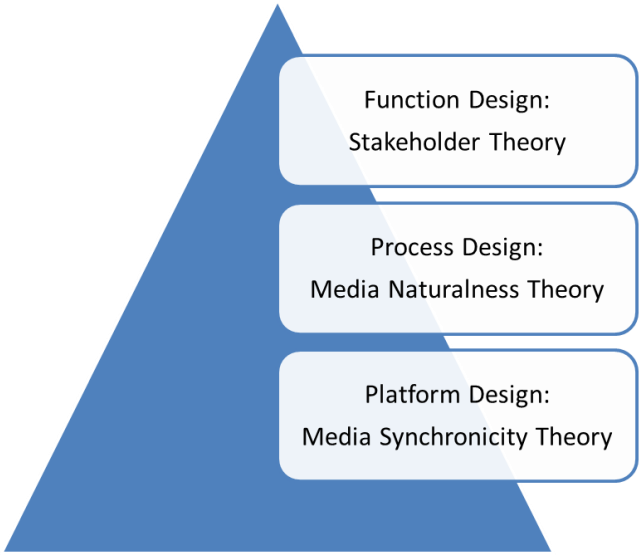


Figure 3.1 Design Levels and Kernel Theories

Electronic appointment reminding can be regarded as a computer-mediated communication between providers and patients. To better understand this type of communication, an examination of prior appointment reminders is helpful. Traditionally, providers mail or call patients to remind them of their upcoming appointments. Compared to direct face-to-face communications, both postal and telephone reminders are delivered through mediated channels. In this sense, they are comparable to the appointment reminders delivered through digital networks, such as emails and SMS.

The two traditional approaches vary in how synchronous the communications can be. Postal reminders are mostly dilatory and unidirectional: it may take days for letters and post cards to reach the recipients and many do not reply even if confirmation slips are included (Can et al., 2003). On the other hand, telephone reminders are largely immediate and bi-directional: patients communicate with providers verbally and may confirm the appointments or reschedule in a real-time manner. However, telephone reminder is interruptive: if a person is busy or away, he or she may not pick up the phone and the reminder effort may be simply ignored. Sometimes

the call may be transferred to voicemail, but it is uncertain when or whether actual retrieval happens.

Unlike postal and telephone reminders, SMS reminders are instantly delivered, and recipients may read them anytime at their convenience (Fjeldsoe, Marshall, & Miller, 2009). Thus, SMS reminders exhibit a level of synchronicity somewhere between postal and telephone approaches. In comparison with email reminders, SMS reminders do not require Internet access and account login. Rather, the reminder messages are pushed directly to cellphones. In this sense, SMS reminders are more synchronous than email reminders.

Media synchronicity theory can serve as a kernel theory from the IS field to address the synchronicity aspects of electronic media (Dennis, Fuller, & Valacich, 2008; Dennis & Valacich, 1999). This theory posits that media synchronicity is not a one-dimensional concept, but has multiple facets. The media capabilities that lead to different levels of media synchronicity can be classified into two general categories: transmission capabilities and processing capabilities (Dennis et al., 2008).

Transmission capabilities include transmission velocity related to the speed of delivery and parallelism related to the number of simultaneous conversation threads (Dennis et al., 2008). Processing capabilities include rehearsability related to whether it allows senders to fine tune a message during encoding and reprocessability measures the degree to which a medium allows a message to be reexamined during decoding (Dennis et al., 2008). In addition, symbol sets indicate the capability of a medium to encode a message in one or multiple modes (e.g. text, graph, voice, video) (Dennis et al., 2008). Such a capability plays a crucial role in both information transmission and encoding/decoding, and it belongs to both transmission and processing capabilities.

As shown in Table 3.1, existing appointment reminder systems vary in the transmission and processing capabilities. The transmission capabilities depend on the nature of media used. Velocity determines how fast messages are delivered between providers and patients. Postal reminders take days to deliver, but telephone, email, and SMS reminders are delivered with light-speed electric signals. Phone calls and text messages are directed to particular phone numbers, and users do not have to log into an account to access. Requiring Internet access and the use of smartphones or computers, email reminders are less directly accessible than telephone and SMS reminders, which explains why velocity of email is rated as moderate, whereas phone and SMS are high in this regard.

Table 3.1 Media Characteristics of Extant Medical Appointment Reminders

	Communication Medium			
Media Characteristics	Mail	Phone	Email	SMS
Transmission Velocity	Low	High	Moderate	High
Parallelism-Multiplicity	High	Low	High	High
Parallelism-Interactivity	Low	High	Low/Moderate	Low/Moderate
Rehearsability	High	Low	High	High
Reprocessability	Moderate	Low	Moderate	Moderate
Symbol sets	Low/Moderate	Low	Low/Moderate	Low

Parallelism has two dimensions related to: 1) the number of parties involved at the same time; and 2) whether the transmission is uni-directional or two-way (cf.Herring, 1999). In the context of medical appointment reminding process, the first dimension is related to whether the messages can be sent to multiple recipients simultaneously, denoted as “multiplicity”, and the second dimension concerns whether the recipients can reply to the messages through the same channel, denoted as “interactivity”. Unlike other media, telephone reminders are mostly handled in a one-to-one manner, leading to low multiplicity. Mail, e-mail, and SMS reminder messages can be sent in batches automatically (e.g. all reminders are sent out 2 days before appointments). The high multiplicity reduces the workload of providers.

In terms of interactivity, patients rarely send mails to confirm or cancel an appointment due to the inconvenience; rather they may choose to call providers on the phone, especially when they need to reschedule appointments. Therefore, mail is low and phone is high with respect to interactivity. Most email- and SMS-based systems require patients to call the offices if they cannot make the visits, though it is technically possible to respond to reminder messages. In this sense, such systems lack interactivity in design. Some SMS-based systems allow users to reply to the reminder messages but it is just mainly for the purpose of appointment confirmation or cancellation, and cannot be regarded as full interactivity either. For example, existing systems such as the Talksoft Automated Appointment Reminder Systems (talksoftonline.com) let users confirm or cancel appointments but rescheduling is still handled manually through callback.

The processing capabilities involve encoding and decoding of messages. For traditional reminder systems, it is clear that providers are the senders of messages and patients are the recipients. Rehearsability concerns message encoding by providers, and reprocessability deals with message decoding by patients. For providers, phone reminders from providers are not editable compared to written messages, and that is why phone is rated low on rehearsability while other media are rated high. When patients receive reminders, they can keep the records if the messages are delivered in writing, such as mail, email and SMS, rather than orally as in the case of telephone reminders. Nevertheless, the receivers cannot do much with the messages (e.g. editing and responding) other than bookkeeping. Thus, the reprocesability ranges between low for phone and moderate for the rest of the media.

Almost every media used for medical appointment reminding typically involves a single symbol set. For instance, mail, email and SMS use written text, and telephone uses verbal language. In some cases, providers may include graphics and tables in mail and email reminders,

but they are inconsequential. Thus, symbol sets is the capability that vary the least across different media.

According to media synchronicity theory, media of different levels of synchronicity facilitate different types of communication purposes in terms of conveyance and convergence. Conveyance refers to "the discussion of preprocessed information about each individual's interpretation of a situation, not the raw information itself", whereas convergence refers to "the transmission of a diversity of new information…to enable the receiver to create and revise a mental model of the situation" (Dennis et al., 2008, p. 580). One major proposition of media synchronicity theory is that communications for conveyance purposes usually require media of relatively low level of synchronicity, but communications for convergence purposes generally demand media of relatively high level of synchronicity (Dennis et al., 2008).

Appointment reminding process through media like mail and email can be regarded a communication process for conveyance purpose. That is, reminder messages convey the reminders from providers to patients; if a patient cannot make an appointment, the person need to call the office to reschedule it. In comparison, telephone reminders may also serve the convergence purpose by allowing patients to discuss rescheduling options with providers directly. As expected, telephone has a relative high level of media synchronicity compared to mail and email.

Most existing SMS-based reminder systems (e.g. doctorconnect.net, 1call.com, clienttell.net, and voiceshot.com) are also for the purpose of conveyance only as patients still have to call the office to reschedule appointments if needed. Even with two-way SMS (e.g. talksoftonline.com), patients may only choose one of the two options, confirm or cancel, and cannot reach an agreement on rescheduling appointments with the use of the same media. Mobile

appointment reminders in patient-centered care, on the other hand, need to facilitate both conveyance and convergence processes for collaborative schedule management between providers and patients.

The comparison of different media shows the relative advantages (or the lack of significant disadvantages) of using SMS as the technical platform for mobile appointment reminders. Yet platform design just lays the foundation for higher-level designs. For instance, the same technical platform may support various forms of communication. In the case of appointment reminders based on SMS, there are one-way and two-way approaches. In this sense, the identification of communication platform is just a necessary condition for the development of design theory.

Based on evolutionary psychology, media naturalness theory addresses how different approaches of electronic communication may lead to different levels of communication effectiveness (Kock, 2004). The main premise is that computer-mediated communication is the most effective when it mimics the face-to-face communication to which human brain has evolved to adapt (Kock, 2005b). In the design of electronic communication process, therefore, the burden is on the sender to make messages more human-like for the recipient (Kock, 2007). The theory's emphasis on the high importance of speech suggests that the naturalness of electronic communication largely depends on the degree to which in-depth dialogue is supported (Kock, 2004). Though electronic media may filter out important face-to-face communication elements, the sender can adapt the communication process in a relatively natural way to compensate for increased cognitive effort and communication ambiguity (Kock, 2009).

In addition to media characteristics (which media synchronicity theory focuses on), therefore, media naturalness theory emphasizes the design of electronic communication process

as well. Despite the lack of naturalness rooted in electronic media, human users may compensate for cognitive obstacles if the design allows for complex collaborative tasks (Kock, 2005a). How well individuals can adapt communication behavior to overcome inherited limitations, therefore, largely depends on process design. For mobile appointment reminders in patient-centered care, collaborative appointment management requires sophisticated design of communication process. A good communication design may greatly enhance the effectiveness of computer-mediated communication, even comparable to that of face-to-face communication (Kock, 2007).

Among different appointment reminders, the most natural is the phone reminder. Usually, it starts with a reminder message, followed by a question whether a patient can make the appointment or not. The recipients know that the other end is a person they can reason with. So if the answer is no, the patient is expected to be given other options among which the person can choose the one that fits his/her schedule. Existing one-way SMS reminder is the least natural in the sense that recipients cannot interact with the system. Even with the existing two-way SMS reminder, patients can only confirm or cancel appointments without the chance to negotiate alternative schedules. In contrast with such a limited interactivity, therefore, the full interactivity in human reminder process can be termed "reciprocity."

To enhance the effectiveness of mobile appointment reminders in patient-centered care, it is preferred that the communication process follows that of the phone reminder. That is, patients are able to confirm or cancel appointments, as well as negotiate new schedules if needed. Unlike phone reminder, however, minimum human intervention is needed on the provider side to save the labor cost. This requires that the SMS-based reminder system be able to generate adaptive

options for patients as if they are "talking" with clinicians on the other side. Such a design of communication process, therefore, can be described as "automated reciprocity."

Based on the platform design that allows both conveyance and convergence through SMS media, the process design enables higher-level function design for reciprocal appointment reminders. When different healthcare providers implement reminder systems, the general process of automated reciprocity remains the same. Yet the specific function design may vary depending on the situated requirements of different user groups. In patient-centered care, not only patients collaborate with physicians but also the administrators of healthcare organizations have to make sure that the activities meet regulatory requirements such as the Health Insurance Portability and Accountability Act (HIPPA). In this sense, patients, physicians and administrators are the stakeholders in patient-centered care (Lapointe, Mignerat, & Vedel, 2011).

Originally detailed by Freeman (1984), the stakeholder theory addresses the value-oriented relationships among the key players in an organization to align different interests of those groups. In short, the stakeholder theory attempts to address the "principle of who or what really counts". Gilmartin and Freeman (2002) extended the stakeholder theory to the field of healthcare and proposed several principles in terms of the needs to build integrative strategies that appeal to multiple stakeholders, unleash the power of innovation in healthcare delivery, and commit to ongoing regulatory reform. These principles are all relevant to the design of mobile reminder systems for patient-centered care.

The basic premise of stakeholder theory is that the identification of who and what really counts lays the foundation for balancing group interests to optimize their overall good (Mitchell, Agle, & Wood, 1997). It is consistent with the principle of patient-centered care to include patients as key players to participate in the shared decision making regarding their own health to

enhance overall healthcare service quality. The identification of the gap of interests among stakeholders is critical for healthcare reform and innovation as it leads to electronic health initiatives in patient-centered care (Samaras & Samaras, 2012). The use of information and communication technology (ICT) allows the integration of healthcare services to balance the needs of different stakeholders (Wee, Zhou, & Tayi, 2015).

For the use of mobile appointment reminders in patient-centered care, patients and providers comprise the two sides of equation. Whereas cellphones are the end-user devices for patient users, personal computers (PC) and/or tablets are the back-end devices for provider users to manage schedules. Yet not everyone on the provider side has direct access but clinician users including nurses, physician assistants and doctors. On the other hand, healthcare organization administrators overlook all operations including appointment management for service effectiveness. Thus, the stakeholders of mobile appointment reminders include patients, clinicians and administrators, who obviously have different needs.

For each stakeholder, there are also multiple needs that are not necessarily consistent with each other either. As shown in Table 3.2, the initial purpose of patient-centered appointment management points to the primary need of patients to meet situation flexibility: they prefer the provision of more options to cater for different situations. The communication process, however, may create a potential risk of privacy leakage. That is, someone else may accidentally or purposefully "eavesdrop" on the messages, and acquire patients' sensitive health information. Thus, the secondary need of patients is privacy protection.

Table 3.2 Needs of Stakeholders

Stakeholder	Primary Needs	Secondary Needs
Patient	Situation Flexibility	Privacy Protection
Clinician	Schedule Observance	Patient Retention
Administrator	Legal Compliance	Cost Effectiveness

For clinicians, the main purpose of appointment reminders is to help patients stick to their appointment schedules to make healthcare service management more predictable. Yet, making it too restrictive for patients leads to their total skipping of appointments when there are schedule conflicts. Considering the competition from alternative healthcare providers, patients may churn away due to inflexibility and inconvenience. To retain patients, clinicians want to give some leeway for patients to choose alternative slots if they cannot make the original. Schedule Observance and Patient Retention, therefore, are the primary and secondary needs of clinicians for mobile appointment reminders.

Whereas patients and clinicians are mostly concerned about individual appointments, the administrators of healthcare organizations care more about macro-level performances. Regarding mobile appointment reminders, legal compliance is the major concern, as appointment details such as place and purpose may be considered as protected health information (PHI) based on HIPAA. Potential violation can lead to expensive lawsuits and interruption of service operations. On the other hand, the saving of labor cost is the major economic motivation of automated appointment reminders in place of manual telephone reminders. Thus, legal compliance in terms of privacy concern and cost effectiveness in terms of labor saving comprise the primary and secondary needs of healthcare organization administrators.

Across different stakeholders, their primary and secondary needs may or may not be consistent with each other. In Table 3.2, the consistent needs are linked with straight lines, and

inconsistent needs are linked with double-headed arrows. As the primary need and secondary need of each stakeholder are somewhat contradictory to each other, the primary need of one stakeholder and the secondary need of another stakeholder are likely to be consistent, as between Situation Flexibility and Patient Retention, Schedule Observance and Cost Effectiveness, as well as Legal Compliance and Privacy Protection. Also, the primary/secondary need of one stakeholder is likely to be inconsistent with that of another, as between Situation Flexibility and Schedule Observance, as well as Privacy Protection and Cost Effectiveness.

In patient-centered care, for example, Situation Flexibility as the primary need of patients is conducive to Patient Retention as the secondary need of clinicians, but makes Schedule Observance as the primary need of clinicians somewhat more difficult. On the other hand, Privacy Protection as the secondary need of patients is consistent with Legal Compliance as the primary need of administrators, but the extra human involvement due to limited information disclosure may compromise the original purpose of Cost Effectiveness as the secondary need of administrators.

Clinicians and administrators, on the other hand, have mostly consistent needs as they share the same interest as healthcare providers. The differentiation between two helps identify different needs in stakeholder analysis. For the system design of mobile appointment reminders, however, they can be grouped together under providers as a whole.

3.3 A Reciprocal Approach of Appointment Reminder

The gap between patient requirement for self-management of health-related schedules and the limited capabilities of current appointment reminder systems calls for a new design. As aforementioned, SMS is the technology of choice for appointment reminder in patient-centered

care for the considerations of accessibility requirement. The current SMS-based reminder systems are limited in patient participation: users only passively receive reminders with little ability to manage their own medical schedules. In this sense, such systems do not truly meet the requirement of patient-centered care since providers exercise full control over patients in the reminding process.

This study proposes a design of SMS-based reminder system that enables patient users to actively manage schedules beyond just receiving alerts. A solution is to combine the functionalities of a reminder system and a scheduling system to enhance active schedule management for patients. This may reduce medical noncompliance, which is one of the primary factors that hinder effective disease control and prevention (Brown & Bussell, 2011). Patients missed scheduled activities mainly for two reasons: lapse of memory and conflict in schedule (Norris et al., 2014). Current appointment reminder systems provide a solution to the first issue, but hardly address the second.

For instance, a patient usually schedules a medical appointment a few weeks or months ahead of time, but may not be able to make it due to an unanticipated user priority event. When the person receives a one-way reminder under this circumstance, he/she can do little with it. The new design should give the patient rescheduling options for situation flexibility. The patient is likely to choose an available slot, and avoid the total skipping of the appointment.

Providers also benefit from the new approach. The basic reminder function enhances schedule observance of patients, and reduces no-shows that cause confusion and waste in terms of time and material set aside. Given other options, a patient is more likely to indicate the inability to come to an appointment rather than turning away from a reminder. Based on accurate information, providers can make better management of their schedules and associated resources.

Providing a “safe net” for patients in schedule management, the reciprocal approach is able to enhance patient retention for providers. Finally, the integration of scheduling and reminder systems may significantly reduce the cost for providers to manually communicate with patients and rearrange appointments.

Figure 3.2 depicts the general process design of the proposed reciprocal approach and compares it with existing approaches that are limited in user interactions. The process comprises of communication among three components: end-user device, reminder system and scheduling system. Patient cellphone is the main end-user device, and the reminder system communicates with it in form of text messages. Such communication is based on the information from the scheduling system.

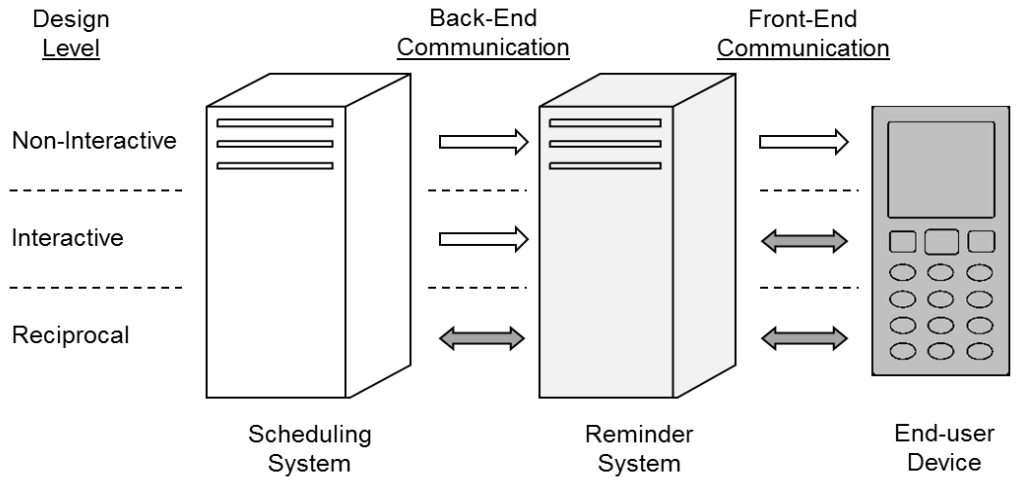


Figure 3.2 General Process Design

Physically, the scheduling system and reminder system can be separated on different computer servers or collocated on one machine. Nevertheless, they are functionally different: the scheduling system is basically a database server that handles schedule information, and the reminder system is a telecommunication server that directly interacts with end-user devices. This architecture is similar to that of Websites with both database and Web servers.

The non-interactive approach only allows one-way communication from the reminder system to patient cellphones in form of reminder messages. The existing interactive approach makes the front-end communication two-way by allowing patients to reply to reminder messages. However, the communication between the scheduling system and reminder system is one-way. The reciprocal approach further makes the back-end communication two-way, allowing patients to manage the data in the scheduling system through the reminder system.

3.4 Meta Requirements

The design of such a reciprocal reminder system needs to follow certain general requirements at different levels. This study groups such Meta design requirements into platform design requirements, process design requirements and function design requirements. At each level, the Meta requirements can be derived from the kernel theory in question, respectively: media synchronicity theory for platform design, media naturalness theory for process design and stakeholder theory for function design. The discussion leads to the formulation of design principles that guide the development of design artifacts.

3.4.1 Platform Design Requirements

The reciprocal reminder approach helps bridge the gap between healthcare providers and patient users on appointment management. On the one hand, providers want to minimize no-shows on scheduled appointments. On the other hand, some clients may not be able to make the appointments and have to reschedule for legitimate reasons. Unidirectional reminders cannot satisfy user needs from both sides. Some email- and SMS-based reminder systems require patients to send back confirmation massages. Though the communication is two-way, patients

still have to call back to reschedule appointments if they cannot make it. The optimum solution for both providers and patients is collaborative appointment management.

To facilitate the communication between providers and patients on appointment reminding, confirmation, cancellation and rescheduling, the SMS platform as the electronic media must provide sufficient communication capabilities. As per the media synchronicity theory, the delivery of reminding messages is for the conveyance purpose to inform patients of upcoming appointments. Meanwhile, confirmation and cancellation are also for conveyance purpose but of the opposite direction. On the other hand, appointment rescheduling requires a patient and a provider to reach an agreement on an alternative time. Thus, the two-way communication is for convergence purpose.

Thus there are two Meta platform design requirements for mobile appointment reminders in patient-centered care: 1) a system must enable message delivery for conveyance purpose; and 2) a system must enable schedule coordination for convergence purpose. The conveyance requirement is needed for all reminder systems to deliver reminder messages. The convergence requirement goes beyond the conveyance requirement for new reminder systems in patient-centered care.

3.4.2 Process Design Requirements

In patient-centered care, patients need more control on informed decision-making related to their own healthcare based on the options available (Davis et al., 2005). In the process of appointment rescheduling through phone calls, providers typically give patients some choices. At the beginning, a provider asks a patient whether he or she is available for the scheduled appointment. If not, the provider may give the next slot(s) available. If the response is still negative, the provider provides more options until they reach an agreement. However, this real-

time two-way communication is costly and time-consuming as a provider can only handle one patient at a time.

A reciprocal reminder system automates the negotiation process between providers and patients on appointment management. As shown in Figure 3.3, the two overall requirements are automaticity and reciprocity. The new system is able to engage in a back-and-forth negotiation with a patient user (i.e., reciprocity) without the need of actual human involvement (i.e., automaticity). This approach is consistent with the premise of media naturalness theory that the effectiveness of computer-mediated communication is enhanced when it mimics human-human interaction for collaborative tasks. The existing approaches, on the other hand, lack either reciprocity or automaticity.

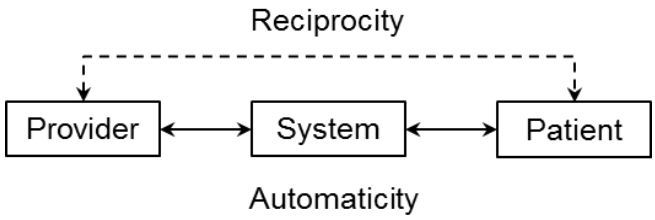


Figure 3.3 Overall Requirements of Automated Reciprocity

Iivari (2007) summarized the seven archetypes of information systems: 1) processor to automate; 2) medium to mediate; 3) tool to augment; 4) information source to informate; 5) game to entertain; 6) art to artisticize; and 7) pet to accompany. Compared with the last three hedonic archetypes, the first four utilitarian archetypes are particularly relevant to the practical application of interactive reminder systems. The purposes of automating, augmenting, mediating and informating reflect the views of technology as labor substitution tool, productivity tool, social relations tool, and information processing tool respectively (Orlikowski & Iacono, 2001).

The two process design requirements are directly tied to the first two archetypes. That is, automaticity corresponds to labor substitution, and reciprocity corresponds to social mediation such that users can negotiate appointment schedules through the reminder system. The next two archetypes are related to productivity and information access respectively. In patient-centered care, patient users want to make informed decision with the access to healthcare information directly related to them, while keeping the privacy concern under control. On the other hand, provider users want to enhance the productivity so that they can serve more patients by minimizing cost and no-shows, while ensuring legal compliance. Thus users and providers have different requirements specific to their own needs.

3.4.3 Function Design Requirements

A reciprocal reminder system must cater to the primary need of patients in terms of situation flexibility. To do so, it provides patients the information regarding existing appointments as well as available slots in case of schedule conflicts. With the information given, patients are able to confirm or reschedule appointments, and the system must allow a patient user to choose an alternative slot that works for the individual in the rescheduling process. As it is a process in which the user is given options to choose from in order to adapt to different situations, the first requirement of the new system from the patient perspective can be denoted as Situation Adaptivity. This requirement is mainly about patient access to alternatives: to reschedule an appointment, a patient wants to evaluate various options against a situation and choose the one that is the most suitable.

In addition to the adaptation to user situation, the new system design of mobile appointment reminders must take care of the privacy protection need of patients. Recipients of electronic reminders may not want others to know about their medical conditions. For instance,

when a person switches from one carrier or plan to another, the cellphone number is likely to change. If the individual does not update the information with a healthcare provider, an appointment reminder message may be sent to a wrong recipient. If a cellphone is misplaced or stolen, the information on it may also get leaked. To avoid possible privacy breaches, the reminder messages and subsequent communications should not contain protected health information (PHI), such as the location and purpose of a medical appointment. This enhances privacy protection for patients as well as legal compliance for providers. On the other hand, the design of a system is inconsiderate to patients if it reveals the details of their medical appointments in reminder messages. The second patient-side design requirement, therefore, can be denoted as Privacy Sensitivity.

On the provider side, design requirements are not necessarily consistent with those on the patient side. One of the primary concerns of providers is patient compliance, the extent to which preferred medical practices are followed (Miller, Hill, Kottke, & Ockene, 1997). In the context of medical appointments, patients need to come to clinics at the time scheduled based on their health conditions and previous treatments. This provider-side design requirement can be termed "schedule compliance". Some situations are more restrictive than others, for example: the tuberculosis (TB) skin test result should be checked within 72 hours. If a patient cannot make it to such an appointment, the reminder system should give alternative slots that are within the required time frame.

The Schedule Compliance requirement puts a limit on the number and scope of alternatives that a mobile reminder system should offer as providers are typically unwilling to give patients too much freedom. From the patients' perspective, however, they may prefer more choices based on the Situation Adaptivity requirement. In this sense, Schedule Compliance and

Situation Adaptivity constitute two opposite forces along the option dimension where the design of reciprocal reminder systems has to strike a balance on the appropriate range of choices.

Similarly, patients usually do not want mobile reminder messages to disclose too many details about medical appointments based on the Privacy Sensitivity requirement, but it may not be the case for providers. One motivation for providers to implement automated mobile reminders is to minimize expensive manual intervention in the appointment management process. If a reminder message is too simple and vague, a patient recipient may not recognize the source or recall the appointment made a few weeks or months back in time. The individual is likely to either ignore the messages or call the office for clarification, which compromises the purpose of automatic appointment reminders. Rather, providers want the messages to be concrete enough to convince patient users so that they can respond in a quick manner. This requirement on the provider side, Message Convincingness, locates on the other end of disclosure dimension from Privacy Sensitivity.

The relationships among the requirements specific to each user group is summarized in Figure 3.4. There are two dimensions of reciprocal reminder system design that are related to the options given and details disclosed respectively. Though patient-side and provider-side design requirements are somewhat contradictory to each other along those dimensions, they may reflect the common goals across different dimensions as patients and providers share the same overall interest in patient-centered care as well. In the top half, Schedule Compliance on the provider side along the option dimension and Privacy Sensitivity on the patient side along the disclosure dimension are for the common goal of Assurance as they help avoid potential troubles that may interrupt healthcare service. In the bottom half, Message Convincingness on the provider side along the disclosure dimension and Privacy Sensitivity on the patient side along the option

dimension are for the common goal of Convenience as they facilitate the collaboration between providers and patients for better appointment management.

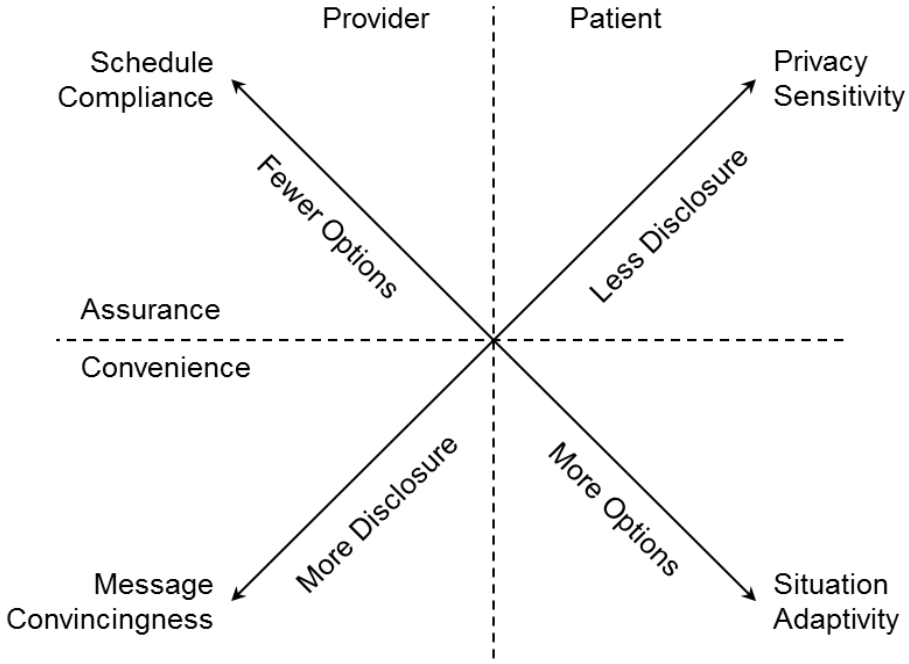


Figure 3.4 Patient- and Provider-Side Requirements

On the other hand, the extent to which provider-side requirements and patient-side requirements are contradictory to each other depends on particular contexts. For instance, when a medical condition is less sensitive (e.g. dental appointment), patients may not be concerned about the disclosure of appointment details, in contrast to a contagious disease. Therefore, the design of reciprocal reminder systems may adapt to different contexts in terms of the range of alternative choices and disclosure of appointment details.

3.5 Design Principles

The Meta requirements of reciprocal reminder system can be translated into a set of design principles in terms of needed system capabilities. First of all, the new design must

accomplish both conveyance and convergence purposes of collaborative appointment management in patient-centered care. That is, new reciprocal appointment reminders not only deliver reminder messages to patients but also allow them to reach new agreements with providers on alternative appointment schedules if they cannot make the original. The second overall design principle of reciprocal reminder systems is that they must support the mediated communication processes for collaborative appointment management in terms of automated reciprocity between patients and providers. These two overall principles on goals and processes have implications on the more specific principles to guide the design of reminder systems such that they cater to the needs of different user groups in appointment management.

Principle #1: Design to accomplish both conveyance and convergence purposes of collaborative appointment management in patient-centered care

Principle #2: Design to facilitate automated reciprocity processes between providers and patients

There are different design requirements of reciprocal mobile reminders in patient-centered care for providers and patients due to their different needs. Patients have Situational Adaptivity and Privacy Sensitivity requirements, and providers have Schedule Compliance and Message Convincingness requirements. Corresponding to each requirement, there is a more specific design principle.

Principle #3: Design to balance user requirements from both patients and providers

Situation Adaptivity allows patients to reach an agreement with providers on new appointments when there is a need to reschedule the existing ones. This is the key feature of reciprocal reminder system in patient-centered care. Patients are to be given a variety of options so that they can evaluate and select the best options that meet their schedules. From the

perspective of patients, this requirement helps them achieve the convenience goal. From the providers' point of view, however, the Schedule Compliance requirement constrains the range of options as healthcare-related activities need to be scheduled according to patients' health conditions and medical procedures. If patients are given "limitless" rescheduling options, Schedule Compliance is likely to be compromised. The encoding of messages, therefore, must place a certain limit on the options offered to ensure Schedule Compliance.

Principle #3a: Sufficient appointment management options are given for situation adaptivity to meet the patient-side convenience goal

Principle #3b: Limited appointment management options are given for schedule compliance to meet the provider-side assurance goal

The design of reciprocal reminder systems must strike a balance between patient-side situation adaptivity and provider-side schedule compliance requirements. It may adapt the way that options are given to different medical procedures and patient conditions. Take TB skin test for instance, options must be given within 72-hour window. Regular check-ups, on the other hand, allow more leeway. For most appointments, the extensions of one to two weeks may be acceptable. In case a patient is still undecided given all the options, the system may send a message explaining the importance of compliance and ask patients to choose from the given options to the best of their ability. Of course, patients can always call the office directly to ask for manual handling of special circumstances.

In addition to the option dimension, patients and providers have different requirements along the disclosure dimension. For patients, it is preferred that fewer details of their medical appointments are disclosed for the sake of privacy protection. For providers, more details would enhance message convincingness to help patients recall the appointments and believe in the

authenticity of messages. The balance between two forces facilitates the achievement of assurance goal for patients and convenience goal for providers in patient centered care.

Principle #3c: Limited disclosure of appointment information is made for privacy sensitivity to meet the patient-side assurance goal

Principle #3d: Sufficient disclose of appointment information is made for message convincingness to meet the provider-side convenience goal

In reciprocal reminder design, the initial reminder message may contain only limited information about an upcoming appointment, such as time. If a patient user wants to know more about the appointment, the person may request details of the appointment in another message with a certain passcode, such as the last four digits of social security number or telephone number on record. In this way, patients and providers may achieve both assurance and convenience goals related to information disclosure.

3.6 Design Artifacts

A reciprocal appointment reminder system comprises the hardware and software components of scheduling system and reminder system as shown in Figure 3.5. Providers use their computers and mobile devices to interact with the scheduling system through the Web Server to access the appointment information in the Database. Patients use their cellphones to interact with the reminder system through the GSM Modem (hardware device that send and receive short text messages) and SMS Gateway (software that operates the modem).

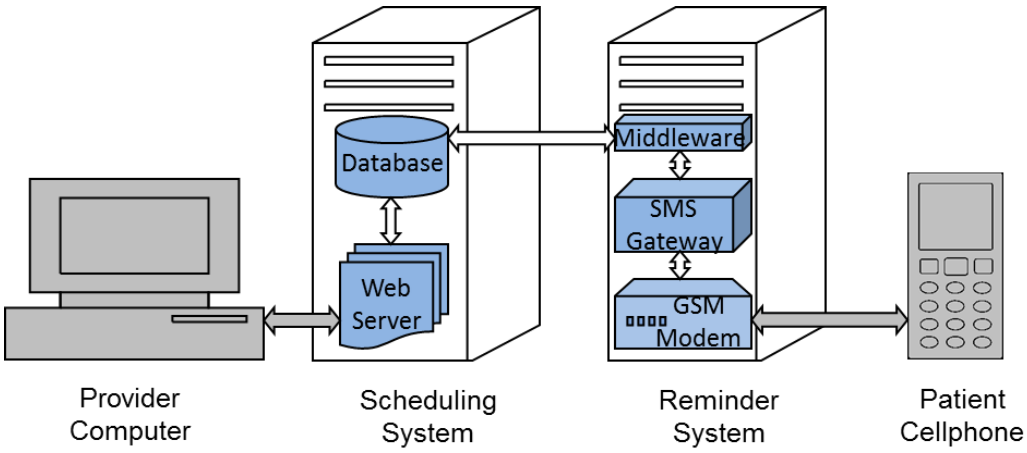


Figure 3.5 Major System Components

The middleware connecting the scheduling system and reminder system through Database and SMS Gateway is the main software component that implements the essential reciprocal reminder algorithms. The other software components including SMS Gateway, Web Server and Database as well as operating system are all free yet powerful open-source packages, as listed in Table 3.3. Together with the hardware including server machine and GSM Modem, they enable the system to meet both the convenience and assurance goals of appointment management in patient-centered care (Design Principle #1). The two-way information flows through all the components facilitate automated reciprocity processes between providers and patients (Design Principle #2).

Table 3.3 Software Components

Component	Product	Source	Capability
SMS Gateway	Kannel	kannel.org	>50 messages/second
Database	MySQL	mysql.com	8 million terabytes
Web Server	Apache	www.apache.org	>500 requests/second
Operating system	Debian	www.debian.org	Depending on hardware

The development of a reciprocal reminder system includes the programming of a middleware that handles user interactions in terms of message generation and reception. The

detailed design depends on the specific settings in which the system is used. In particular, the patient-side Meta requirements in terms of Situation Adaptivity and Privacy Sensitivity as well as the provider-side Meta requirements in terms of Schedule Compliance and Message Convincingness need to be considered. The middleware can be implemented with a high-level programming language like Python. Such a general-purpose language is widely used for scripting to generate dynamic content based on database access. The middleware so implemented generates reminder messages based on the schedule database, and updates it based on user feedback. Through the web server, providers can retrieve up-to-date schedule information.

Patients directly communicate with the reminder system through user interface, and different architecture designs lead to different interface designs shown in Figure 3.6. Non-interactive interface only displays a reminder message. Interactive interface gives users the options for confirmation or cancellation. Reciprocal interface enables deeper user-system dialogue that allows a patient to reschedule an appointment.

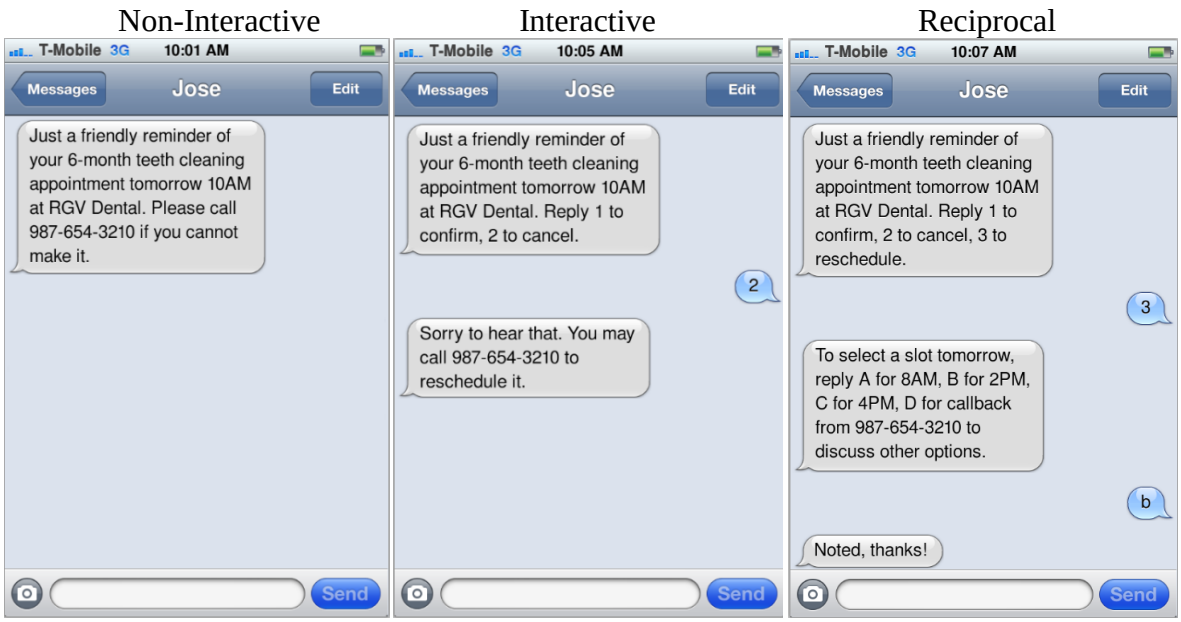


Figure 3.6 Comparison of User Interface Designs

The reciprocal interface design adapts processing capabilities to the requirements of each user group (Design Principle #3). In particular, a patient receives reasonable number of options to evaluate at a time in the process of appointment negotiation, which corresponds to Principle #3a regarding patient-side convenience to meet Situation Adaptivity requirement. A provider, on the other, provides a few available slots relatively close to the original appointment, which demonstrates Principle #3b in terms of provider-side Schedule Compliance requirement. In terms of appointment information disclosure, the sample screenshot illustrates that for a less sensitive medical appointment like teeth cleaning, more details may be disclosed, which pertains to Principle #3c regarding patient-side assurance to meet Privacy Sensitivity requirement. Meanwhile, the information disclosed helps the patient to recall the appointment made a long time ago and prevent the individual from ignoring the reminder or calling the office for clarification, which follows Principle #3d on provider-side convenience to meet Message Convincingness requirement.

3.7 General Design Methods and Testable Propositions

In addition to the design principles on the properties of an IT artifact, a complete design theory needs to address how to implement it in different contexts. For reciprocal reminder systems, specific requirements vary across different medical procedures and user preferences. For example, some diseases such as fast-developing cancers require narrow margin on the allowable options on alternative schedules due to their acute nature. Delaying the appointments may jeopardize patients' health. Other chronic diseases such as arthritis may not be as demanding. Therefore, the first general design method is that the design process needs to strike a balance between provider-side Schedule Compliance requirement and patient-side Situation Adaptivity requirement based on medical contexts. In addition, the preference and tolerance of information disclosure are also likely to vary across different circumstances. It is necessary to consult providers and patients for their opinions so as to balance patient-side Privacy Sensitivity requirement and provider-side Message Convincingness requirement. Figure 3.7 summarizes the design theory and illustrates how the general design methods are derived from Meta requirements and design principles.

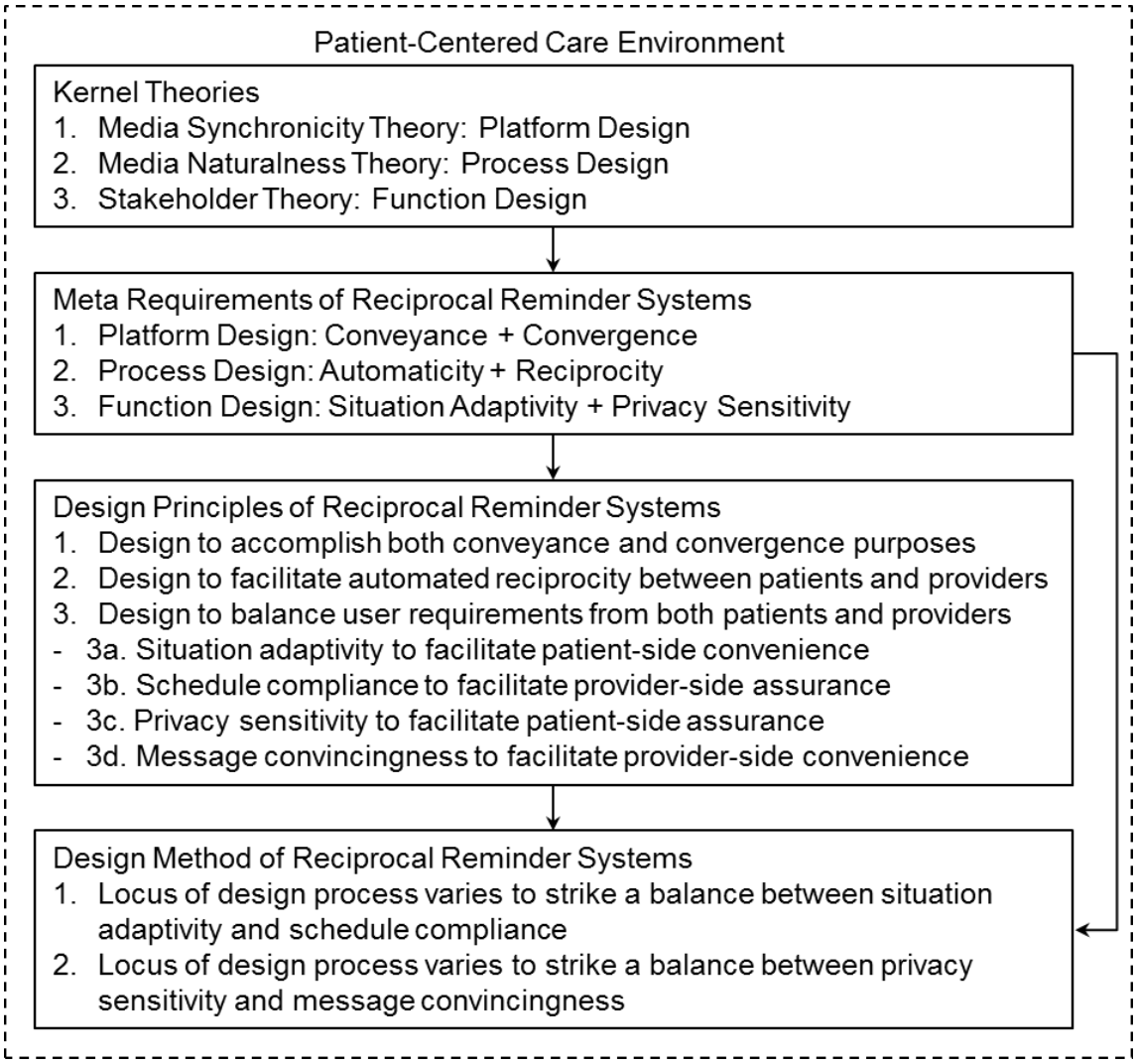


Figure 3.7 A Design Theory for Reciprocal Reminder Systems

Finally, a design theory should include a set of testable research propositions that predict whether the major design goals can be achieved with the implementation of the IT artifact in question based on the matching between meta requirements and design principles (Walls et al., 2004). Hence the following research propositions describe the relationships between the variation of design aspects and the effectiveness of appointment management.

P1 (platform design proposition based on media synchronicity theory): A reminder system designed to accomplish both conveyance and convergence purposes is more

effective than less comprehensive systems for collaborative appointment management in patient-centered care.

P2 (process design proposition based on media naturalness theory): A reminder system designed to facilitate automated reciprocity between providers and patients is more effective than less reciprocal systems for collaborative appointment management in patient-centered care.

P3 (function design proposition based on stakeholder theory): A reminder system designed to balance user requirements from both patients and providers is more effective than less balanced systems for collaborative appointment management in patient-centered care.

Empirical studies may test the propositions by comparing the outcomes of different designs in patient-centered care. Through the adjustment of Situation Adaptivity and Privacy Sensitivity, it is possible to examine the relationships between design features and user behavior. Chapter 4 discusses the psychological constructs that can be used to capture user behavior, and Chapter 5 describes an experiment that controls the design features to test their effects on psychological constructs.

3.8 Evaluation and Justification of Proposed Design Theory

This study proposes a design theory of a new class of reciprocal reminder systems in the context of patient-centered care based on kernel theories. The development of such a design theory integrates the understanding of user behavior, the design of technical artifacts and the context of healthcare practices. The Meta requirements are identified and the design principles are proposed for the implementation of reciprocal reminder systems. Furthermore, general design

methods and testable research propositions are developed to provide some guidelines on future empirical studies. Following the seven guidelines proposed by Hevner et al. (2004) to evaluate design science studies, Table 3.4 lists the responses of this study.

Table 3.4 Evaluation of Design Theory Development

Guidelines	Development Activities
Design as an artifact	This study develops both architectural and interface designs.
Problem relevance	The importance and relevance of the research problem are discussed.
Design evaluation	Testable propositions to evaluate design effectiveness in different user contexts are discussed.
Research contribution	A reciprocal mobile reminder system can assist both providers and patients to manage appointments in patient-centered care. The solution provides patients control over appointment scheduling, and releases workload for providers from manual processing. Based on SMS technology, the system is widely accessible and easy to use.
Research rigor	The design of reciprocal mobile reminder system is practically based on the requirement of patient-centered care and theoretically grounded on kernel theories.
Design as a search process	The proposed design is compared with existing reminder approaches (non-interactive, interactive) to retain their strengths and overcome their weaknesses. The design principles are proposed based on the general patient-centered care requirements and specific user requirements.
Communication of research	The design theory proposed represents an early attempt to present the design of reciprocal mobile reminder system to industry and academia.

The design theory may enhance patient participation in healthcare related to their medical appointments in the era of patient-centered care. Patient-centered care aims to improve the quality of healthcare services through the following seven aspects: 1) access to care; 2) patient engagement in care; 3) use of information technology to support care; 4) care coordination; 5) integrated care and smooth information transfer; 6) patient feedback; and 7) publicly available information on practices (Davis et al., 2005). The proposed design theory can enhance all the seven aspects to some extent. Therefore, the design theory meets its goals to enhance patient

experiences and health in medical services with the help of accessible and easy-to-use information technology.

The reciprocal approach combines scheduling functionality with reminding functionality, and streamlines information processing in patient self-management of medical schedules. The detailed designs can be adapted to various circumstances. For patients, such a system plays the role of “schedule advisor” rather than mere “alarming-clock”. Assimilation of such a system enhances the adherence of patients to medical appointments and interventions. For providers, the adoption allows them to keep track of medical scheduling and make informed decisions. Thus the new approach is likely to have positive impacts on patient wellbeing, provider efficiency, and service effectiveness.

CHAPTER IV

SUBJECTIVE CONSONANCE WITH MOBILE SYSTEMS

Like the proposed reciprocal appointment reminders, mobile systems based on wireless telecommunication technologies (e.g. 4G) and handheld devices (e.g. cell phone, tablet) are in the process of exponential expansion in their number, user base and market value (Turban, King, Lee, Liang, & Turban, 2015). The growth rate of mobile data service users has been 15 times faster than that of wired Internet users since 2008 (Jahns, 2013). In 2014, the number of mobile devices in use surpassed the global population of 7.2 billion, and worldwide penetration of mobile phones passed 50% (Kemp, 2015). In 2012, 44 billion mobile applications were downloaded, generating USD 12 billion revenue with these numbers expected to increase to 200 billion downloads and USD 64 billion respectively by 2017 (Portio, 2013).

The mobile application market is highly competitive as users have so many choices (Rakestraw, Eunni, & Kasuganti, 2013). As people can easily switch from one application to another, the investigation of mobile system adoption remains a challenging yet important task for researchers (Kranz, Murmann, & Michahelles, 2013). Compared with other traditional information systems used in organizations, mobile systems are based on personal devices, such as cellphones, smartphones and tablets. Individuals have a wide range of choices due to the plethora of products available. This makes such mobile systems somewhat distinct from organizational systems that have been the main focus of information systems research. The

existing theories/models and their constructs are generally tailored to organizational systems rather than personal systems.

One construct that is particularly relevant to organizational systems rather than personal systems like mobile systems is subjective norm or social influence. In the field of information systems, subjective norm and social influence are used in theories and models such as the extended technology acceptance model (TAM2; Venkatesh & Davis, 2000) and the unified theory of acceptance and use of technology (UTAUT; Venkatesh et al., 2003). Such constructs capture the external influence from others on an individual's use of information systems.

Compared with organizational systems, the use of mobile systems may not be subject to external social pressures as much as internal value beliefs (Yang & Jolly, 2009). An individual's use and adoption of a mobile system may largely depend on whether it meets the person's preferences or not. For example, a user may reject a mobile system if the messages that it delivers or the rules that it implies contradict the person's beliefs. Such a normative influence from inside may play an important role in mobile system user behavior.

Based on the review of relevant literature, this study develops a psychological construct "subjective consonance" to capture the influence of internal normative beliefs on IS user behavior. In particular, it identifies the dimensions of content domain and develops measures for each. The construct and measurement are validated with empirical observations collected from mobile system users. It is expected that the construct conceptualization and operationalization enrich technology adoption research by taking the internal normative beliefs into account for the investigation of user retention in the mobile system market that is becoming increasingly competitive.

4.1 Theoretical Background

In the information systems field, subjective norm and similar constructs like social influence were adapted from theories in social psychology, especially theory of reasoned action (Fishbein & Ajzen, 1975) and theory of planned behavior (Ajzen, 1991). Subjective norm in these seminal theories is generally defined as the perceived social pressure to conduct a certain behavior or not (Fishbein & Ajzen, 1975). In the information systems field, subjective norm was first included in TAM2 and conceptualized as a user's perception about using a system due to the influence of significant others (Venkatesh & Davis, 2000).

Researchers found that subjective norm may not necessarily apply to all information systems, especially personal systems (Lin & Bhattacherjee, 2010). In addition to such external normative beliefs, human behavior is also influenced by internal normative beliefs, such as the moral norm of being honest. Compared with the external subjective norm of which the source of influence is directly from relevant others, the internal normative beliefs are based on the value systems of an individual (Kelsen, 1991). Both external and internal normative beliefs are useful in explaining human social behavior, in addition to rational and procedural theories of beliefs (Khalil, 2011).

Compared with simple tools (e.g. hammer), information systems can have complex interactions with users through input and output interfaces (Bodker, 1989). Most mobile systems have very intuitive interfaces that allow users to interact with them in different ways other than mouse and keyboard, such as touching, tilting, speaking, and imaging (Nahavandipoor, 2014; Saffer, 2008). Some systems even "chat" with users with customized messages, and these dialogue systems are human-like as they may show affection as well as reasoning (Skowron, Rank, Świderska, Küster, & Kappas, 2014). When an individual uses such intelligent personal

systems, they may establish perceptions that are related to the social interactions among people, such as trust (Kelton, Fleischmann, & Wallace, 2008).

When people use mobile systems on their personal devices, therefore, they want to be treated fairly in terms of how well the systems fit their needs and preferences (Barkhuus & Polichar, 2011). In organizational behavior research, such a normative belief of fairness in social interactions is found closely related to perceived justice (Greenberg & Cropanzano, 2001; Lee, Pillutla, & Law, 2000). In fact, the concept of organizational justice is conceived as the "normative ideal" from the beginning (Greenberg & Colquitt, 2013, p. 4).

There has been a long history in management and sociology research that regard organizations as institutions in which employees have to abide by the rules and policies in carrying out their jobs (Zucker, 1987). In a similar way, once information systems are established, they regulate how users do things. In this sense, information systems have institutional characteristics and users are "social actors" that need to follow the rules in interacting with the systems (Kling & Iacono, 1989; Lamb & Kling, 2003). The examination of organizational justice dimensions, therefore, may provide insights on the internal normative beliefs involved in the use of information systems, especially mobile systems.

Researchers identified four types of organizational justice: informational, interpersonal, procedural, and distributive as shown in Table 4.1 (Cropanzana, Bowen, & Gilliland, 2007). Among them, distributive justice is associated with outcome. In technology adoption research, people's perception related to the outcome of using information systems has been conceptualized commonly as the perceived usefulness (Davis, 1989), satisfaction and performance expectancy (Venkatesh et al., 2003). Thus the distributive aspect of organizational justice is already considered in existing adoption literature.

Table 4.1 Aspects of Organizational Justice

Aspect	Expectations
Informational Justice	Sharing relevant information with stakeholders
Interpersonal Justice	Treating stakeholders with dignity, courtesy, and respect
Procedural Justice	Appropriateness of process in dealing with stakeholders
Distributive Justice	Appropriateness of outcome in dealing with stakeholders

The other aspects of organizational justice, however, have not yet been taken into account to explain people's intention to use information systems. Nevertheless, different justice aspects can find their corresponding concepts in the field of information systems. First, informational justice is closely related to the concept of transparency, which concerns the disclosure of relevant information to users so that they can make better decisions (Mitchell, 1998; Street & Meister, 2004). Affecting user productivity, the quality and amount of information shared with users largely depends on the design and implementation of information systems (Laudon & Laudon, 2004).

Interpersonal justice pertains to the concept of etiquette in information systems research, which also indicates the level of courtesy and respect exhibited on a technology platform to human users (Preece, 2004). Researchers found that the etiquette-related design of a system may make a difference in how users perceive their relationship with it, such as trust, just the effect of politeness on the relationship among people (Parasuraman & Miller, 2004).

Procedural justice is pertinent to the concept of workflow process in the information systems literature, which suggests that a system, once implemented, controls the procedures of how users do things (Zur Muehlen, 2004). Because of this, researchers suggest that system developers need to recognize the importance of process design to bridge the gap between people

and technology with the implementation of process-aware information systems (Dumas, Van der Aalst, & Ter Hofstede, 2005).

Researchers found that procedural justice and distributive justice that employees perceive in organizations are somewhat hard to be distinguished from each other as outcome largely depends on process (Colquitt, Conlon, Wesson, Porter, & Ng, 2001). Unlike an organization, an information system does not "decide" the distribution of resources, but rather facilitate user completion of tasks. To a user, therefore, the outcome associated with using a system is more of a task-related motivation than a normative belief associated with the system itself (Deci & Ryan, 2011; Mitchell, Gagné, Beaudry, & Dyer, 2012). On the other hand, informational justice and interpersonal justice can be grouped together under the umbrella term of interactional justice (Colquitt, 2001). In this sense, the normative beliefs associated with the interactions and procedures in dealing with an information system are likely to affect user adoption.

4.2 Construct and Nomological Network

The literature review suggests the need of a psychological construct to capture the internal normative beliefs involved in the use of personal information systems like mobile systems. Compared with the externally oriented subjective norm, such a construct may be labeled as "subjective consonance" to indicate how fair and well an individual feels being treated as preferred in the use of an information system. The research of organizational justice provides useful insights on the content domain of this construct.

As shown in Table 4.2, there are three components of subjective consonance: transparency consonance, process consonance and etiquette consonance, which correspond to the informational, procedural and interpersonal aspects of organizational justice, respectively. They

are also closely related to the information quality, system quality and service quality in the extended information system success model (DeLone & McLean, 2003). Transparency consonance concerns information disclosure and pertains to the information quality. Process consonance depends on how the system is designed to facilitate the interaction process with users, and is related to system quality. Finally, etiquette consonance indicates human-like characteristics that a system exhibits during its interactions with users and such characteristics are typically captured in information systems research with service quality that involves human-human interactions.

Table 4.2 Components of Subjective Consonance

Component	Root	Definition	Quality
Transparency Consonance	Informational Justice	The perceived degree to which a system shares sufficient relevant information.	Information
Process Consonance	Procedural Justice	The perceived appropriateness of interaction process with a system	System
Etiquette Consonance	Interpersonal Justice	The perceived courtesy and respect shown by a system.	Service

Though the three components of subjective consonance are all related to internal normative beliefs, they depend on different aspects of system design that are relatively independent from each other. That is, a system may perform pretty well in some aspects but not others. Therefore, subjective consonance is a formative construct in nature as its indicators are not necessarily consistent and interchangeable, unlike reflective constructs of which the indicators covary with each other (Petter, Straub, & Rai, 2007). On the other hand, transparency consonance, etiquette consonance and process consonance are reflective constructs by themselves as each comprises a single dimension measured with homogenous items. In this sense, subjective consonance is a "reflective first-order and formative second-order" higher-order construct (Diamantopoulos, Riefler, & Roth, 2008).

The central hypothesis of this study is that subjective consonance captures people's normative beliefs in using personal information systems like mobile systems in a more pertinent way than subjective norm. Thus, the nomological network that investigates the relationship between subjective consonance and system adoption can be based on an existing model that includes the subjective norm or a similar construct that captures external normative beliefs. One such model is the aforementioned UTAUT (Venkatesh et al., 2003), which includes the normative construct of Social Influence to predict behavioral intention together with effort expectancy and performance expectancy.

Figure 4.1 gives a nomological network of subjective consonance to test its predictive validity. This model is based on the core part of UTAUT comprising the direct effects of Performance Expectancy, Effort Expectancy and Social Influence on Behavioral Intention. In place of Social Influence, Subjective Consonance is used to predict Behavioral Intention related to the use of innovative personal mobile systems. Unlike the other two unidimensional predictors, performance expectancy and effort expectancy, Subjective consonance comprises three components: transparency consonance, etiquette consonance, and process consonance.

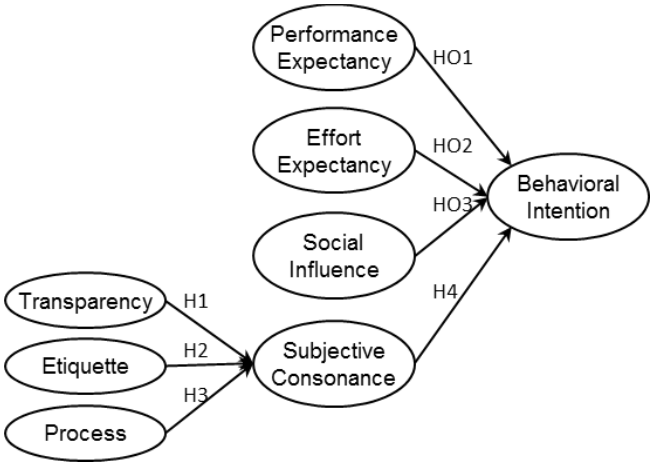


Figure 4.1 Nomological Network of Subjective Consonance

The relationship between subjective consonance and behavioral intention needs to be examined based on the existing studies of organizational justice. Researchers found that different aspects of organizational justice contribute to people's loyalty to an organization (Aryee, Budhwar, & Chen, 2002). In the same token, all the components of subjective consonance are likely to enhance a person's intention to adopt and stick to a mobile system for a relatively long period of time. Hence the main research hypotheses are as follows:

H1: Transparency consonance contributes to the formation of subjective consonance.

H2: Etiquette consonance contributes to the formation of subjective consonance.

H3: Process consonance contributes to the formation of subjective consonance.

H4: Subjective consonance has a positive effect on the behavioral intention to use a mobile system.

In order to examine the contribution of subjective consonance to the explanation of the dependent variable of behavioral intention, the effects of the other predictors, performance expectancy and effort expectancy need to be controlled as well. The next two research hypotheses are described based on UTAUT:

HO1: Performance expectancy has a positive effect on the behavioral intention to use a mobile system.

HO2: Effort expectancy has a positive effect on the behavioral intention to use a mobile system.

Regarding social influence, its effect on behavioral intention in the context of user behavior related to mobile systems may not be as salient as subjective consonance. Nevertheless, its relationship with the outcome variable is still hypothesized in order to compare the effect between that of subjective consonance.

HO3: Social influence has a positive effect on the behavioral intention to use a mobile system.

4.3 Methodology

To assess the construct validity and nomological validity of subjective consonance, empirical observations need to be collected from users of mobile systems. This section describes the methodology in terms of measurement, sample, procedure and analysis.

4.3.1 Measures

The three components of subjective consonance including transparency consonance, etiquette consonance, and process consonance are measured with the items developed based on the scales of informational justice, interpersonal justice and procedural justice used in the organizational justice studies (Paterson, Green, & Cary, 2002). Key words like "accessible", "respect", and "process" were adopted and the specific wording was adapted to the IS context. In addition, three items were developed to capture the overall subjective consonance. Following the recommended procedure to develop valid measurement (MacKenzie, Podsakoff, & Podsakoff, 2011), the initial items were reviewed by several experts in academia and practice, and minor changes were made based on the feedback. Then a pilot study was conducted to collect some preliminary data from student subjects to make sure that the response patterns were as expected.

Performance expectancy, effort expectancy, and behavioral intention are measured with the items in the original UTAUT study (Venkatesh et al., 2003). In addition, social influence measures are also included in the questionnaire for the comparison of explanatory power with subjective consonance. Table 4.3 gives the measurement items used in this study. The leading

statement for all subjective consonance questions read: “The system meets my preference in terms of…”

Table 4.3 Measurement Items

Construct	Items
Transparency Consonance	The system gives me all necessary options.
	The system makes information easily accessible to me.
	The system gives relevant information for my planning.
Etiquette Consonance	The system respects my rights as a patient user.
	The system is courteous and polite to me.
	The messages from the system are not intrusive at all.
Process Consonance	I like the process of using the system.
	My communication with the system works just as expected.
	The way in which the system works appeals to me.
Overall Subjective Consonance	I find the system fits my way of doing things.
	The system matches my personal preferences.
	The system functions the way I want it to.
Performance Expectancy	The system allows me to obtain what I want.
	I find the system useful.
	Using the system helps me get the job done.
Effort Expectancy	It is easy for me to use the system.
	Dealing with the system is straightforward to me.
	Using the system is not demanding at all.
Behavioral Intention	I predict I would use the system.
	I intend to use the system for appointments.
	I am hesitant to use the system.
Social Influence (Subjective Norm)	I am probably expected by others to use the system.
	Most people important to me may think I should try it.
	My friends/relatives would like me to use the system.

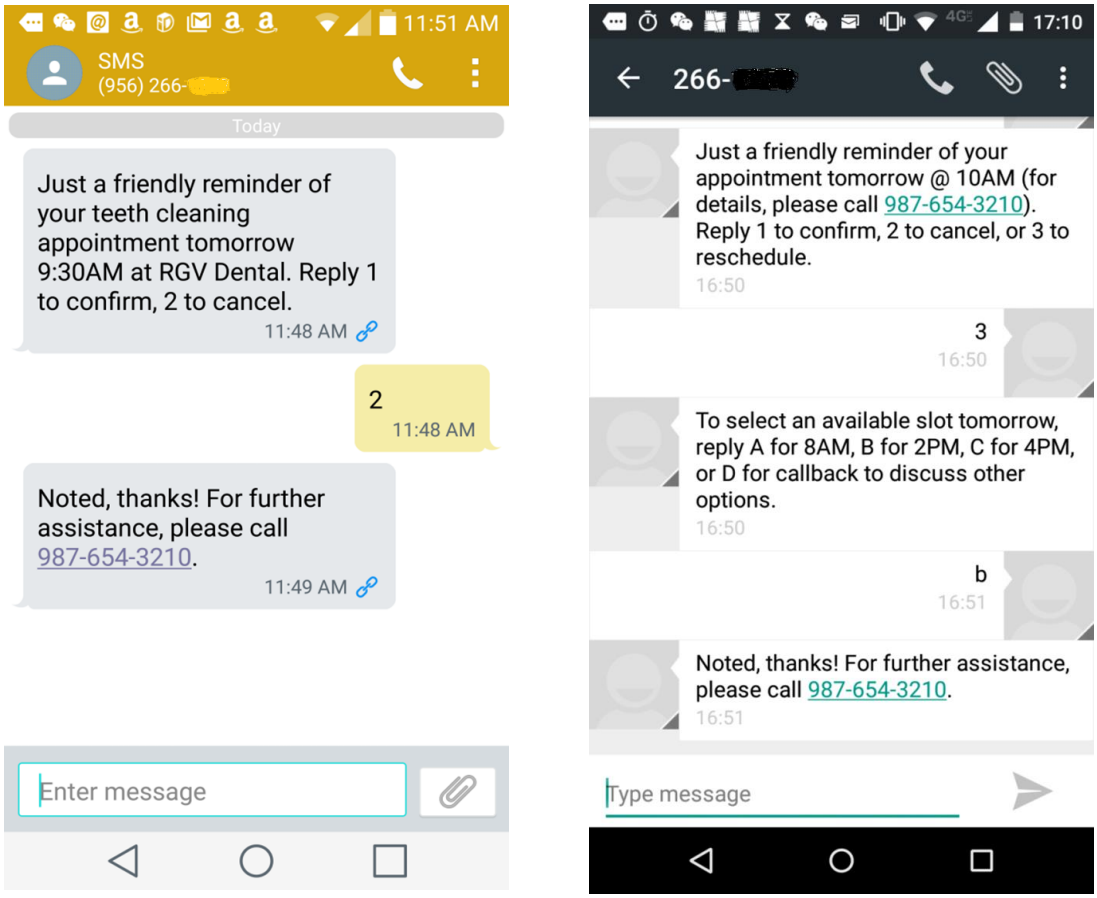
4.3.2 Subjects

The target population of this study comprises users of mobile systems. Most of the adults in the United States subscribe wireless telecommunication services with wireless penetration in

the country exceeding 104% as some own two or more cellphones (cf. Wireless Quick Facts at ctia.org). Almost all working professionals have cellphones, and use mobile systems and texting frequently (Thurlow & Poff, 2013). This study recruited graduate students enrolled in Master of Business Administration (MBA) and Master of Science in Health Sciences (MSHS) online programs, most of whom had full-time jobs. A filtering question indicated that almost all of them received medical appointment reminders previously by phone, email and/or texting. They were appropriate subjects of an empirical study to validate the subjective consonance construct. Together, 195 were recruited as voluntary participants. Considering the need to use factor analysis and other statistical analyses to validate the subjective consonance construct, the sample size of 195 should be sufficient.

4.3.3 Procedure

For measurement validation and model testing, this study collected empirical observations using system tryout and survey questionnaire. The scenario is that the dental clinic of an individual plans to replace existing SMS-based appointment reminders with new reciprocal mobile appointment reminders. To let participants have the first-hand experiences with both old and new systems, two demonstration systems were built, and Figure 4.2 compares their screenshots.



Existing System New System

Figure 4.2 Screenshots of Demonstration Systems

Based on the number given on the questionnaire instruction, each participant sent a text message "old" initiate the traditional appointment reminding process. The existing system's reminder message only gives two options: confirm and cancel. After completing the process, participants sent another message "new" to the same number. The new system, on the other hand, gives an additional rescheduling option. Participants were asked to try out the rescheduling option before answering the questionnaire. Their responses were based on their experiences with the new system in comparison to the existing one. The whole process took less than 10 minutes in most cases. Among the 195 responses, three were incomplete, leading to the valid sample size of 192.

4.4 Results

Based on the responses, the measurement validity of subjective consonance can be assessed. Measurement validity refers to whether a measurement instrument measures what it is supposed to measure (Cronbach, 1984). Table 4.4 reports the response patterns of each measure instrument used in this study. All items in the questionnaire were of the 5-level Likert scale, and the responses of participants were relatively positive with reasonable variability, as the mean scores were above the middle point of 3 and the standard deviations were around 0.6.

For an instrument to be valid, item responses should exhibit reasonable internal consistency as relevant items are supposed to measure the same concept (Nunnally & Bernstein, 1994). All reliability coefficients in terms of Cronbach alphas were above 0.7, indicating acceptance internal consistency among the indicators of each construct. Also supporting the convergent validity, all the values of average variance extracted (AVE) were above 0.5, which indicates that the explainable variance exceeds measurement error (Kerlinger & Lee, 1999).

On the other hand, discriminant validity concerns whether the responses to the items of different constructs are distinguishable, which can be assessed by comparing the square root of AVE and correlation coefficients associated with each construct. In this study, the smallest squared root of AVE was 0.85, larger than the largest correlation coefficient 0.72. This supported the discriminant validity of each construct, as the shared variance with other constructs did not exceed the shared variance among the indicators. Also as shown in Table 4.5, all factor loadings were greater than cross-loadings, confirming discriminant validity (Chin, 2010).

Table 4.4 Measurement Validation

Construct	Mean (SD)	α	AVE	V1	V2	V3	V4	V5	V6	V7	V8
V1: Transparency Consonance	4.36 (.52)	.82	.73	**.85**							
V2: Etiquette Consonance	4.28 (.66)	.88	.80	.55	**.89**						
V3: Process Consonance	4.29 (.57)	.86	.78	.57	.51	**.88**					
V4: Overall Subjective Consonance	4.20 (.68)	.87	.80	.47	.43	.60	**.89**				
V5: Performance Expectancy	4.41 (.60)	.85	.77	.63	.48	.59	.72	**.88**			
V6: Effort Expectancy	4.45 (.62)	.87	.79	.58	.45	.52	.49	.68	**.89**		
V7: Behavioral Intention	4.34 (.60)	.85	.76	.62	.51	.61	.61	.69	.57	**.87**	
V8: Social Influence	3.42 (.65)	.87	.80	.23	.13	.34	.29	.15	.27	.23	**.89**

Note: α - Cronbach's Alpha; AVE - Average variance extracted; All correlation coefficients were significant at the 0.05 level. The bold on the diagonal of correlation matrix indicates the squared root of AVE.

Table 4.5 Factor Loadings and Cross Loadings

Indicator	Performance	Effort	Social	Consonance	Transparency	Etiquette	Process	Intention
Performance 1	**.887**	.603	.184	.668	.548	.444	.577	.627
Performance 2	**.853**	.561	.055	.549	.575	.429	.403	.548
Performance 3	**.890**	.620	.140	.675	.558	.433	.577	.644
Effort 1	.666	**.914**	.208	.440	.560	.425	.479	.518
Effort 2	.624	**.901**	.295	.478	.527	.441	.530	.474
Effort 3	.529	**.859**	.220	.402	.483	.358	.389	.540
Social 1	.124	.224	**.864**	.268	.192	.190	.255	.213
Social 2	.109	.231	**.911**	.271	.139	.030	.289	.184
Social 3	.159	.264	**.912**	.228	.279	.121	.406	.226
Consonance 1	.635	.493	.151	**.885**	.469	.450	.512	.557
Consonance 2	.679	.448	.279	**.922**	.406	.345	.492	.546
Consonance 3	.625	.381	.331	**.875**	.407	.360	.627	.537
Transparency 1	.462	.396	.210	.314	**.823**	.447	.464	.495
Transparency 2	.589	.546	.230	.466	**.885**	.494	.535	.534
Transparency 3	.563	.538	.158	.422	**.854**	.515	.486	.582
Etiquette 1	.406	.432	.194	.350	.592	**.848**	.485	.429
Etiquette 2	.464	.437	.072	.353	.502	**.918**	.428	.502
Etiquette 3	.455	.365	.093	.441	.450	**.909**	.460	.445
Process 1	.561	.516	.381	.590	.550	.477	**.889**	.633
Process 2	.545	.430	.364	.566	.528	.464	**.911**	.499
Process 3	.465	.425	.168	.442	.451	.408	**.846**	.468
Intention 1	.585	.496	.232	.586	.498	.409	.537	**.895**
Intention 2	.637	.526	.222	.542	.598	.485	.558	**.915**
Intention 3	.596	.484	.156	.473	.555	.447	.503	**.809**

For subjective consonance, there are three subconstructs: transparency consonance, etiquette consonance and process consonance. To further examine their construct validity, a measurement model shown in Figure 4.3 was tested with confirmatory factor analysis (CFA). Compared with exploratory factor analysis (EFA), CFA is less subject to sampling error due to theory-based modeling (Kline, 1998). Model fit indices were at the acceptable levels. Chi-square statistic (χ^2) was 52.161 with the model degrees of freedom (*df*) at 24, leading to the ratio of 2.173 between chi-square and degrees of freedom (χ^2/df). The relative fit indices were above 0.90: non-norm fit index (NNFI) was 0.956, comparable fit index (CFI) was 0.970. The root mean square error of approximation (RMSEA) was equal to 0.078, below the 0.08 threshold. The factor loadings were higher than factor correlations, confirming convergent validity and discriminant validity for subjective consonance subconstructs.

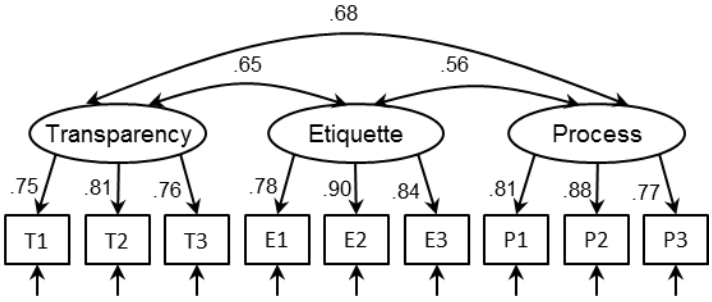


Figure 4.3 Measurement Model of Subjective Consonance Components

To examine whether transparency consonance, etiquette consonance and process consonance covers most of the content domain of subjective consonance, a multiple-indicators-multiple-causes (MIMIC) model as in Figure 4.4 was developed. In a MIMIC model, there are both formative and reflective indicators of a latent variable indicating its causes and effects (MacCallum & Browne, 1993). In the model, the latent variable subjective consonance has three formative indicators, corresponding to the index scores (i.e., average score of measures for each

construct) of transparency consonance, etiquette consonance and process consonance, and three reflective indicators, corresponding to the three measurement items of overall subjective consonance. As per rule-of-thumb cutoff criteria (Hooper, Coughlan, & Mullen, 2008), this model exhibited an acceptable goodness-of-fit (χ^2/df = 2.84; NNFI =0.952; CFI = 0.987; RMSEA= 0.098).

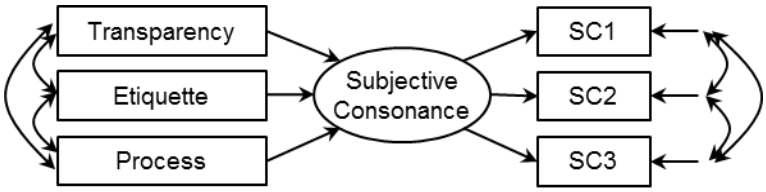


Figure 4.4 MIMIC Model of Subjective Consonance

The latent variable in the middle of MIMIC model is equivalent to the first-order canonical correlation function between its formative and reflective indicators (Bagozzi, Fornell, & Larcker, 1981). If the transparency, etiquette and process aspects of subjective consonance comprise its most important components, the first-order canonical function should explain the majority of covariance and make the second-order function insignificant. This study assessed the additional covariance explained by the second-order canonical correlation function as shown in Figure 4.5. There is supporting evidence that no other important aspects of subjective consonance are left out if the second-order function is insignificant.

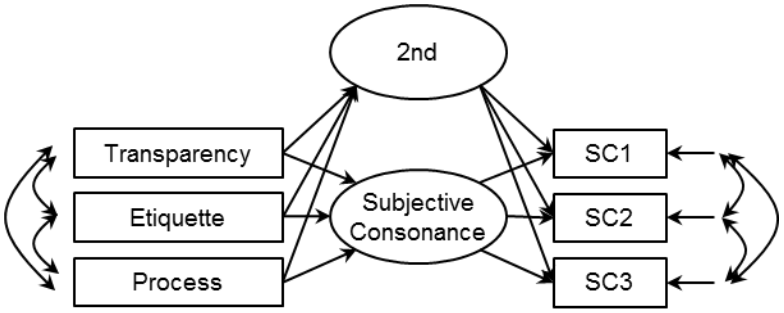


Figure 4.5 Second Canonical Correlation Function

The significance of each canonical correlation function can be evaluated with the chi-square difference test (Fan, 1997). The significance of first-order canonical correlation in Figure 4.4 can be tested against its null model, of which the chi-square statistic was 590.46. Then the second-order canonical correlation function in Figure 4.5 can be tested against the first-order canonical correlation. Though there is a third canonical correlation, it is not necessary to test the significance if the second-order canonical correlation is insignificant. In each test, the change in degrees of freedom was six, and the chi-square statistics for the first and second canonical correlation functions were 11.360 and 1.372 respectively. As shown in Table 4.6, the first canonical correlation function (1^{st} r_c) was highly significant, but the second canonical correlation function (2^{nd} r_c) was not significant. Thus Transparency Consonance, Etiquette Consonance, and Process Consonance can account for most of the variation in Overall Subjective Consonance.

Table 4.6: Significance Tests for Canonical Correlation Functions

Null Hypothesis	Difference in χ^2	Difference in *df*	P-value
1^{st} r_c=0	579.10	6	< 0.001
2^{nd} r_c=0	9.988	6	> 0.10

Once the measurement of subjective consonance is validated, the nomological network in which it predicts user intention to adopt a mobile system together with performance expectancy

and effort expectancy can be tested. Subjective consonance is a formative construct, and partial least square (PLS) is more capable to handle formative latent variables than covariance-based structural equation modeling (SEM) (Hair Jr, Hult, Ringle, & Sarstedt, 2014; Wetzels, Odekerken-Schröder, & Van Oppen, 2009). Model estimates can be benchmarked with those obtained from the default UTAUT model that includes social influence rather than subjective consonance. It is expected that the explanatory power of subjective consonance exceeds that of social influence for the case of innovative personal systems like mobile appointment reminders.

Table 4.7 Hierarchical PLS Estimates

Model	Baseline	Full	Simplified
Hypothesized Relationship\R-Square	.512	.581	.530
HO1: Performance Expectancy→Intention	.571**	.381**	.420**
HO2: Effort Expectancy→Intention	.159*	.067	.170**
HO3: Social Influence→Intention	.106*	.049	.068
H1: Transparency → Consonance	-	.393**	-
H2: Etiquette → Consonance	-	.394**	-
H3: Process → Consonance	-	.406**	-
H4: Consonance → Intention	-	.382**	.205**

Note: * - Significant at 0.05 level; ** - Significant at 0.01 level. Baseline - Model that contains only UTAUT core constructs as the predictors of behavioral itnention; Full - Model that includes the second-order construct of Subjective Consonance in addition to UTAUT core constructs; Simplified - Model that replaces the second-order construct with the first-order construct of overall Subjective Consonance.

To evaluate the effect of Subjective Consonance in a more accurate way, this study tests research hypotheses in a hierarchical manner as shown in Table 4.7. The first step is to enter the UTAUT constructs as control variables. All of them had significant effects on Behavioral Intention: Performance Expectancy was the most salient, whereas Social Influence was the least, with Effort Expectancy in the middle. Together, the independent variables explained 51.2% variance of the dependent variable. When subjective consonance constructs were added, an additional 6.9% variance was explained. Transparency Consonance, Etiquette Consonance and

Process Consonance made mostly even contributions to the formation of Subjective Consonance. Subjective Consonance, in turn, made the most difference in Behavioral Intention, even slightly more than Performance Expectancy. Due to the suppression of its strong effect, Effort Expectancy and Social Influence became insignificant.

In addition to the full model, the simplified model that replaces the second-order formative construct with the first-order Overall Subjective Consonance was estimated. Considering the weighing of measurement items for Subjective Consonance, the additional explanatory powers it brought were comparable between the two models. The three measurement items of Overall Subjective Consonance led to an *R*-square increase of 0.18, or 6% per item, compared to the *R*-square increase of 0.69 for 9 items in total for full model, or 7.67% per item. Unlike the full model, however, the inclusion of Overall Subjective Consonance mainly suppressed the effect of Social Influence but not Performance Expectancy and Effort Expectancy.

4.5 Discussions and Implications

To capture user normative beliefs related to the adoption of innovative mobile systems, this study develops the construct of subjective consonance in addition to the commonly used social influence in IS research. The premise is that the use of newly designed personal systems is more subject to the internal aspect of normative belief than the external aspect. Based on the organizational justice literature, it identifies the major components of subjective consonance: transparency consonance corresponding to informational justice, etiquette consonance corresponding to interpersonal justice, and process consonance corresponding to procedural justice. It also describes the research design of an empirical study to assess the construct validity and predictive subjective consonance.

Compared with social influence and other similar constructs that are externally oriented, subjective consonance indicates the consistency or gap between one's own value systems and perceived system characteristics. Such an internal normative belief is particularly relevant to the use and adoption of personal systems like mobile systems. As the mobile system market expands exponentially, there is a need to evaluate new designs from user perspective. Subjective consonance may provide some valuable insights to developers in addition to existing constructs.

The main challenge of capturing such internal normative beliefs is that they have multiple aspects, in contrast to the unidimensional construct of subjective norm. For such a multi-dimensional construct, its content domain needs to be comprehensive but not excessive to include irrelevant parts. This study conceptually cross-validates the three components of subjective consonance with information quality, system quality and service quality from the information system success model. In this sense, the construct development is cross-disciplinary in nature as it is based on social psychology and organizational behavior as well as different theories in information system research.

For a newly designed mobile system, potential users are not very likely to be affected by peers as few had the exposure yet. Rather, the normative influence mainly comes from inside. In this study, it is found that the Social Influence had a weaker effect on Behavioral Intention than Performance Expectancy and even Effort Expectancy (considering mobile reminder systems are relatively easy to use). When Subjective Consonance was added, Social Influence became insignificant. In the simplified model where Subjective Consonance was measured with the same number of items as other constructs, in particular, only Social Influence became insignificant. This suggests that the internal aspect of normative belief in terms of Subjective Consonance

plays a more salient role in the adoption of newly designed systems than the external aspect in terms of Social Influence.

Subjective consonance may provide researchers and practitioners further insights on people's adoption of personal systems like mobile reminder systems in the current competitive market. With similar choices available, users can easily switch from one system to another. The functionality and usability are now the basic requirements, but may not be adequate to retain users. Rather, fine-tuning the mobile systems based on user preferences and expectations can make a difference between success and failure. With the construct and instrument of subjective consonance, developers may look into transparency, etiquette and process requirements and enhance system designs. In this way, user adoption research may look into the IS "black-box" and inform system designs as recommended by Benbasat and Zmud (2003).

The two sets of measurement instruments of subjective consonance, the overall scale and the sub-scales in terms of transparency, etiquette and process, are complementary to each other and can be used for different purposes. If the main purpose of a study is just to assess the general impact of subjective consonance on user behavior, the overall scale is preferred as it is simpler. However, the three sub-scales are more useful when the main interest is to find out which aspect of system design can be enhanced in terms of transparency, etiquette and process. The results of this study suggest that the two measurement instruments yield similar but somewhat different results. On one hand, the overall construct of subject consonance is able to serve as a proxy of three aspects in terms of transparency consonance, etiquette consonance and process consonance. On the other, the overall measure does not provide in-depth insights as the sub-scales do.

CHAPTER V

MOBILE REMINDER DESIGN AND USER BEHAVIOR

Chapter 3 proposes a design theory of reciprocal reminder systems with a set of testable research propositions. These propositions concern different design features of reminder systems in terms of situation adaptivity and privacy sensitivity. In this chapter, the relationships between these design features and user behavior are investigated. As the reciprocal reminder system is designed for promoting patient-centered care, this study focuses on patient-side user behavior. The main rationale is that patients are the main end-users of such a system, and their intention to use it is a necessary condition for its adoption and diffusion.

To test the effects of different designs, an experiment was designed and conducted to control the aforementioned three design features. Based on existing information systems and behavioral theories, a research model is established to identify relevant psychological constructs and hypothesize the relationships among them. Collected from users in laboratory settings, empirical observations are used to test the hypothesized relationships and evaluate different designs.

5.1 Theoretical Background

The most well-known theory regarding the relationship between information systems characteristics and user behavior is the information systems success model (ISSM) by DeLone

and McLean. In their first model are two exogenous variables related to system design: system quality and information quality; they have direct effects on usage intentions and user satisfaction (DeLone & McLean, 1992). The authors later extended their model by including the third exogenous variable service quality (DeLone & McLean, 2003). For mobile systems like reciprocal appointment reminders, system quality is related to their hardware setup, whereas information quality and service quality are related to their communications with users.

Compared with the other well-known theory on user behavior, technology acceptance model (TAM) and related theories, ISSM includes the variables more closely related to the characteristics of information systems as exogenous variables. To study the relationship between mobile reminder system design and user behavior, it is important to include design features in the research model. Nevertheless, TAM and related models use the psychological constructs such as perceived ease-of-use and perceived usefulness to predict behavioral intention (Davis, 1989). This kind of theorizing is based on the psychological theories, especially Theory of Reasoned Action and Theory of Planned Behavior. Such models have achieved high predictive power of behavioral intention in terms of R-square around 30-40% (Venkatesh et al., 2003).

The Theory of Reasoned Action prescribes that attitude and subjective norm predict behavioral intention that leads to actual behavior (Fishbein & Ajzen, 1975). Later on, Ajzen (1991) added perceived behavioral control as the third variable to predict behavioral intention. The extended technology acceptance model (TAM II) included perceived usefulness, perceived ease of use and subjective norm as the core predicting variables, corresponding to attitude, perceived behavioral control and subjective norm respectively (Venkatesh & Davis, 2000). The later unified theory of acceptance and use of technology (UTAUT) includes performance expectancy, effort expectancy and social influence as the core model, corresponding to perceived

usefulness, perceived ease of use and subjective norm respectively, together with facilitating conditions at the organizational level and other control variables (Venkatesh et al., 2003).

Though the TAM, UTAUT and related models have exhibited high predictive power, they have been criticized for their largely exclusion of IT artifacts from the theorizing (Benbasat & Barki, 2007). However, the psychological approach may still be useful if the characteristics regarding information system design are taken into account. To examine the relationship between mobile reminder design features and user behavior, the research model in this study includes constructs related to both ISSM and TPB.

5.2 Research Model

Figure 5.1 gives the research model used in this study. In this model, there are three layers, design features, psychological antecedents and behavioral outcome. Design features and behavioral outcome are adapted from ISSM, and in between them, the psychological antecedents are extended from TAM, TPB and UTAUT. In particular, the design features of mobile reminder system include situational adaptivity and privacy sensitivity corresponding to service quality and information quality receptively. Rather than having direct impacts on behavioral outcome in terms of behavioral intention as ISSM claims, their relationships were mediated by psychological antecedents including performance expectancy, effort expectancy and subjective consonance, which are adapted from UTAUT.

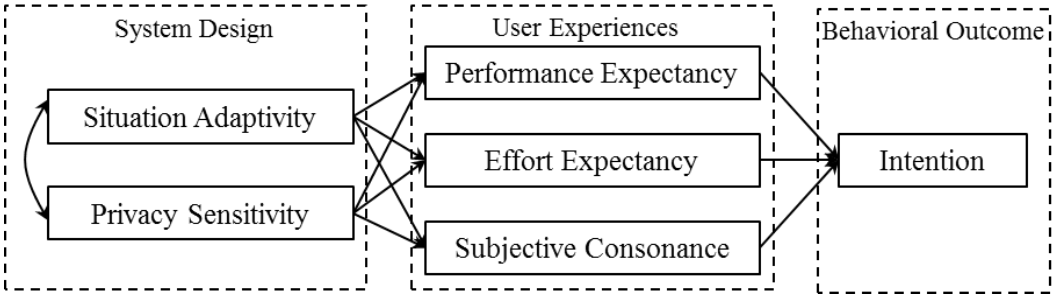


Figure 5.1 Research Model

Table 5.1 lists the components, their definitions, theoretical roots and operationalization approaches. Situation adaptivity and privacy sensitivity are design features that are to be operationalized as experiment treatments in the empirical study. Behavioral intention is the behavioral outcomes operationalized as the psychological constructs. Also operationalized as the psychological constructs, performance expectancy, effort expectancy and subjective consonance are the mediators between the design treatments and behavioral outcome.

Table 5.1 Model Components

Component	Definition	Theoretical Root	Operationalization
Situation Adaptivity	System provides options to accommodate user situations	ISSM: Service Quality	Design Treatment
Privacy Sensitivity	Limited information disclosure to protect user privacy	ISSM: Information Quality	Design Treatment
Effort Expectancy	Perceived demandingness to handle system usage	TAM: Perceived Ease of Use; UTAUT	Psychological Construct
Performance Expectancy	Perceived system helpfulness to facilitate what users want to do	TAM: Perceived Usefulness; UTAUT	Psychological Construct
Subjective Consonance	Perceived consistency between system design and user preference	TPB, TAM: Subjective Norm	Psychological Construct
Behavioral Intention	Perceived likelihood to use the system in the future	TPB, ISSM; UTAUT	Psychological Construct

Note: ISSM - Information System Success Model (DeLone and McLean, 1992; 2003); TPB - Theory of Planned Behavior (Ajzen, 1991); TAM - Technology Acceptance Model (Davis et al., 1989).

5.2.1 Design Features

Situation Adaptivity refers to the design feature that gives users options to choose for the accommodation of their different situations. This allows users of a mobile reminder system to "negotiate" with the system, rather than just passively receiving reminder messages from it (or simple choice between confirmation and rejection). It concerns the design of a system that makes it capable of providing alternatives and processing the feedback from users. Such a design feature regarding whether an system is able to adapt to user needs is closely related to the service quality in ISSM, which refers to the capability to provide desirable services based on user requests (DeLone & McLean, 1992).

Privacy sensitivity refers to the design feature that tailors information disclosure based on user privacy concerns. In the context of a mobile reminder system, this feature allows users to receive customized reminders based on the nature of their appointments. For example, some health conditions and interventions are more sensitive than others, and the reminder messages can be tailored to conceal some appointment information such as clinic and purpose. Such a design feature regarding whether a system is able to tailor message content to individual users is closely related to the information quality in ISSM, which is related to how information is produced and delivered to users by a system (DeLone & McLean, 1992).

Situation adaptivity and privacy sensitivity are human-like characteristics that allow a user to interact with a system as if he or she is communicating with another person. For mobile appointment reminders, situation adaptivity enables users to negotiate appointment schedules without manual intervention. Instead of calling a healthcare provider, a patient just needs to use the system to reschedule an appointment. The system retrieves current schedule information, provides the available slots and makes changes based on user choice. In addition, privacy

sensitivity limits information disclosure based on appointment nature, letting users feel that the system is considerate. Both design features are conducive to the service quality in ISSM, which is related to how system implementation, use and maintenance facilitates business operations (DeLone & McLean, 1992).

5.2.2 Psychological Antecedents

Performance expectancy indicates the perception of how the use of a system helps an individual achieve the goal that motivates the person to use the system in the first place. People use mobile reminder system to get informed of the upcoming appointment and take needed actions. How well the system helps them achieve the goal of appointment management has a direct impact on their future use of the system. Such a perception is originally captured by the construct of perceived usefulness in TAM and later renamed as performance expectancy in UTAUT (Venkatesh et al., 2003). In TAM's root theory TPB, the corresponding construct is attitude, defined as the degree of favor or disfavor toward an action. On one hand, perceived usefulness is a little bit too specific to the property of a system; on the other hand, attitude is a little bit too general. Performance expectancy comes somewhere in between as it implies whether the use of system is helpful for task accomplishment.

Effort Expectancy represents a user's overall perception of task demandingness during the whole process of using a mobile reminder system. It is closely related to the perceived behavioral control in TPB, which is well recognized as the psychological state that regulates human task-related endeavor (Ajzen, 1991). As a tool-mediated behavior, information system use actually comprises two actions: the action of using the system itself and the action of accomplishing the task with the system. In TAM and later UTAUT theories, the perceived behavioral control related to system usage is labeled as perceived ease-of-use and effort

expectancy respectively (Venkatesh et al., 2003). Whereas perceived behavioral control is more closely related to task accomplishment, perceived ease-of-use is more closely related to system usage. Meanwhile, effort expectancy captures both, making it appropriate for studying user adoption of mobile appointment reminder systems.

Subjective consonance refers to the perception of whether the use of a mobile reminder system is consistent with a user's preference. An information system, once implemented and used, imposes certain rules for users to follow (Orlikowski & Gash, 1994). Whether the implied rules are consistent with users' belief systems influence their use of the system (Melone, 1990). In TPB, the influence of such a belief system is captured with the construct subjective norm, which refers to perceived social pressure of whether or not a person is supposed to perform a behavior (Ajzen, 1991). For more self-oriented behavior, researchers found that personal norm in terms of internal standard based on internalized values or expectations plays a more salient role (Parker et al., 1995; Schwartz, 1977). In the adoption of an innovation, personal norm may play a more important role than social norm as the innovation is not well known to the majority of people (Jansson, Marell, & Nordlund, 2011). In this study of user behavior related to an innovative system like mobile reminder system, therefore, subjective consonance captures the normative belief involved.

5.2.3 Behavioral Outcome

Behavioral Intention is the most common behavioral outcome used in behavioral theories, such as TRA, TPB, TAM, UTAUT and related theories. It refers to how likely a person believes that he/she is likely to perform a behavior in the near future (Ajzen, 1991). In this study, it refers to how likely a person will use a mobile reminder system for upcoming medical appointments.

5.3 Research Hypotheses

Situation adaptivity is the design feature that enables a mobile reminder system to provide options for users to accommodate different situations. Users can confirm/reject appointments as well as rescheduling appointments if needed. When patients cannot make it to an appointment due to schedule conflict, the system gives alternatives to original appointments. This helps patient users to achieve the goal of using the system for better appointment management. This feature also gives them the ultimate control of the whole process by asking for and taking options. Catering to patient needs to negotiate appointment scheduling, the design is likely to meet user expectations. Hence the following hypotheses:

H1a: Situation adaptivity has a positive effect on performance expectancy.

H1b: Situation adaptivity has a positive effect on effort expectancy.

H1c: Situation adaptivity has a positive effect on subjective consonance.

Privacy sensitivity is directly related to the design of a mobile reminder system that tailors messages to patient privacy concerns. The customization is based on the understanding of user needs, which should also help them obtain the reminder messages in the way that they like. When a message contains information that a user does not want others to see, on the other hand, the person may worry about it and spend extra effort to delete it. Thus users expect mobile appointment reminders to be sensitive to their privacy concern. A system demonstrating such ability is likely to invoke sense of agreement from users. Therefore, the following relationships are hypothesized.

H2a: Privacy sensitivity has a positive effect on performance expectancy.

H2b: Privacy sensitivity has a positive effect on effort expectancy.

H2c: Privacy sensitivity has a positive effect on subjective consonance.

Situation adaptivity and privacy sensitivity may interact with each other in affecting user perceptions of a mobile reminder system. That is, there is likely a synergy between these two design features, leading to a "one plus one greater than two" effect. For instance, a user may be hesitant to use a system lacking privacy consideration anyway, even though it adapts to different situations. Thus, when both situation adaptivity and privacy sensitivity are present, a system is much more likely to get approval from users. Below are the related hypotheses.

H3a: The positive interaction between situation adaptivity and privacy sensitivity has a positive effect on performance expectancy.

H3b: The positive interaction between situation adaptivity and privacy sensitivity has a positive effect on effort expectancy.

H3c: The positive interaction between situation adaptivity and privacy sensitivity has a positive effect on subjective consonance.

As per UTAUT, performance expectancy and effort expectancy comprise the utility function leading to behavioral intention regarding the use of an information system. For a new design of mobile reminder system, on the other hand, the external regulation from social influence may not be as strong as the internal regulation from subjective consonance. If a user does not agree with the way that a system is implemented for use, the person may be hesitant to use it. Even if the individual uses the system for a while, the internal conflict may eventually lead to the switch to another system that is consistent with user preference. Thus the performance expectancy, effort expectancy and subjective consonance are the psychological antecedents to behavioral intention.

H4a: Performance expectancy has a positive effect on behavioral intention.

H4b: Effort expectancy has a positive effect on behavioral intention.

H4c: Subjective consonance has a positive effect on behavioral intention.

5.4 Methodology

This section describes the research methodology used for the empirical study to test the research model proposed in the previous section. First, it gives the measurement of each construct in the model. Then, it discusses the research design in terms of experiment treatments related to different designs of mobile reminder systems. The next section describes the target population and sampled participants. Finally, it discusses the statistical analyses of observations, including measurement validation and hypothesis testing.

5.4.1 Measurement

Most of the measures of the psychological constructs in the research model are adapted from previously developed and validated instruments for similar constructs. For those measures, there are of course some changes in wording to fit the context of this study. The exception is subjective consonance, for which the measurement scale is newly developed for this study. Table 5.2 lists all the measurement instruments and their sources. All the items are of the seven-level Likert scale (i.e., 1-strongly disagree, 2-disagree, 3-somewhat agree, 4-neutral, 5-somewhat agree, 6-agree, and 7-strongly disagree).

Table 5.2 Construct Measurement

Construct	Measurement Items	Source
Performance Expectancy	The system allows me to obtain what I want.	Davis, Bagozzi, and Warshaw (1989); Venkatesh et al. (2003)
	I find the system useful.	
	Using the system helps me get the job done.	
Effort Expectancy	It is easy for me to use the system.	Davis et al. (1989); Venkatesh et al. (2003)
	Dealing with the system is straightforward to me.	
	Using the system is not demanding at all.	
Subjective consonance	I find the system fits my way of doing things.	Self-developed
	The system matches my personal preferences.	
	The system functions the way I want it to.	
Behavioral Intention	I predict I would use the system.	Davis et al. (1989); Venkatesh et al. (2003)
	I intend to use the system for appointments.	
	I am hesitant to use the system.	

The measurement items of Performance Expectancy, Effort Expectancy and Behavioral Intention were adapted from TAM (Davis et al., 1989) and UTAUT (Venkatesh et al., 2003). Subjective consonance is a construct that captures the personal norm involved in the use of information systems. Its root construct in TPB is subjective norm, which is the perceived social pressure to engage in certain behavior or not (Ajzen, 1991). The extended models of TAM also capture such normative beliefs from external influences for information systems used in organizations (Venkatesh & Davis, 2000). For a new personal system introduced to patient-centered care like mobile reminder systems, however, the use is more subjective to internal normative beliefs than social influence. The personal norm construct and its measurement in the social psychology, on the other hand, capture the internal conflict due to the moral values (Parker et al., 1995).

In the study of information system user behavior, there is a need to develop measures of normative beliefs in terms of internal conflicts between value systems and the use of a system of a certain design. The newly-developed items captured both the positive aspect in terms of consistency between one's value system and rules implied by technology use, as well as the negative aspect in terms of conflict. The development and validation of subjective consonance measurement were discussed and described in the previous chapter.

5.4.2 Research Design

To test the research model, this study uses the experiment method as it is effective to maximize systematic variance due to treatments but control extraneous and error variance (Kerlinger & Lee, 1999). The experiment controls two design features: Situation Adaptivity (SA) and Privacy Sensitivity (PS). Each feature has two levels: low (0) versus high (1). The two-by-two factorial design leads to a total of four experimental treatments as shown in Table 5.3.

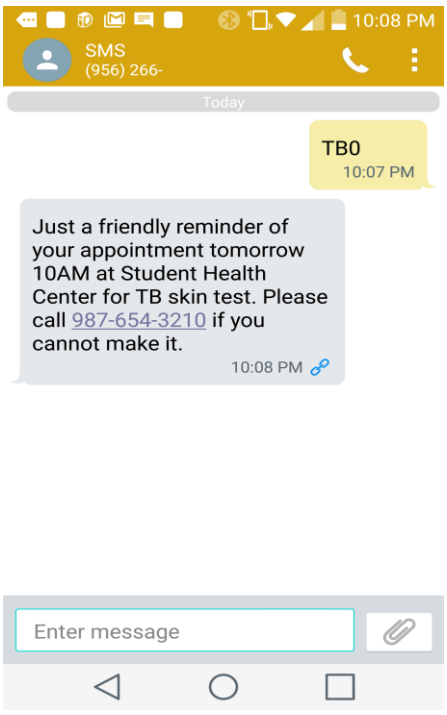
Table 5.3 Experimental Treatments

Design Features	Low Sensitivity	High Sensitivity
Low Adaptivity	A0S0	A0S1
High Adaptivity	A1S0	A1S1

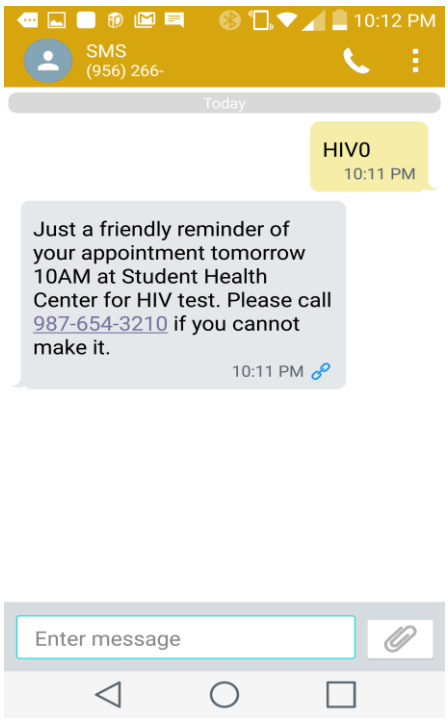
The experiment adopts the completely randomized design: participants are to be randomly assigned to one of the four treatment groups and get exposed to the corresponding system design. Meanwhile, each participant is put in two scenarios that impose different levels of privacy concerns: tuberculosis (TB) skin test versus human immunodeficiency virus (HIV) test. For each, a participant viewed the system design relevant to the scenario before answering the questions on Performance Expectancy, Effort Expectancy, Subjective Consonance and

Behavioral Intention. Thus there are two responses from each participant, one for each scenario, based on the same system design. To reduce the influence of possible learning effects, the scenarios were given to participants in a random order.

The baseline or control treatment (T0) is low on both dimensions. This simulates traditional reminder system that just sends one-way reminder messages to users as shown in Figure 5.2. Participants of the study use this treatment as a baseline with which other designs are compared to. For each question of the seven-level Likert scale (i.e., 1-7), participants are informed that the baseline design corresponds to the neutral point of four. For a design treatment given later, participants are supposed to give a higher rating if they believe that it is better than the baseline design in that aspect, or vice versa.



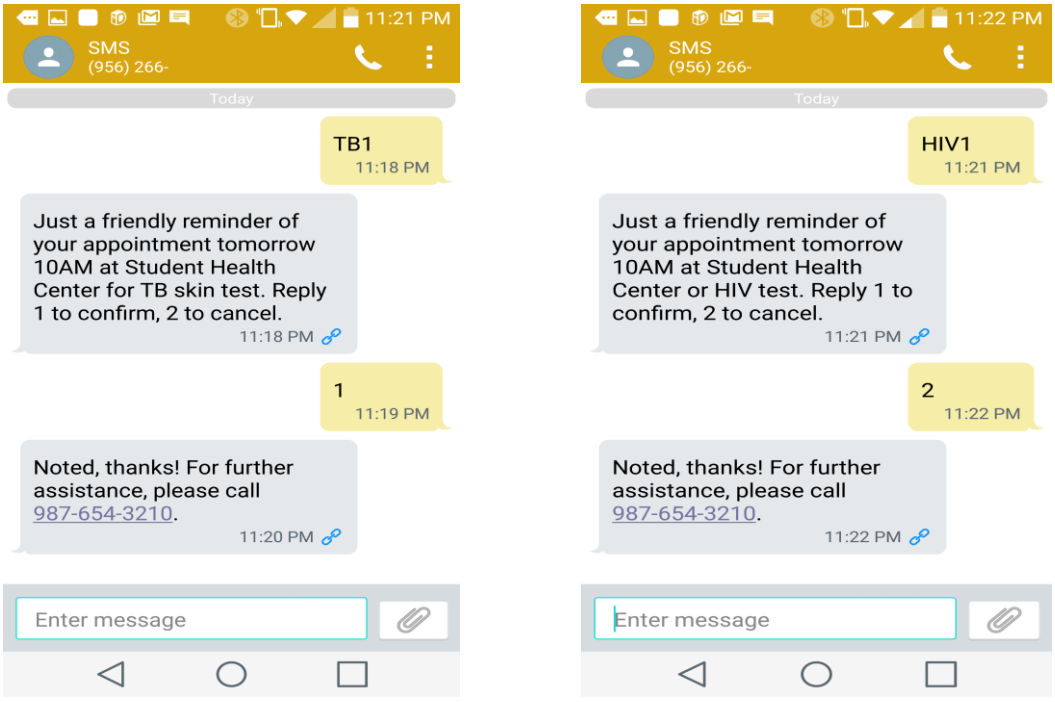
TB Skin Test



HIV Test

Figure 5.2 Baseline/Control Treatment (T0)

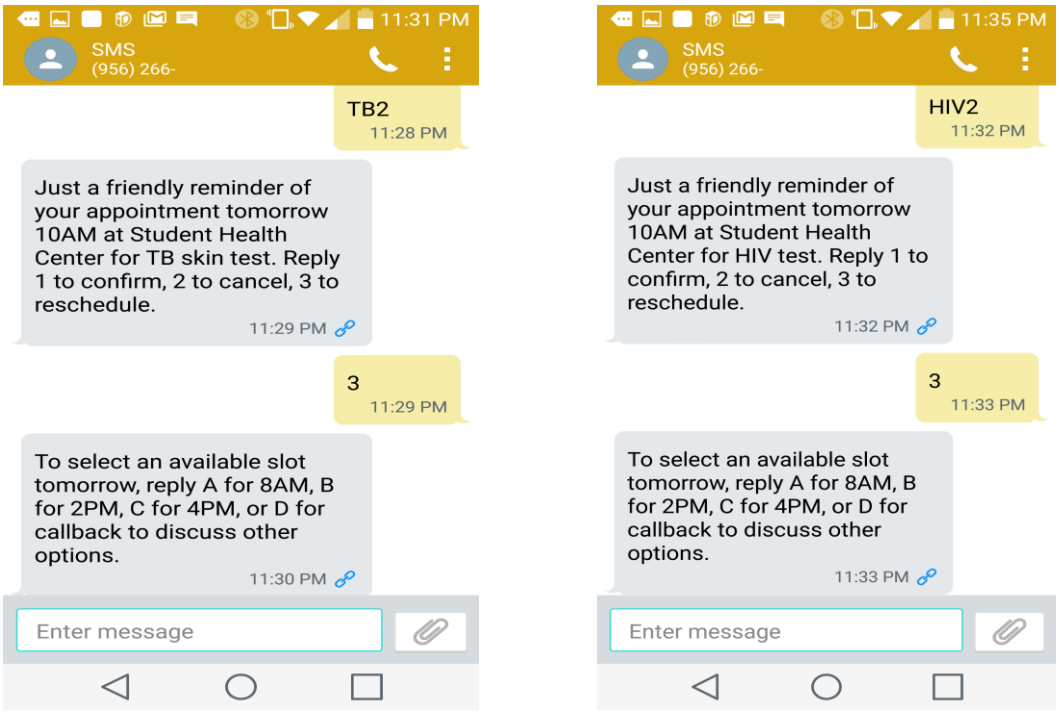
The first design treatment (T1) allows users to interact with the system, but is still low on situation adaptivity and privacy sensitivity. As shown in Figure 5.3, the design allows a user to confirm or reject an appointment. For mobile reminder systems, such interactivity provides the basis for situation adaptivity and privacy sensitivity. That is, high-level situation adaptivity and privacy sensitivity cannot be achieved if users are not given options to choose from. In this sense, the first design serves as the baseline for the other treatments.



TB Skin Test HIV Test

Figure 5.3 Design Treatment One (T1)

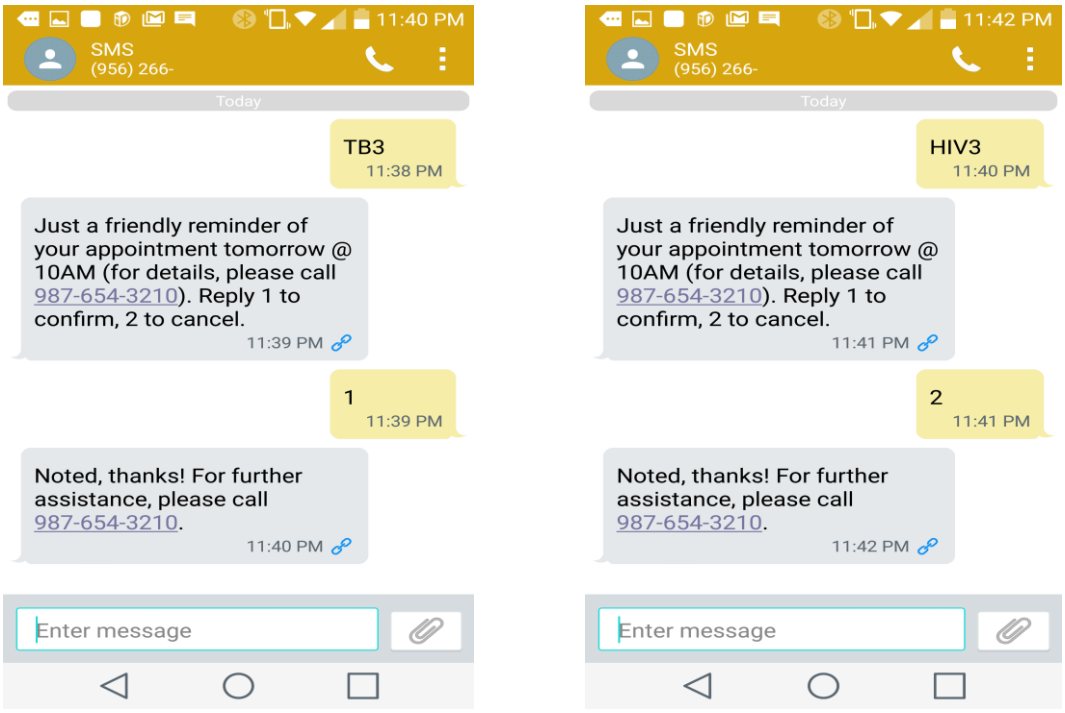
The second design treatment (T2) is high on situation adaptivity, but low on privacy sensitivity. As shown in Figure 5.4, the design gives a user the options of other slots available if the person cannot make the original. Rather than calling the office to reschedule, the user may just enter a number and the system confirms the new appointment time if the rescheduling is successful. Meanwhile, the design discloses appointment details, including appointment purpose and location. In this way, the effect of situation adaptivity on user behavior can be assessed.



TB Skin Test HIV Test

Figure 5.4 Design Treatment Two (T2)

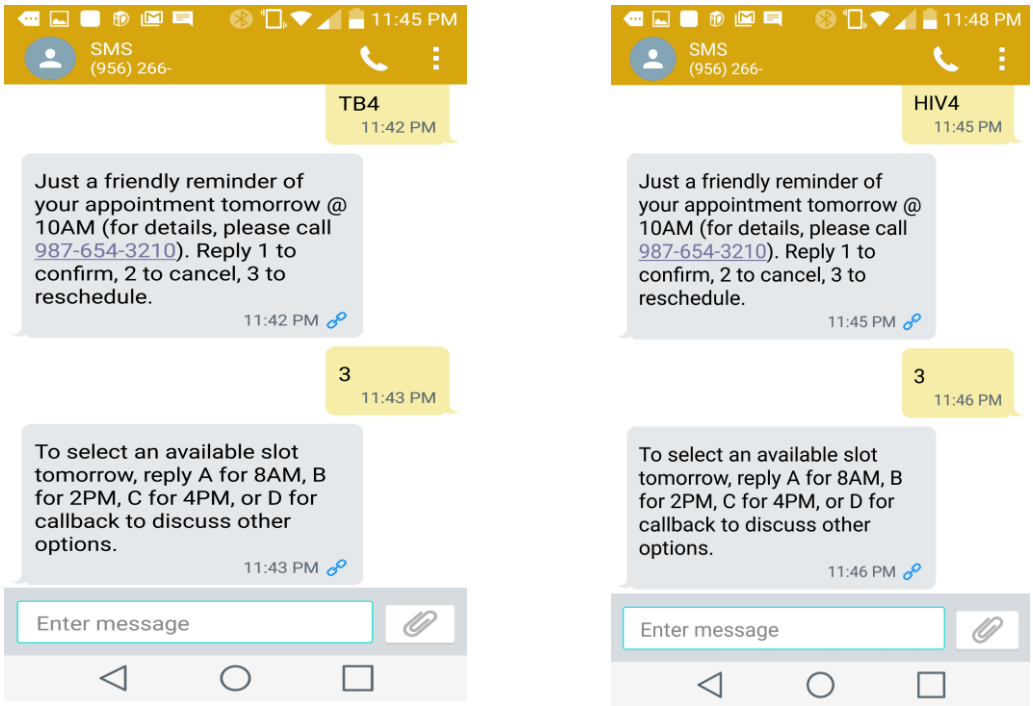
The third design treatment (T3) is low on situation adaptivity, but high on privacy sensitivity. As shown in Figure 5.5, the design conceals appointment details, including appointment purpose and location, in the initial reminder message to protect user privacy. If a user cannot remember what the appointment is for, there is a number through which he/she can ask for more details. That number is the only means for rescheduling appointment as users can only use texting for appointment confirmation and cancellation.



TB Skin Test HIV Test

Figure 5.5 Design Treatment Three (T3)

It is possible that situation adaptivity and privacy sensitivity interact with each other in their effects on user behavior. Testing such an interaction effect, the fourth design treatment (T4) is high on both situation adaptivity and privacy sensitivity. As shown in Figure 5.6, the design hides appointment details in the reminder message and allows users to reschedule appointments if needed.



TB Skin Test HIV Test

Figure 5.6 Design Treatment Four (T4)

To validate the treatments, a pilot study was conducted with 76 student subjects. They were assigned into two groups, 35 for the TB test scenario and 41 for the HIV test scenario. In either group, participants went through the four system designs and answered six questions of seven-level Likert scale after the exposure to each. As shown in Table 5.4, three questions were developed to measure perceived situation adaptivity and perceived privacy sensitivity, respectively. They are also used in the evaluation of final design later.

Table 5.4 Design Perceptions

Construct	Measurement Items
Perceived Situation Adaptivity	The system adapts to different user situations.
	The messages from the system show flexibility.
	The options given enable a meaningful dialogue.
Perceived Privacy Sensitivity	The system caters to the privacy need of users.
	The system protects sensitive health information.
	The system discloses just enough information.

Table 5.5 gives the descriptive statistics for manipulation check. The results confirmed that the user perceptions of the treatments were consistent with the corresponding design characteristics. Treatment 1 is low on both situation adaptivity and privacy sensitivity, and the average responses to both perceived adaptivity and sensitivity were around the neutral point of 4. Treatment 2 is high on situation adaptivity but low on privacy sensitivity, leading to higher average responses to perceived adaptivity than to perceived sensitivity. Treatment 3 is low on situation adaptivity but high on privacy sensitivity, leading to lower average responses to perceived adaptivity than to perceived sensitivity. Treatment 4 is high on both situation adaptivity and privacy sensitivity, and the average responses to both perceived adaptivity and sensitivity were quite positive. In addition, the HIV scenario is more sensitive than the TB scenario, and the responses varied more widely across different levels of privacy sensitivity for the former than the latter. Therefore, the results support the validity of both design treatments and experiment scenarios.

Table 5.5 Manipulation Check

Perception	Treatment 1	Treatment 2	Treatment 3	Treatment 4
TB Scenario				
Adaptivity	4.36 (.85)	5.90 (.66)	4.42 (.88)	6.02 (.69)
Sensitivity	4.28 (.89)	4.52 (.84)	5.22 (.79)	5.59 (.74)
HIV Scenario				
Adaptivity	4.19 (.86)	5.74 (.77)	4.54 (.82)	5.82 (.72)
Sensitivity	3.83 (.99)	4.09 (.94)	5.95 (.75)	6.04 (.73)

Note: Standard deviations given in the parentheses beside the means.

5.4.3 Subjects

For this experimental study, student subjects are generally appropriate as the main purpose is for general theory testing rather than generalizing the specific findings to the population (Compeau, Marcolin, Kelley, & Higgins, 2012). Almost all college students have

cellphones, and use texting and other mobile systems more frequently than phone calls (Lenhart, 2012). Therefore, the target population of this study is the undergraduate students at a Southwest university. The tuition and fee grant all the students free-of-charge access to the services provided by Student Health Services. Together, 209 students were elicited to participate in this study. Though there are two responses collected from each participant, one for each scenario (TB skin test vs. HIV test), they are to be used separately in multi-group analyses. In each group, there is no within-subject variance but only between-subject variance. This largely controls the influence of possible learning effects, in addition to the randomization of scenario exposure order. Thus the sample size was still 209, sufficient for measurement validation as well as hypothesis testing. It comprised 51 for Treatment 1 (neither adaptive nor sensitive design), 52 for Treatment 2 (adaptive but not sensitive design), 53 for Treatment 3 (sensitive but not adaptive design), and 53 for Treatment 4 (both adaptive and sensitive design).

5.5 Results

Most of the measures used in this research were adapted from existing studies. The only exception is subjective consonance, of which the instrument was developed and validated in Chapter 4. Table 5.6 reports the response patterns of data collected from the experiment across two scenarios. The descriptive statistics show that Treatment One (neither adaptive nor sensitive design) and Treatment Four (both adaptive and sensitive design) saw the lowest and highest responses on average for all constructs, respectively. This is expected as they represent the least and most considerate designs to user needs. For Treatment Two (adaptive but not sensitive design) and Treatment Three (sensitive but not adaptive design), however, the patterns were somewhat different across two scenarios. Participants clearly preferred situation adaptivity to

privacy sensitivity for TB test appointment reminders, but not so much for HIV test appointment reminders.

Table 5.6 Reliability Coefficients and Descriptive Statistics

Construct	α	T1	T2	T3	T4
TB Test Scenario					
Performance Expectancy	.902	4.75 (.85)	6.28 (.55)	5.27 (.67)	6.46 (.66)
Effort Expectancy	.827	4.98 (.81)	6.23 (.57)	5.37 (.65)	6.40 (.66)
Subjective Consonance	.869	4.67 (.73)	6.19 (.70)	5.19 (.79)	6.26 (.66)
Behavioral Intention	.939	4.73 (.92)	6.42 (.58)	5.29 (.84)	6.50 (.58)
HIV Test Scenario					
Performance Expectancy	.816	4.80 (.66)	5.94 (.51)	5.78 (.53)	6.67 (.44)
Effort Expectancy	.735	4.94 (.60)	5.87 (.61)	5.74 (.49)	6.64 (.46)
Subjective Consonance	.804	4.60 (.64)	5.75 (.71)	5.60 (.56)	6.53 (.54)
Behavioral Intention	.935	4.90 (.76)	5.91 (.66)	5.73 (.62)	6.75 (.41)

Note: α - Cronbach's Alpha; Standard deviations given in the parentheses beside means. T1-Treatment 1 (Neither Adaptive nor Sensitive); T2-Treatment 2 (Adaptive but not Sensitive); T3-Treatment 3 (Sensitive but not Adaptive); T4-Treatment 4 (Both Adaptive and Sensitive).

All reliability coefficients were above the threshold of 0.7, indicating an acceptable level of internal consistency. Nevertheless, the responses exhibited a somewhat lower level of consistency for the HIV test scenario than the TB test scenario. This is probably due to the fact that HIV test is more sensitive than TB test, and the associated discomfort may have led to larger variation in the responses from participants. As shown in Table 5.7, all factor loadings were greater than cross-loadings, supporting discriminant validity (Chin, 2010).

Table 5.7 Factor Loadings and Cross-loadings

Indicator	Performance	Effort	Consonance	Intention
Performance 1	**.864**	.348	.563	.576
Performance 2	**.919**	.376	.477	.547
Performance 3	**.852**	.477	.465	.525
Effort 1	.576	**.761**	.480	.539
Effort 2	.453	**.909**	.464	.406
Effort 3	.474	**.805**	.503	.587
Consonance 1	.606	.393	**.820**	.553
Consonance 2	.584	.380	**.797**	.622
Consonance 3	.450	.516	**.908**	.436
Intention 1	.608	.404	.480	**.899**
Intention 2	.563	.410	.496	**.921**
Intention 3	.593	.405	.537	**.872**

As there are two sets of responses collected from each participant, one for each scenario, this study conducts a multi-group analysis (MGA) to separate them. Compared with that through covariance-based structural equation modeling (SEM), the MGA through partial least square (PLS) allows for the direct comparison of each path coefficient across different groups. Therefore, this study uses SmartPLS to conduct MGA using Scenario as the grouping variable, and Table 5.8 reports the results.

Table 5.8 PLS Multi-Group Analysis

Hypothesized Relationship	TB	HIV	diff
H1a: Situation Adaptivity -> Performance Expectancy	.564***	.389***	.175**
H1b: Situation Adaptivity -> Effort Expectancy	.498***	.404***	.094
H1c: Situation Adaptivity -> Subjective Consonance	.570***	.491***	.079
H2a: Privacy Sensitivity -> Performance Expectancy	.216***	.301***	-.084
H2b: Privacy Sensitivity -> Effort Expectancy	.145**	.315***	-.170**
H2c: Privacy Sensitivity -> Subjective Consonance	.184**	.383***	-.199**
H3a: Adaptivity*Sensitivity -> Performance Expectancy	.698***	.834***	-.136*
H3b: Adaptivity*Sensitivity -> Effort Expectancy	.634***	.867***	-.233***
H3c: Adaptivity*Sensitivity -> Subjective Consonance	.634***	.855***	-.221***
H4a: Performance Expectancy -> Behavioral Intention	.440***	.466***	-.025
H4b: Effort Expectancy -> Behavioral Intention	.068	.239**	-.171
H4c: Subjective Consonance -> Behavioral Intention	.419***	.223***	.196

Note: *-Significant at 0.1 level; **-Significant at 0.05 level; ***-Significant at 0.01 level.

Except for the path between Effort Expectancy and Behavioral Intention for the TB test scenario (probably due to the suppression effect of salient Subjective Consonance in that group), all path coefficients were significant at 0.05 level (mostly at 0.01 level). Design features in terms of Situation Adaptivity and Privacy Sensitivity as well as their interaction term had the expected positive effects on user perceptions. Then user perceptions including Performance Expectancy, Effort Expectancy and Subjective Consonance led to the formation of Behavioral Intention related to the use of mobile appointment reminders.

Across the two scenarios, on the other hand, half of the path coefficients varied significantly whereas the other half did not. Among the variants, HIV test scenario saw five higher path coefficients, but TB test scenario only saw one. The effect of Situation Adaptivity on Performance Expectancy was stronger for the TB test scenario than it was for the HIV test scenario. Meanwhile, the effects of Privacy Sensitivity on Effort Expectancy and Subjective Consonance were stronger for the HIV test scenario than it was for the TB test scenario. This suggests that Privacy Sensitivity did ease user concerns when medical appointments are sensitive in nature.

5.6 Final Design Evaluation

The experiment results suggest that Situation Adaptivity and Privacy Sensitivity do have synergetic effects on user experiences in terms of performance expectancy, effort expectancy and subjective consonance. Such a synergy is further reinforced when the nature of appointments calls for more considerations. Therefore, it is preferred that mobile reminder systems implement both design features. In the next section, the final design is to be implemented for the evaluation by healthcare practitioners.

To evaluate the final design, a demonstration system was developed as shown in Figure 5.7. Healthcare professionals and apprentices were recruited from the Master in Physician Assistant Studies (MPAS) and Master of Science in Health Science (MSHS) programs at a Southwest university. Altogether, there were 106 participants. They tried out the system by sending a text message "Alt" to the number listed in the instruction. This initiated the reminding process in which participants were told to select the additional rescheduling option. Once done, they were asked to answer a questionnaire.

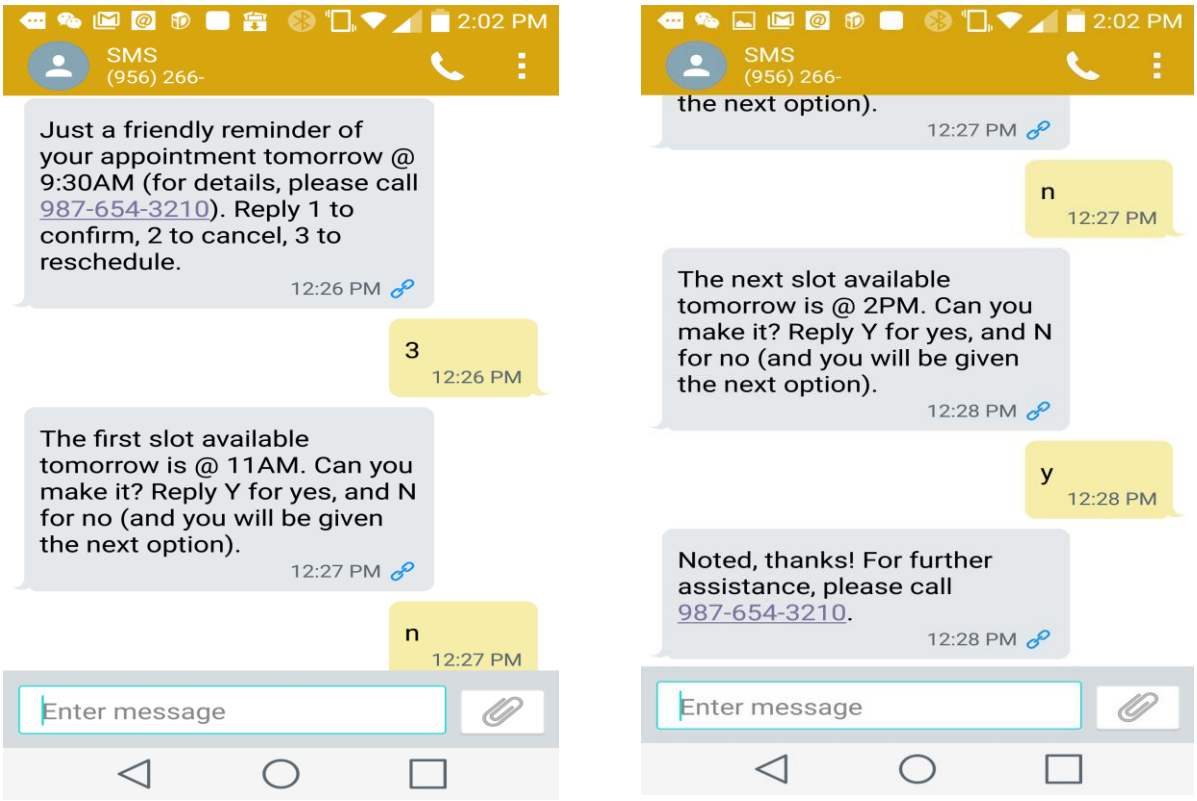


Figure 5.7 Demonstration System

In addition to the psychological constructs used in the experimental study, the questionnaire included the aforementioned measures of perceived situation adaptivity and perceived privacy sensitivity (see Table 5.4). The purpose is to find out whether the design had the intended effects on relevant user perceptions. Table 5.9 gives the descriptive statistics,

reliability coefficients, average variance extracted (AVE) and correlation matrix of the constructs used in the evaluation study. User perceptions of design features in terms of situation adaptivity and privacy sensitivity were quite positive (5.5 or above on average for 7-level Likert scale) and reliable (coefficients alpha >0.7). Other psychological constructs in the model also elicited relatively positive and internally consistent responses.

Table 5.9 Measurement Validation

Construct	Mean (SD)	Alpha	AVE	V1	V2	V3	V4	V5	V6
V1: Perceived Adaptivity	5.63 (1.11)	.77	.67	**.82**					
V2: Perceived Sensitivity	5.50 (1.16)	.79	.69	.72	**.83**				
V3: Performance Expectancy	6.33 (0.89)	.91	.85	.60	.58	**.92**			
V4: Effort Expectancy	6.33 (0.94)	.94	.89	.47	.48	.86	**.94**		
V5: Subjective Consonance	6.27 (0.95)	.89	.83	.54	.51	.86	.83	**.91**	
V6: Behavioral Intention	6.31 (1.07)	.93	.88	.42	.48	.77	.76	.82	**.94**

Note: AVE - Average variance extracted; All correlation coefficients were significant at the 0.01 level. The bold on the diagonal of correlation matrix indicates the squared root of AVE.

In addition to convergent validity, the results supported discriminant validity as the squared root of average variance extracted (AVE) for each construct was larger than its correlation coefficients with other constructs. As shown in Table 5.10, all factor loadings were greater than cross-loadings, reassuring discriminant validity (Chin, 2010).

Table 5.10 Factor Loadings and Cross Loadings

Indicator	Adaptivity	Sensitivity	Performance	Effort	Consonance	Intention
Adaptivity 1	**.771**	.603	.443	.342	.406	.329
Adaptivity 2	**.829**	.635	.577	.426	.481	.448
Adaptivity 3	**.862**	.646	.709	.678	.674	.568
Sensitivity 1	.727	**.881**	.659	.551	.698	.572
Sensitivity 2	.551	**.810**	.492	.394	.426	.341
Sensitivity 3	.592	**.803**	.408	.290	.286	.210
Performance 1	.621	.595	**.916**	.778	.810	.684
Performance 2	.629	.559	**.944**	.864	.798	.728
Performance 3	.753	.653	**.919**	.773	.785	.762
Effort 1	.584	.465	.811	**.935**	.744	.699
Effort 2	.605	.502	.844	**.966**	.819	.731
Effort 3	.579	.524	.817	**.945**	.833	.755
Consonance 1	.526	.469	.796	.826	**.911**	.853
Consonance 2	.590	.588	.771	.715	**.930**	.748
Consonance 3	.689	.628	.788	.763	**.895**	.656
Intention 1	.552	.486	.784	.769	.791	**.946**
Intention 2	.509	.440	.683	.691	.741	**.933**
Intention 3	.541	.468	.748	.710	.804	**.949**

With the confidence in the psychometric properties of constructs, the next step is to examine their relationships as hypothesized in Figure 5.8. The model looks like the research model in the previous section except for design features: in this model, they are user perceptions rather than experiment treatments. Otherwise, the relationships among constructs remain about the same.

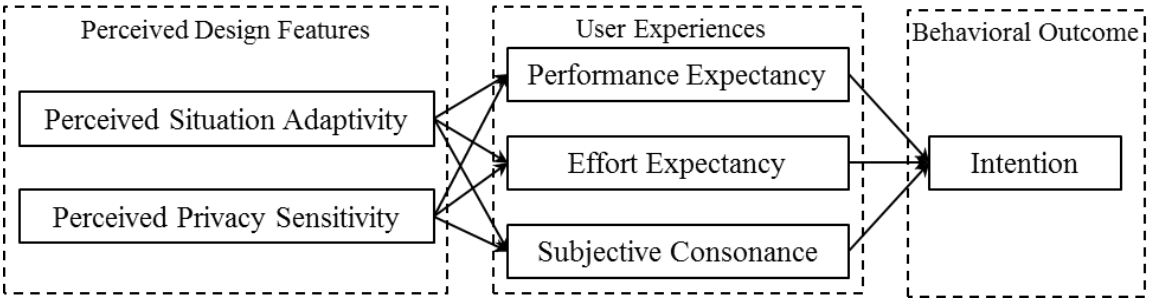


Figure 5.8 Perceptions of Design Features and User Behavior

Table 5.11 reports the model estimates using the same partial least square (PLS) method so that the results are comparable with those in the previous section. The results confirmed the situation adaptivity is the most noticeable design feature that has strong effects on user experiences in terms of performance expectancy, effort expectancy and subjective consonance. Meanwhile, perceived privacy sensitivity makes a bigger difference in subjective consonance and performance expectancy than in effort expectancy. In addition, subjective consonance explains the most variance in behavioral intention, whereas effort expectancy explains the least, with performance expectancy in between.

Table 5.11 Partial Least Square Estimates

Path	Coefficient
Perceived Situation Adaptivity -> Performance Expectancy	.542***
Perceived Situation Adaptivity -> Effort Expectancy	.527***
Perceived Situation Adaptivity -> Subjective Consonance	.453***
Perceived Privacy Sensitivity -> Performance Expectancy	.239**
Perceived Privacy Sensitivity -> Effort Expectancy	.123
Perceived Privacy Sensitivity -> Subjective Consonance	.269**
Performance Expectancy -> Behavioral Intention	.200*
Effort Expectancy -> Behavioral Intention	.146
Subjective Consonance -> Behavioral Intention	.531***

Note: *-Significant at 0.1 level; **-Significant at 0.05 level; ***- Significant at 0.01 level.

These results support design rationales as situation adaptivity and privacy sensitivity have expected effects on user perceptions and behavior. Between the two, situation adaptivity is more important than privacy sensitivity as the former is the key design feature that makes a mobile reminder system truly reciprocal. Meanwhile, privacy sensitivity is still critical as it reassure users of the trustworthiness about the system. Therefore, the two design features play different roles in persuading users to switch to a reciprocal reminder system. As the participants of the evaluation study were healthcare practitioners, their agreement that such a new design of mobile appointment reminders provides a solution in patient-centered care confirms its theoretical soundness and practical relevance.

CHAPTER VI

CONCLUSION

This study develops a design theory of reciprocal appointment reminder systems based on kernel theories. Media characteristics are compared and different user requirements are identified for collaborative appointment management in patient-centered care. The analysis leads to the design principles and research proposals. Furthermore, this study moves on to the assessment of major design features including situation adaptivity and privacy sensitivity in terms of their effects on user experiences and behavior. The experiment results support the importance of both design features. Figure 6.1 illustrates the process of this design science research following Peffers et al. (2007)'s approach.

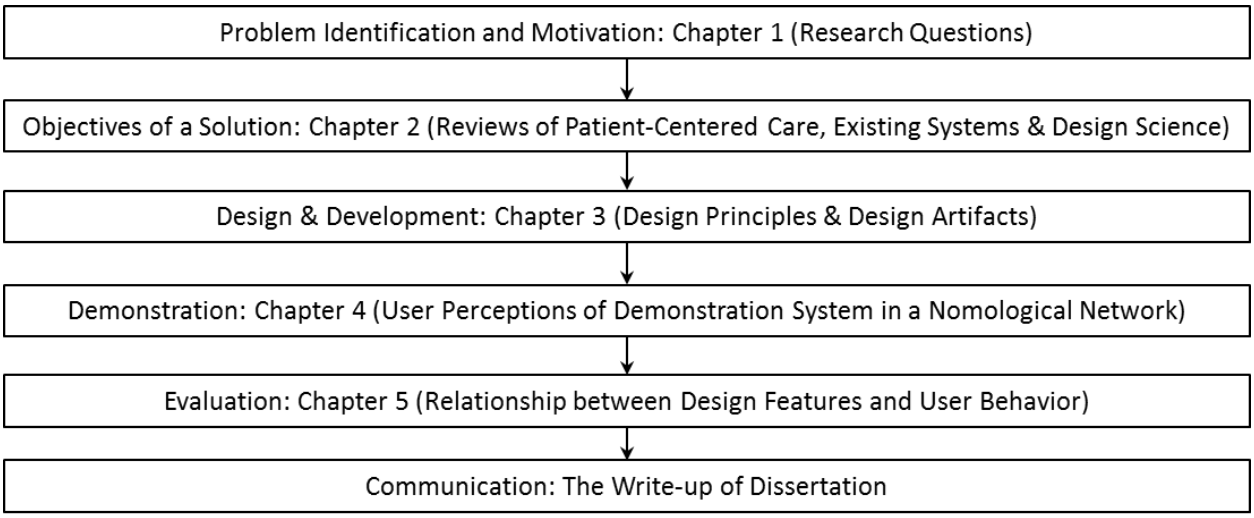


Figure 6.1 Design Science Research Process Following Peffers et al. (2007)

A demonstration mobile system was implemented to incorporate both situation adaptivity and privacy sensitivity for appointment reminders. Participants used their cellphones to interact with the system to try out the new design. This allows them to give more accurate evaluation of the proposed system design. Also the observations collected from participants based on their first-hand experiences with the innovative system are helpful to validate the newly developed subjective consonance construct and its instrument.

The contribution of this study to the health information system design research has two folds in terms of theory and practice. The main theoretical contribution is the proposal of a design theory to guide the development of mobile appointment reminders in patient-centered care. In addition, this study conceptualizes the subjective consonance construct and its nomological network with other constructs to study user behavior with reciprocal mobile reminders. Based on the organizational justice literature and information system success model, it develops and validates the psychometric measures of transparency consonance, etiquette consonance, process consonance and overall consonance. The empirical findings suggest that personal norms may outweigh social norms in people's adoption of such innovative mobile systems. It is necessary to take such a personal norm into account in the study of how the implementation of design features in terms of situation adaptivity and privacy sensitivity affects user experiences. More importantly, personal norm may be considered in other contexts where information systems are used for personal reasons.

For practitioners, this study provides some useful guidelines and tools for the design, development and evaluation of mobile appointment reminders in patient-centered care. First of all, it delineates the design principles and design artifacts in terms of user interfaces. The demonstration system developed for this study instantiates the implementation of such a

reciprocal reminder system. Meanwhile, the measurement instruments of subjective consonance and other constructs allow developers to evaluate system designs from user perspective.

The main limitation of this study is in the scenario-based methodology for collecting data from potential users of reciprocal appointment reminders. That is, all participants in this study are not real patient users but who imagine that they use such a system once it is available. It is possible that actual user behavior may vary in the context of real medical appointment management. This points to the direction of future field studies after healthcare providers implement the system to evaluate and configure detailed system design with the feedback from real users.

In the real-world settings, there are other sources of influence such as user demographics and user environment that also need to be taken into account. For instance, age and education may play important roles in the use of mobile reminder systems. Whether users are on the move or under stress may also impact usage behavior. In the current study, there is a relatively lack of variation in such variables but they can be used as control variables in future field studies.

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APPENDIX

APPENDIX

EXPERIMENT INSTRUCTION

Treatment 1 (Order 1)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text TB0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text TB1 to the same number to try it out. As you can see, the system displays the appointment details, including purpose, time and place. You may respond to the reminder with confirmation, or the system will ask you to call the office for rescheduling. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. Please text HIV1 to the same number to try it out (HIV0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 1 (Order 2)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text HIV0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text HIV1 to the same number to try it out. As you can see, the system displays the appointment details, including purpose, time and place. You may respond to the reminder with confirmation, or the system will ask you to call the office for rescheduling. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. Please text TB1 to the same number to try it out (TB0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 2 (Order 1)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. One day before the

appointment, the app sends a text reminder to your cellphone. Please text TB0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text TB2 to the same number to try it out. As you can see, the system displays the appointment details, including purpose, time and place. In addition, it allows you to reschedule appointments based on the slots available. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. Please text HIV2 to the same number to try it out (HIV0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 2 (Order 2)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text HIV0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text HIV2 to the same number to try it out. As you can see, the system displays the appointment details, including purpose, time and place. In addition, it allows you to

reschedule appointments based on the slots available. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. Please text TB2 to the same number to try it out (TB0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 3 (Order 1)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text TB0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text TB3 to the same number to try it out. As you can see, the system does NOT display the appointment details unless asked. You may respond to the reminder with confirmation, or the system will ask you to call the office for rescheduling. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center.

Please text HIV3 to the same number to try it out (HIV0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 3 (Order 2)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text HIV0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text HIV3 to the same number to try it out. As you can see, the system does NOT display the appointment details unless asked. You may respond to the reminder with confirmation, or the system will ask you to call the office for rescheduling. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. Please text TB3 to the same number to try it out (TB0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 4 (Order 1)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text TB0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text TB4 to the same number to try it out. As you can see, the system does NOT display the appointment details unless asked. In addition, it allows you to reschedule appointments based on the slots available. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. Please text HIV4 to the same number to try it out (HIV0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

…

Treatment 4 (Order 2)

Welcome. Your willingness to participate in this study is greatly appreciated!

This study asks you to evaluate a new design of a mobile system to remind users of upcoming appointments against the old one that just sends out one-way reminder messages. Assume that you scheduled a human immuno-deficiency virus (HIV/AIDS) test with Student Health Center. One day before the appointment, the app sends a text reminder to your cellphone. Please text

HIV0 to 956-266-XXXX to view the old design, which sends a one-way reminder message. For the new design, please text HIV4 to the same number to try it out. As you can see, the system does NOT display the appointment details unless asked. In addition, it allows you to reschedule appointments based on the slots available. In the following, please answer a few questions about your experiences.

…

The same design can be used for different types of appointments. This time, assume that you scheduled a tuberculosis (TB) skin test with Student Health Center. Please text TB4 to the same number to try it out (TB0 for the old one-way design if you want comparison). In the following, please answer a few questions about your experiences.

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BIOGRAPHICAL SKETCH

Ying Wang earned her Bachelor of Art degree in Accounting from Shanghai University of Finance & Economics in August 2002. In May 2006, she received her Master of Science degree in Management Information Systems from Texas A&M University, at College Station. In December 2016, she was awarded the PhD degree in Business Administration with a concentration on Information Systems by The University of Texas Rio Grande Valley.

While pursuing her degree, Dr. Wang worked as a lecturer for the Department of Information Systems. She taught a variety of online and face-to-face courses and had excellent student evaluation of teaching. Dr. Wang was the recipient of the Outstanding PhD Student Award by the College of Business Administration at The University of Texas Rio Grande Valley. She also received a Distinguished Paper Award from the Information Systems Education Conference and a Meritorious Paper Award from the Conference on Information Systems Applied Research.

Dr. Wang published a number of research articles on health informatics, user behavior, and online education. Her recent publications appeared in the *Journal of Computer Information Systems*, *Information Systems Frontiers*, *Communications of the Associations for Information Systems*, *Computers in Human Behavior*, *Industrial Management and Data Systems*, *Information Systems Education Journal*. She can be reached by e-mail: yw.annie@gmail.com.