OLDER ADULTS' USER EXPERIENCES WITH MOBILE PHONES: IDENTIFICATION OF USER CLUSTERS AND USER REQUIREMENTS

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ABSTRACT

This research addressed how older adults experience their mobile phones in their everyday lives and how mobile phones could be designed to best meet their needs. Two studies were conducted using a mixed-research method to identify representative user clusters and to understand user experiences. In Study 1, 154 older adult mobile phone users completed a questionnaire to investigate 1) functional usage, 2) perception about mobile phone quality, and 3) other aspects of user experiences (e.g., motivations of acquisition and learning method). Results showed that older adults are generally conservative mobile phone users who use a few functions of mobile phones and perceive their phone to be difficult to use. Understanding error messages, menu navigation, and text input were found to be most difficult for them. Female users perceived their phones to be more difficult to use than male users. Three user clusters (explorers, basicians, and minimalists) were identified based on mobile phone usage behavior, and their characteristics were described. User satisfaction was effected by three attributes of mobile phones: usefulness, ease of use, and pleasure of use, indicating that developers need to focus on improving all factors when designing a mobile phone for older adults.

Study 2 used a more holistic approach to describe older adults' user experiences. The aims of Study 2 were 1) to capture stories that reflected user experiences, 2) to identify barriers that older adults faced through the course of user experience and 3) to provide recommendations to improve user experiences. Qualitative data was collected in the form of existential phenomenology-based interviews. Twelve older adult mobile phone users (over age 56), representing the three clusters found from Study 1, participated in this study. The domestication of technology theory was adopted as a framework to describe instances and themes represented in users' utterances and behaviors. Results showed that, regardless of their abilities to operate technology, older adults used a limited number of mobile phone functions because of their parsimonious cost-benefit analyses when integrating technologies into their lives. A theoretical explanation for this phenomenon was provided using socio-emotional selectivity theory. Barriers (perceptual, cognitive, attitudinal, knowledge, and information barriers) were found to hinder older adults' utilization of mobile phone technology over the four dimensions of the domestication process (appropriation, objectification, incorporation, and conversion). Recommendations to resolve those barriers were provided and related to published literature. This study proved that the domestication of technology theory can be a useful analytical tool for describing and understanding user experiences and capturing users' needs. Detailed discussion about its applicability to user needs analysis process was provided. A set of user requirements along with diverse user profiles were developed as outcomes of this research.

DEDICATION

To Jiang Nan
My beloved wife who always loves me and sacrifices herself for me,
My best friend who always cheers me up,
My best research critic who provides sharp questions, and
Mother of my little angel, Yejee.
This achievement is yours.
I love you.

To my family in Korea and China
Your dedication has led me to where I am now.
Thanks for your love and support.

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CHAPTER 1. INTRODUCTION

1.1. Background

The world is growing older. The United Kingdom anticipates that 50% of the adult population will be aged 50 or over by the year 2020 (Laslett, 1998). In the United States, 12.4 % of the whole population was over the age of 65 in 2004, and 20% is anticipated by 2030 (Day, 1996; U.S. Census Bureau, 2005). Considering the increasing number of older adults, it is imperative to consider how technology design can meet the needs and wants of this important user group.

There have been numerous studies on technology design for older adults (Fisk, Rogers, Charness, Czaja, & Sharit, 2004), but much of the work has focused on indoor and stationary applications such as desktop computers (Zajicek & Brewster, 2004). Older people, however, need support not only in stationary situations, but also in mobile situations inside and outside their homes (Goodman, Brewster, & Gray, 2004). This research focuses on one of the most popular mobile consumer products, mobile phones.

In recent years, mobile phones have become pervasive throughout the world. In 2004, there were approximately 1.7 billion mobile phone subscribers in the world, and it is anticipated that 2.6 billion phones will be in use by the end of the year 2009 (Business Communications Review, 2005). The United States has seen a 56 percent increase in the adoption of mobile phone services in the last six years (1999 – 2005), and nearly 194 million mobile subscribers were reported in 2005, which accounted for 66% of the population (CITA, 2005).

Mobile phone adoption by older adults is also radically increasing. A recent Yankee Group report estimated that about 50 percent of Americans ages 65 to 74 were mobile subscribers, and 30 percent of those ages 75 to 94 had mobile phones in 2005 (Brown, 2005). Despite the increasing adoption rates among older adults, few studies investigated their specific characteristics and needs for mobile phones. As a result, it is still difficult to find mobile phone handsets or mobile services that are compatible with older adults' needs and preferences (Mann et al., 2004). It is imperative to consider how mobile phone technology can meet the needs and wants of the older adult population that has been marginalized in mobile phone research.

1.2. Research problems

1.2.1. Mobile phone design in a systems-level scope

Mobile phones are consumer products embedded deeply in users' everyday life (Palen & Salzman, 2002). Carried by users virtually any time and anywhere, mobile phones play various roles beyond a communication means. Mobile phones represent users' identities and social status (Jordan, 2000; Swallow, Blythe, & Wright, 2005), help users look stylish (Leung & Wei, 2000), and facilitate social relationships in younger generations (Taylor & Harper, 2002; Yoon, 2003). Numerous studies in marketing and social science found that consumers adopted mobile phones for different reasons, such as entertainment and fun (Nysveen, Pedersen, & Thorbjornsen, 2005; Sarker & Wells, 2003). This indicates that although usability remains as an important aspect, other factors beyond usability, such as affective aspects, need to be considered in evaluating and designing mobile phones.

Mobile phones are complex socio-technical systems that require interactions beyond the hardware and software of the handset (Palen & Salzman, 2002). By entering into contractual relationships with service-providers, the user must integrate information from the device manufacturer, sales people, and customer service representatives among others. In a naturalistic study, Palen and Salzman (2002) showed that the user experience of mobile phone users was ultimately dependent on the interactions occurring within the larger socio-technical system. Additionally, they suggested mobile phone developers and researchers should employ the system-level perspective that looks beyond user-device interaction to better understand the design space to improve the user experience.

Given the unique features of mobile phones above, a traditional task-based design approach that focused exclusively on the user interface design of mobile phone handsets is insufficient to capture the users' total experience. User research for service-based technologies such as this, should consider addressing broader design space outside mobile phone handsets (Hughes, 1987; Palen & Salzman, 2002). Nevertheless, few studies have investigated the design of mobile phones from a systems-level perspective, and far fewer have investigated older adults' user experiences.

1.2.2. Lack of representative user groups

Older adults are a diverse group (Abascal & Civit, 2001). Previous research showed that the diversity within older adults increases in physical, sensory, and cognitive areas (Fisk et al., 2004; Zajicek & Brewster, 2004). There is also a wide variability in other areas such as education level and literacy level as well as in computer skills (Syme & Eisma, 2001). Nevertheless, few empirical studies have investigated the heterogeneity of this population and its relationship with the technology use, although numerous studies focused on comparisons between older people and young people (Marguie, Jourdan-Boddaert, & Huet, 2002; Ziefle & Bay, 2005).

While few studies investigated older adults' mobile phone usage in their lives, two previous studies revealed that older adults tend to use mobile phones for very limited purposes, such as calling or texting in an emergency situation, but are reluctant to use more complex functions (Kurniawan, Mahmud, & Nugroho, 2006; Mann et al., 2004). A detailed review of the previous studies indicated, however, that these results may not be generalizable to the overall older adult population for two reasons. First, those studies were conducted with people who represented particular characteristics (e.g., functional impairment and social-economic background). Second, other studies have shown distinct groups among the older adult population. For example, Morrell et al. (2000) found that there were distinct groups in the older adult population who used computers more than average people. Ziefle and Bay (2005) found that some older users had considerable interest in mobile technology and used their mobile phones as effectively as younger people.

These conflicting research outcomes create a major challenge for mobile phone developers when defining a representative older adult user in the User Centered Design (UCD) process (Syme & Eisma, 2001). UCD methodologies have been developed for user groups with relatively homogeneous characteristics. Unless these older adult groups can be reliably defined, needs analysis and user requirements developments will yield misleading information about users in the design process (Gregor, Newell, & Zajicek, 2002). Despite the critical nature of the issue, few studies have addressed the identification of representative user group(s) in the older adult population for mobile phone design.

1.3. Research objectives and approach

The overarching goal of this research was to investigate older adults' user experiences with mobile phones in order to identify representative user groups within the older adult population and their needs for mobile phone design in a systems-level scope. This research goal was achieved using a mixed-method research approach that included both quantitative (Study 1) and qualitative (Study 2) methods, as shown in Figure 1.

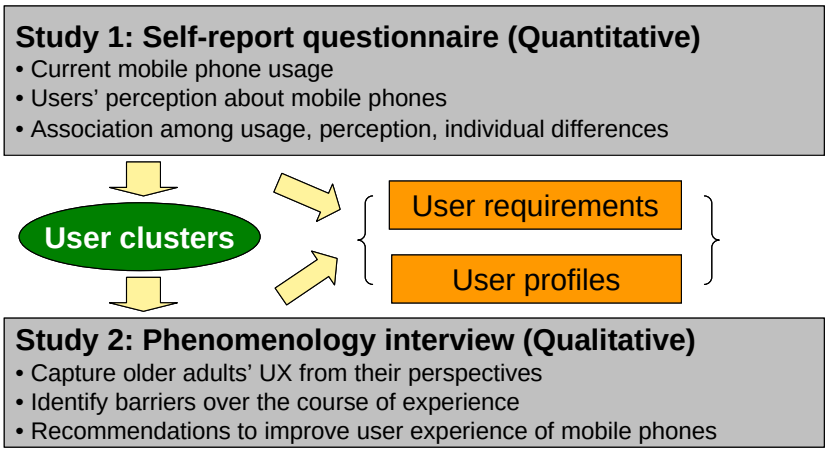


Figure 1. Research approach

In Study 1, a questionnaire was completed by 154 older adult mobile phone users to ascertain aspects of current older adults' user experience and investigate effects of individual differences on user experiences. The aspects of mobile phone user experience included: 1) mobile phone usage pattern, 2) perceived quality of mobile phones, 3) reasons for acquisition, and 4) learning methods. The relationship of these aspects to individual differences (i.e., age, gender, education level, computer usage, and innovativeness) was investigated. A cluster analysis was conducted to determine representative user clusters based on the mobile phone usage pattern.

In Study 2, a phenomenological interview was conducted with a sample of 12 older adults representing the user clusters identified in Study 1 (four participants for each cluster). The main purpose was to gain in-depth understanding of findings from Study 1 and capture rich information about their experience that may have been absent from the previous quantitative

study. Specifically, information regarding contexts of use and barriers to utilization of mobile phone features was elicited and recommendations to improve user experiences were suggested. By integrating findings from the two studies, user profiles or personas for representative user groups among older adults were presented, and a set of user requirements for mobile phones for older adults was developed as additional outcomes of this research.

CHAPTER 2. LITERATURE REVIEW

2.1. User experience

Designing a product that generates a high quality of user experience, hereafter UX, is the ultimate goal for product developers (Norman, 1999); hence, capturing and designing for UX has become a popular research subject in recent years. However, UX remains a strange concept: readily adopted by the human-computer interaction (HCI) community and at the same time critiqued repeatedly for being vague, elusive, and ephemeral (Hassenzahl & Tractinsky, 2006). Conflicting and inconsistent views about UX co-exist in literature, and contemporarily the term 'user experience' is associated with a wide variety of meaning, ranging from traditional usability to beauty, hedonic, affective or experiential aspects of technology use (Hassenzahl & Tractinsky, 2006).

Despite the conflicting views, the most-cited definition of UX is all aspects of a user's (direct and indirect) interaction with a product or service that encompass a user's initial awareness, adoption, learning, and use (Alben, 1996; IBM, 2007; Norman, 1999; Norman, 2004). There have been a number of academic and practical research efforts to develop a comprehensive theory or framework to address UX using two research approaches. One body of research addressed UX using a quantitative approach, and developed a number of metrics to describe and measure UX (Hassenzahl, 2003; Jordan, 2000; Norman, 2004). Another body of research advocated a qualitative approach to provide a richness and detail that may be absent from reductionist quantitative approaches (Forlizzi & Ford, 2000). The aim of this section was to provide a review on previous research approaches and suggest a pragmatic approach that allows mixing of differential approaches.

2.1.1. Quantitative approach

Research in this approach attempts to quantify user experience by developing metrics. In some cases, assessing UX is equated with usability, but most studies in this approach concentrated on adding emotion-related factors to usability metrics. Even under the quantitative approach, three different approaches were found in literature.

The first approach was to add new dimensions to the usability construct. For example,

Logan (1994) suggested that usability can be divided into behavioral usability, which refers to "the ability to complete some functional or goal-directed task within a reasonable time" and emotional usability which refers to "the degree to which a product is desirable or serves a need beyond the traditional functional objective." Kirakowski and Corbett (1993) developed the Software Usability Measurement Inventory (SUMI) based on five dimensions: efficiency, affect, control, learnability, and helpfulness. In the context of consumer electronic product evaluation, Han et al. (2001) subdivided usability into two aspects: performance and image/impression. Also, Ryu and Smith-Jackson (2006) proposed five usability elements for mobile phones: ease of use, helpfulness, affective aspect, minimal memory load, and efficiency.

The second approach hypothesized that UX is separate construct that is distinct from usability. For example, Jordan (2000) proposed a pleasure-based design approach based on the hierarchy of consumer needs that consists of four levels: safety, functionality, usability, and pleasure experience. In this approach, pleasure was defined as "the emotional hedonic and practical benefits associated with products". Also, McNamara and Kirakowski (2005) claimed that three primary elements need to be considered when evaluating technology: functionality, usability, and experience. They defined functionality as a technical issue that answers the question, "What does the product do?" while employing the same definition of usability as the one ISO 9241-11 (1997). However, they did not propose a clear definition or measurement of UX.

The third approach viewed UX as an umbrella term to summarize all the relevant aspects of interaction including usability. Mahlke (2005) presented an integrative model of the user experience process with which she claimed that the total user experience is influenced by two factors: instrumental qualities and non-instrumental qualities. The instrumental qualities are composed of usefulness and ease of use, and the non-instrumental qualities can be grouped with three labels hedonics, aesthetics and pleasure/fun. Another empirical study revealed that usefulness, ease of use, hedonic quality, and visual attractiveness affected the intention to use of websites (Mahlke, 2002).

2.1.2. Qualitative approach

Qualitative methods proponents argue that the quantitative approach can miss some of the insights available in a much wider space of UX (Swallow et al., 2005), suggesting a qualitative approach to capture in-depth UX. Forlizzi and Ford (2000), for example, viewed UX as a continuous stream that flows through the human mind but is continuously influenced by four factors (i.e., users, products, context of use, and social and cultural factors). They argued that UX can be captured using narratives or storytelling since the narratives reflect experiences that have been formalized in the user's mind from subjective perspectives. Also, McCarthy and Wright (2005) argued in their 'felt-life' approach that consumers are not passive creatures; instead, they actively complete the experiences for themselves and may even turn them in completely unintended directions. Therefore, they claimed that, rather than isolating elements of experience, experience must be understood in a holistic and constructionist approach by listening to users' stories of experience with technology. The stories are lively and reflect upon many aspects of user experiences including the person or people users interacted with, their actions, their thoughts and beliefs, the context in which the experience is taking place, the tools in use, expectations, memories, anxieties, hopes and the unfolding life of these elements (McCarthy & Wright, 2005). It was emphasized that in order to capture users' rich experiences, an interviewer should question in a focused, yet non directive and unstructured way (Light, 2006).

2.1.3. Summary of user experience literature

Previous literature illustrated that UX is a large and complex concept, and two different approaches (quantitative vs. qualitative) have been used to address it. These two approaches seem to stem from two major research paradigms – 'positivist' and 'interpretative' approaches (Creswell, 2003). In the research area where the dichotomy – quantitative versus qualitative – dominates, numerous pragmatic studies using the mixed-method have shown that integration of these approaches within the same study can be complementary to each other to solve practical problems (Caracelli & Greene, 1997; Creswell, 2003). As a pragmatic study to improve older adults' user experience, this research addresses user experience using the mixed-method.

2.2. Mobile phone components

Previous studies indicated that mobile phone interfaces consist of four components: hardware user interface, software user interface, external interface, and service interface, and the user experiences of mobile phone users are ultimately dependent on the interaction with each of those components (Ketola & Roykkee, 2001; Palen & Salzman, 2002). The hardware interface includes hardware ergonomics, input methods, and communication methods, whereas the software interface focuses on menu design such as font size, color, and menu navigation logic.

Table 1. Mobile phone interface components

Interface	Category	Exemplar items
User interface (Hardware)	Hardware factors	Weight, size, shape, balance, touch and feeling, display size and resolution
	Input methods	Key pad design (size, height, shape), special keys, navigation tools, softkeys, key labels and icons.
	Audio, Voices	Ringing tones, sound quality
	Communication methods	Radio link, bluetooth, infrared, cable
	Detachable parts	SIM card and battery
User interface (Software)	Software factors	Font size and color, icon design, audio design
	Menu design	Interaction logic, control key combination, layout menu structures, menu labels, graphic and audio design
	Applications	Utility applications, game applications, office applications
External interface	User support	Local help, manuals, documentation
	Accessories	Charger, hands-free sets, external keyboard, snap-on color cover
	Supporting software	PC software, downloadable applications
Service interface	Services	Service coverage, calling plan, sales communication, phone bill
	Service applications	Text messaging service, email, GPS, navigation service

The external interface involves features that help in using the device but are not physically part of the device itself, such as user support elements, accessories, and supporting software. Lastly, the service interface is the component that facilitates the use of the phone service provided by the service provider or carrier such as: special calling plan services, text messaging services, and business practices including calling plan agreement, sales communications, other information resources, and phone bills. Table 1 summarizes the four

components.

2.3. Previous studies on mobile phone use by older adults

Despite the increased use of mobile phones among older adults, there is little related research investigating how older adults use their mobile phones. Ziefle and Bay (2005) conducted an empirical study to examine aging effects on the usability of different mobile phones. In their study, younger (20-35 years) and older (50-64 years) novice users performed four experimental tasks using two phones with different cognitive complexity that was determined by the number of production rules to complete each task. Their research indicated that the younger group had better performance compared to older adults. However, this study also found that older adults' performance was improved significantly with a less complex phone. This implied that a more considerate design can compensate for performance decrements present in older adults by meeting their specific needs.

Kurniawan et al. (2006) conducted a focus group study with seven older female participants using an exploratory approach. This study found that older women would most likely use mobile phones only in emergencies, and they seldom used the phone for casual conversations. The research revealed usability problems associated with small buttons, complex menus, complicated functions, and small screens. Although this exploratory study provided potentially valuable information about the older adult's experience, their findings cannot be generalized due to the small number of participants and the nationality of participants (British) because nationality is one cultural factor that may affect mobile phone usage patterns (Choi, Lee, & Kim, 2006).

Recently, the Rehabilitation Engineering Research Center on Technology for Successful Aging conducted a large-scale survey with 596 elders with impairments (Mann et al., 2004). In this survey, they found that the majority of elders (60%) valued their mobile phone, but a large proportion (87%) used the mobile phone for emergencies only, while one third of elders reported using their mobile phone daily. Suggestions for improving phone design included increasing button size, display size, overall size of the phone, and decreasing the complexity of the phone. Although results of this study undoubtedly reflect some older adults' perspectives on mobile

phone designs and features, the applicability of these results is also limited since the population studied in the survey was the elderly with impairments, which presumably impacted their use of mobile phones. There is a need for studies investigating active healthy older users' perspectives.

2.4. Theories on technology adoption and use

Human-computer interaction (HCI) is a discipline that is concerned with the design, evaluation and implementation of interactive computing systems for human use (Hassenzahl, Platz, Burmester, & Lehner, 2000). While HCI research studies report the effects of user interface design and individual differences on task performance using interactive systems, research from management information systems (MIS) provides the theoretical models to explain the dynamics of technology adoption and use which is also an important part of the user experience.

Two representative theories were found to provide insight into understanding older adults mobile phone adoption and use: Innovation Diffusion theory and Technology Acceptance Model (TAM) (Davis, 1989; Rogers, 2003). Although some differences exists, the basic theory is that users' adoption decisions or utilization of interactive systems is subject to a wide range of factors that can be grouped into two major categories: user characteristics and attributes of systems. A brief introduction of the two theories will be provided first, followed by detailed descriptions for variables of user characteristics and technology attributes.

2.4.1. Innovation diffusion theory

The innovation diffusion theory seeks explanations for when and how a new idea, new practice, or newly introduced technological innovation is adopted or rejected over time in a given society (Rogers, 2003). The diffusion process is conceived as fundamentally a communication process, in which both mass media and interpersonal channels play important informing and persuasive roles. According to this theory, the individual's technology adoption decision is subject to a wide range of factors that can be grouped into four major categories: (1) adopter-related personality variables such as innovativeness (the degree to which one individual is relatively earlier to adopt than are others), (2) socioeconomic influences, (3) interpersonal

communications influence including mass media, and (4) attributes of an innovation, such as relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003).

Research in innovation diffusion theories provided insights into predicting mobile phone usage in the older adult population. Rogers (2003) identified five segments of technology adopters based on the innovativeness: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggard, and found that earlier technology adopters tend to be young, male, and have more years of formal education, higher social status, and have more experience with other technologies (e.g., computer, internet, and email). Numerous research studies have supported this pattern (Kwon & Chidambaram, 2000; Leung & Wei, 1999; Morrell et al., 2000; Wei, 2001), as shown in Table 2.

Table 2. Previous studies on the effects of user characteristics on technology use

Study	Objectives	Variables found to be significant
Leung and Wei (1999)	To identify factors affecting mobile phone adoption based on diffusion theory	1) socioeconomics (age, gender, education, occupation, household income), 2) innovativeness (telecommunication technology), 3) mass media use, 4) attitude toward mobile phones (incompatibility, relative disadvantage, complexity, absence of benefits)
R. Wei (2001)	To identify predictive factors for mobile adopters and to compare with the data collected in the study above.	1) socioeconomics (age, gender, education, occupation, household income), 2) innovativeness (telecommunication technology), 3) mass media use, 4) attitude toward mobile phone (incompatibility, relative disadvantage, complexity, absence of benefits), 5) knowledge about information technologies
Tjostheim and Bose (2001)	To identify different segments of mobile commerce users	1) socioeconomics (age, gender, education, household income, and community type), 2) internet use
Kwon and Chidambaram (2000)	To identify factors affecting mobile phone adoption and use	1) socioeconomics, 2) perceived ease of use, 3) apprehensiveness, 4) extrinsic motivation, 5) intrinsic motivation, 6) social pressure
Nysveen et al. (2005)	To identify significant factors on intention of mobile service	1) motivational influences (expressiveness, enjoyment, usefulness, and ease of use), 2) attitudinal influences, 3) normative pressure, and 4) perceived control.
Lu et al. (2003)	To identify significant factors on the wireless internet use via mobile technology	1) perceived usefulness, 2) perceived ease of use, 3) social influences, and 4) wireless trust environment

A synthesis of the research findings above suggests that mobile phone usage patterns are

affected by user characteristics even within the older adult population such that (1) younger individuals, (2) individuals with higher education level, (3) males, and (4) individuals using other information technologies (e.g., computer, email, and the internet) more frequently will be more likely to utilize various mobile phone features more frequently.

However, it should be noted here that the hypothesis proposed above was based on an assumption that earlier adopters utilize the technology innovation more than later adopters since the technology adopter segments in innovation diffusion theory was based on innovativeness, which is the time of innovation adoption (Rogers, 2003). Little research has been done to investigate the relationship between innovativeness and utilization of the technology after the technology adoption.

2.4.2. Technology acceptance model

The technology acceptance model (TAM) was originally developed to understand workplace adoption of new technology. TAM postulates several conceptually independent determinants of a person's attitude toward using new technology (Davis, 1989; Davis, Bagozzi, & Warshaw, 1992). The first determinant is perceived "usefulness" of the technology and refers to the degree to which using the system or technology will improve the user's performance in the workplace. TAM also postulates a second determinant, the ease of technology use, defined as the degree to which a person believes that using a technology will be free from effort. A more recent addition to the TAM is the pleasure construct, or the extent to which the activity of using the technology is perceived to provide reinforcement in its own right, apart from any performance consequences (Davies, Bagozzi, & Warshaw, 1989). The pleasure construct, such as enjoyment and fun, has been reported to affect technology adoption for specific computer applications (Davis et al., 1992) and for microcomputer usage (Igbaria, Parasuraman, & Baroudi, 1996; Igbaria, Schiffman, & Wieckowski, 1994).

This characterization of technology is consistent with attributes of products that HCI research suggested to measure product quality. Usability is widely accepted as one attribute of measuring product quality, defined by the International Standard Organization (ISO, 1997) as "the extent to which a product can be used by specified users to achieve specified goals with

effectiveness, efficiency and satisfaction in a specified context of use." However, recent research in HCI suggested inclusion of the non-instrumental qualities such as hedonics, aesthetics and pleasure/fun, as described in Chapter 2.1.1. A synthesis of the research findings on TAM and HCI suggested three constructs to measure quality of mobile phone user experience: usefulness, ease of use, and pleasure. To measure these constructs, existing literature was reviewed and relevant question items were adopted with modifications to fit the context of mobile phone evaluation.

2.4.2.1. Usefulness

Usefulness was defined as the extent to which an individual perceives that using a mobile phone is beneficial to their lives. In this research effort, four questions were selected and modified from the instrument developed by Davis (1989) as below:

- I find my cell phone useful in my life.
- My cell phone has all the functions and capabilities I expect it to have.
- My cell phone allows me to use my time efficiently.
- My cell phone makes my life easier.

2.4.2.2. Ease of use

Ease of use is defined as the extent to which a person believes that using the system will be free of effort (Davis, 1989). The HCI community developed several usability questionnaires to measure subjective usability, such as the Software Usability Measure Inventory (SUMI) (Kirakowski & Corbett, 1993), the Questionnaire for User Interaction Satisfaction (QUIS) (Chin, Diehl, & Norman, 1988), and the Computer System Usability Questionnaire (CSUQ) (Lewis, 1995). However, there have been concerns that these questionnaires are too generic to measure a consumer product such as mobile phones (Ryu & Smith-Jackson, 2006).

In response to this problem, Ryu and Smith-Jackson (2006) recently developed a questionnaire set that specifically measures mobile phone usability, called the Mobile Phone Usability Questionnaire (MPUQ). The MPUQ consists of 72 items that measure six factors:

learnability and ease of use, helpfulness and problem solving capabilities, affective aspect and multimedia properties, commands and minimal memory load, control and efficiency, and typical tasks for mobile phones. Despite its specialization to mobile phones, MPUQ appeared to be too generic as well when seen from the mobile phone interface components described in section 2.1, and its lengthy design can be problematic for a questionnaire study.

Therefore, this study pre-selected a set of 12 questions to measure the ease of use based on the mobile phone user interface framework suggested by Ketola and Roykkee (1995) and previous existing usability questionnaire instruments: the IBM computer usability satisfaction questionnaire (Lewis, 1995) and the MPUQ (Ryu & Smith-Jackson, 2006). The 12 items include simplicity, learnability, text reading on screen, label reading on buttons, menu navigation, error message understanding, error recovery, button press, text input, reference material, battery replacement, and battery charge. Below are the specific questions:

- It is simple to use my cell phone.
- It was easy to learn to use my cell phone.
- It is easy to read texts on the screen.
- It is easy to navigate the menu of the phone.
- My cell phone gives error messages that clearly tell me how to fix problems.
- Whenever I make a mistake using the cell phone, I recover easily and quickly.
- It is easy to read labels on buttons.
- It is easy to press buttons.
- It is easy to input text.
- Supplemental reference materials (e.g., user manual) provided with the phone is easy to understand.
- It is easy to replace the battery.
- It is easy to charge the battery.

2.4.2.3. Pleasure of use

Pleasure of use was defined as the extent to which users believe that using a mobile

phone is pleasurable in its own right (Davis et al., 1992). This construct includes hedonic qualities of mobile phones such as attractiveness, aesthetics, and entertainment. In this research effort, four questions were selected from previous studies (Igbaria et al., 1994; Nysveen et al., 2005):

- My phone design is attractive.
- The screen design of my phone is pleasant.
- I find my phone entertaining.
- My phone makes appealing sound.

2.4.2.4. Association with satisfaction

Traditionally, HCI research and other disciplines adopted "satisfaction" as a subjective measure of the product quality, defined as an affective state that is the emotional reaction to a product or service experience (Oliver, 1980; Spreng, MacKenzie, & Olshavsky, 1996). User satisfaction has been recognized as a key measure of system success in the information systems area (Bailey & Pearson, 1983; Baroudi, Olson, & Ives, 1986). Therefore, user satisfaction can be used as a surrogate measure for overall mobile phone quality. The findings from previous research based on TAM suggest research hypotheses: the usefulness (H_1), the ease of use (H_2), and the pleasure of use (H_3) of mobile phones affect the user satisfaction positively. The hypothesized research model for user satisfaction is illustrated in Figure 2.

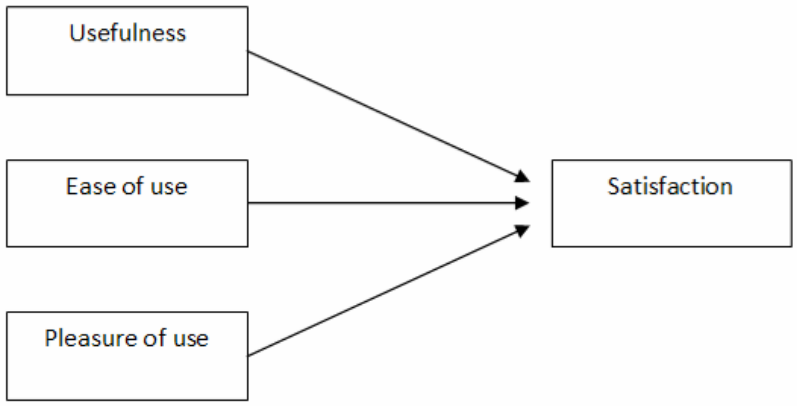


Figure 2. The hypothesized research model for user satisfaction

2.5. Needs analysis and user requirements development

User-centered design (UCD) refers to a multidisciplinary design approach that places users at the center of the design process (Courage & Baxter, 2005). As the first step of UCD, the user needs analysis/requirements development emphasizes the active involvement of users to gain a clear understanding of users' needs and to represent them in user requirements.

User needs refer to the first and least formal data representing problems that hinder users in achieving their goals or opportunities to improve the likelihood of users' achieving their goals (Kujala, 2002). The user needs are affected by the context of use that includes users' characteristics, users' goals, and environments in which a product is used.

User requirements refer to the formal descriptions that state any function, constraint, or other property needed to satisfy user needs (Kujala, Kauppinen, & Rekola, 2001). They include information about particular user needs to be satisfied by the future product. User requirements are distinct from technical requirements; the latter describes how the product will be implemented and the former describes the feature/attributes from users' perspectives (Courage & Baxter, 2005).

In spite of the need for user requirement analysis, it is a challenging process for designers who need to capture requirements as early as possible because most often users do not know what they want or they cannot articulate their needs. Robertson (2001) categorized the types of requirements into conscious and unconscious requirements. The conscious requirement is something that users are particularly aware of because they have experience with it or are aware of the piece of technology. Examples of conscious requirements are "I want the phone to fit in my pocket" or "I want the battery to last longer". On the other hand, the unconscious requirement is something that users are not aware of because either they are already used to having this requirement met from the product they used or they cannot imagine it within their understanding of the technology. To understand the unconscious requirements, developers need to help users extend their thoughts by showing more competitive features.

Needs analysis/user requirements development can be conducted in several ways such as interviews, questionnaires, scenario analysis, and prototype evaluation (Courage & Baxter, 2005; Robertson, 2001). However, organizing needs analyses that account for the complex interplay

between the user, the environments, and system factors relevant to product design is a challenge for developers.

To support this process, Smith-Jackson et al. (2003) developed a framework, called Needs Analysis and Requirements Acquisition (NARA). Designed to integrate well with simple elicitation methods such as focus groups and interviews, NARA is conducted based on four specific procedures: (1) elicit, (2) construct, (3) implement, (4) evaluate. The framework also presented a systematic process to translate information into requirements: 1) isolate elements, 2) isolate recurrences of elements across users, 3) develop decision rules to prioritize and cluster elements, 4) summarize element clusters into user requirements, and 5) develop affirmative statements that communicate the users' needs in terms of the design of the product or system. Kujala et al. (2001) suggested, based on their experience with four industrial partners, that list-based requirements including user need tables are a useful way to represent user needs to make them understandable and useful for designers, and use cases should be developed based on real users' behaviors to help designers to gain a coherent view of the product.

2.6. Summary

The review of the literature found that research on older adults' mobile phone use is limited. The majority of previous studies considered older adults to be a homogeneous group of people who are reluctant to adopt new technologies. However, other research revealed various groups among the older adult population; therefore, older adults are assumed to be as heterogeneous as young people in their user characteristics and technology use and adoption (Ellis & Allaire, 1999; Syme & Eisma, 2001). Few empirical studies have investigated the diversity existing in this population in terms of mobile usage pattern and their needs. For this reason, this research was designed to identify different user groups in this population and to capture their unique needs for mobile phones.

The literature suggested that using theoretical frameworks is beneficial to understand diversity of older adults and their unique needs. Two representative theories, Technology Acceptance Model (TAM) and Innovation Diffusion (ID) theory (Davis, 1989; Rogers, 2003), proposes that technology adoption and use is subject to a wide range of factors that can be

grouped into two major categories: user characteristics and perceived attributes of systems. User characteristics include age, gender, education level, experience with other technologies, and innovativeness. The perceived attributes of mobile phones includes usefulness, ease of use, and pleasure of use. This research investigated how these variables affected older adults' mobile phone usage to provide a better understanding of the kinds of support needed for older adults to improve their user experience. Details of the study are described in the following section.

CHAPTER 3. A SURVEY OF MOBILE PHONE USE IN OLDER ADULTS (STUDY 1)

3.1. Overview

This study was designed to address a fundamental question: *currently, how do older adults use their mobile phones and how do individual differences influence their mobile phone use and preferences?* Specific questions were as follows:

- Research question 1: *How do older adults use their mobile phones, and are there age and gender differences in mobile phone use?*
- Research question 2: *Are older adult mobile phone users homogeneous in terms of mobile phone usage pattern? If not, how many user clusters can be formed? What are the effects of user characteristics (age, gender, innovativeness, experience with other technology: computer, internet, and socio-economy status) on their usage patterns?*
- Research question 3: *How will usefulness, ease of use, and pleasure of use affect user satisfaction with mobile phones? Will there be differences between gender, age, and clusters in terms of influences of each factor on user satisfaction?*

To answer these questions, a self-report questionnaire was conducted to describe characteristics of mobile phone user experience. The aspects measured in this study were 1) reasons for mobile phone acquisition, 2) methods of learning about mobile phones, 3) mobile phone usage pattern, 4) perceived quality of the current mobile phone (usefulness, ease of use, pleasure of use, and satisfaction), and 5) demographic information. Results of this study are presented in three separate analyses to answer each of the three research questions above.

3.2. Method

3.2.1. Sample and procedure

The data for this study were gathered by a self-report questionnaire (see Appendix A.). Respondents were sought using a convenience sampling method by two means: local communities in Virginia and online senior communities. Twenty seven local senior centers and AARP local chapter meetings located in Virginia agreed to facilitate participant recruitment.

Contact persons were identified and reached by either personal visit or telephone to inform them of the purpose of this study. They were asked to distribute the survey to members who owned a mobile phone. An advertisement for this survey was also posted on numerous senior related websites including online communities and forums (See Appendix B for the list of the local and online communities contacted for this study).

A total of 154 older adults from 20 states in the U.S.A. who were mobile phone users participated in this study. There were 118 participants (76.6%) from Virginia, and 36 people (23.4%) were from the remaining 19 states. The large number of Virginia residents resulted from the sampling method, which was concentrated in Virginia.

The mean age of the participants was 70.8 years (*SD*=7.0; *Min*= 56; *Max*=90), and the length of their mobile phone ownership was 7.2 years (*SD*=4.6; *Min*= 1; *Max*=21). Of these respondents, there were 99 young-old adults (64%) aged 55 to 74 and 55 old-old adults (36%) aged 75 or above. An unbalanced gender distribution was found in the sample population (Table 3). There were 101 females and 53 males, yielding a relatively low male-female ratio (the number who were male times 100 divided by the number who were female) of 52.4, compared to 70 from the 2000 U.S. Census summary (U.S. Census Bureau, 2001).

Table 3. Participants' age and gender distribution

Age group	**Young-old (N=99)**				**Old-old (N=55)**			
Age	**56-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85-90**	**Total**
Female	4	17	24	19	29	5	3	101
Male	2	9	13	11	12	6	0	53
Total	6	26	37	30	41	11	3	154
%	3.9	16.9	24	19.5	26.6	7.1	1.9	100

Participants represented a wide range of residence areas (27.3% from urban areas, 46.1% from suburban areas, 25.2% from rural areas, 1.9% no answer), education attainment levels (from high school to graduate school), and household annual incomes (from less than $10,000 to more than $100,000). However, the education level of participants was higher than the overall U.S. senior population as people with bachelor or higher degrees accounted for 72.1% in the sampling population, compared to 37.1% from the 2005 U.S. Census summary (U.S. Census

Bureau, 2005). This may demonstrate a typical pattern of technology adoption that begins with those with higher education levels (Rogers, 2003). One hundred forty five people (94.2%) reported that they were healthy, and nine people reported various minor disabilities such as hearing disabilities, visual disabilities, and lower extremity disabilities.

An independent t-test indicated that there were no significant gender differences on age, income, innovativeness, computer use, and email use. A chi-square test of independence revealed that the male participants had higher education levels, as 84.9% of male participants attained the college or above education level, compared to 65.4% of female participants χ^2 (3, N=154) = 16.01, $p < .01$.

3.2.2. Measures

The survey included questions regarding various aspects of users' experiences with mobile phones (refer to Appendix A). The first set included inquiries on general mobile phone use: (a) the length of mobile phone ownership (referred to 'innovativeness' in the innovation diffusion theory) (b) reasons for phone ownership and (c) learning methods of mobile phone features. For the reasons for phone ownership, participants were asked to rate the six reasons for their phone ownership: personal communication (with family or friends), business communication (with business partners), information seeking (e.g., news or driving directions), information saving (e.g., phone numbers or personal notes), entertainment (e.g., music or game), and safety and security. The ratings were collected using a 5-point Likert scale with the following anchors: 1-Strongly disagree and 5-Strongly agree (Likert, 1932). In the second question, participants were asked to indicate the extent to which they used four methods (i.e., manual, asking someone, customer service, and trying myself) in learning about mobile phones features. The four learning methods were identified in a previous study (Lee, Smith-Jackson, Nussbaum, Tomioka, & Bhatkhande, 2004) and measured using a 5-point Likert scale (1-Strongly disagree and 5-Strongly agree).

The second set consisted of inquiries about current mobile phone usage including (c) the current phone type and (d) frequency of use of 20 specific functions (i.e., make a call, receive a call, phonebook, speed dial, call history, voice message checking, text messaging, voice memo,

change ringer tone, calculator, calendar, alarm, multimedia messaging service, camera, game, internet, voice activation, clock, listening to music, and speaker phone). Those 20 functions were selected since they were relatively common across differing phone manufacturers at the time of study. A four-point scale was used: 1- never and 4- frequently. Perceived quality of mobile phones was measured using three constructs (usefulness, ease of use, and pleasure of use) described in the literature review (refer to section 2.4.2). Overall satisfaction was also measured using a single item in response to the following: Overall, I am satisfied with my mobile phone. This item was reported on a 5-point Likert scale, anchored at the end points with strongly disagree (1) and strongly agree (5). Preferences for mobile phone functions were also examined. Participants were asked to mark all functions they desired to have in a phone in the future from among 23 functions (email, emergency call button, and audio display in addition to 20 functions that were listed in current mobile phone use).

Questions on user characteristics included: demographic characteristics (i.e., age, gender, education, current occupation, residence state, residence area, household income, and disability), and technology use (i.e., computer, email, and internet). The last section included open-ended questions where participants were asked to describe problems they faced with their current mobile phone or features of future mobile phones that they wish to have in the future.

3.2.3. Data analysis

Three separate data analyses were performed using SPSS (version 15.0) to answer each of the three research questions (Figure 3). The objective of Analysis 1 was to describe older adults' mobile phone experience and investigate effects of age and gender on mobile phone usage. One-way repeated measures Analyses of Variance (ANOVAs) were used to analyze the questionnaire responses. The sphericity assumption was tested using the Mauchly's test (Howell, 2002). When violations of sphericity were found with a significance level of .05, one of two correction methods (the Greehouse-Geisser correction and the Huynh-Feldt correction) was used to adjust the degrees of freedom. When the value of epsilon was lower than .75, the Greehouse-Geisser correction was used (Howell, 2002). Bonferroni *t* tests were used for multiple comparisons in post-hoc tests with a significance level of .05. The effects of age and

gender were tested using the independent samples t-test. Due to the differential sample size between age and gender groups, Levene's test was used to test homogeneity of variances. When violations were found (α= .05), independent samples t-tests assuming unequal variances were used.

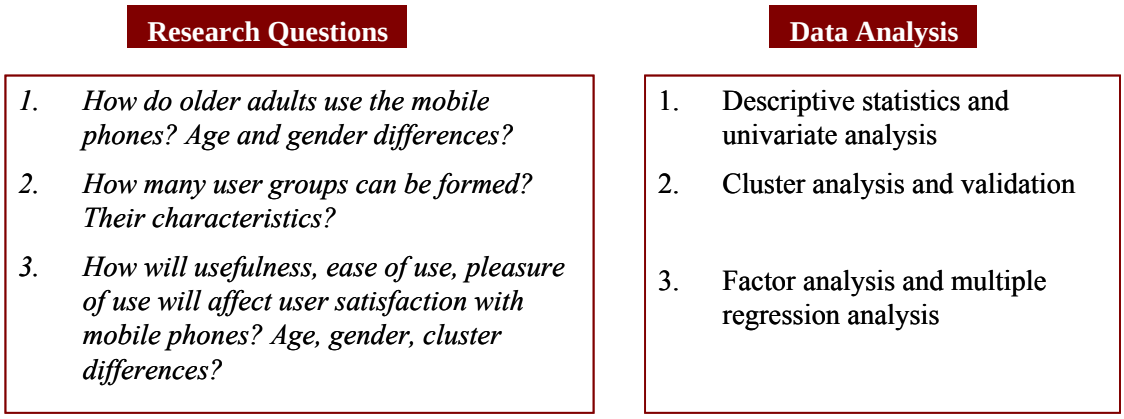


Figure 3. Data analysis scheme for Study 1

The objective of Analysis 2 was to identify representative mobile phone user groups based on their mobile phone usage pattern and examine the relationship between mobile phone usage behavior and user characteristics (e.g., age, gender, education, innovativeness, computer usage, and length of mobile phone ownership). Two-step cluster analysis was performed to segment participants according to the usage pattern of their current mobile phones. The Two-step clustering component was used for two reasons. First, it was suggested as an appropriate method in clustering a large data set from previous studies (Everitt, Landau, & Leese, 2001; Hair, Tatham, Anderson, & Black, 1998). Second, it provides the capabilities to determine the optimal number of clusters while other traditional clustering methods, such as hierarchical clustering, require analyzers to determine the number of clusters, which can be an arbitrary decision (Everitt et al., 2001). The two-step auto cluster procedure suggests the optimal number of clusters based on the Bayesian Information Criterion method (Weakliem, 1999). To investigate possible heterogeneity among clusters, One-way ANOVAs were used to test differences of the three clusters in the questionnaire responses. Pair-wise comparisons using

the Tukey HSD (α= .05) were performed in post-hoc tests.

The main objective of Analysis 3 was to test the validity and reliability of the mobile phone quality instrument and to investigate the effects of the three constructs (usefulness, ease of use and pleasure of use) on user satisfaction that was considered to be the overall metric of product quality. Refer to Figure 2 for hypothesized relationships among mobile phone product quality measures. To test construct validity of the instrument, an exploratory factor analysis was conducted using principal components analysis with varimax rotation. The internal consistency reliability was assessed by computing Cronbach's alphas (Howell, 2002). A multiple regression was conducted to test individual effects of the three constructs on user satisfaction.

3.3. Results of Analysis 1

3.3.1. Reasons for mobile phone ownership

A repeated measures ANOVA with Huynh-Feldt correction indicated that there were significant differences among the average ratings of the six reasons for mobile phone ownership, $F(4.52, 650.23) = 168.50$, $p < .01$. The Bonferroni comparison ($\alpha = .05$) indicated that the first reason for phone ownership is safety and security, followed by personal communication (Figure 4).

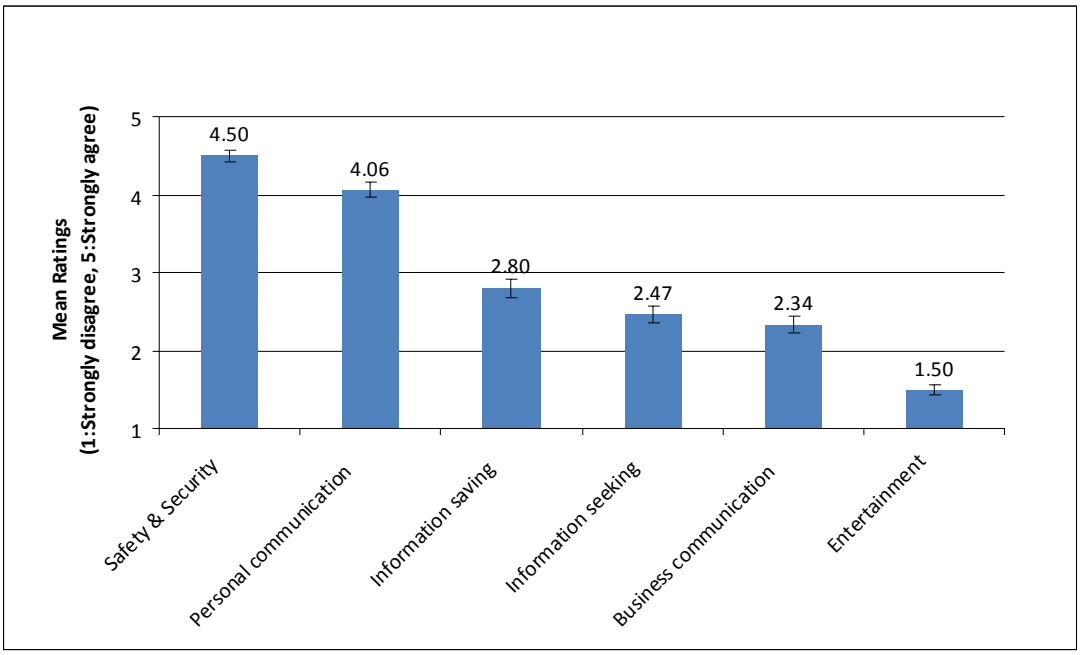


Figure 4. Mean ratings (+SE) for reasons for mobile phone ownership

The independent samples t-test assuming unequal variances revealed that males owned mobile phones for business communication more than females, $t(90.69) = -2.81$, $p < .01$,while females owned the phones more for safety and security, compared to males, $t(83.98) = 2.10$, $p < .05$, as shown in Figure 5. No age effect was found on reasons for phone ownership.

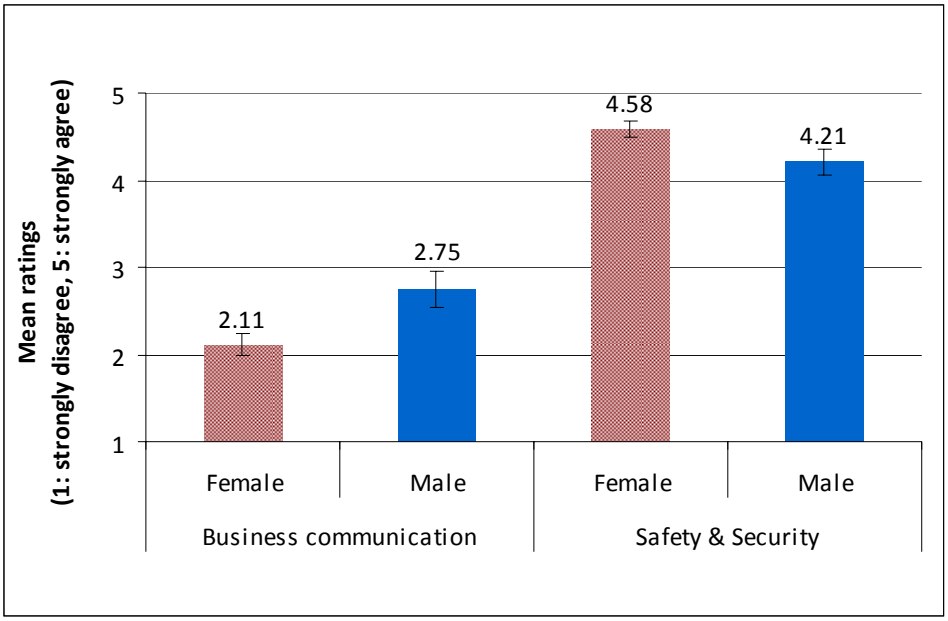


Figure 5. Gender differences on reasons for mobile phone ownership

3.3.2. Learning methods about mobile phone use

A repeated measures ANOVA using Huynh-Feldt correction revealed that there were significant differences among the learning methods, $F(3, 418.15) = 12.73$, $p < .01$. The repeated contrast using a Bonferroni comparison ($\alpha = .05$) indicated that 'trying oneself' and 'asking someone' were used significantly more often than reading the manual or customer service (Figure 6).

The interaction between learning method and gender was found to be significant, $F(2.95, 406.01) = 6.23$, $p < .01$. Males tried first to learn about operation of their phone features by themselves, and if they did not do the operation successfully, they referred to manuals (Figure 7). On the contrary, 'asking someone' was the preferred learning method for females followed by 'trying myself'. The 'user manual' was the least preferred learning method for female users. No age effect was found on learning methods.

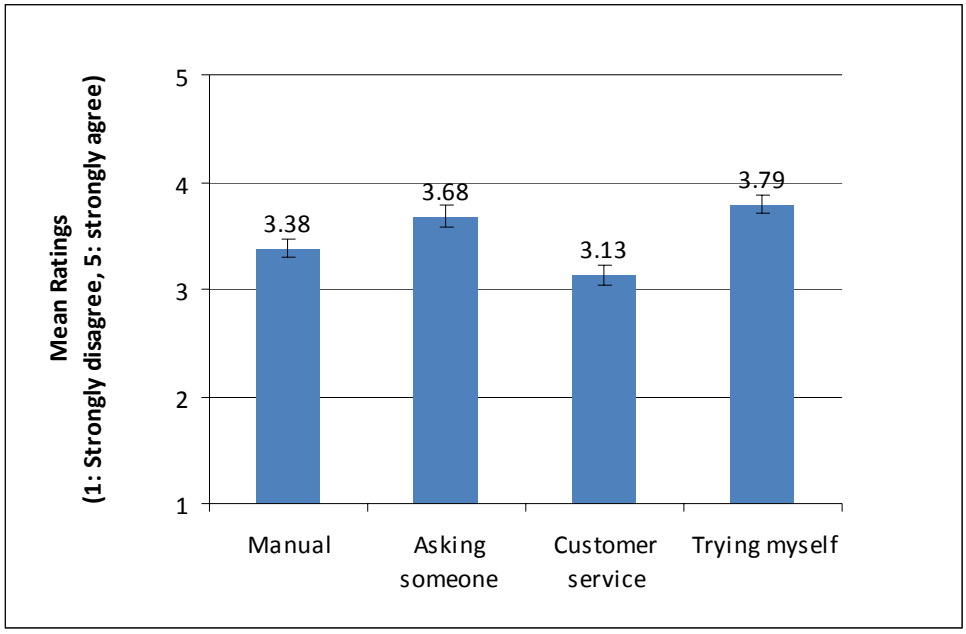


Figure 6. Mean ratings (+SE) for learning methods about mobile phone use

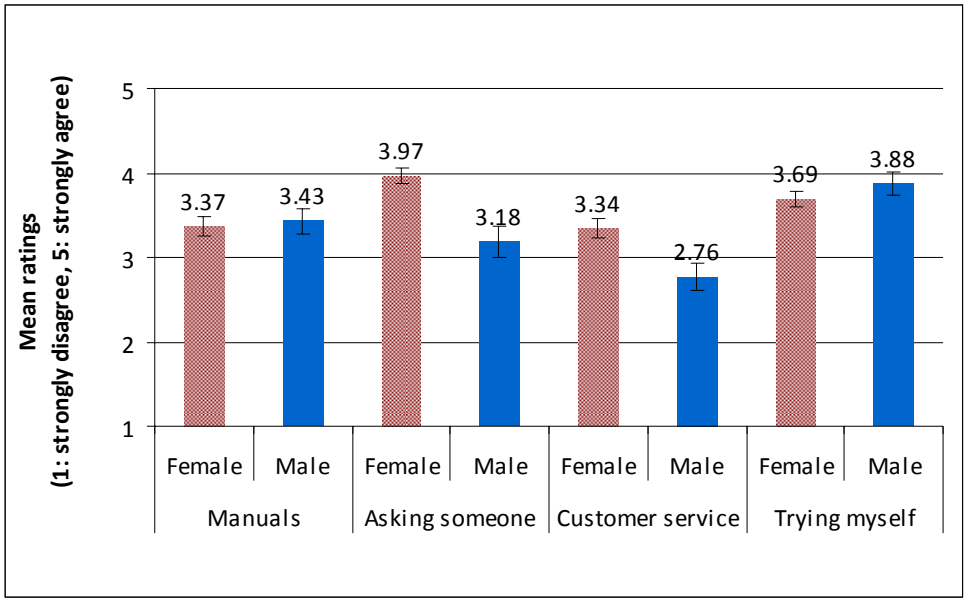


Figure 7. Gender differences on learning methods

3.3.3. Use of mobile phone features and frequency

A repeated measures ANOVA with Greenhouse-Geisser correction revealed that there

were significant differences among use of mobile phone features, $F(8.93, 1365.56) = 153.97$, $p < .01$. Figure 8 indicates that participants used a few mobile phones functions frequently such as calling and receiving, phonebook, voice message checking, and clock. The rest of the functions were used very rarely or not at all while 'speed dial', call history', 'change ringers' and 'speaker phone' were used more often than other functions.

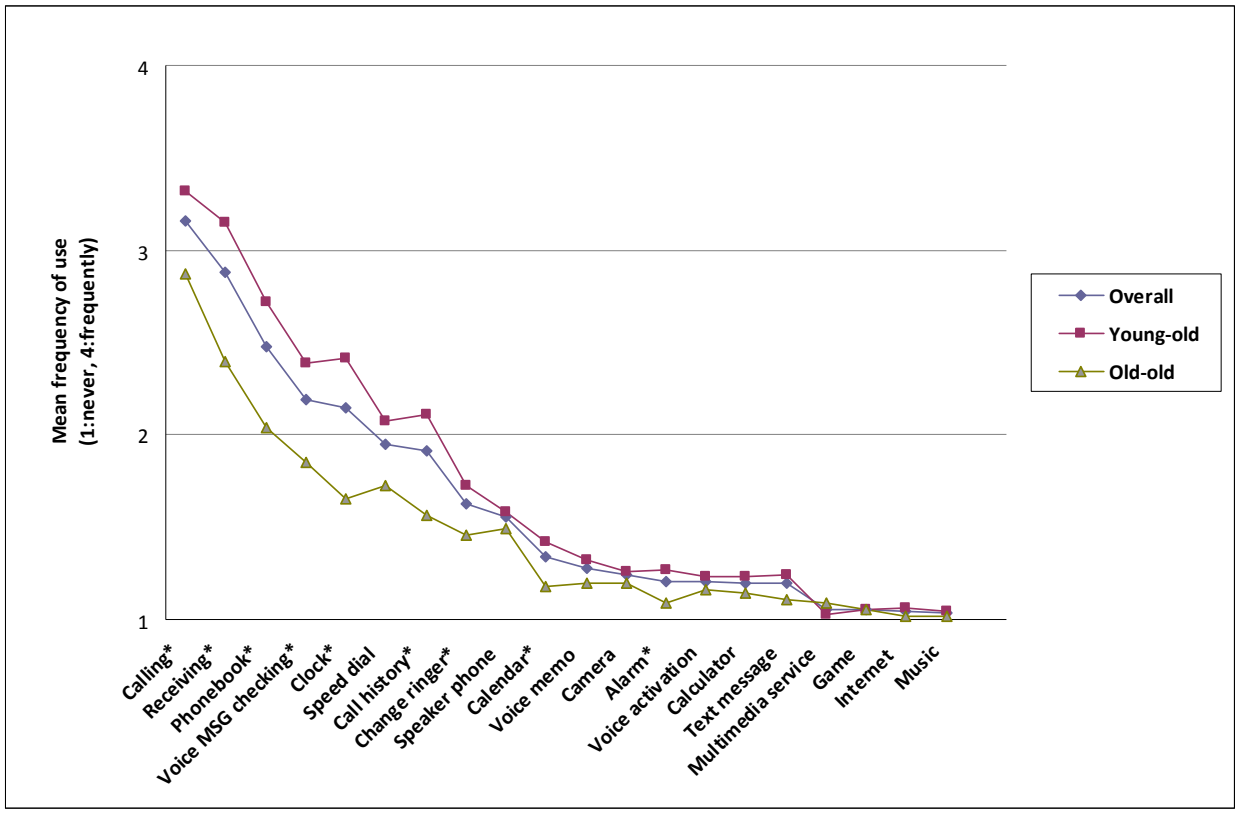


Figure 8. Mobile phone feature usage by older adults and age groups (*: age effect at $p < .05$)

No gender difference was found on mobile phone function use. However, there were significant differences between age groups on the use of the following features: calling [$t(99.99) = 3.52$, $p < .01$], receiving [$t(105.04) = 5.24$, $p < .01$], phonebook [$t(115.61) = 3.79$, $p < .01$], call history [$t(129.82) = 3.72$, $p < .01$], voice message checking [$t(116.63) = 3.12$, $p < .01$], change ringer [$t(131.85) = 2.35$, $p < .05$], calendar [$t(150.76) = 2.61$, $p < .01$], alarm [$t(151.27) = 2.41$, $p < .05$], and clock [$t(134.57) = 4.51$, $p < .01$], respectively. The young-old adults used the

features above more frequently, compared to the old-old adults.

3.3.4. Subjective evaluation of current mobile phones

Figure 9 shows the mean ratings for each measure of mobile phone quality: usefulness, ease of use, pleasure of use, and satisfaction. Participants rated their phone marginally positive for all measures, but the 'ease of use' received the lowest rating, indicating that the usability of the phone needs to be improved. An independent sample t-test found the effect of gender in the 'ease of use' construct, $t(115.88) = -2.05$, $p < .05$, indicating that females perceived their phones to be significantly more difficult to use than males.

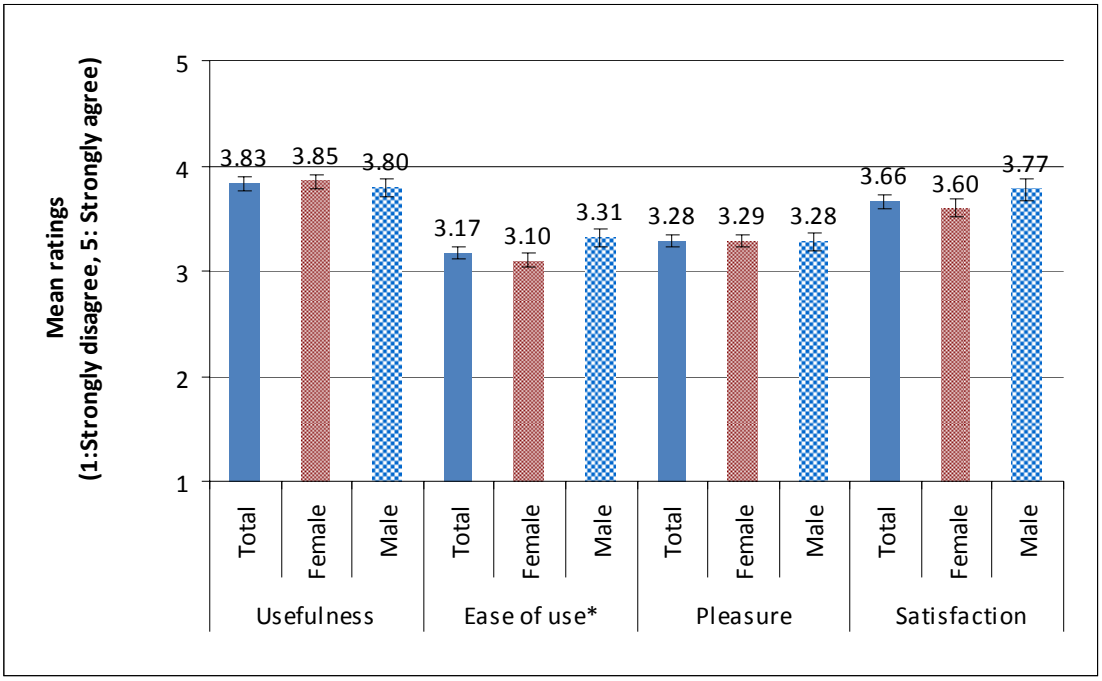


Figure 9. Mean ratings of mobile phone quality (*: gender effect at $p < .05$)

The mean ratings of 12 individual items under the 'ease of use' construct were examined to identify problematic UI components (Figure 10). A repeated measures ANOVA with Greenhouse-Geisser correction found that there were significant differences in the mean ratings of the individual items, $F(8.62, 1284.64) = 37.14$, $p < .01$. The Bonferroni comparison ($\alpha = .05$) indicated that understanding error message (M=2.55, SD= .86), inputting text (M=2.68, SD= .88),

and understanding reference material (*M*=2.76, *SD*=1.02) received significantly lower ratings than other components.

To examine what specific problems females faced compared to males, an independent t-test was conducted on individual items of 'ease of use', but there was no significant difference on any of the items. A detailed review on the individual items of 'ease of use' revealed that females perceived every aspect of their mobile phone to be slightly more difficult compared to males, and this subtle difference on individual items was cumulative and became significant in the overall 'ease of use', which was a sum of those 12 items. The same analysis was conducted to examine the effect of age, but no significant difference was found between the age groups.

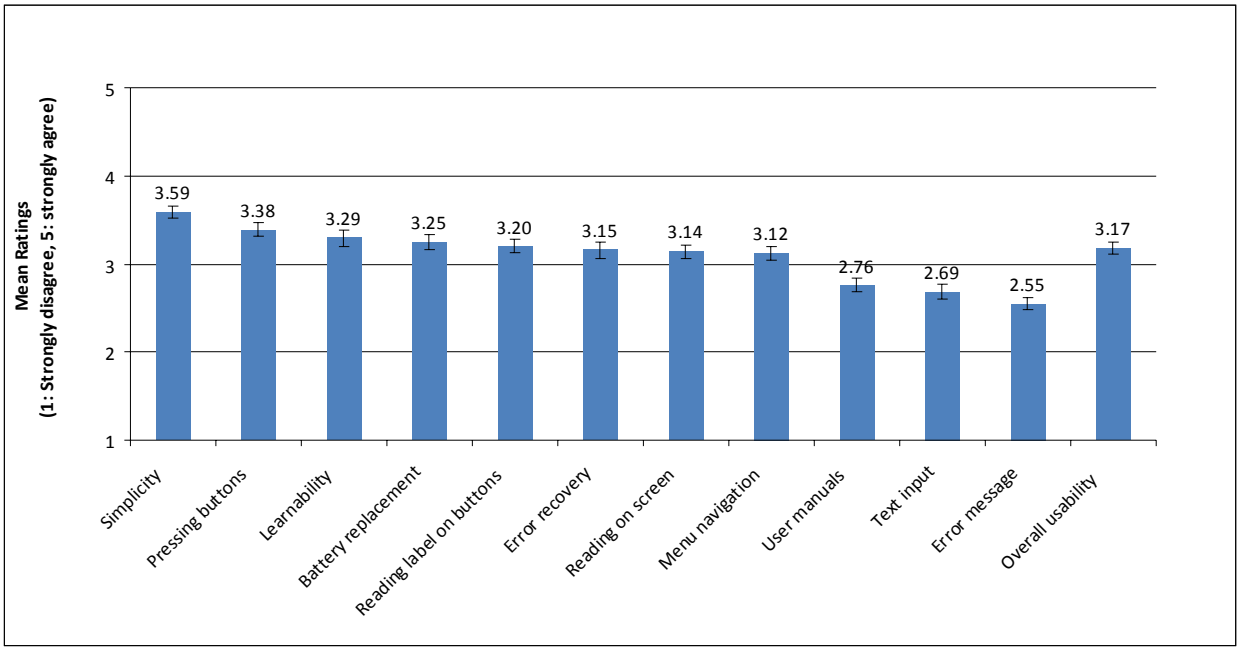


Figure 10. Mean ratings of individual 'ease of use' items

3.3.5. Functions desired

Participants were asked to check features that they wished to have in their phone in the future. The mean number of features that individuals desired was 9.3 (*SD*=4.7). The features desired by more than 50% of participants were: 1) making /receiving a call, 2) phonebook, 3) emergency call, 4) voice- message checking, 5) speed dial, 6) ringer change, 7) clock, and 8) call history, as shown in Figure 11.

An independent samples t-test revealed that there was no gender effect on the number of features desired. However, when their preference on the individual feature was compared by gender, males showed a stronger interest on the calendar feature compared to females $\chi^2(1, N=149) = 4.45, p < .05$.

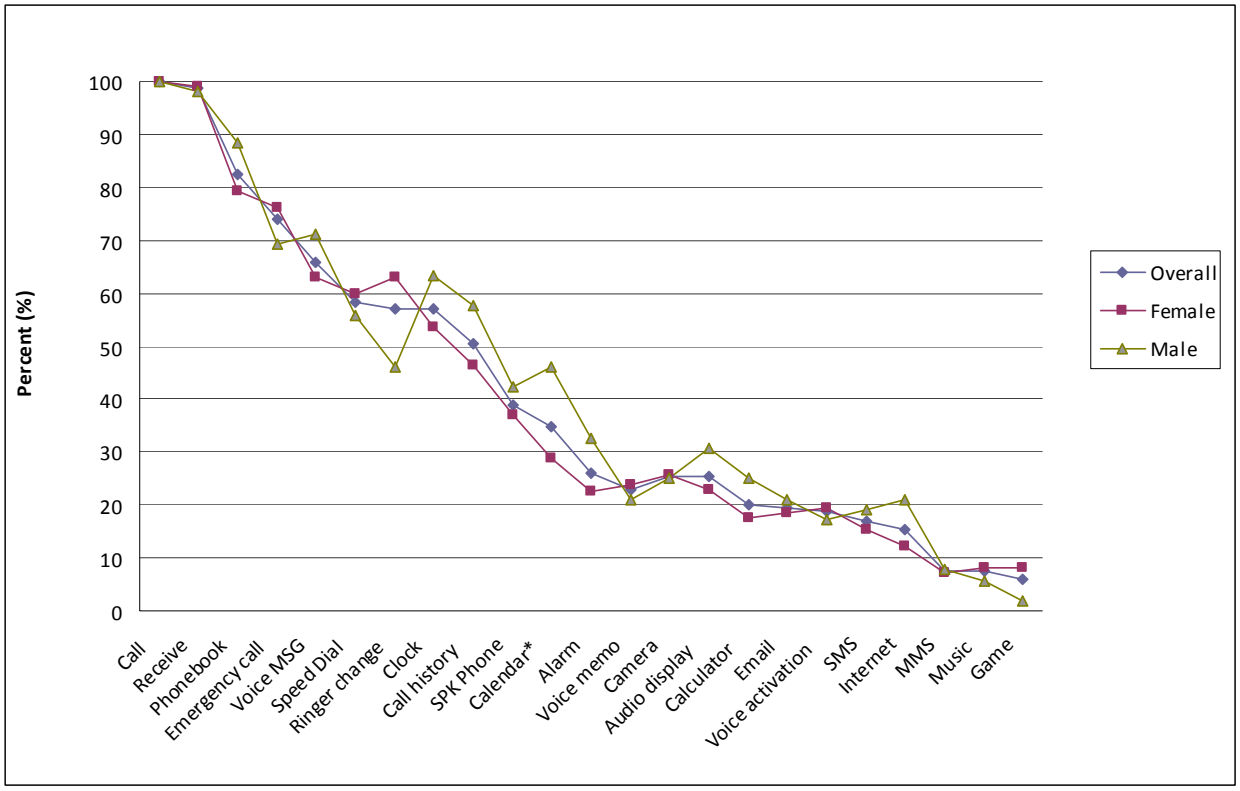


Figure 11. Features desired by gender groups (*: gender effect at $p < .05$)

The effect of age on desired functions was examined (Figure 12). The young-old adults wanted more features than the old-old adults, t (102.66) = 2.41, $p < .05$. The mean number of features that the young-old group wanted on their phone was 9.91 (SD=4.30) while 8.11 (SD=4.38) features were desired by the old-old group. A chi-square test found that the young-old group expressed a strong interest on the following features: phonebook, X^2 (1, N=149) = 4.98, $p < .05$, call history X^2 (1, N=149) = 4.51, $p < .05$, and clock, X^2 (1, N=149) = 5.35, $p < .05$.

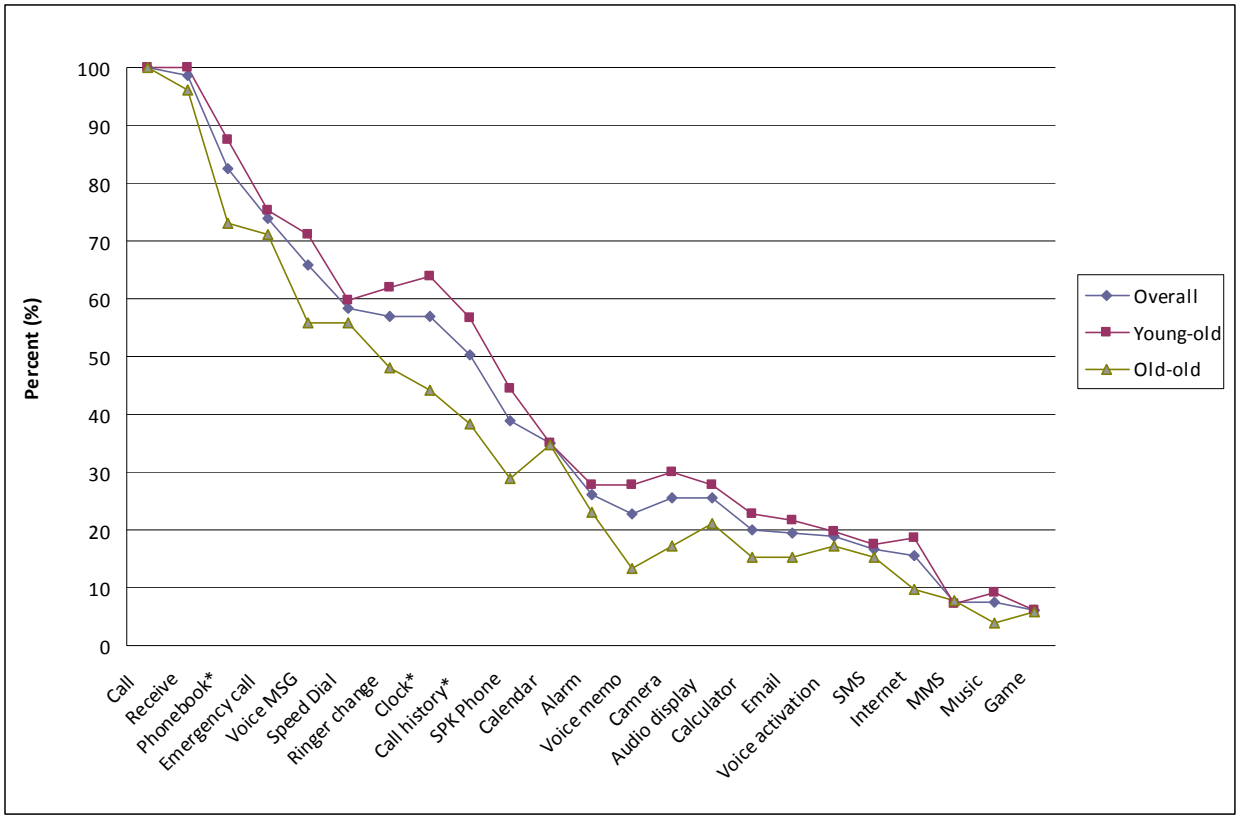


Figure 12. Features desired by age groups (*: age effect at $p < .05$)

3.4. Discussion of Analysis 1

The objective of this study was to investigate mobile phone use of the older adult population and to examine the effects of gender and age. This study revealed several new findings and supported previous findings.

First, it was found that older adults owned a mobile phone primarily for security & safety and personal communication with their family and friends; hence, they used few features of mobile phones. Features used frequently or somewhat frequently included phone call, phonebook, voice message checking, and clock. Other features were used very rarely or not at all. This finding is consistent with previous studies on mobile phone use in older adults (Kurniawan et al., 2006; Mann et al., 2004). It indicates that, regardless of the age-related disabilities and nationalities of older adults, older adults are conservative in their mobile phone use.

This finding is also supported by feature preferences. Overall, older adults wished to have basic phone features regarding communication and safety that included phone call, phonebook, emergency call, voice-message checking, speed dial, ringer change, clock, and call history. It suggests that mobile phone developers need to consider these features as basic features and enable easy access among older adults. Shneiderman (1998) supports this stating that the choice between basic user needs and extended functionality of a technical device has to be balanced carefully because novice users can perform best when they can accomplish simple tasks within a limited functionality. Older adults may perform best with a limited functionality that consists of the features above.

Second, this study revealed that, overall, older adults perceived their current mobile phone as difficult to use; understanding error messages, text input, and the reference manual were the main challenges in mobile phone use. Several characteristics of older adults may affect their interaction with mobile phones. The decline of memory functions and spatial abilities with age may interfere with feature navigation, which is further complicated by unfamiliarity with technical terms in error messages (Zajicek & Brewster, 2004). A previous study with a limited number of participants found that older adults were found to consequently delve into distraction, not easily navigating their way back once entering a wrong path within the menu (Ziefle & Bay, 2005).

This study showed that older adults relied on user manuals as one learning method but experienced difficulties in using them. Few studies investigate how user manuals can be designed better for older adults. More empirical studies are needed to investigate how and why older adults face those difficulties during the operation of the mobile phone in their lives. These were investigated in Study 2.

Third, this study found gender differences on perception about ‘ease of use’ and learning methods. Overall, female users tended to perceive their mobile phone to be more difficult to use, compared to male users. However, there was no difference in their mobile phone usage (i.e., the number of features used and frequency). Females learned about their mobile phone by asking someone while males tried to learn about their mobile phones themselves. Previous HCI studies revealed that females have lower self-efficacy toward computers, and their low self-

efficacy affects their perception about computers (Beckwith & Burnett, 2004; Busch, 1995). It is speculated, therefore, that females' lower perception of 'ease of use' was due to their self-efficacy although they had the same knowledge about the phone. However, this speculation needs to be tested in experimental research.

The effect of age on mobile phone usage was clear as well. The young-old group used and desired more features in their phone, compared to the old-old group, indicating that innovation diffusion theory may be applied to mobile phone feature adoption decision. Previous research revealed that computer knowledge and computer interest were negatively related to age, whereas computer anxiety was positively related to age in older adults (Ellis & Allaire, 1999). This study provided similar findings with mobile phones in that young-old users showed more interest in various features of mobile phones compared to the old-old users. However, the age effect was not found in their perception of ease of use. This result was somewhat surprising since it was anticipated that the old-old users might face more difficulties in their mobile phone use. However, it can be speculated that because old-old users tended to use fewer features of their mobile phones they encountered fewer problems in their use.

3.5. Results of Analysis 2

3.5.1. Two-step cluster analysis

The Two-Step cluster analysis identified three clusters, and clear separation among the clusters was indicated by the minimization of the BIC value and BIC change between adjacent numbers of clusters (Table 4). The resulting clusters were: 46 participants (29.9%) in Cluster 1, 63 (40.9%) in Cluster 2, and 45 (29.2%) in Cluster 3, respectively.

Table 4. The result of the cluster solution

Number of Clusters	Schwarz's Bayesian Criterion (BIC)	BIC Change(a)	Ratio of BIC Changes(b)	Ratio of Distance Measures(c)
1	5119.14			
2	4788.67	-330.47	1.00	1.87
3	4740.24	-48.43	0.15	1.74
4	4829.77	89.53	-0.27	1.05
5	4927.37	97.60	-0.30	1.23

3.5.1.1. Phone usage profiling

Figure 13 shows the mean ratings on the usage of 20 phone features across clusters. Users in Cluster 1, referred to as “explorers” hereafter, appeared to be active mobile phone users who used various communication features frequently such as make/receive a call, phone book, speed dial, call history, and voice message checking, while using other features such as ringer change, calculator and calendar rarely. Users in Cluster 2, termed as “basicians” hereafter, were characterized by less frequent use of basic communication features, compared to explorers, and little use various additional features. Cluster 3, referred to as “minimalists” hereafter, included low-end users who utilized a mobile phone very rarely. Minimalists placed and received calls rarely, and they did not use any other features at all. The differences in phone usage among clusters were tested using a one-way ANOVA. A significant difference was found from the use of all 20 features among three clusters at $p < .05$.

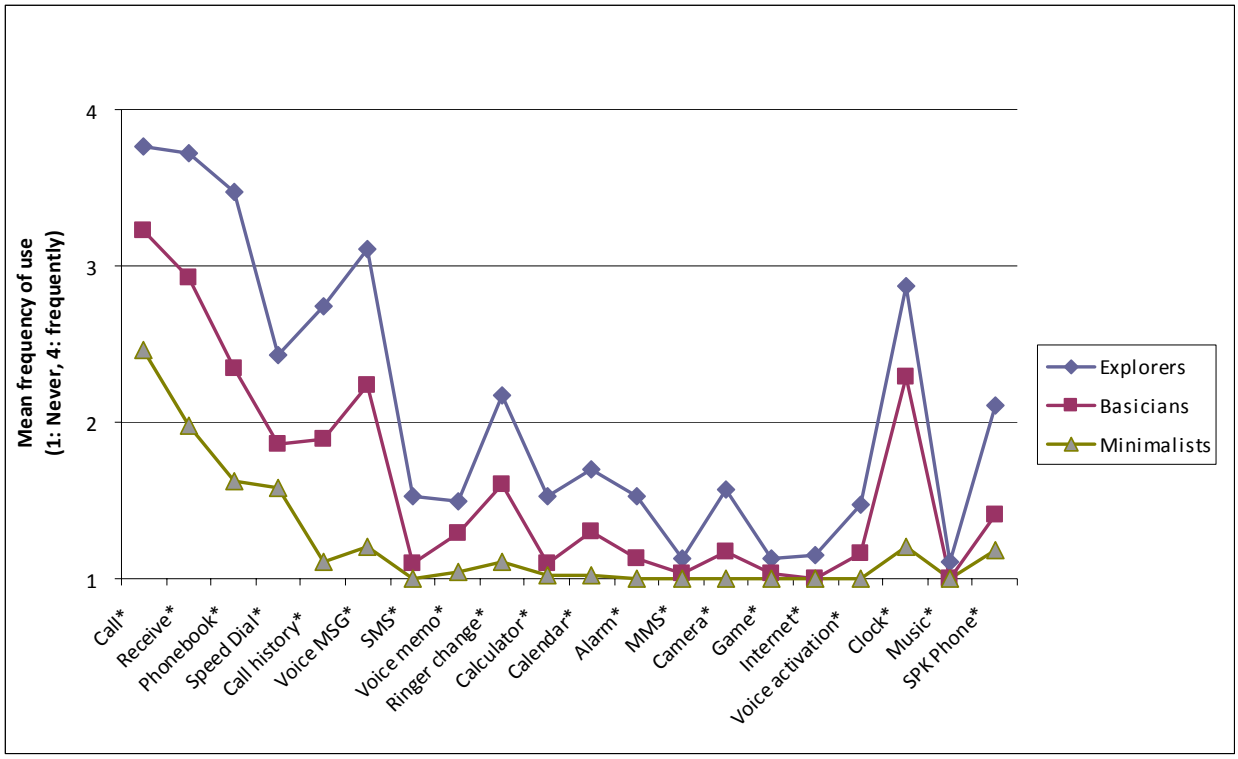


Figure 13. Mobile phone usage by clusters (*: $p < .05$)

3.5.1.2. Demographic profiling

Table 5 summarizes the mean value and frequency distributions for the demographic variables, technology use, and innovativeness within and across clusters, respectively. A one-way ANOVA revealed that age was significantly different among clusters, $F(2,151)=13.11$, $p < .01$, and a pair-wise comparison using the Tukey HSD ($\alpha = .05$) revealed that explorers were significantly younger than minimalists at $p < .01$. While no significant difference was found among other demographic variables, a one-way ANOVA found a significant difference on the length of mobile phone ownership (innovativeness) among clusters, $F(2,147)=8.98$, $p < .01$. A pair-wise comparison using the Tukey HSD ($\alpha = .05$) revealed a significant difference among all groups, indicating that explorers owned a mobile phone longer than basicians and minimalists, and basicians longer than minimalists.

Table 5. Composition of demographic profiles within and across clusters

		Explorers	Basicians	Minimalists	Statistics
		N= 46	*N* = 63	*N* = 45	
Age		68.22	69.78	74.84	*F (2, 147)* =23.2, *p*< .01*
Gender	Female	26	45	30	X^2=2.65, *p*= .27
	Male	20	18	15	
Education	< High school	1	0	0	X^2=6.96, *p*= .33
	High School	10	17	15	
	College	16	30	17	
	Graduate School	19	16	13	
Residence	Urban	12	18	12	X^2=5.70, *p*= .30
	Suburban	26	23	22	
	Rural	8	21	9	
Income	< $10,000	0	2	1	X^2=15.29, *p*= .12
	10,000 – 24,999	8	4	8	
	25,000 – 49,999	7	18	11	
	50,000 – 74,999	7	17	7	
	75,000 – 99,999	7	5	5	
	> $100,000	12	8	4	
Computer Use		4.93	4.95	4.44	*F*=1.31, *p*= .27
Internet Use		4.74	4.68	4.09	*F*=1.77, *p*= .17
Email Use		4.80	4.77	4.24	*F*=1.34, *p*= .27
Length of phone ownership		9.49	6.52	5.83	*F (2, 150)* =8.98, *p*< .01*

3.5.2. Effects of demographic characteristics on the user classification

To determine if a combination of user characteristic variables (age, gender, education, innovativeness, and computer use, internet use, and email use) can predict user classification, a multinomial logistic regression was performed using the stepwise procedure. The resulting model indicated that age, innovativeness, and internet use were significant variables in predicting the cluster classification (Table 6). The model was a good fit (-2log-likelihood = 118.71, χ^2 = 203.53, *df* = 134, *p*< .01) in that it could predict the classification at 79.9% accuracy. The Nagelkerke's pseudo-R^2 was .84. This indicated that those who were relatively younger, adopted the mobile phone earlier, and used the internet frequently, tended to be high-end mobile phone users who utilized more features and frequently.

Table 6. Resulting model of the multinomial logistic regression

Variables	-2 Log Likelihood of Reduced Model	Chi-Square	*df*	*p*
Intercept	118.71			.
Age	221.96	103.25	56	.01
Innovativeness	187.44	68.73	40	.01
Internet Use	136.47	17.76	10	.05

3.5.3. Validation of the cluster solution

3.5.3.1. Reasons for mobile phone ownership

A one-way ANOVA was conducted with reason for phone ownership (Table 7). There were significant differences on the mean ratings of the three reasons: personal communication, business communication, and information saving. A pair-wise comparison with the Tukey HSD (α = .05) revealed that explorers have a higher mean value for the three reasons than both basicians and minimalists, at $p < .01$. This result indicated that besides communication with family members, explorers used their phone for more diverse purposes, such as information saving and business, than other two groups. Regardless of the user type, participants had a mobile phone mainly for safety reasons and not for entertainment.

Table 7. Differences among clusters on motive of phone ownership

Motives	User group	*N*	Mean (*SD*)	Statistics
Personal Communication	Explorers	46	4.35 (1.04)	F (2, 148)=10.99, $p < .01$
	Basician	62	4.26 (1.07)	
	Minimalist	43	3.37 (1.20)	
Business Communication	Explorers	46	2.74 (1.51)	F (2, 144)=4.51, $p < .05$
	Basician	61	2.31 (1.30)	
	Minimalist	40	1.90 (1.00)	
Information Saving	Explorers	46	3.30 (1.36)	F(2, 145) = 0.92, $p < .01$
	Basician	61	2.84 (1.27)	
	Minimalist	41	2.12 (1.36)	

3.5.3.2. Methods of learning about mobile phones

A one-way ANOVA was conducted with the ratings for four learning methods. A significant difference among clusters was found on 'trying myself', F(2, 149)=8.21, $p < .01$. The Post-hoc Tukey HSD (α= .05) revealed that explorers and basicians used 'trying myself' as

a more preferred learning method compared to minimalists. The mean rating indicated that explorers and basicians used 'trying myself' as the chosen learning method, while minimalists preferred 'asking someone'. However, 'reading manual' and 'customer services' were the last option for all three groups, indicating that manual was not considered to be useful to all three groups (Figure 14).

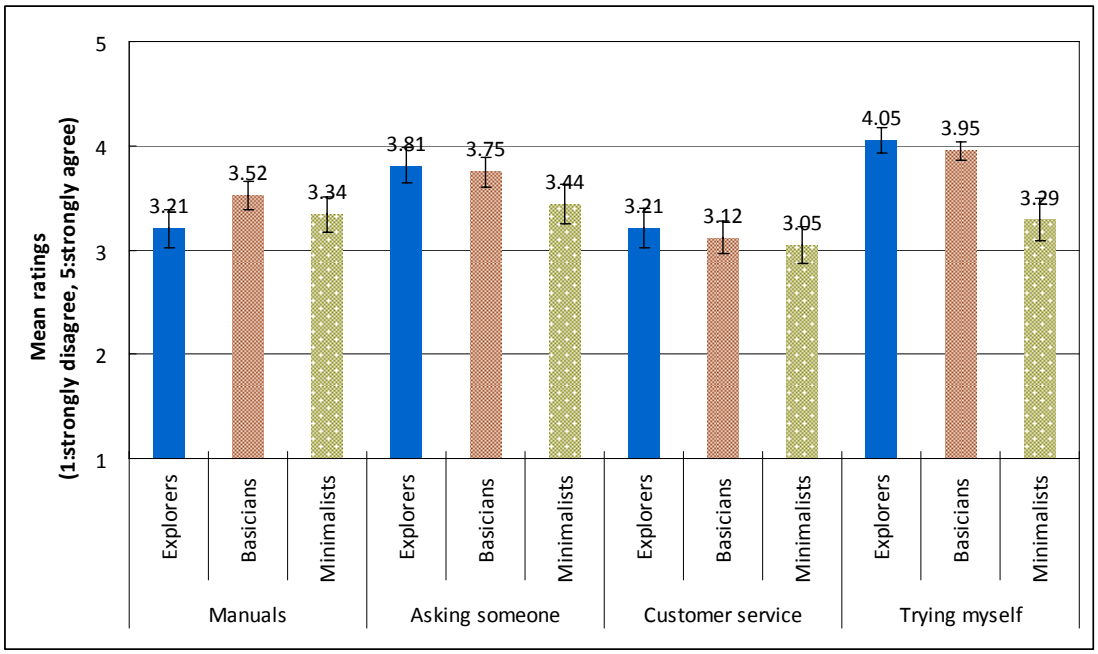


Figure 14. Differences in learning method among clusters

3.5.3.3. Subjective evaluation about their mobile phones

A one-way ANOVA was conducted to examine differences of four attributes of mobile phones: usefulness, ease of use, pleasure of use, and satisfaction. A significant difference was found for usefulness, ease of use, and pleasure of use, $F(2, 149)=17.39$, $p< .01$, $F(2, 148)=6.20$, $p< .01$, and $F(2, 149)=9.79$, $p< .01$, respectively. The Tukey HSD ($\alpha= .05$) revealed that explorers perceived their phone to be more useful, easier to use, and more pleasurable to use than basicians and minimalists (Figure 15). There was no significant difference in the satisfaction among clusters ($p= .07$).

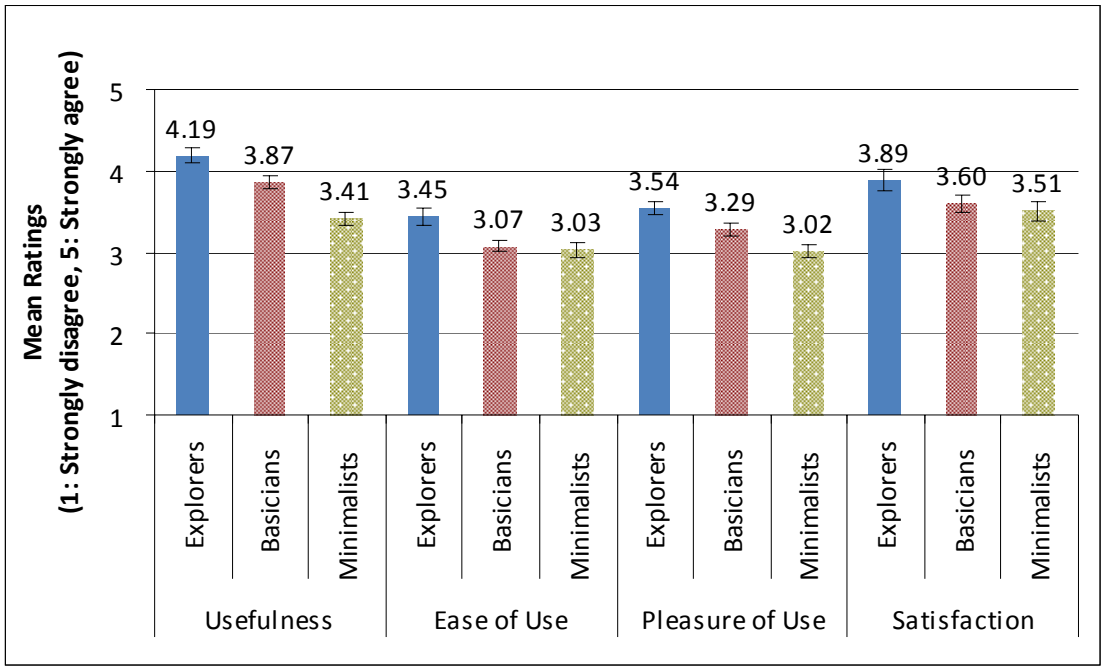


Figure 15. Mean ratings for quality attributes of mobile phones

The mean ratings of 12 individual 'ease of use' items were examined to compare detailed usability problems among clusters. A one-way ANOVA revealed a significant difference for simplicity [$F(2,148)=4.67$, $p< .05$], menu navigation [$F(2,148)=7.03$, $p< .01$], recovery from mistake [$F(2,147)=8.98$, $p< .01$], and battery replacement [$F(2,148)=6.41$, $p< .01$]. The Post-hoc Tukey HSD ($\alpha= .05$) revealed that explorers perceived their phones significantly easier on the four items than basicians and minimalists. Basicians and minimalists, specifically, reported serious problems with four items: 'menu navigation', 'understanding error message', 'text input', and 'user manual' commonly (Figure 16).

3.5.3.4. Features desired by clusters

Figure 17 shows features that participants desired to have in their phone in the future (Figure 17). A one-way ANOVA revealed a significant difference in the number of desired features among the three clusters, $F(2,146)=25.06$, $p< .01$. Explorers wanted to have about 12 features while basicians and minimalists wanted to have about nine and six features, respectively. Table 8 shows the mean number of features that each cluster desired and descriptions of the

features. Explorers expressed their interest about additional features beyond communication, such as a camera feature. Meanwhile, minimalist users desired to have only basic communication features that included make/receive calls, clock, phonebook, speed dial, and voice message. These results provide a list of features that developers should consider including in the phone for each cluster. However, it should be noted that this result is not necessarily complete since it was gathered based on 23 features listed in the questionnaire and other features may be desired, as they become available.

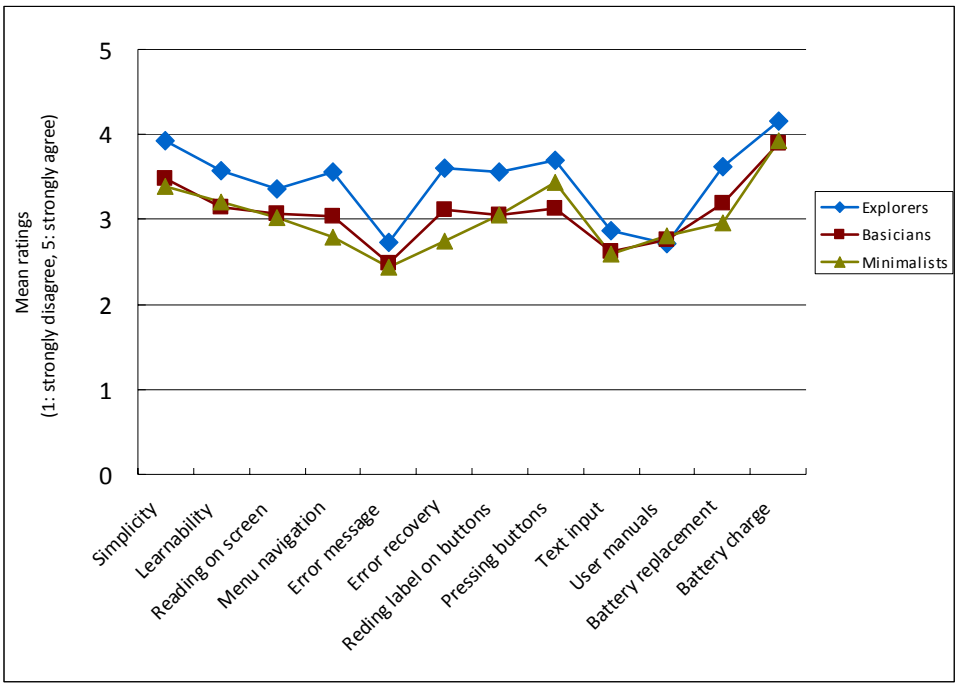


Figure 16. Subjective evaluation on current mobile phones by clusters

A Chi-square test was conducted to compare preferences for each individual feature among clusters, and a significant difference was found for phonebook, speed dial, call history, voice message checking, text messaging, voice memo, ringer change, calendar, camera, internet, email, voice activation, clock, and speaker phone at $p < .01$.

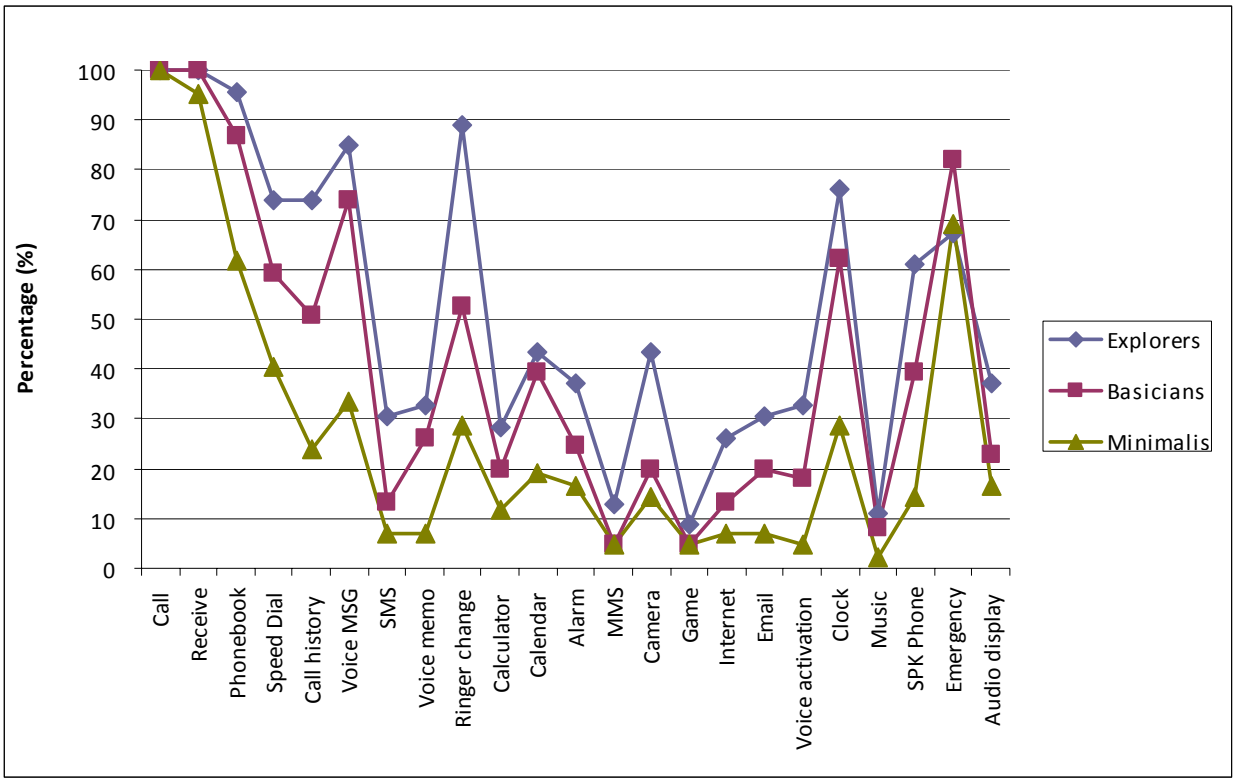


Figure 17. Phone features desired by clusters

Table 8. Features desired by each cluster

Clusters	Mean # of features (*SD*)	Features desired (in the order of features with highest frequency)
Explorers	11.96 (4.41)	Call, receive, phonebook, speed dial, ringer change, voice msg., clock, speed dial, call history, emergency, speaker phone, camera or calendar
Basicians	9.41 (3.51)	Call, receive, phonebook, emergency, voice msg., clock, speed dial, ringer change, call history, speakerphone or calendar
Minimalists	6.19 (3.56)	Call, receive, clock, phonebook, speed dial, voice message
Total	9.29 (4.40)	

3.6. Discussion of Analysis 2

Despite increasing mobile phone use by older adults, there was scarce empirical knowledge about behavioral and demographic characteristics of mobile phone users in the older adult population. The lack of such research created a critical challenge for mobile phone

developers who need to define representative target users. This study using the Two-Step cluster analysis suggested that older adult mobile phone users could be classified into three segments in terms of their mobile phone usage behavior as follows:

- Explorers (*N*=46, 30%): This group, composed of relatively young-old people (*M*= 68.22, *SD*=6.80). People in this group appeared to be early adopters who tended to adopt technology innovation earlier. They appeared to be high-end mobile phone users as they used various features for communication purposes (e.g., phone calls, phonebook, voice message checking, speed dial, and call history) while trying out additional features like camera, ringer change, and calculator. They also appeared to have knowledge about their phone since they perceived their current mobile phone to be relatively easy to use. This group desired more features in their mobile phone including call, receive, phonebook, speed dial, ringer change, voice msg., clock, speed dial, call history, emergency, speaker phone, camera or calendar.
- Basicians (*N*=63, 41%): This group was characterized by the use of a few features for communication purposes (e.g., phone calls, phonebook, and voice message checking). They appeared to have limited knowledge about mobile phones as they perceived their phone difficult to use. This may explain why they do not try out additional features like the camera and calculator features. The features basicians desired included call, receive, phonebook, emergency, voice message, clock, speed dial, ringer change, call history, speakerphone or calendar.
- Minimalists (*N*=45, 29%): This group, composed of the old-old participants (*M*= 74.84, *SD*=6.00), appeared to be low-end users who use a mobile phone for emergencies only. People in this cluster used their phone very rarely and then only to place a call without using the phonebook feature. They seemed to have limited knowledge about their phone as they perceived their phone difficult to use. Features desired by this group included call, receive, emergency call, phone book, speed dial, and voice message. They could be described as late adopters.

This cluster solution is the only known research to segment older adult mobile phone users who were reported to be homogenous in previous studies (Kurniawan et al., 2006; Mann et al., 2004). The findings of this study indicated older adults are not homogeneous in their mobile usage and provides information for strategic segmentation for mobile phone development by identifying desired features and common problems among the users of each group.

As Shneiderman (1998) recommends, the functionality of a technical device should be balanced with user needs carefully because novice users perform best when they can manage simple tasks within a limited functionality. Meanwhile, experts can profit from a powerful system with a broad functionality. According to the descriptions of characteristics for each cluster, it is reasonable to assume that explorers are considered to be towards the expert level while minimalists to be novice users. Mobile phone developers can refer to this cluster solution as a target user group in the development process. Usability engineers can also take benefit from this cluster solution when they recruit participants for usability evaluation.

This study revealed that age, innovativeness (time of adoption of mobile phone) and internet use were significant predictors with 75.2 % prediction accuracy, indicating that people who are younger, use the internet more frequently, and are earlier mobile phone adopters are higher-end mobile phone users. This study, therefore, empirically confirmed that earlier technology adopters actually utilized the technology more than later adopters after their adoption decision. Utilization of mobile phone was defined by usage frequency and usage variety that referred to the different applications used by users (Ram & Jung, 1994). This finding has significant implications for target user selection methods and understanding their characteristics during product development. First, three predictors of user clusters can be effective when product development teams recruit target users. Second, a large body of innovation diffusion research revealed various characteristics of innovators or earlier adopters, and these findings may be useful in understanding characteristics of high- or low-end users. For example, Ram and Jung (1994) found that earlier adopters tended to seek more information about products, and based on the findings of this study, it may be reasonable to assume that high-end users also seek more information about products.

3.7. Results of Analysis 3

3.7.1. Measurement assessment

3.7.1.1. Construct validity

Construct validity determines the extent to which a scale measures a variable of interest (Bryman, 2004). The construct validity is assessed by convergent (the degree to which multiple attempts to measure the same concepts are in agreement) and discriminant validity (the degree to which measures of different concepts are distinct). To test construct validity, an exploratory factor analysis was conducted using principal components analysis with varimax rotation. Six factors were determined using the Kaiser-Gutman criterion as they yielded eigenvalues greater than one while explaining 67.38% of the total variance (Hair et al., 1998). Table 9 represents the results of the factor analysis.

Table 9. Factor analysis results (EU: ease of use, UF: usefulness, PU: pleasure of use)

Item	Component					
		2	3	4	5	6
EU-4	.84					
EU-2	.80					
EU-1	.67			.36		
EU-3	.65					
EU -6	.59		.33			
EU -10	.52		.33		.46	
EU -5	.48		.37			
EU -9	.45		.36			
UF-1		.81				
UF-3		.79				
UF-4		.79				
UF-2		.63		.35		
EU-8			.85			
EU-7	.33		.81			
PU-2				.88		
PU-1				.86		
PU-4					.75	
PU-3		.30			.68	
EU-12						.83
EU-11						.73

Usefulness (UF) was found to be uni-dimensional, but ease of use (EU) and pleasure of use (PU) appeared to have multiple dimensions. Three dimensions were extracted for EU: navigation-related (item 1-6, 9, 10), battery-related (item 11-12), and button-related EU (item 7-8). The PU appeared to have two dimensions: aesthetics (item 1 and 2) and entertainment (3 and 4). Factor loadings for all variables were greater than .45, indicating acceptable discriminant validity (Hair et al., 1998).

Since several items in the EU scale were found to have cross loadings, the principal component analysis with varimax rotation was performed again within the 12 items of EU, and it yielded the same three constructs but item 9 was assigned to the button-related EU dimension. The resulting five dimensions and the appropriate items are shown in Table 10.

Table 10. Factor analysis on the ease of use scale

Scale items	1	2	3
EU-4	.89		
EU-2	.86		
EU-1	.63		
EU-6	.62		
EU-3	.60		
EU-5	.54		
EU-10	.48		
EU-12		.80	
EU-11		.77	
EU-8			- .95
EU-7			- .83
EU-9			- .58

3.7.1.2. Internal consistency reliability

The internal consistency reliability was assessed by computing Cronbach's alphas. These alpha coefficients are displayed for each of the three quality constructs as well as their sub-dimensions in Table 11. While the alpha value for the three attributes ranged from .74 to .88, two sub-dimensions (i.e., battery-related EU and entertainment) were found to have .60 alpha value, which is lower than the widely-accepted cut-off, .70 (Nunnally, 1978). However, given the exploratory nature of the study and the small number of question items in these

dimensions, validity and reliability of the scales were considered adequate.

Table 11. Resulting dimensions and internal consistency reliability

Quality attributes (cronbach α)	Sub-dimensions and Items	Cronbach α
Ease of use (0.88)	Navigation-related ease of use	.85
	1) It is simple to use my cell phone.	
	2) It was easy to learn to use my cell phone.	
	3) It is easy to read texts on the screen.	
	4) It is easy to navigate the menu of the phone.	
	5) My cell phone gives error messages that clearly tell me how to fix problems.	
	6) Whenever I make a mistake using the cell phone, I recover easily and quickly.	
	10) Supplemental reference materials (e.g., user manual) provided with the phone is easy to understand.	
	Button-related ease of use	.80
	7) It is easy to read labels on buttons.	
	8) It is easy to press buttons.	
	9) It is easy to input text.	
	Battery-related ease of use	.60
	11) It is easy to replace the battery.	
	12) It is easy to charge the battery.	
Usefulness (0.83)	1) I find my cell phone useful in my life.	.83
	2) My cell phone has all the functions and capabilities I expect it to have.	
	3) My cell phone allows me to use my time efficiently.	
	4) My cell phone makes my life easier.	
Pleasure of use (0.74)	Aesthetics	.92
	1) My phone design is attractive.	
	2) The screen design of my phone is pleasant.	
	Entertainment	.60
	3) I find my phone entertaining.	
	4) My phone makes appealing sound.	

3.7.2. Hypothesis testing

3.7.2.1. Factors affecting on satisfaction

A multiple regression analysis was performed to test the hypothesized relationships among mobile phone quality attributes. Table 12 shows a summary of the regression model. The combination of three variables significantly predicted user satisfaction, $F(3, 143) = 54.903$, $p < .01$, with all three variables significantly contributing to the prediction. The beta weights

suggested that the EU affected user satisfaction most significantly on user satisfaction, followed by PU and UF. The R^2 was .54, indicating that 54% of the variance in user satisfaction was explained by the model. Therefore, the initial hypotheses were supported.

Table 12. Results of multiple regression analysis (with three attributes)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	-0.316	0.341		-0.927	0.355
X1: Usefulness	**0.169**	**0.081**	**0.133**	**2.087**	**0.039**
X2: Ease of Use	**0.623**	**0.088**	**0.470**	**7.071**	**0.000**
X3: Pleasure of Use	**0.416**	**0.089**	**0.303**	**4.658**	**0.000**

Note: Bold indicates significant variable

A multiple regression was conducted using the six sub-dimensions that were identified in the factor analysis to examine individual effects of the sub-dimensions on the user satisfaction. The effects of usefulness, navigation-related EU, button-related EU, and aesthetics were found to be significant at $p < .05$ (Table 13). Among the four, the navigation-related EU and aesthetics had the greatest impact on the user satisfaction, as shown in the standardized coefficients. This model explains 57% of observed variance in user satisfaction, which was highly significant, $F(6, 14139) = 31.33$, $p < .01$. The battery-related EU and entertainment were not influential factors on user satisfaction of the older adult mobile phone users.

Table 13. Results of multiple regression analysis (with six sub-attributes)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	0.008	0.352		0.022	0.982
X1: Usefulness	**0.183**	**0.079**	**0.144**	**2.309**	**0.022**
X2: Ease of use: Navigation	**0.061**	**0.012**	**0.362**	**4.933**	**0.000**
X3: Ease of use: Buttons	**0.068**	**0.023**	**0.218**	**2.998**	**0.003**
X4: Ease of use: Battery	-0.051	0.034	-0.090	-1.495	0.137
X5: Pleasure: Aesthetics	**0.147**	**0.034**	**0.273**	**4.345**	**0.000**
X6: Pleasure: Entertainment	0.055	0.040	0.088	1.374	0.172

Note: Bold indicates significant variable

Figure 18 illustrates a summary of the multiple regression analysis along with internal consistency reliability for the six attributes of mobile phone quality.

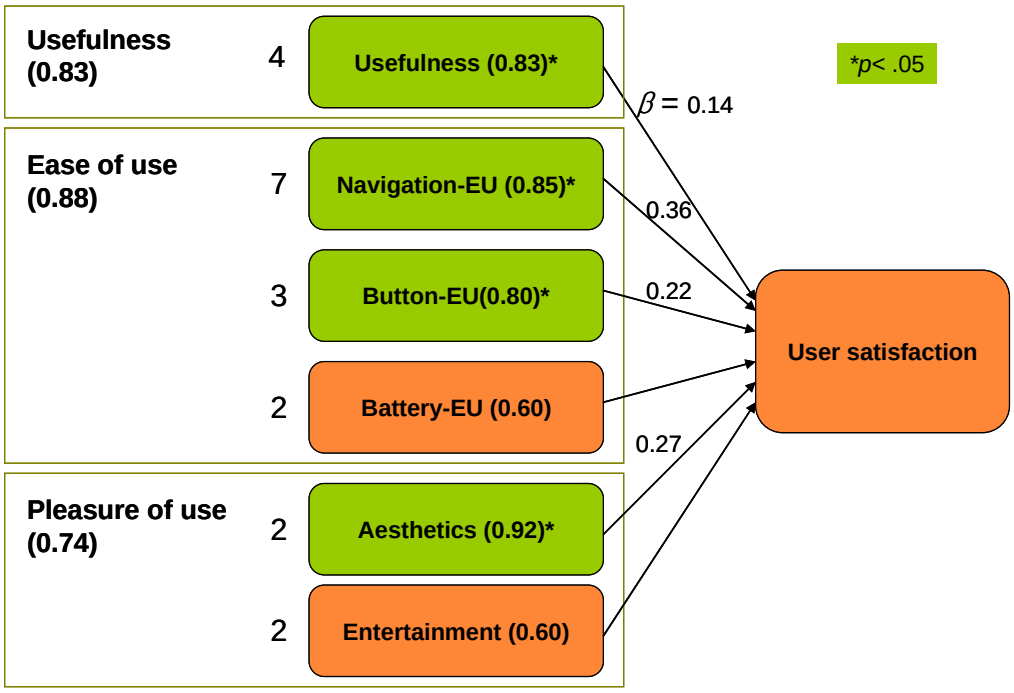


Figure 18. A multiple regression model of user satisfaction and reliability of the instrument

3.7.2.2. Individual items affecting satisfaction

As a diagnostic approach, the multiple regression analysis using stepwise regression was used to identify specific individual items that influenced user satisfaction. A total of 20 individual items were included as independent variables. The results of the regression identified five items that affect user satisfaction significantly as below:

- EU-1: It is simple to use my cell phone.
- EU-7: It is easy to read labels on buttons.
- PU-1: My phone design is attractive.
- UF-2: My mobile phone has all the functions and capabilities I expect it to have.
- PEU-10: Supplemental reference materials (e.g., user manual) provided with the phone is easy to understand.

The five predictors accounted for 67% of observed variance in the user satisfaction, F (5, 140) =56.89, p< .01. As shown Table 14, standardized beta weights indicated that two usability issues, simplicity of use (β =0.39, p< .01) and ease of reading labels (β =0.23, p< .01), are relatively more important attributes to improve user satisfaction, followed by attractive design (β =0.21, p< .01), functionality (β =0.16, p< .01), and well designed user manuals (β =0.16, p< .01). It is worth highlighting that simplicity had the greatest impact on user satisfaction among this group of older adults.

Table 14. Results of multiple regression analysis (with individual question items)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	0.164	0.241		0.681	0.497
X1: EU-1: Simplicity	0.341	0.055	0.390	6.171	0.000
X2: EU-7: Ease of reading labels on button	0.167	0.041	0.232	4.025	0.000
X3: PU-1: Attractive design	0.213	0.055	0.211	3.859	0.000
X4: UF-2: Necessary functionality	0.161	0.054	0.164	3.006	0.003
X5: EU-10: References	0.128	0.046	0.157	2.771	0.006

3.7.2.3. The effects of user characteristics on user satisfaction

To determine if the user characteristic variables influenced user satisfaction after product attribute variables were taken into consideration, a hierarchical regression was conducted. A total of 13 variables were selected and grouped into two blocks: product-attribute block (i.e., usefulness, navigation-EU, button-EU, battery-EU, aesthetics, and entertainment) and user characteristic block (i.e., gender, age, educational level, innovativeness, computer use, internet use, and e-mail use). A hierarchical regression was used since it accounts for the variance from the third or confounding variables before the variables of interest are entered into the model (Pedhazur, 1997). The product attribute block was entered first and the user characteristic block in the second block. Due to the multi-collinearity issue found among user characteristics, a stepwise procedure was used in the second block.

The results of the hierarchical regression revealed that while the product attributes were the dominant predictors of satisfaction (R^2 Change = .57), two user characteristics, age and

computer use, also significantly affected user satisfaction, as shown in Table 15 and 16. In examining the Beta weights, it is shown that age affected user satisfaction in a positive direction (i.e., the older a participant was, the higher satisfaction level he/she gave on the rating.

Table 15. The hierarchical regression model summary

Model	R^2	Adjusted R^2	R^2 Change	F Change	p
1 (Product attributes)	0.568	0.549	0.568	29.352	0.000
2 (Product attributes, Age)	0.589	0.567	0.021	6.692	0.011
3 (Product attributes, Age, Computer use)	0.602	0.578	0.013	4.449	0.037

In contrast, the effect of computer use was found to be negative, meaning that the less often a participant used computers, the higher the satisfaction level he/she gave. It is speculated that as old-old participants have less experience with computers, their expectations for technology (i.e., mobile phones) may be relatively lower than the young-old participants who use computer more often, and this lower expectation may cause them to be generous when rating their satisfaction with their phones. However, the impact of user characteristics was relatively subtle (R^2 Change = 0.03).

Table 16. The hierarchical regression model and coefficients

Model	Variables	Unstandardized Coefficients		Standardized Coefficients	t	p
		B	Std. Error	Beta		
3	(Constant)	-0.767	0.676		-1.135	0.259
	Usefulness	**0.173**	**0.080**	**0.135**	**2.157**	**0.033**
	Navigation_EU	**0.067**	**0.012**	**0.398**	**5.364**	**0.000**
	Button_EU	**0.051**	**0.023**	**0.165**	**2.190**	**0.030**
	Battery_EU	-0.050	0.033	-0.090	-1.496	0.137
	Aesthetics	**0.180**	**0.036**	**0.326**	**5.073**	**0.000**
	Entertainment	0.026	0.039	0.043	0.673	0.502
	Age	**0.015**	**0.007**	**0.129**	**2.203**	**0.029**
	Computer use	**-0.064**	**0.028**	**-0.122**	**-2.109**	**0.037**

Note: Bold indicates significant variable

3.7.3. Differences among user groups

The following section discusses how multiple regression models of user satisfaction differed among diverse user groups. A total of seven multiple regression models were developed and compared by: age (young-old vs. old-old), gender (male vs. female), and user clusters (explorer vs. basicians vs. minimalists).

3.7.3.1. Gender differences on user satisfaction

The female group

Navigation-related EU, aesthetics, and entertainment were significant attributes affecting user satisfaction for female users (Table 17). The usefulness, button-EU, and battery-EU were not significant. This model explained 57% of observed variance in the user satisfaction, $F(6, 87) = 19.37$, $p < .01$. It is notable that both hedonic attributes (aesthetics and entertainment) made a significant impact on female users' satisfaction.

Table 17. Results of multiple regression analysis (female participants)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	-0.297	0.468		-0.634	0.528
Usefulness	0.157	0.103	0.121	1.533	0.129
Navigation_EU	**0.061**	**0.017**	**0.359**	**3.690**	**0.000**
Button_EU	0.044	0.029	0.136	1.509	0.135
Battery_EU	-0.044	0.044	-0.077	-1.010	0.315
Aesthetics	**0.172**	**0.049**	**0.284**	**3.513**	**0.001**
Entertainment	**0.116**	**0.049**	**0.186**	**2.351**	**0.021**

Note: Bold indicates significant predictors

The male group

Results indicated that button-related EU, aesthetics, and navigation-related EU were significant attributes affecting user satisfaction for male users (Table 18). This model explains 68% of observed variance in the user satisfaction, $F(6, 45) = 16.01$, $p < .01$. The impact of button-related EU was the greatest on male users' satisfaction. It is possible that the larger fingers of male users may account for more concerns about button size, compared to female users.

Table 18. R Results of multiple regression analysis (male participants)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	0.745	0.534		1.396	0.170
Usefulness	0.232	0.123	0.191	1.881	0.066
Navigation_EU	**0.054**	**0.018**	**0.325**	**2.962**	**0.005**
Button_EU	**0.128**	**0.035**	**0.428**	**3.679**	**0.001**
Battery_EU	-0.104	0.054	-0.177	-1.916	0.062
Aesthetics	**0.165**	**0.047**	**0.371**	**3.496**	**0.001**
Entertainment	-0.118	0.066	-0.195	-1.801	0.078

Note: Bold indicates significant predictors

3.7.3.2. The age differences on user satisfaction

The young-old group

Usefulness, navigation EU, and aesthetics were significant attributes affecting user satisfaction for young-old users (Table 19). This model explained 66% of observed variance in the user satisfaction, $F(6, 89) = 28.48$, $p < .01$. While the button EU was not significant, navigation EU was the most dominant factor on user satisfaction.

Table 19. Results of multiple regression analysis (young-old participants)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	-0.713	0.428		-1.668	0.099
Usefulness	**0.353**	**0.110**	**0.243**	**3.199**	**0.002**
Navigation_EU	**0.061**	**0.015**	**0.339**	**3.943**	**0.000**
Button_EU	0.052	0.027	0.159	1.877	0.064
Battery_EU	-0.061	0.039	-0.105	-1.558	0.123
Aesthetics	**0.162**	**0.052**	**0.255**	**3.141**	**0.002**
Entertainment	0.075	0.048	0.114	1.548	0.125

Note: Bold indicates significant predictors

The old-old group

Results indicated that the navigation EU was the only significant attribute for user satisfaction in the old-old group (Table 20). This model explained 43% of observed variance in

the user satisfaction, $F(6, 43) = 5.31$, $p < .01$. None of the hedonic attributes influenced user satisfaction of the old-old group. It is speculated that the old-old group does not give much regard to hedonic attributes since the usability is bigger concern for them.

Table 20. Results of multiple regression analysis (old-old participants)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	1.507	0.591		2.550	0.014
Usefulness	-0.069	0.117	-0.078	-0.585	0.562
Navigation_EU	**0.057**	**0.020**	**0.432**	**2.856**	**0.007**
Button_EU	0.049	0.041	0.174	1.191	0.240
Battery_EU	0.023	0.069	0.047	0.339	0.736
Aesthetics	0.074	0.046	0.211	1.605	0.116
Entertainment	0.022	0.072	0.044	0.313	0.756

Note: Bold indicates significant predictors

3.7.3.3. User cluster effect

Explorers

Button EU, usefulness, and aesthetics were significant attributes on user satisfaction among the explorers (Table 21). This model explained 72% of observed variance in the user satisfaction, $F(6, 37) = 15.84$, $p < .01$. Navigation EU did not impact user satisfaction among explorers, unlike other user groups. Instead, the button EU was found to affect the explorers' user satisfaction to the greatest degree. In Analysis 2, people in this group were characterized as skillful users who used various features while perceiving the phone easy to use. Given their unique characteristics, it was thought that this group may have control over the menu navigation by understanding the name of functions and their relative location within the menu; consequently, navigation EU that mainly asked about software issues (e.g., navigation and simplicity) was not a significant factor on their satisfaction. Instead, aspects of hardware features, such as button and aesthetics were more influential on their satisfaction.

Table 21. Results of multiple regression analysis (the explorers)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	-0.919	0.671		-1.370	0.179
Usefulness	**0.480**	**0.162**	**0.297**	**2.971**	**0.005**
Navigation_EU	-0.003	0.020	-0.019	-0.137	0.892
Button_EU	**0.182**	**0.040**	**0.615**	**4.575**	**0.000**
Battery_EU	-0.092	0.055	-0.189	-1.673	0.103
Aesthetics	**0.148**	**0.060**	**0.255**	**2.480**	**0.018**
Entertainment	0.097	0.055	0.179	1.754	0.088

Note: Bold indicates significant predictors

Basicians

Results showed that usefulness and navigation EU were significant attributes of user satisfaction for basicians (Table 22). This model explained 60% of observed variance in the user satisfaction, $F(6, 53) = 13.47$, $p < .01$. No hedonic attributes were significant in this group. As this group is characterized by a limited knowledge of their phone, they appeared to consider usability and usefulness as a bigger concern over hedonic aspects.

Table 22. Results of multiple regression analysis (the basician)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	-0.668	0.651		-1.026	0.309
Usefulness	**0.418**	**0.141**	**0.304**	**2.952**	**0.005**
Navigation_EU	**0.078**	**0.020**	**0.401**	**3.993**	**0.000**
Button_EU	0.008	0.035	0.027	0.241	0.811
Battery_EU	-0.064	0.051	-0.109	-1.252	0.216
Aesthetics	0.115	0.064	0.203	1.808	0.076
Entertainment	0.097	0.069	0.150	1.401	0.167

Note: Bold indicates significant predictors

Minimalists

Navigation EU and aesthetics were significant attributes of user satisfaction in this group (Table 23). This model explained 56% of observed variance in the user satisfaction, $F(6, 35) = 7.42$, $p < .01$. In Analysis 2, this group was characterized by rare phone use without the use of

features beyond dialing a number. Given their 'minimal use' characteristics, it was expected that hedonic attribute would influence their satisfaction since they may have been less concerned about usability issues. However, button-related EU did not significantly affect user satisfaction.

Table 23. Results of multiple regression analysis (the minimalists)

Variables	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
(Constant)	0.090	0.926		0.097	0.923
Usefulness	-0.020	0.178	-0.014	-0.112	0.911
Navigation_EU	**0.085**	**0.027**	**0.497**	**3.137**	**0.003**
Button_EU	0.067	0.051	0.200	1.297	0.203
Battery_EU	0.007	0.089	0.010	0.078	0.938
Aesthetics	**0.181**	**0.060**	**0.357**	**3.026**	**0.005**
Entertainment	-0.024	0.096	-0.033	-0.250	0.804

Note: Bold indicates significant predictors

3.7.3.4. Summary of multiple regression model among user characteristics

Results indicated the concept of usefulness, ease of use, and pleasure of use, collectively appeared to influence user satisfaction, but they vary in prominence by user group. Table 24 summarizes the differences in multiple regression models by showing Beta weights for significant predictors. Detailed discussion will be provided in the next section.

Table 24. Summary of multiple regression analyses

Variable	Classification	Usefulness	Navigation EU	Button EU	Aesthetics	Entertainment
Gender	Female		0.359		0.284	0.186
	Male		0.325	0.428	0.371	
Age	Young-old	0.243	0.339		0.255	
	Old-old		0.432			
Cluster	Explorers	0.297		0.615	0.255	
	Basicians	0.304	0.401			
	Minimalists		0.497		0.357	

3.8. Discussion of Analysis 3

The objective of this analysis was to test the validity and reliability of the survey

instrument used to measure three mobile phone quality attributes (usefulness, ease of use, and pleasure of use) and to investigate the effects of each attribute on user satisfaction. Results showed that the validity and reliability of the instrument was established. Factor analysis revealed sub-dimensions of two attributes: ease of use (navigation-related, button-related, and battery-related ease of use) and pleasure of use (aesthetics and entertainment).

This study determined that user satisfaction is significantly affected by the three attributes (usefulness, ease of use, and pleasure of use). Overall, ease of use was the most influential factor for older adults, and, specifically, navigation-related ease of use was the most dominant attribute affecting user satisfaction. However, this study also found that hedonic attributes such as aesthetics played a substantial role in influencing older adults' user satisfaction. This implies that the hedonic quality should be explicitly taken into account when designing a mobile phone for older adults while more focus should be given on usability issues.

However, the impact of each attribute on user satisfaction varied in different user groups (age, gender, user clusters). To examine the gender difference, two regression models compared the female and male groups. The impact of hedonic attributes was much greater on female users' satisfaction than male users' satisfaction. This was an interesting result since females' association with hedonic aspects was often reported in the consumer behavior research area. For example, Holbrook (1986) reported that, compared to males, females were more visually oriented and more intrinsically motivated by hedonic aspects that involved satisfying expressive needs such as sensory stimulation and fun. Also, Shim (1996) reported that boys tended to focus more on solely utilitarian aspects in shopping decisions, while girls tended to focus on both utilitarian (e.g., price-conscious or value for money) as well as hedonic (e.g., fashion-consciousness) factors for decision making. These supporting data led to the conclusion that female older adults were more associated with hedonic aspects of mobile phones, compared to male users.

Unlike females, the male's user satisfaction was primarily affected by the button EU and navigation EU. This finding supported males' utilitarian disposition again. It is speculated that the difference in the impact of button EU was due to the different finger size since it is reasonable to assume that males who have bigger fingers experienced more usability problems

with small buttons on mobile phones, compared to females (Diffrient, Tilley, & Bardagjy, 1974).

Differences in age groups showed that both pragmatic and hedonic attributes impacted user satisfaction among the young-old group, while the old-old group's satisfaction was affected by the navigation EU only. This implies again that developers need to focus on developing an easy navigation mechanism for the old-old group.

A difference among user clusters was found as well. The satisfaction of explorers was affected by both pragmatic and hedonic attributes, but the navigation EU was not a significant factor on satisfaction. It is speculated that their expertise on mobile phones was such that navigation was no longer an issue for them. However, navigation EU was the most influential factor as compared to the other two groups (basic and minimal users). All of these findings suggested that designers need to have different strategies for improving user satisfaction when they target specific user groups in their product development.

In the end, this study provided diagnostic information on improving user satisfaction to inform mobile phone developers. Findings from a multiple regression analysis with individual items suggested that the user satisfaction of the older adults would increase by improving the following components of mobile phone UIs: 1) simple design, 2) user manual, 3) labels on buttons, 4) overall aesthetics, and 5) necessary features: phone call, phonebook, emergency call, voice- message checking, speed dial, ringer change, clock, and call history. The study suggested simplicity as central issue, but the present study does not provide the definition of what exactly makes a phone simple. However, findings of previous usability studies on mobile phones suggest that it may be achieved by limited features, transparent function name, and large sized hardware design (Ziefle & Bay, 2005).

There are both limitations and future research opportunities associated with this study. First, even though this research demonstrated that hedonic attributes play a substantial role in forming a sense of satisfaction, this study did not provide specific information of what makes a mobile phone attractive and entertaining to older adults. Both quantitative and qualitative approaches are needed to identify specific design factors that are able to stimulate the perception of hedonic quality. For example, Sevener (2003) conducted Semantic Differential (SD) method to investigated the effect of the aesthetics properties of products on inducing the feeling of

product pleasure on consumers using a table-clock sample. This study found that the property form, identified as the overall shape of the product and color, was influential in consumers' perception. This type of study can be conducted with mobile phones to investigate what aesthetic properties of mobile phone lead to users' satisfaction.

Second, previous studies indicated that there are numerous specific hedonic attributes such as novelty and originality (Hassenzahl & Tractinsky, 2006; Helander & Tham, 2003), but this study included only four items for the hedonic attributes. A comprehensive study with more hedonic attributes needs to be conducted to detail the effect of these attributes.

Third, previous studies indicated that user satisfaction is a complex construct comprised of several concepts (Bailey & Pearson, 1983; Lindgaard & Dudek, 2003). In the context of mobile phones that were described in a socio-technical system in the earlier section of this dissertation, there may be many more factors affecting their satisfaction, such as price and customer services (Goode, Davies, Moutinho, & Jamal, 2005; Lindgaard & Dudek, 2003). However, this study used a limited number of constructs: usefulness, ease of use, and pleasure of use with a focus on mobile phone handsets. Clearly, a great deal of research is needed to elucidate the notion of user satisfaction of mobile phones as well as to understand the relationship among other constructs beyond mobile phone handsets.

Fourth, the instrument of mobile phone quality was developed based on the TAM framework, and the validity and the reliability of this instrument were confirmed in this study. Therefore, this instrument may be effective to 1) assess new products during product evaluation, 2) make comparisons between products or versions of products, and 3) set targets for future application development. However, there should be caution when usability engineers or product development teams use this instrument to measure the usefulness attribute. The usefulness in this instrument was measured by such questions as "I find my cell phone useful in my life" to assess users' perception about relative benefit of mobile phone to users' lives. Therefore, the designer may be placed in an uncomfortable position knowing the product is not useful by users, but having no idea about how to improve it. Therefore, it is recommended to include questionnaire items addressing the motivation for mobile phone use and functional usage patterns to make inferences on ways to improve usefulness.

3.9. Summary

The objectives of Study 1 were to survey current mobile phone usage among older adults and investigate the relationship between user characteristics and mobile phone usage. The specific goals were:

- To survey older adults' mobile phones usage and investigate the effect of age and gender on various aspects of mobile phone usage: reasons for phone ownership, learning methods, phone usage pattern, and subjective evaluation about the phone quality.
- To identify user clusters that share similarities in their mobile phone usage and verify if user segmentation in innovation diffusion theory can be applied to distinguish people in different adoption level of mobile phone.
- To investigate the effects of three attributes (usefulness, ease of use, and pleasure of use) on user satisfaction.

Results from Study 1 are summarized below:

1) Overall older adult mobile phone users are relatively conservative users in that they use a few features of mobile phones for personal communication and use it primarily for security and safety. Features most frequently used were phone call, phonebook, voice message checking and clock
2) Older adult mobile phone users perceived their phone to be difficult to use. Specifically, menu navigation, text input, and the reference manual were major challenges to them.
3) Older adult mobile phone users' satisfaction was affected by perceived usefulness, ease of use (EU), and pleasure of use (PU).
4) Gender differences were found as follows:
    A. Female users perceived their current mobile phone to be more difficult to use, as compared to male users. Female tended ask someone when learning about mobile phones, compared to males who preferred to try it out themselves.
    B. As male and female mobile phone usage was found to be similar, it was speculated

that lack of self-efficacy may lead to gender differences.

C. Female users' satisfaction was more influenced by hedonic attributes (i.e., aesthetics and entertainment), compared to male users.

5) Age differences were found as follows:
   A. Young-old users (55-75 years old) used and indicated a desire for more features; however, the perception of ease of use was the same regardless of age group.
   B. Young-old users' satisfaction was influenced by navigation, usefulness, and aesthetics while navigation EU was the only significant factor on their satisfaction.
6) Based on mobile phone usage pattern of 20 features, three distinct clusters were identified: explorers, basicians, and minimalists, and profiles of each group were developed.
7) Three user characteristics variables (age, innovativeness, and internet use) were significant predictors for three user clusters at 75.2% accuracy. These predictors are useful in selecting target users in product development.

3.10. Limitations

Results of this study should be applied with caution due to limitations in the data collection method. First, this study used the convenience sampling method where the majority of participants were assumed to be members of senior centers. Therefore, the sample may not be representative of the entire older adult population. For example, the mean education level of the sample was higher than the overall U.S. senior population, and the majority of the sample was healthy retirees. In addition, the older adults who volunteered may be more likely to use mobile phones more frequently or have more experience than the larger population of older adults.

Second, it should be noted that this study used a relative frequency scale (1: never, 4: frequently), rather than an absolute scale (e.g., once a month), to measure the use of mobile phone features. This may introduce some potential bias in the questionnaire response across user clusters since individuals may have differential interpretation on the relative frequency scale based on their absolute frequency of use. For example, it is possible that explorers' response of

'somewhat frequently' may be equal to minimalists' response of 'frequently' in an absolute scale.

Third, it should be noted that there was no distinction made between those who did not use a certain feature although the feature was available and those who did not use a certain feature because of its unavailability. The questionnaire in this study was initially designed to ask participants to indicate whether they did not use a certain feature due its unavailability, but participants did not answer it properly due to the complex design of the questionnaire.

Fourth, the underlying assumption of data analyses in this study (e.g., gender and age differences) was that the type of mobile phone that participants owned is a random variable. Although it is a reasonable assumption as participants were selected from various areas, it is possible that there may be some unknown pattern in the phone models that older adults owned. To test this assumption, participants were asked in the questionnaire to fill in the phone model name that they owned, but few participants were able to answer it correctly although there was information provided for participants to locate the model name from their handset. Given this problem, telephone interviews administered by trained interviewers are recommended for future replication of this research.

CHAPTER 4. QUALITATIVE USER STUDY (STUDY 2)

4.1. Introduction

The purpose of the study was to 1) gain in-depth understanding of older adults' user experiences from their perspectives, 2) identify barriers that diverse user groups of older adults faced through the course of user experience and 3) to develop a set of recommendations to improve user experience with mobile phones. To address these research goals, semi-structured interviews were conducted with 12 older adults; four individuals represented each of three user clusters identified in Study 1. This qualitative research method was designed based on two research paradigms: domestication of technology theory and phenomenological inquiries. Detailed information about the two research approaches is provided below.

4.2. Research background

4.2.1. Domestication of technology theory

Domestication of technology is a concept within studies of the sociology of technology to describe and analyze the processes of technology's acceptance, rejection and use (Haddon, 2003; Siverstone, Hirsch, & Morley, 1992). It was developed from the 'social shaping of technology' perspective, where the user is perceived as having a dominant role in defining the nature, scope and functions of the technology (MacKenzie & Wajcman, 1999). This approach runs contrary to technology determinism, where technology is perceived to develop independently of society, with a significant impact on societal change (Ward, 2005).

Domestication, in the traditional sense, refers to the taming of a wild animal (Haddon, 2003). Using the same metaphor, the domestication of technology refers to the process where users bring an artifact from the public realm to the private and tame, gain control, shape or ascribe meaning to the artifact in users' lives (Siverstone, 1994; Siverstone & Haddon, 1996). According to Silverstone et al. (1991), the domestication of technology is a multi-dimensional negotiation process among users, artifacts, and social context, and it runs neither in a smooth nor in a straight line (Haddon, 2003). While users try to shape the technology by acquiring skills to use it, some artifacts continue to 'disobey', some only from time to time, and many of these technologies become an integral part of everyday life (Sørensen, 2005). Influenced by

numerous factors such as artifact design or users' limited knowledge, the domestication process results in varying degree of success.

According to Siverstone and his colleagues, the domestication process is conducted in four phases or dimensions: appropriation, objectification, incorporation, and conversion (Siverstone, 1994; Siverstone et al., 1992). Theoretical descriptions for each dimension are provided below along with potential usefulness of these dimensions in user experience research.

4.2.2. Dimensions of domestication

The first dimension, appropriation, is the process of possession or ownership of the artifact. This is the point at which an artifact moves from the world of commodity to the owner's possession, thereby, giving it significance (Haddon, 2003). In the appropriation, both actual and potential consumers are engaged in imaginative work where they view or hear about the artifact and the artifact is constructed as an object of desire not only to fulfill specific functions but also as a construction of the desire for difference and social meaning (Siverstone & Haddon, 1996). Therefore, this dimension involves all transactions included in the passage of artifacts from the market to users' lives and motives for approaching to the product.

Second, through objectification, the users ascribe their cognitive values and aesthetics to the technology (Siverstone et al., 1992). Thus, the technology is given its meaning and place in users' lives. Objectification is expressed in usage but also in the physical dispositions of objects in the spatial environment (Haddon, 2006). For example, after purchasing a technology, a user decides what role the technology should play in his/her life. Clearly, the users determine how the physical artifact is placed and displayed in the domestic arrangement. Therefore, this dimension is related to the meanings of technology in users' lives, mobile phone carrying behaviors, and aesthetic embellishments of mobile phones.

Incorporation is the process during which artifacts are used in everyday life, and the level of functionality depends on how it is incorporated into everyday life (Siverstone et al., 1992). Technologies are selected with specific features in mind and should serve in the way users intend. However, sometimes, some technologies do not comply with users' intentions, and do not fit into the routines of users' everyday lives (Haddon, 2006). Therefore, the

incorporation dimension involves a number of usability issues in user experience research.

Fourth, there is the conversion process at which the product reaches a 'taken-for-granted' status to become a part of the user's life (Siverstone et al., 1992). Technologies are brought for a certain feature in users' mind, but they may become functional in ways somewhat different from the intentions of designers or marketers. They may have many functions, but functions may change or disappear (e.g., many home computers brought for educational purposes have become game machines). Therefore, this dimension is relevant to unintended uses of technology, adaptations made by users, or features that users may desire in the future.

Although the domestication of technology theory originated in the social sciences to investigate social consequences of technology use, this theory is useful to understand user experiences and capture users' needs since it provides a theoretical scheme to frame user experience in four dimensions. Given ambiguous definitions and elements that contemporary user experience studies provided, the domestication of technology theory offers a theoretical foundation of user experiences (Hassenzahl & Tractinsky, 2006). Table 25 shows operational definitions of the four dimensions and examples of potential themes relevant in user experience studies.

Table 25. Four dimensions of domestication process

Dimension	**Description**	**Examples of potential themes relevant in user experience research**
Appropriation	Process of possession or ownership of the artifact.	- Motivation to buy a product - Route to acquire information about a product - Experience when purchasing a product
Objectification	Process of determining roles product will play	- Meaning of a technology - What function will be used in users' life? - Where is it placed? How is it carried?
Incorporation	Process of interacting with a product	- Difficulties in using a product (usability problems) - Learning process (use of instructional manual)
Conversion	Process of converting technology to intended feature use or interaction	- Unintended use of product features - Unintended way of user interaction - Wish lists for future products

4.2.3. Existential-phenomenology approach

Phenomenology is a unique qualitative research strategy and an appropriate means of

capturing the dynamics of human phenomena (Patton, 1990). Although philosophical roots of this methodology are diverse, the common objective of this research approach is to understand the lived experience of others from the subjective or first person point of view with three important distinctions: (a) the unassumptive and non-intervening study of a personally or socially significant phenomenon which (b) is investigated as a natural experience, rather than as a conceptualization, with the (c) goal of understanding characteristic and essential themes (Patton, 1990; van Manen, 1990).

With its philosophical roots, existential-phenomenology is a philosophy that is concerned with the experiential underpinning of knowledge (Patton, 1990). This philosophy assumes that the relationship between our perception and the objects we perceived is not passive, and that human consciousness actively constitutes the objects of experience (Thompson, Locander, & Pollio, 1989). Therefore, this approach attempts to inductively and holistically understand the hidden meanings and the essence of human experience in context-specific settings. Based on this philosophy, Thomson et al. (1989) presented a research method – the phenomenological interview- with the goal to attain a first-person description of some specified domain of experience. The interview method and analysis is characterized as 1) establishing equality between interviewer and interviewee, 2) utilizing descriptive questions such as "What was X like?", 3) avoiding asking "why" question, 4) establishing an interpretive group, and 5) identifying global themes.

Thompson et al (1989) explained that the interpretive group affords three benefits during the data analysis process. First, the interpretive group facilitates bracketing by questioning the assumptions each member employs. If one member is unaware that he or she has failed to bracket a theme, other members of the group may see this failure. Second, the perspective of the group is broader than that of any one individual and, thus, a pattern that might not have been noticed by a single research may be seen by the group. Also, the perspective of a single researcher may become sedimented; that is, the researcher may become focused on certain aspects of the transcript while failing to see others. Lastly, the group also offers a means of avoiding any sense of monotony and doubt that may plague a lone researcher. The interpretive group can bring an energizing effect on the interpretive process by sharing ideas. To maximize

the benefits above, group members should provide immediate feedback by noting whether they can also see the interpretation in the transcript.

4.3. Method

4.3.1. Participants

Semi-structured interviews were conducted with 12 people who had participated in the previous study (the questionnaire study), with four participants representing each of the three user clusters. The participant sample was selected using a criterion sampling, one of purposeful sampling technique where the researcher sets criteria and selects participants (Patton, 1990). There were three criteria for participants: 1) participation in Study 1 and an indication of interest in the subsequent study and 2) domiciled in Virginia to enable a face-to-face interview, and 3) representative of each cluster. Based on these criteria, the responses on each participant's survey were reviewed, and a representative sample was selected.

Table 26. Participant descriptions

Subject	Cluster	Age	Gender	Phone ownership (Years)	Comfort with computers	Comfort with phone	Satisfaction with phone
1	Explorer	64	M	10	1	3	Satisfied
2	Explorer	63	F	7	1	1	Not satisfied
3	Explorer	59	F	10	1	3	Satisfied
4	Explorer	67	F	10	2	1	Not satisfied
5*	Basician	69	M	3	3	2	Not satisfied
6	Basician	71	F	5	1	4	Satisfied
7*	Basician	83	F	2	2	3	Not satisfied
8	Basician	69	M	9	1	3	Satisfied
9	Minimal	84	M	10	1	1	Satisfied
10	Minimal	77	F	9	3	5	Not satisfied
11	Minimal	68	F	5	1	5	Not satisfied
12	Minimal	76	F	10	3	3	Satisfied

* hearing difficulties

Table 26 shows the demographic characteristics of the participants. There were eight females and four males, and their ages ranged from 58 to 84. The gender was not balanced due to the increased drop ratio of male participants. The average length of phone ownership was 7.5 years (*SD*=2.87). All participants were healthy and active retirees at the time of the study,

but two participants reported minor hearing difficulties and one participant reported minor memory loss due to a recent stroke. Participants' comfort level with computer and mobile phones was measured using a 5 point Likert rating scale, 1: strongly agree (comfortable) to 5: strongly disagree (not comfortable). The average comfort level with computers was 1.45 (*SD*=0.65), and comfort with mobile phones was 2.72 (*SD*=1.31), indicating that participants were less comfortable with mobile phones than they were with computers.

4.3.2. Interview procedures

Once participants were recruited, the interviews were scheduled and conducted at participants' homes or at a public library in participants' residence area. The selection of location was intended to create a relaxed atmosphere to encourage an open dialogue (Thompson et al., 1989). All participants were asked to bring their own phone and other components they would like to talk about, such as instruction manuals.

At the beginning of each interview, participants were briefed on the nature of the study and their rights as participants. If the participants chose to continue, they first completed an information consent procedure approved by the Virginia Tech Institutional Review Board (refer to Appendix E and F for the IRB approval and informed consent form). Next, they were asked to answer background information including their mobile phone model, ownership, their comfort level with computers, and mobile phones (Appendix G).

The semi-structured interview was then conducted using open-ended questions for the following main issues: 1) experience when purchasing a phone, 2) experience learning how to use a phone, 3) experience with current mobile usage and the role that mobile phones play in their everyday lives, and 4) desires for future mobile phones and mobile applications.

The interviews were deliberately conversational in nature as guided by Thomson et al. (1989), starting with questions, such as "Please explain your experience when you bought this phone." The interview scripts are provided in Appendix H. The interview guide was used to ensure that pertinent issues were covered while participants were allowed to speak freely about their experiences.

Since previous HCI studies reported older adults' difficulty in articulating their

experience with technologies (Fisk et al., 2004; Newell & Dickinson, 2001), there were two additional activities during the interview. First, in the middle of the interview, participants were asked to perform a task of saving the interviewer's phone number and name into their mobile phone using the phonebook feature. It was emphasized that the purpose of the task was to evaluate the design of mobile phone not their ability in using the phone. When participants performed the task the interviewer observed and video-taped participants' performance. If a participant expressed his/her inability to perform the task, the interviewer provided instructions to complete the task and asked questions about difficulties they were faced with.

As the second activity, participants were given a prototype phone model (LG-KG920: refer to Appendix I for the detailed specifications) in the end of the interview, and their reactions were elicited. The use of the prototype was intended to provide participants with options to compare with their current phones when participants spoke about good or bad mobile phone design for them. Thus, the prototype was selected for three reasons: 1) the phone had not yet been released to the U.S. market by the time of the interview, so no participant had had previous experience with the phone, 2) the phone had various functionalities including a high quality camera, MP3 player, calendar, games, and internet-enabled features, and 3) the phone had unique hardware characteristics such as a large phone size, large screen size, small buttons, and numerous shortcuts that can be compared to participants' current phones.

At the end of the interview, participants were given time (termed as the Q & A session hereafter) to ask the interviewer any question related to the phone operation such as features they wanted to learn and features they want to have. When participants asked about a feature to learn, the interviewer provided coaching while encouraging participants to solve the problem on their own first. Conversation and participants' action during the Q & A session were also recorded. Each interview took approximately 1.5 hours. All interview sessions were video-taped, and participants' utterances were transcribed for further data analysis.

4.3.3. Data analysis

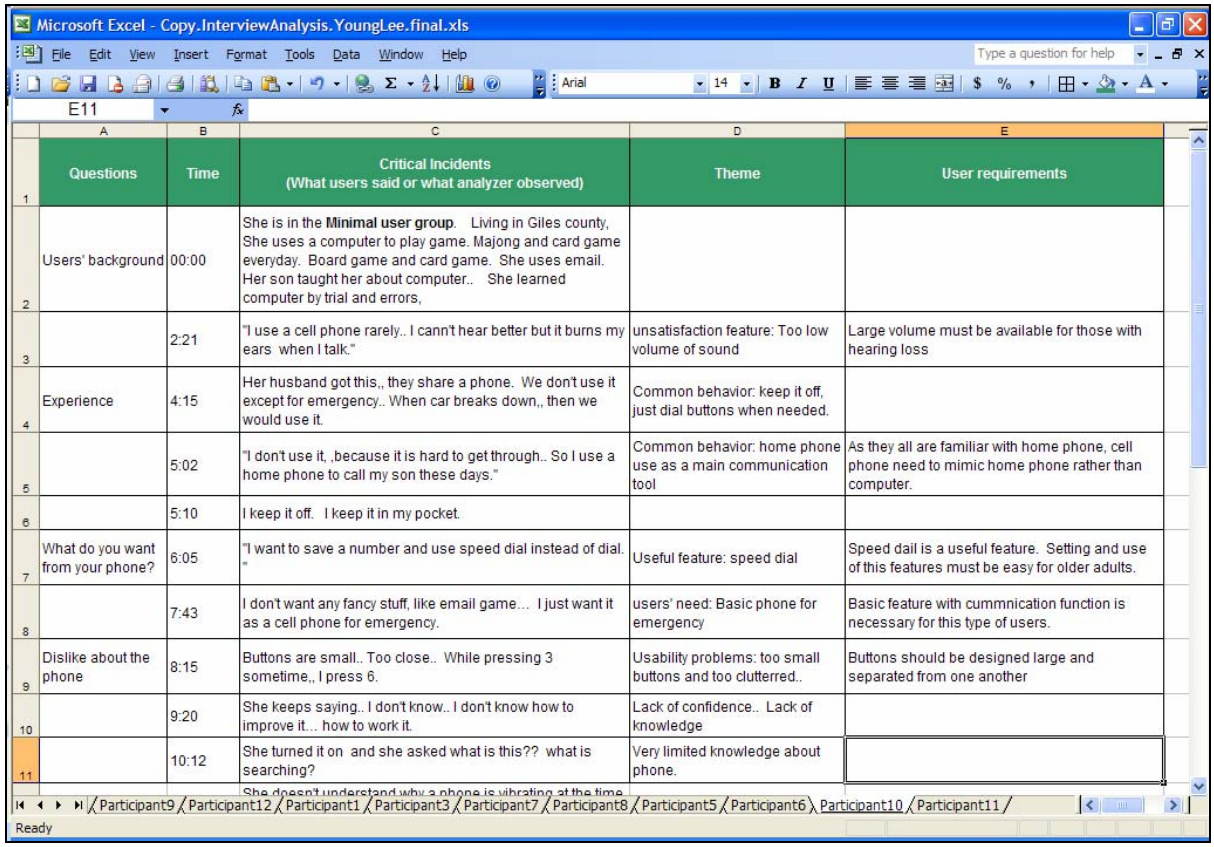
A mixture of qualitative assessment methods, as shown in Figure 19, was used for data analysis (Miles & Huberman, 1984; Strauss & Corbin, 1990; Thompson et al., 1989). As

suggested by Thompson et al (1989), an interpretive group was composed of three people, the experimenter of this research and two graduate students who were enrolled in the Human Factors Engineering program at Virginia Tech. The two graduate students had previous experience in mobile phone user interface design or user research.

Qualitative Assessment methods

1. Interpretive group (Thompson, 1989)
2. Open coding process (Strauss & Corbin, 1990)
3. Development of matrix tables (Miles & Huberman, 1984)
4. Classification by the domestication dimensions

Figure 19. Data analysis scheme



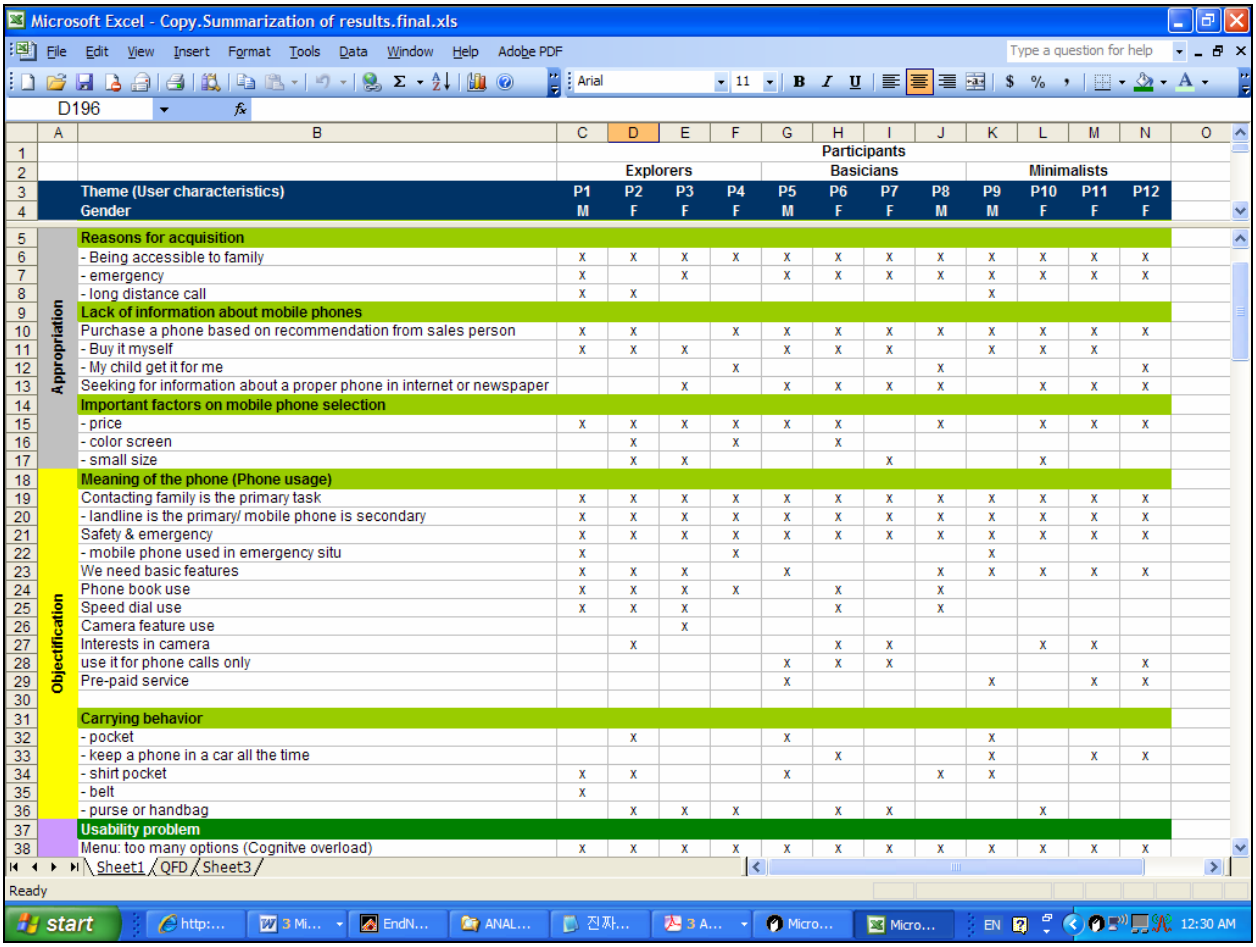
	A	B	C	D	E
1	Questions	Time	Critical Incidents (What users said or what analyzer observed)	Theme	User requirements
2	Users' background	00:00	She is in the **Minimal user group**. Living in Giles county, She uses a computer to play game. Majong and card game everyday. Board game and card game. She uses email. Her son taught her about computer.. She learned computer by trial and errors,		
3		2:21	"I use a cell phone rarely.. I cann't hear better but it burns my ears when I talk."	unsatisfaction feature: Too low volume of sound	Large volume must be available for those with hearing loss
4	Experience	4:15	Her husband got this,, they share a phone. We don't use it except for emergency.. When car breaks down,, then we would use it.	Common behavior: keep it off, just dial buttons when needed.	
5		5:02	"I don't use it, ,because it is hard to get through.. So I use a home phone to call my son these days."	Common behavior: home phone use as a main communication tool	As they all are familiar with home phone, cell phone need to mimic home phone rather than computer.
6		5:10	I keep it off. I keep it in my pocket.		
7	What do you want from your phone?	6:05	"I want to save a number and use speed dial instead of dial. "	Useful feature: speed dial	Speed dail is a useful feature. Setting and use of this features must be easy for older adults.
8		7:43	I don't want any fancy stuff, like email game… I just want it as a cell phone for emergency.	users' need: Basic phone for emergency	Basic feature with cummnication function is necessary for this type of users.
9	Dislike about the phone	8:15	Buttons are small.. Too close.. While pressing 3 sometime,, I press 6.	Usability problems: too small buttons and too clutterred..	Buttons should be designed large and separated from one another
10		9:20	She keeps saying.. I don't know.. I don't know how to improve it… how to work it.	Lack of confidence.. Lack of knowledge	
11		10:12	She turned it on and she asked what is this?? what is searching?	Very limited knowledge about phone.	

Participant9 / Participant12 / Participant1 / Participant3 / Participant7 / Participant8 / Participant5 / Participant6 / Participant10 / Participant11 /

Ready

Figure 20. An example of data logging template developed in Microsoft Excel

The three analyzers first participated in a training session. In the training session, they were briefed on objectives of the study and provided instructions on data analysis along with the data logging template that was developed in Microsoft Excel (Figure 20). After the training session, the analyzers individually reviewed the interview videos along with transcriptions and summarized critical incidents using the data logging template. The data of 12 participants were analyzed using the generative or open coding process where the data were broken down into discrete parts, closely examined and questions were asked about the phenomena as reflected in the data (Strauss & Corbin, 1990). It was an 'open' process in that the individual analyzer engaged in exploration of the data without making any prior assumptions about what each of analyzers might discover (Patton, 1990; Strauss & Corbin, 1990).



Microsoft Excel - Copy.Summarization of results.final.xls

		Theme (User characteristics)	Participants											
			Explorers				Basicians				Minimalists			
		Gender	P1 M	P2 F	P3 F	P4 F	P5 M	P6 F	P7 F	P8 M	P9 M	P10 F	P11 F	P12 F
	Appropriation	Reasons for acquisition												
		- Being accessible to family	x	x	x	x	x	x	x	x	x	x	x	x
		- emergency	x		x		x	x	x	x	x	x	x	x
		- long distance call	x	x							x			
		Lack of information about mobile phones												
		Purchase a phone based on recommendation from sales person	x	x		x	x	x	x	x	x	x	x	x
		- Buy it myself	x	x	x		x	x	x		x	x	x	
		- My child get it for me				x				x				x
		Seeking for information about a proper phone in internet or newspaper			x		x	x	x	x		x	x	x
		Important factors on mobile phone selection												
		- price	x	x	x	x	x	x		x		x	x	x
		- color screen		x		x		x						
		- small size		x	x				x			x		
	Objectification	Meaning of the phone (Phone usage)												
		Contacting family is the primary task	x	x	x	x	x	x	x	x	x	x	x	x
		- landline is the primary/ mobile phone is secondary	x	x	x	x	x	x	x	x	x	x	x	x
		Safety & emergency	x	x	x	x	x	x	x	x	x	x	x	x
		- mobile phone used in emergency situ	x			x					x			
		We need basic features	x	x	x		x			x	x	x	x	x
		Phone book use	x	x	x	x		x		x				
		Speed dial use	x	x	x			x		x				
		Camera feature use			x									
		Interests in camera		x				x	x			x	x	
		use it for phone calls only					x	x	x					x
		Pre-paid service					x				x		x	x
		Carrying behavior												
		- pocket		x			x				x			
		- keep a phone in a car all the time						x			x		x	x
		- shirt pocket	x	x			x			x	x			
		- belt	x											
		- purse or handbag		x	x	x		x	x			x		
		Usability problem												
		Menu: too many options (Cognitve overload)	x	x	x	x	x	x	x	x	x	x	x	x

Figure 21. A sample of matrix table

Upon the completion of the individual review, the three analyzers worked together to develop code schemes. As suggested by Thompson et al. (1989), the three analyzers shared their own interpretations, consulted about their findings with other researchers, and developed unified codes with consensus. The interpretive group analyzed the data of participant 1 to develop initial themes using the data logging template. Using the preliminary sets of themes, the interpretive group preceded through data analysis for the remaining participants. Following the 'constant comparative analysis method' (Strauss & Corbin, 1990), data from the remaining participants were contrasted with the core concepts of participant 1, and vice versa. Newly emerging concepts from remaining participants' data were constantly added and checked across participants.

At the end of the analysis, a matrix table was developed by the experimenter to visualize all code schemes that were sorted into four dimensions of domestications, and across-case contrasts and pattern clustering were performed using the matrix table (Miles & Huberman, 1984). A sample of the matrix table is shown in Figure 21, and the entire matrix is provided in Appendix J. The emerging concepts for each dimension of domestication will be described in the results section.

4.4. Results

The qualitative data analysis identified several themes through the four domestication dimensions, as shown in Table 27. Detailed descriptions for each theme are provided below.

4.4.1. Appropriation

Two themes were identified in the appropriation dimension: reasons for acquisition and lack of information.

4.4.1.1. Reasons for mobile phone acquisition: being accessible to family

Participants provided similar reasons for mobile phone acquisition: to be accessible to family members or close friends and safety. Participants (P3, P6, and P9) with ailing or aging family members needed a phone to be accessible to them. For example, P6 remarked: *"Well, the reason I needed a phone was because my husband was very ill, he has cancer, and I would*

like to be accessible by him any time or call him to ask if he is ok". Similarily, P9 commented: "*Everyday I needed to telephone my sister, who is 95 years old living herself in Cincinnati, Ohio. Wherever we go I call her morning and evening to make sure she's alright…And I use these things (mobile phone)".*

Table 27. Summaries of findings through the four dimensions of domestication

Dimensions	Themes	Descriptions
Appropriation	■ Reasons for acquisition	■ Reasons for buying a phone were to be accessible to family members and to provide safety during road trips.
	■ Lack of information about mobile handset and mobile services	■ No information resources for selecting mobile phone handsets and mobile services is available.
Objectification	■ Meaning of product in lives	■ Mobile phone is used as a secondary communication tool for communication and safety. Female users showed potential to use a phone for recreation.
	■ Carrying behavior	■ Differential responses among genders: ■ Males keep it on their belt or shirt pocket ■ Females keep it in their purse
Incorporation	■ Perceptual and sensorial aging-related problem	■ A number of faulty product designs were found that did not reflect older adults' perceptual and cognitive aging: visual, dexterity, and hearing decline
	■ Cognitive-related problems	■ Older adults were faced with difficulties because of a lack of consideration of older adults' cognitive aging: reduction of working-memory capacity, general slowing of mental processes, and decline of the ability to repress irrelevant information.
	■ Lack of self-efficacy	■ Some older adults (basicians and minimalists) were found to lack self-efficacy that prevented them from utilizing mobile phone features.
	■ Lack of basic knowledge	■ Three knowledge thresholds (gaps) were found: the mechanism of softkeys, text input, and error recovery (i.e., a clear button).
Conversion	■ Individual adaptation or transformation of technology	■ Phonebook and speed dial were perceived as useful but difficult to use for basicians and minimalists. Technology and human adaptation were found (using a piece of paper or development of utilization strategies)

For others (P1, P2, P4, and P8), a mobile phone was needed to communicate with their children and serve as a safety tool on the road as they are frequent travelers. P1 remarked, *"I live in*

New York but drive down to Blacksburg, Virginia every two weeks to take care of my grandchildren. I needed to call to my daughter using my phone, but my friends in New York also call me on this". P4 also reported her frequent visit to her daughter living Washington D.C. although she lived in Florida. During her travel, she needed a phone to contact her daughter and friends living Florida.

4.4.1.2. Lack of information about mobile phones

Participants expressed that they lacked information resources about mobile handsets and services to choose proper one for their needs. Five participants (P1, P4, P5, P6, P8, and P10) reported that they had to rely on a sales person's recommendation when purchasing a phone. However, recommendations were often made based on a business purpose and not on users' needs. An illustrative example, P5, remarked: *"I went into [shop name]. Figuring that I needed to buy a cell phone for emergencies, if nothing else. And so I asked them if they had such phones, he said "Yes, here they are". And they showed several brands. And then said to the clerk "Which one do you recommend?" And they recommended this. Now, I know more about this phone, and I know this phone is not desirable to me."* P8 also remarked: "*I didn't have choices. Oh! This is a great phone. The sales person just showed one and we just took it."*

Realizing the difficulty using current mobile phones, some older adults (P3, P6 and P11) were found desperately looking for a phone for their needs. For example, P6 remarked: *"I was looking for a phone that is easy for me and with a few basic functions. I searched the Internet and asked friends but could not find one that I wanted."* She (P6) finally found an article from the New York times weeks ago and brought the article to the interview and asked for the interviewer's opinion about the phone models complaining that there is no information resource that she can refer to: *"Now I know how to use computers and the internet… I was told that there are… lots of information there, but why ….no website that tell older adults which phone is good for them or… recommend one?"* P11 also indicated a desire to have websites to provide expert reviews about phones and recommendations for older adults.

4.4.2. Objectification

The objectification concerned the meaning that users gave to mobile phones and carrying behaviors. Three different meanings were identified and differences of carrying behavior between genders were found.

4.4.2.1. Meaning of mobile phones: Secondary communication tool

Consistently, participants indicated using a home phone (a landline phone) as the primary communication tool for various purposes such as making an appointment for social activities and getting information from others. Conversely, the mobile phone was a secondary means to communicate with family members or close friends when they were away from home. Six participants (P5, P7, P8, P9, P11 and P12) shared a mobile phone with their spouse. For this reason, they stressed that the mobile phone design should be focused on basic communication features, such as phonebook, speed dial, and voice message checking rather than other unnecessary features. For example, P8 quoted: *"We (P8 and his wife) use it for mobile phone.. No interest in other function like camera. Just for basic communication. Just leave a (voice) message."* Similarly, P1 commented: *"Well, I mean, it has many features... And it seems to me that most of that stuff I don't really care about. I don't really care about games and texting. It's not particularly worthwhile. So it's got a lot of features that I, really don't care very much about. It's just that I just don't need it. I just don't find any use for most of these things. So I mean the most important thing is the contacts, the ability to call people and receive, you know the ability to call and receive from as many places as I can. And, the ability to um, I like speed dial so I can use the contacts and that's about it. I mean it's a phone I'm using a phone as a phone."*

4.4.2.2. Meaning of mobile phones: Safety

All participants carried their phone for safety reasons. In particular, a health-related emergency situation was the top concern for them since they believed that either they or their spouse would be likely to be involved in an emergency situation in the near future. Three participants (P1, P4, and P9) reported being in an emergency situation in the time period between their survey response and interview (approximately about three months). These participants

along with other participants explained the benefit of having a mobile phone in such cases and emphasized that a mobile phone needs to enable quick and easy operation for an emergency call. P1 explained: *"Well it would be nice if I had emergency call…for example, I had a kidney stone when I was out on a golf course, I had a kidney stone. And uh, I had my cell phone with me and I could've, if I thought about it I would've called the main office to send someone out to come and pick me up... Um, But I can imagine that I would imagine out on the golf course and if I just had a 9-1-1 key or something like that I suppose I could program that in. I've never called 9-1-1- so I don't even know how it works. Um, But I um, don't know if I am around here, do I have to press 9-1-1 or do I have to press 1-5-4-0-9-1-1 or…I don't know how it would work."*

Also, participants emphasized easy operation and the location tracking functionality using GPS since it is often that they spend time with their grandchildren. For example, P2 quoted: *"I heard if you press 911, they can't locate you unless you have one of those GPS phones. So I want to have GPS in my phone. If I dial 911 or two year old granddaughter, when I pass out, then they can locate you. Just like that. And two year old grand daughter call 911 and they can locate us when I passed out. That will be nice if there is one button that is supposed to call 911 as a safety feature because if my granddaughter has to press this and this, it will bother them."*

P4 explained her car accident experience where she lost her consciousness and was sent to hospital by a rescue corps, while emphasizing the importance of emergency contact feature that can be embedded in mobile handset or service: *"I am allergic to all these. I used to wear a bracelet but it was too small to include such a long list of allergic substances. When I had an accident, I was given many drugs that I have allergy to. They said they were able to get numbers of my family, so if they can do that with my phone.. I mean you do 411 for phone number and 911 for emergency. Wouldn't it be great to have, say, 511, and you press 511, all appear here is the list of my allergy and people for them to contact. I think it is crucial these days. Wouldn't it be easy for someone to be able to press 511 and see? Oh! she is allergic to these and here is her daughter. I am not talking about privacy. I lose this phone, and I don't want to give my medical records. It is not giving medical records. You are giving life threatening information that doctors need to know. To me, it is such a simple addition feature that doesn't cost extra."*

4.4.2.3. Meaning of mobile phone: Pleasure

Despite an emphasis on the importance of basic communication features of mobile phones, some of the participants among the explorer cluster had integrated their mobile phone into other aspects of their lives: pleasure. An illustrative example, P3, emphasized the importance of the camera feature on her mobile phones while she showed pictures of her dog and grandchildren on her mobile phone: *"See my dog and grand children here. Well, for me it (camera) is good because every now and then, you get really down, you down and out and you want to see something that would make you happy, and I can either look at my grandson or dog. [laugh.. while looking at those pictures] They make me happy, and that's truly the way I feel."*

All eight female participants actively used the camera function or showed their interest in it while none of male participants showed any interest in it. Five females (P2, P6, P7, P10, and P11) expressed their desire to download the pictures to their computers to send pictures to their family members and friends. This type of hedonic usage was often reported in the studies investigating young students' technology use (Berg et al., 2003). However, it was interesting to see that older adults, especially female users, showed an interest in this type of new technology culture. However, interestingly, this hedonic usage of the camera feature was not found from any male participant. For instance, a male participant, P2, who reported a camera feature on his phone remarked: *"I played around with the picture taking capability but I really wasn't interested in it"*. Other male participants P5 and P8 explicitly commented on the camera feature: *"That (camera) doesn't appeal to me. It just.. just a waste of time"*.

The female participants in this study had more willingness to adopt the fun features of technology than males. Five out of eight female participants (P3, P6, P7, P11, and P12) reported that they liked playing games such as board games and card games. Three of them actually played games on their computers everyday.

All participants in the explorer group noted their use of text messaging in the previous study, but it was found that they had passive experience by receiving a text message from the service provider, and none of the participants used text messaging actively. They were aware of the text messaging service and considered it as an alternative means of communication, but they did not feel a need for the service and regarded it as more of a hassle than it was worth due to the

difficulty of text input.

4.4.2.4. Carrying behaviors

The places in which mobile phones were located or carried by users were diverse. Four participants (P6, P9, P11, and P12), members of either the basician or minimalist group, reported that they keep their phone in the compartment of their car and turn it on only when they need to make a call. The rest of the participants reported carrying their phone with them outside of the home.

Gender differences in carrying behaviors seemed to exist, which requires differential hardware and external user interface design. Male participants reported that they carry a phone either on a belt clip (P1) or in a shirt pocket (P5, P8, and P9); hence, they stressed a need for a phone to be thin because the thickness of the phone is a critical factor for the comfort level when worn on their belt or in their shirt pocket. In addition, those who keep the phone in their shirt pocket stressed the importance of width of the phone to fit into their shirt pocket. P5 remarked: *"That part is good. Um. but still this phone is thinner, and bigger, and therefore it fits in a man's pocket, which is good for me"*. Similarly, P8 commented: *"If it was a little bit wider, it would probably fit better in most pockets. Because what happens now is when I put it in my pocket, it will eventually wind up sort of catty-corner like this and then it will be hard to get out without taking a chance at breaking the uh the antenna. If it was a little bit wider, it would fit better in a man's [shirt] pocket."* Two advantages of carrying a phone in their shirt pocket were: 1) they can better feel it (vibration) and 2) they can better reach it. Another male participant (P1) stressed a need for designing a belt clip that holds a phone more securely or a strap to protect their phone from falling out of their shirt pocket.

Most female participants (P2, P3, P4, P6, P7, and P10) indicated that they carried their phone in their purse or handbag, which led to their preference for a phone with some thickness to ease locating a phone in their purse. For example, P4 remarked: *"I like the size [of my phone]... I tried RAZR [a phone model representing thinness] , but I don't like it. It's too small. Sometimes, I need to find it easily from my purse, but I can't find it"*. Due to the unique carrying behavior, female participants requested features that facilitate locating their phone in

their purse, such as a feature that turns lights on and blinks when ringing.

4.4.3. Incorporation

The incorporation dimension included barriers that older adults experienced during the mobile phone use and the learning process. It was observed (or verbalized) that those barriers arose due to faulty product design that did not consider the older adults' aging related changes (sensory-perceptual aging and cognitive aging), the lack of self-efficacy, and the lack of basic knowledge.

4.4.3.1. Design errors related to sensory-perceptual aging

The majority of usability-related difficulties resulted from a design that did not take into account age-related sensory-perceptual changes. The most common problems related to visual abilities. Although participants did not have severe visual impairments, they experienced declines in eyesight significant enough to make it more difficult to use mobile phones. Eleven participants expressed difficulty in reading the screen and labels on buttons, and those perceptual barriers prevented even explorers from using various features. For example, P1 who had expertise on his phone operation remarked about pictures on his contact list of his mobile phone: *"I tried a few times [camera]. I have about five or seven pictures on there. Uh, that I've saved and then I've attached them to the people [in my contact list]. So that when a person calls, their picture comes up. But the problem is if I don't have my glasses on, I can't see the picture. The picture is so tiny."*

P7, who had minor hearing losses, explained their negative experience due to their declines in auditory acuity: *"I can't hear the ringing sometimes because my hearing problem also sometimes difficult to hear others' talk.* P2 also remarked about the arthritis in his hand that prohibited him from using additional features on his mobile phone: "*I don't know. I…I don't use [text messaging and scheduler on mobile phone] I have trouble writing. You know, my, I have arthritis in my hands so I don't like to write very much.*

4.4.3.2. Design errors related cognitive ability changes

Cognitive aging is accompanied by a reduction of memory capacity, a general slowing of mental processes, and a decline in the ability to repress irrelevant information (Van Gerven, Paas, Van Merrienboer, & Schmidt, 2000). Participants faced difficulties because those cognitive changes were not reflected in the mobile phone design. For example, seven participants (P1, P2, P3, P5, P7, P10, and P11) faced problems during the task performance session because the mobile phone hardware component design did not consider older adults' overall slowing of mental process. Regardless of their skill level with the mobile phone, participants generally required more time to choose an option or type letters during the menu navigation, but the screen backlight turned off too quickly for them to proceed to the next step, which resulted in an extra button click that eventually led to an incorrect navigation path. It was recommended that the screen light duration setting be removed or be set longer than one minute to compensate for the slower mental process of older adults.

In another example, speed dial was also often cited as a useful feature, but it was found that few participants (P1 and P7) used it because the contemporary design did not consider one of the cognitive aging process, a reduction of memory capacity and span. For example, an illustrative participant, P5 could not use the speed dial feature although he had set it for his children on his phone. P5 remarked: *"I had time to kill when I was at my daughter's home in Pennsylvania. And I decided.. to put all the kids names in and .. put them on speed dial.. Now if you asked me today to use speed dial and call one of my kids, I don't know how to do it… I know what speed dial is..it's like just one through nine or something.. And I can just hit twenty and hit ring and it will go and call the children.. But I don't remember who's twenty, who's seventeen, who's three…".* To solve this problem, it was recommended to provide the speed dial number assignment along with contact list that is visible on the display when users turn on the phone to place a call.

Another type of usability-related problem was associated with older adults' decline in the ability to discriminate between relevant and irrelevant information. All participants reported that their mobile phone employed too many features that make the phone operation complicated. For example, P1 stated: *"It's got a lot of features that I really don't care very much about... Um,*

but you know, it's…I can ignore that, but it makes it complicated when I use it. I just don't find any use for most of these thing.". Inclusion of too many features in a mobile phone also influenced usability of the manual. Ten of the participants (P2, P3, P5, P6, P7, P8, P9, P10, P11, and P12) explained that they were initially overwhelmed by the thickness of the manual, and it was difficult to find instructions for the tasks that they wanted to perform. P7 explained her impression of the technical documentation that came with her phone: *"I tried once [reading the manual] and gave up because too many features are here. And I am overwhelmed. It is hard to find things that I want. I never find here how to retrieve a missing call. It was very frustrating, you see because it's a simple thing and I just couldn't find a simple straight answer for that."*

4.4.3.3. Lack of self-efficacy

Overall, participants in the explorer group appeared to have a high level of self-confidence in their ability to use a mobile phone, but most participants (basicians and minimalists) lacked self-efficacy, which prevented them from full utilization of mobile phones. One participant, P5, showed his fear of trying to save a number on his phone. He remarked: *"Should I do that now? I need a manual then. Without a manual? Well don't let me… alright… you showed me how to … if I put something in, you showed me how to get it out, ok? OK?"* However, he was encouraged to try to complete the task himself, and it turned out he could finished the task successfully without any guidance from the interviewer. After that, he gained his confidence: *"Maybe… it's.. it's the emotional thing, for me as an older person, I told you some people are afraid… afraid to fail. I thought I didn't know how to get into all of that. But I did it. See? I don't know how to explain this to you. See? The problem is I'm cool right now. I'm in 'logic mode' not 'emotional mode'. And when I set my mind to it, I can do it."*

Another reflection of the lack of self-efficacy was emanated by the act of attribution, usually observed among female participants (P6, P10, P11, and P12). They tended to attribute the failure of task performance to themselves such as "*it is my fault. I should have read a manual*".

4.4.3.4. Lack of basic knowledge about mobile phones

As this study included various user groups ranging from explorers to minimalists, wide differences in the knowledge about mobile phones were observed among participants. Some explorers and basicians (P1, P4, and P8) appeared to have surprisingly broad knowledge of their phone which was atypical from the stereotype of older adults found in previous studies (Kurniawan et al., 2006; Mann et al., 2004). Participants of this type showed their expertise during task performance by operating the menu navigation and inputting text as skillfully as young people.

On the contrary, some basicians and minimalists (P6, P7, P10, P11, and P12) appeared to have very limited knowledge about their phone. When those with limited knowledge were asked to perform a task they expressed their apprehension immediately. They expressed some level of anxiety while learning a way to use a feature: *"Can I press this button? I don't want to break it" or "I am little bit worried"*. While the interviewer provided coaching to help them complete a task, three main difficulties were identified: 1) understanding the use of softkeys (multi-purpose keys), 2) understanding the text input method, and 3) error recovery (i.e., a clear button that takes users to one step back in the menu navigation or that erases an error in the text input mode). It was observed, however, that once they overcame those knowledge barriers, their learning process proceeded rapidly, and some participants (P10 and P11) could even complete a task without further coaching.

After the completion of the task, perception of the mobile phone operation was positively influenced. For example, P11 was a completely novice user who had no understanding of the message 'search for network' when she turned on her phone. At the beginning of the task performance, she was provided with instructions regarding the three tips in the previous paragraph, and she could navigate the menu and complete the task by herself with minimal coaching. This resulted in increased confidence: *"That wasn't difficult at all, no that was easy!"*

Those with limited knowledge (P6, P7, P10, P11, and P12) reported that they could not make use of contemporary instructional manuals properly due to difficulties in following and understanding the instructions. The use of other media was suggested as an alternative form of

instructional manual. P6, for example, remarked: *"I think they [phone manufacturers or service providers] would need to have a training class for older adults like me… You know, the young people spend more time doing this, but older people like me are not used to use it...And it's like using computers, they need a little extra help… [if they can't afford it] It could.. just have it on a CD to give more directions on it, and person coming out just like video training. That would work for me."*

4.4.4. Conversion

Through the domestication process, users tried to gain control of a technology but sometimes the technology did not respond as desired due to a complex user interface design that did not match with users' needs or mental models. In this case, users attempted to make an adaptation to fit the technology into their mental model.

During the interview, it was discovered that participants employed various adaptation strategies for the phone book feature. Participants who were not comfortable with the menu navigation appeared to apply the metaphor of a landline phone in mobile phone adaptation by using a familiar object: a piece of paper. P7, for instance, demonstrated her way to use the phonebook and speed dial feature (picture in left of Figure 22). After she saved phone numbers into her phonebook with help from her daughter, she wrote down the numbers on a piece of paper with speed dial allocation numbers. She kept the piece of paper in the leather case along with her phone, and she referred to it to recall the number to press to call her daughter. She believed this was the best method, rather than navigating through all the steps of the menu.

Similarly, P11 wrote phone numbers on a piece of paper and taped it on the back side of the phone, as shown in Figure 22 (right). When she called someone, she looked at the (paper) phonebook to refresh her memory and dialed the number. She expressed that it was her preferred way to use the phone, and she did not want to change this way. Other participants (P8 and P12) expressed difficulty remembering their own phone number, so they wrote it on a piece of paper affixed to the back of the phone, as shown in Figure 23.

Some users developed their own strategy to use mobile phone features very efficiently. For example, P1, who was a high-end user, showed his strategies in utilizing the speed dial

feature of his phone. To overcome the cognitive overload in memorizing numerous speed dial numbers, P1 assigned his family members to numbers on the second row of key pad (number 4,5, and 6 keys) and his friends to the third row numbers (7,8, and 9 keys).

Figure 22. Conversion example 1: phonebook

Figure 23. Conversion example 2: self-phone number

4.5. Discussion

This study was conducted to understand user experiences of older adults with their mobile phones to identify implications for functionalities, interface, interaction design and opportunities for new products and technologies. Semi-structured interviews with 12 individuals were conducted, and older adults' user experiences and challenges were presented using a framework of domestication of technology theory. This study revealed, as the

domestication of technology theory suggested, that adoption and use of mobile phones is a negotiation process between users and technology design, and users shaped the technology (mobile phone) to their lives depending on their life pattern and their ability to tame the technology (Siverstone & Haddon, 1996). The representation of user experience within the domestication of technology framework provided a set of propositions for understanding what their experiences with mobile phone are like, what barriers they experience with their mobile phone, and how to improve their experience. A subsequent literature review was conducted within psychosocial and cognitive areas to provide theoretical or empirical evidence for each proposition. The following discussion is structured around two issues: 1) recommendations for improving the user experience and 2) the applicability of domestication of technology theory in the user requirements capturing process.

4.5.1. Recommendations to improve mobile phone user experience of older adults

4.5.1.1. Emphasis on easy operation of two basic features (communication and safety)

This study revealed that overall older adults, regardless of their ability to operate technology, used few features on their mobile phone and showed little interest in additional mobile phone features beyond communication functionality, such as internet and text messaging. This study included a wide range of differential mobile phone users based on the three cluster solutions in previous study, but even the explorer-type participants' mobile phone usage was found to be limited to basic phone features. This study of various user types, therefore, supported previous research findings that suggested older adult's limited phone usage (Kurniawan et al., 2006; Mann et al., 2004).

This study, however, revealed that this phenomenon is due to the aging process that changes their social lives and emotions, which can be explained by socio-emotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999). The main assertion of socio-emotional selectivity theory posits that individuals are guided by an essential set of socio-emotional goals throughout life, but with increasing age, perceived limitations on time lead to reorganizations of goal hierarchies; hence they limit their energy selectively and behave in ways that decrease the experience of negative emotions (Carstensen et al., 1999; Löckenhoff & Carstensen, 2004).

Older adults, therefore, tend to selectively limit their social interactions and focus on relatives and close friends (Carstensen et al., 1999). Also, older adults tend to be present-oriented: they are reluctant to spend their time with learning new technology unless they are convinced with sufficient expected benefits (Melenhorst, Rogers, & Caylor, 2001).

A similar pattern was found in mobile phone adoption and usage by older adults. Participants in this study were retirees whose lifestyles ranged from being relaxed in a retirement community to traveling frequently from city to city to take care of grandchildren. Regardless, their lifestyles were centered around their family and close friends, and a mobile phone played the role of connecting them for communication or safety reasons. The landline phone was still found to be positioned in their lives as the primary communication tool to the external world with which they complete most daily tasks such as making appointments with others. In addition, participants tended to be present-oriented: they tended to keep the landline phone as a primary tool rather than replacing it with a mobile phone. They were also reluctant to learn new features of mobile phones since they were not convinced of the benefits of additional mobile phone features (i.e., internet and text messaging), compared to existing technology in their home, such as the landline phone, computers, and internet. Therefore, older adults' choices about mobile phone use seemed to be based on a cost-benefit analysis that considered the ratio between the expected benefits and the investment of time and energy.

This theoretical explanation provided practical implications for mobile phone design. First, easy operation of two basic functionalities (i.e., communication and safety) should be emphasized in the mobile phones for older adults. The previous quantitative study also supported this recommendation as participants consistently emphasized five features: call/receive, phonebook, speed dial, voice message, and emergency button. Second, older adults' decisions to use mobile phone features rely heavily on perceived usefulness and usability, and their expectation about usability is extremely high. Increasing the usefulness and usability of mobile phones can be achieved by reducing barriers that older adults encounter through the course of domestication. These are described in the following sections.

4.5.1.2. Age-related perceptual and cognitive declines should be accommodated

This study found that various age-related perceptual and cognitive declines affected older adults' mobile phone usages, and those declines need to be accommodated in the mobile phone design. Previous research indicated that age-related perceptual and cognitive changes affect older adults' abilities to use computers as well as their preferences and priorities for the user interface design (Craik & Salthouse, 2000). This study extended the previous findings to mobile phone design by identifying specific usability problems that older adults encountered due to each type of age-related changes. There were substantial individual differences in rate and degree of functional change among participants, but the efficacy of product design that accommodates the aging-process will be effective for the entire older adult population. The following design recommendations for mobile phone handset design were developed based on findings of this study and related research (Craik & Salthouse, 2000; Fisk et al., 2004):

- Maximize easy operation of button press by controlling the following design components: protrusion of buttons, button size, button pitch (space between buttons), button background lights, and button labels.
- Maximize easy reading information on display by controlling the following design components: screen size, screen resolution, font size on screen, screen contrast, screen brightness, and screen backlight duration.
- Accommodate users' perceptual aging process by providing the following design options: Speaker loudness, font size on display, and vibration strength.
- Accommodate older adults' cognitive aging process by including design considerations:
  - Minimize demand on working memory by minimizing key presses
  - Avoid technical jargon
  - Minimize irrelevant screen information
  - Allow extra time to read information and type letters during menu navigation

4.5.1.3. Knowledge and attitudinal barriers should be supported

This study found that a lack of knowledge, combined with low self-efficacy, hindered

some older adults from fully utilizing mobile phones. Participants with limited knowledge about mobile phones (most basicians and minimalists) were often overwhelmed by the contemporary design of instruction manuals that describe all functionality in one booklet. They indicated a need to have alternative instruction delivery methods, rather than paper-based manuals. Previous theoretical and empirical studies suggested video-based behavioral modeling as a potentially beneficial support. Video-based behavioral modeling is a training method in which a video-taped model demonstrates the behaviors required for performance; trainees, then, imitate the model's behavior in practice or work situations (Gist, Schwoerer, & Rosen, 1989). Goldstein and Sorcher (1974) proposed that behavioral modeling enhances performance in managerial training. Bandura's social learning theory (1986) also suggested that self-efficacy perceptions develop from a gradual attainment of skills and experience over time through observation of a model. A number of studies supported these theoretical principles empirically. For example, Rogers et al. (1996) found that online video-based instruction resulted in older adults' improved learning in the use of automatic teller machine (ATM) transactions compared to text instructions in paragraph format. Video-based training increased older adults' learning and task performance in the use of a home medical device (Mykityshyn, Fisk, & Rogers, 2002). Gist et al. (1989) found that viewing a videotaped model resulted in greater software self-efficacy compared to a tutorial-type for a spreadsheet application.

4.5.1.4. "Threshold concepts" should be highlighted

This study revealed three concepts that hinder people with lower domain knowledge levels when using a mobile phone: the function of softkeys, text input, and error recovery (i.e., a clear button). Research in the education area defines these concepts as "threshold concepts", concepts that are difficult to learn yet necessary for making progress and suggested that the threshold concepts should be highlighted in the curriculum for an effective learning process (Meyer & Land, 2005).

Previous studies suggested that the threshold concepts can be mastered using two learning stages in the design of instructional manuals: an initial declarative stage and a subsequent procedural stage (Anderson, 1983). A learner at the declarative stage must map

declarative or factual knowledge onto stored general procedures to perform a new task. When declarative knowledge is compiled into new task-specific procedures, the learner no longer engages in this laborious mapping process and speed and accuracy increase (Anderson, 1983; Van Gerven et al., 2000). The theory of the two learning stages recommends that the instructional manual for mobile phones, regardless of whether video- or paper-based, must provide sufficient information about the three threshold concepts as a fundamental declarative knowledge. An empirical study supports this proposition. Mead et al. (1999) found that the provision of fundamental declarative knowledge resulted in superior error recovery performance by older adults during ATM (automatic teller machines) menu navigation.

4.5.1.5. Information barriers should be removed through Internet-based resources

This study revealed that older adults need access to information about mobile handsets and mobile services to select a system that meets their needs. This information is not readily available to them on the Internet or elsewhere. Due to the 'information barrier', some older adults were mismatched with improper mobile phones, which exacerbated their difficulties with mobile phones. As suggested by participants in this study, the Internet appeared to be a proper way to offer such information since every participants showed some level of familiarity with it. A recent survey on older adults' Internet use supported this recommendation. A survey of 1461 older adults found that 36% of them indicated their interest in getting information about consumer products from the Internet to become a better informed consumer (SeniorNet, 2004). For those who do not use the Internet, in-person presentations from a consumer watch group would also be a good recommendation. In fact, during the research period, the experimenter was invited to numerous senior centers to present information about fundamental mobile technologies and to recommend phone models for older adults.

In addition, some participants lack an understanding of features on their mobile phones. Sending informative emails or postal mails to describe the relative benefits and useful strategies of mobile phone features (i.e., the way P1 used the speed dial feature) may be beneficial to older adults.

4.5.1.6. Users' conversion should be understood

As McCarthy and Wright (2005) found, this study reinforced that users are not passive creatures; instead, they actively complete the experience for themselves and may even turn in unintended directions. Depending on their capabilities and preferences, users actively seek a solution to achieve a goal. Understanding how users have modified existing product design is important since it facilitates the generation of various design solutions to improve the user experience (Norman, 2002). In this study, some of basicians and minimalists who were not comfortable with the menu navigation created design modifications using a piece paper to facilitate their own use of the feature. This led to two design considerations. First, removing a navigation step from the phone book use seems to be the key design issue. A phone could display a contact list on the default screen, showing names and phone numbers along with speed dial numbers without requiring an initial button click to access the directory. Second, one could provide an adhesive paper phonebook as an accessory.

4.5.1.7. Potential gender difference on mobile phone use for pleasure

This study identified a gender difference in the use of mobile phones for pleasure (recreational uses). Female participants utilized or had more interest in the camera feature for feeling pleasure and sharing personal experience with other friends, compared to male participants. This finding parallels previous emotion theories and empirical findings of gender differences in social and communication behaviors (Brody, 1997; Caldwell & Peplau, 1982; Walker, 1996). Previous studies found that women are more emotional and expressive than men in maintaining social relationships, which means that women tend to engage in intimate conversation and emotional sharing with their close friends or families (Caldwell & Peplau, 1982; Christensen, Baumann, Ruggles, & Sadtler, 2006). The same result was also found in other technology use such as telephone and email. Lacohee and Anderson (2001) found that small talk and emotional sharing were considered legitimate motives for women to contact their friends, and women tend to use the telephone more often than men to sustain a larger circle of friendship. Boneva et al. (2001) also found the same result in email use by showing that women use email more often for emotional sharing with close friends.

This study extended the same gender difference to mobile phone feature use by finding that the camera feature along with other fun features appeal to female users more than male users. More empirical investigations, however, need to be conducted to test this proposition and to identify what functions and elements of the user interface appeal to female users' pleasure.

4.5.2. Applicability of the domestication of technology theory to needs analysis

This study revealed that the domestication of technology theory can be a useful analytical tool for describing and understanding the complexity of the user experience and capturing users' needs in two main regards. First, the domestication concept provides a theoretical lens that leads to broader theoretical and practical implications than technology determinism perspective where technology is understood as ready-made artifacts whose use is non-negotiable and determined by its designers' intention (Berg, 1999; Sørensen, 2005). In the domestication concept, technology adoption and use is viewed as a reciprocal change wherein users shape technology for themselves and technology changes users' skill and attitude; therefore, the domestication concept invites balanced focus on three main sets of features of technology use:

1) Meaning of the technology: The main advantage of the domestication concept is the explicit attention to the meaning of artifact (Haddon, 2006; Sørensen, 2005). During the domestication process, users may ascribe new and changing meanings to the artifacts in their lives. The domestication concept guides the product development team to roles that the artifact eventually could play in users' everyday life, which helps broaden design space for a new product by facilitating identification of conscious and unconscious user requirements (Robertson, 2001).
2) Learning process: The domestication concept placed the main focus onto the individual user struggling with taming a product to integrate it into his/her everyday life (Siverstone & Haddon, 1996). Therefore, it helps the product development team to focus on learning processes, which facilitates the development of user supports such as instructional manuals or training materials. This concept leaves room to integrate fertile concepts from cognitive

psychology, such as the concept of mental models (Mead et al., 1999) and cognitive overload theory (Van Gerven et al., 2000), into the user requirements capturing process.

3) Technology adaptation: Another advantage of the domestication concept is the 'social shaping of technology' perspective, where the user is perceived to take a dominant role in defining the nature, scope and functions of the technology. This perspective lead to explicit attention to a set of practices that users create to integrate the technology into routines of their lives. It broadens design space by allowing designers or usability engineers to realize unexpected consequences of their design.

Second, the domestication of technology theory provides a promising theoretical scheme to study user experiences by framing the 'career' of technologies in users' lives with four dimensions: appropriation, objectification, incorporation, and conversion. As discussed earlier, despite a growing acceptance of the need to focus on user experience, user experience is not well developed conceptually, and it remains as an elusive concept that resists specification and finalization (Berg, 1999). Given the lack of theoretical basis in analyzing user experience, the four dimensions can offer a theoretical foundation to approach to user experience holistically and pragmatically. Figure 24 shows how the four dimensions were used to describe older adults' user experience with mobile phones. While describing user experiences through the four dimensions, various barriers facing older adults were identified, and this research presented a set of recommendations to reduce those barriers as a means to improve the user experience.

4.6. Limitations

This study has some limitations. As intended, the study used strategic sampling for diversity since each sample was considered to represent an aspect of older adults' characteristics. However, as participants in this study were recruited from the sample of Study 1, there may still be a source of bias. For example, all participants in this study showed some level of familiarity with computers and the Internet, which is not generalizable to the overall older adult population. Also, all participants were active older adults with no or minimal impairments.

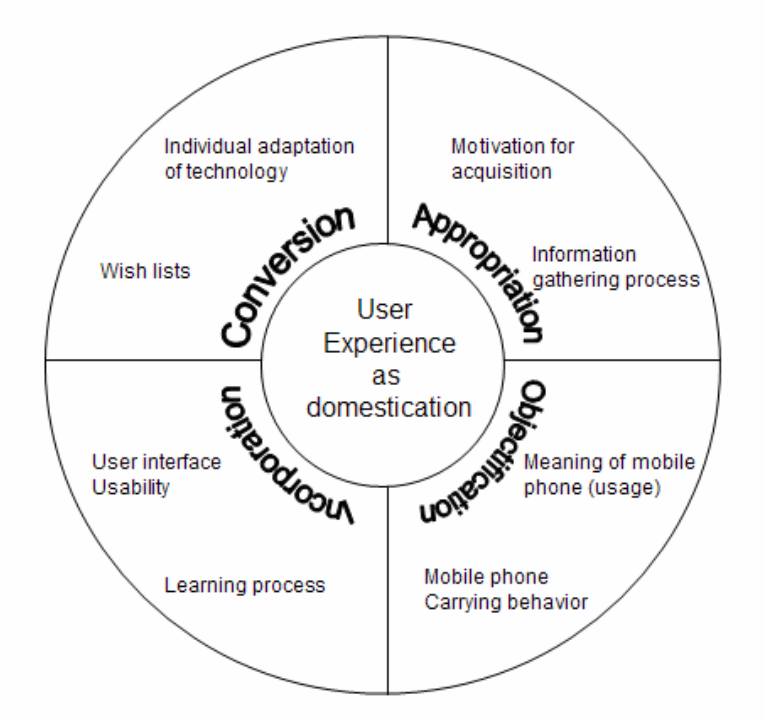


Figure 24. User experience as domestication process

This study used an interpretive group to minimize the subjective bias during the data interpretation process. Among the group, most, but not all, interpretations were similar. In the case of differences, the decision-making process was controlled by the main researcher, which might introduce a degree of bias.

As it can be difficult for older adults to articulate their experience with technologies (Fisk et al., 2004; Newell & Dickinson, 2001), this study included two activities in the semi-structure interview designed to facilitate participant articulation: task performance and reaction to a phone prototype. The two activities naturally guided participants to provide more opinions about usability issues. Researchers who conduct semi-structured interviews with older adults need to select the number of additional activities needed to achieve the goals of the research.

CHAPTER 5. CONCLUSIONS

This dissertation research investigated how older adults experience their mobile phones using both quantitative and qualitative studies based on the mixed-research approach. The objective was to identify representative user clusters in the older adult population and to develop a set of user requirements for mobile phones to improve older adults' user experiences. This chapter integrates the findings from the two studies then discusses the contributions of this research to the field of human factors research on consumer product design.

5.1. Findings and contribution of this research

1) Older adults' cost-benefit analysis and mobile phone feature use

The complementary use of quantitative and qualitative analyses revealed that overall older adults adopted few features of mobile phones, regardless of their ability to use the mobile phone, and theoretical explanations for this phenomenon were provided using socio-emotional selectivity theory (Carstensen et al., 1999). Older adults perform parsimonious cost-benefit analyses when they adopt technologies including mobile phone technology. Currently, older adults seem to be convinced of the benefits of mobile phone use for communication and safety purposes, but they perceive that it is a waste of their energy to read much information in a small display and to input text using a small keypad. This study, therefore, suggested that currently mobile phone design for older adults needs to focus on easy operation of communication features (i.e., phonebook, speed dial, voicemail, and volume control) rather than advanced features (i.e., text messaging, calendar, and internet) that require intensive reading and texting. However, the adoption of advanced mobile services will be likely to be adopted by (explorer-type) older adults if the interaction design minimizes cumbersome button click and text input, as shown in the wish list of future mobile phone features suggested by older adults (Appendix K).

2) Heterogeneity among older adults

This research revealed that older adults are a heterogeneous group in their mobile phone usage and preferences as identified by user clusters. In Study 1, a statistical cluster analysis revealed that older adult mobile phone users could be seen as three groups (explorers, basicians,

and minimalists) in terms of their mobile phone usage pattern. Subsequent analyses in Study 1 revealed differences among the clusters such as age, computer usage, personal traits (innovativeness), and skill levels in the mobile phone operation. Study 2 was conducted to validate those differences and identify further differences qualitatively. Results of Study 2 showed that while there were distinctive characteristic differences between explorers and minimalists, basicians were found to have mixed characteristics from both groups. Some basicians were as skillful in operating mobile phones as explorers, but others showed a lack of knowledge about mobile phones, similar to minimalists. Those basicians who shared similarities in their mental models with minimalists were found to use various communication features, such as phonebook and speed dial, but had no understanding of the features because someone had set up the speed dial for them and they just learned how to use them. Based on the complementary use of results from Study 1 and 2, therefore, two distinct user groups were suggested, and their characteristics were as follows:

- Explorers (30%): This user cluster is composed of people who are relatively young (mean age: 68.22, *SD*=6.80), willing to adopt new technology innovation (innovativeness), and use various technology such as MP3 players and PDA (personal digital assistants). They use computers and the Internet everyday and are skillful in computer use. This group travels frequently in local areas and to other states for visiting their children. They are skillful mobile phone users who used various features of mobile phones for communication purposes (e.g., phone calls, phonebook, voice message checking, speed dial, and call history). Mainly, they use mobile phones to communicate with family members, but sometimes they use it for their business, such as tax consulting service for their community. They usually learn about their mobile phones by interacting with the phone: hence, they don't use the manual. They are skillful in menu navigation and text input as well. This group also desired more features in their mobile phone including call, receive, phonebook, speed dial, ringer change, voice message, clock, speed dial, call history, emergency, speaker phone, and camera.
- Minimalists (29%): This user cluster is composed of people who are relatively old (mean

age: 74.84, *SD*=6.00), not willing to change, and use a computer and the Internet in their lives but not daily. This group appeared to be low-end users who keep a mobile phone for emergencies only. Hence, people in this cluster used the mobile phone rarely in their lives, and the only function used was calling/receiving a call. Due to their minimal experience with mobile phones, this group has very limited knowledge about their mobile phone. They are not able to use the phonebook features due to a lack of understanding about softkeys, text input, and error recovery. This group, who lacked the basic knowledge about the mobile phone and self-efficacy, wanted to learn about mobile phones by following user manuals, but they felt the manual was too difficult for them to use. They preferred a minimal design of mobile phones that include call, receive, emergency call, phone book, speed dial, and voice message.

Table 28. Summary of descriptions for explorers and minimalists

Characteristics	**Explorers**	**Minimalists**
Age	Young	Old
Innovativeness (Willingness to change)	High	Low
Computer and internet use	Frequent	Rare
Knowledge about mobile phone	High	Low
Mobile phone usage	Various features	Make a call and receive
Frequency of phone usage	Frequent	Rare
Service	Monthly payments	Pre-paid phone services
Life style	Frequent traveler	Less frequent traveler

Table 28 summarized the characteristics of the two user groups. Identification of such representative users is a practical contribution to human factor research in product design area since it provides foundations of persona or user profile developments. The success of product design with the user-center design approach depends on defining target users with relatively homogeneous characteristics (Syme & Eisma, 2001). When diversity among users is found, user modeling is required, and persona is one user modeling technique often suggested by other researchers (Cooper, 2004).

A persona, or user archetypes or profile, is a user representation that characterizes a certain user population by a collection of attributes such as demographic information, experience,

motivation, needs, and behaviors (Cooper, 2004; Junior & Filgueiras, 2005; Pruitt & Grudin, 2003). Numerous studies reported the usefulness of personas as 1) they create a strong focus on user and work contexts; 2) they help developers make their goals more explicit and justify their design decisions easily; and 3) they can be a powerful medium for communication across multidisciplinary teams including designers, developers, marketers, and managers (Cooper, 2004; Junior & Filgueiras, 2005; Pruitt & Grudin, 2003). It was suggested that the realistic persona creation process should involve both quantitative and qualitative user research approaches, and this study identified two distinct groups using the user research that was conducted with real users in a mixed-research method (Pruitt & Grudin, 2003).

Identifying distinct groups in the older adult population has practical implications for future mobile phone design. The interest in universal design for information and communications technologies such as mobile phones is growing and crossing disciplines (Bajaj, Mirka, Sommerich, & Khachatoorian, 2004; Shneiderman, 2000). The motivations include the legal requirements for providing access to marginalized users such as older adults and the market opportunities in reaching diverse consumers. However, developing user interfaces that are universally accessible is a great challenge due to the diversity in users such as user knowledge and skill differences.

As one of the strategies accommodating diverse users, Shneiderman (2003) suggested a multi-layer approach. Its underlying concept is that first-time and novice users begin with a minimal set of features at Layer 1. They are most likely to make correct choices when they have only a few options and are protected from making mistakes. After gaining confidence from hands-on experience, users can remain at Layer 1 or progress to higher layers when needed or when they have time to learn further features. Shneiderman (2003) suggested that the success of the multi-layer interface is dependent on understanding users' diversity, and the user clusters identified in this research can serve as target user clusters for multi-layer interfaces of future mobile phones for older adults. In addition, the clusters can also be used in the development or evaluation of other mobile services that are useful for older adults, such as a mobile phone telemedicine system (Gibson, McSharry, & Tarassenko, 2005).

3) Domestication of technology as a user requirement capture tool

This study introduced the domestication of technology theory as a theoretical foundation for capturing user requirements and developed practical dimensions to identify users' needs. Using the four dimensions, this study identified various barriers that older adults were faced with through the course of user experience: information-, knowledge-, attitudinal-, sensorial/perceptual-, and cognitive barriers. When combined with other research findings, a set of recommendations was provided to reduce the barriers. Integrating the recommendations into the framework of mobile phone user interfaces described in Chapter 2.2, a set of user requirements was provided as a final outcome (Appendix L).

Given the lack of theoretical basis in recent user experience research, the domestication concept provided the foundation that human factor engineers can use to address user experiences. It was designed to facilitate the identification of numerous factors of user experience ranging from technology adoption and functional use to detailed user interface design aspects such as usability problems and the learning process, while accounting for a large portion of the whole mobile phone system (Palen & Salzman, 2002). However, it should be noted here that the interpretation of the domestication concept was made in a practice-based approach to solve problems in the real world, and further theoretical research should be conducted to understand how the domestication concept can be applied better in user experience design research.

5.2. Future research directions

Human Factors research traditionally used the scientific or rationalistic paradigm to design or evaluate the effects of user interface design and human factors (Dillon & Morris, 1996). This dissertation research differed from the traditional human factors approach as it was oriented toward a naturalistic inquiry approach (Creswell, 2003). Rather than designing an artificial setting where a prototype is tested by a number of participants, a more naturalistic-type research was conducted to understand older adults' experiences with mobile phones using a questionnaire and semi-structured interviews under the normal consumer market conditions. In this way, this research contributed to understanding older adults' mobile phone usage in their everyday lives, and a set of recommendations was developed to improve older adults' user experiences with

mobile phones. However, those recommendations must be tested in experimental conditions. The recommendations of interest are:

1) The video-based behavioral modeling will be beneficial to novice users by improving task performance and enhancing self-efficacy.
2) Overcoming three threshold concepts (softkey, text input, and error recovery) will improve novice users' task performance and learning process.
3) Gender differences may exist in attitudes toward technology use for pleasure or fun.
4) Gender differences may exist in task performance using mobile phones and that may be related to lower self-efficacy among female users. The association between gender, age, self-efficacy, and task-performance should be investigated.

This research initially identified three user groups (explorers, basicians, and minimalists) in terms of their mobile phone usage pattern, but subsequent qualitative study found that the clusters are not necessarily reflective of their understanding of functionality or their skill level in the mobile phone operation. For example, some basicians were found to use speed dial with no understanding about the feature because someone in their family had set up the feature for them. To identify representative user clusters that share similarities in their feature usage and the skill level, another cluster analysis should be performed with the inclusion of their responses on the 'ease of use' attribute of mobile phones in addition to the feature usage.

The rise of mobile phone use has provided new opportunities for older adults. The mobile technology allows not only ubiquitous communications but also anytime access to some services that are vital for older adults' security and autonomy, and quality of life (Abascal & Civit, 2001). However, it was often found in the past that consumer product design teams were obsessed by negative stereotypes of aging and elderly people, such that older users are often thought of as wheelchair users, severely disabled, hard of hearing, or partially sighted (Huppert, 2003). This research revealed that the stigmatization is no longer true (Lähteenmäki & Kaikkonen, 2004). The older population is as heterogeneous as any other age group or more heterogeneous than others due to the increased variation in physical and cognitive condition and

life experience (Czaja & Lee, 2002; Nicholas, Rogers, & Fisk, 2003). The heterogeneity of this population has become even greater as baby boomers, who were found to be more familiar with computers and healthier than their previous generations, have started joining this population. More user studies need to be conducted to better define the heterogeneity among older adults along with useful mobile applications and interface design development.

CHAPTER 6. REFERENCES

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APPENDICES

Appendix A. Survey sample

Dear Participant,

The cellular mobile phone or cell phone has become very commonplace in society. While much has been studied about designing cell phones for younger people, specific attention has not been directed at older users of cell phones. To address this issue, the Grado Department of Industrial and Systems Engineering at Virginia Tech is conducting research to understand what older adults think about technology in general and how they use cell phones.

We need your help to inform cell phone manufacturers about what you want in a phone. Your input will affect the future design of cell phones.

Please take about 10 to 15 minutes to complete our questionnaire. When you are finished, please return it using the enclosed postage-paid envelope. If you prefer and have Internet access, the questionnaire can be answered online at "https://survey.vt.edu/survey/entry.jsp?id=1158269213360".

Your responses are strictly confidential and will not identify you. If you are willing to participate in a follow-up interview or group discussion, please provide contact information on the last question of the survey.

Thank you for considering our request. Your response will be valuable information in designing a cell phone that is easier to use for older adults and for all individuals.

If you have any questions, please feel free to contact me by phone at 540-808-8843 or by e-mail at yolee10@vt.edu.

Sincerely,

Young S. Lee
Ph.D candidate
Dept. of Industrial Systems Engineering
Virginia Polytechnic Institute and State University

SECTION A. GENERAL QUESTIONS ABOUT CELL PHONE USE

1) Do you own a cell phone?

☐ Yes ☐ No

2) How many years have you owned a cell phone? _____ years

3) Indicate the extent to which you agree with each statement.

The reason I have a cell phone is…	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Personal communication (with family or friends)	☐	☐	☐	☐	☐
Business communication (with business partner or co-workers)	☐	☐	☐	☐	☐
To seek information (e.g., news or driving directions)	☐	☐	☐	☐	☐
To save information (e.g., phone numbers or personal notes)	☐	☐	☐	☐	☐
Entertainment (e.g., music, game)	☐	☐	☐	☐	☐
Safety and security	☐	☐	☐	☐	☐
Others (please describe:)	☐	☐	☐	☐	☐

4) Indicate the extent to which you agree with each statement.

I learn how to use a cell phone by…	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Reading manuals	☐	☐	☐	☐	☐
Asking family or friends	☐	☐	☐	☐	☐
Asking customer service	☐	☐	☐	☐	☐
Trying out myself	☐	☐	☐	☐	☐
Others (please describe:)	☐	☐	☐	☐	☐

SECTION B. QUESTIONS ABOUT YOUR CURRENT CELL PHONE

1) What model of cell phone do you own currently?

- Manufacturer: _____ (e.g., Motorola, Nokia, Samsung, etc.)
- Model name (check the inner side of battery case): _____ (e.g., SPH-A960, etc.)
- Service carrier: _____ (e.g., Verizon, Sprint, etc.)

2) How frequently do you use the following functions of your cell phone?

Functions	I don't know what this is	Not available on my phone	Never	Rarely	Somewhat frequently	Frequently
Make a call	☐	☐	☐	☐	☐	☐
Receive a call	☐	☐	☐	☐	☐	☐
Phonebook (e.g., contacts)	☐	☐	☐	☐	☐	☐
Speed dial	☐	☐	☐	☐	☐	☐
Call history	☐	☐	☐	☐	☐	☐
Voice message checking	☐	☐	☐	☐	☐	☐
Text messaging Service	☐	☐	☐	☐	☐	☐
Voice memo	☐	☐	☐	☐	☐	☐
Change ringer tone	☐	☐	☐	☐	☐	☐
Calculator	☐	☐	☐	☐	☐	☐
Calendar	☐	☐	☐	☐	☐	☐
Alarm	☐	☐	☐	☐	☐	☐
Multimedia Messaging Service	☐	☐	☐	☐	☐	☐
Camera	☐	☐	☐	☐	☐	☐
Game	☐	☐	☐	☐	☐	☐
Internet	☐	☐	☐	☐	☐	☐
Voice activation	☐	☐	☐	☐	☐	☐
Clock	☐	☐	☐	☐	☐	☐
Listening to music	☐	☐	☐	☐	☐	☐
Speaker phone	☐	☐	☐	☐	☐	☐
Others: _____		☐	☐	☐	☐	☐
Others: _____		☐	☐	☐	☐	☐

3) Please answer to the following questions based on your experience with your current cell phone.

Usefulness of the phone	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I find my cell phone useful in my life.	☐	☐	☐	☐	☐
My cell phone has all the functions and capabilities I expect it to have.	☐	☐	☐	☐	☐
My cell phone allows me to use my time efficiently.	☐	☐	☐	☐	☐
My cell phone makes my life easier.	☐	☐	☐	☐	☐

Usability of the phone	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Overall, I am satisfied with how easy it is to use my cell phone.	☐	☐	☐	☐	☐
It is simple to use my cell phone.	☐	☐	☐	☐	☐
It was easy to learn to use my cell phone.	☐	☐	☐	☐	☐
It is easy to read texts on the screen.	☐	☐	☐	☐	☐
It is easy to navigate the menu of the phone.	☐	☐	☐	☐	☐
My cell phone gives error messages that clearly tell me how to fix problems.	☐	☐	☐	☐	☐
Whenever I make a mistake using the cell phone, I recover easily and quickly.	☐	☐	☐	☐	☐
It is easy to read labels on buttons.	☐	☐	☐	☐	☐
It is easy to press buttons.	☐	☐	☐	☐	☐
It is easy to input text.	☐	☐	☐	☐	☐
Supplemental reference materials (such as user manual) provided with the phone is easy to understand.	☐	☐	☐	☐	☐
It is easy to replace the battery.	☐	☐	☐	☐	☐
It is easy to charge the battery.	☐	☐	☐	☐	☐

Pleasurability of the phone	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Overall, my phone design is attractive.	☐	☐	☐	☐	☐
The screen design of my phone is pleasant.	☐	☐	☐	☐	☐
I find my cell phone entertaining.	☐	☐	☐	☐	☐
My phone makes appealing sound.	☐	☐	☐	☐	☐

Satisfaction	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Overall, I am satisfied with my cell phone.	☐	☐	☐	☐	☐

4) Do you have any complaints about your cell phone? Please write down here.

_____

_____

5) Please mark all features that you wish to have on your cell phone in the future.

Features	Yes, I wish to have this function
Make a call	☐
Receive a call	☐
Phonebook (e.g., contacts)	☐
Speed dial: a function to dial a designated number when you press a number key	☐
Call history	☐
Voice message checking	☐
Text messaging Service	☐
Voice memo: a function to save your voice in your phone	☐
Change ringer tone	☐
Calculator	☐
Calendar	☐
Alarm	☐
MMS (Multimedia Messaging Service): a function to send video and audio to another person.	☐
Camera	☐
Game	☐
Internet	☐
E-mail	☐
Voice activation	☐
Clock	☐
Listening to music	☐
Speaker phone	☐
Emergency call button (e.g., 911)	☐
Audio display: a function to read aloud menus and key pressed.	☐

6) Do you have any other functions or services that you wish to have in the future? Regardless of whether it is possible with current technology, please describe here. (For example, I wish to receive health-related information on my phone.)

_____

_____

_____

SECTION C. USE OF TECHNOLOGY

1) How frequently do you use the following?

	Never	1-3 times per month	Once per week	2-3 times per week	Once per day	More than once per day
Computer	☐	☐	☐	☐	☐	☐
Internet	☐	☐	☐	☐	☐	☐
Email	☐	☐	☐	☐	☐	☐

SECTION E. DEMOGRAPHIC INFORMATION

We need some demographic information about you to make a meaningful interpretation of the results. This information will only be used to provide an overall profile of all respondents. It is not analyzed separately for each individual. Please check or write in your answers to these questions.

1) Age: ( ) years old

2) Gender: ☐ Female ☐ Male

3) Highest education attainment:

☐ Less than high school, ☐ High school, ☐ College, ☐ Graduate school

4) Current occupation? ( )

5) Which state do you live in now (e.g., VA, NC)? ( )

6) Which area do you live now?

☐ Urban, ☐ Suburban, ☐ Rural

7) Household annual income:

☐ Less than $10,000 ☐ $10,000 - $24,999 ☐ $ 25,000 - $ 49,999

☐ $50,000 - $ 74,999 ☐ $75,000 - $ 99,999 ☐ Over $100,000

8) Do you have any age-related severe disabilities? Severe disability means something that prevents you from doing daily activities of living without assistance.

☐ Yes ☐ No

8-1) If you answered 'Yes' to Q8, please indicate which of the following (mark all that apply to you).

☐ Visual disability (e.g., legal blindness) ☐ Hearing difficulty

☐ Limited hand movement ☐ Cognitive disability (e.g., problems with memory)

☐ Others: _____

EXIT QUESTION

We are planning to conduct an interview or a group discussion where your preferences on cell phone design will be asked in detail. It will take about 1.5 hours, and your participation will be compensated $15/hour. If you wish to participate in this study, please fill in your name and contact information.

Name: _____

Phone: _____

Email address: _____

Thank you very much for taking the time to complete this survey. Please return the form using the enclosed envelope.

Appendix B. Online communities and senior centers contacted for Study 1

1) Local communities

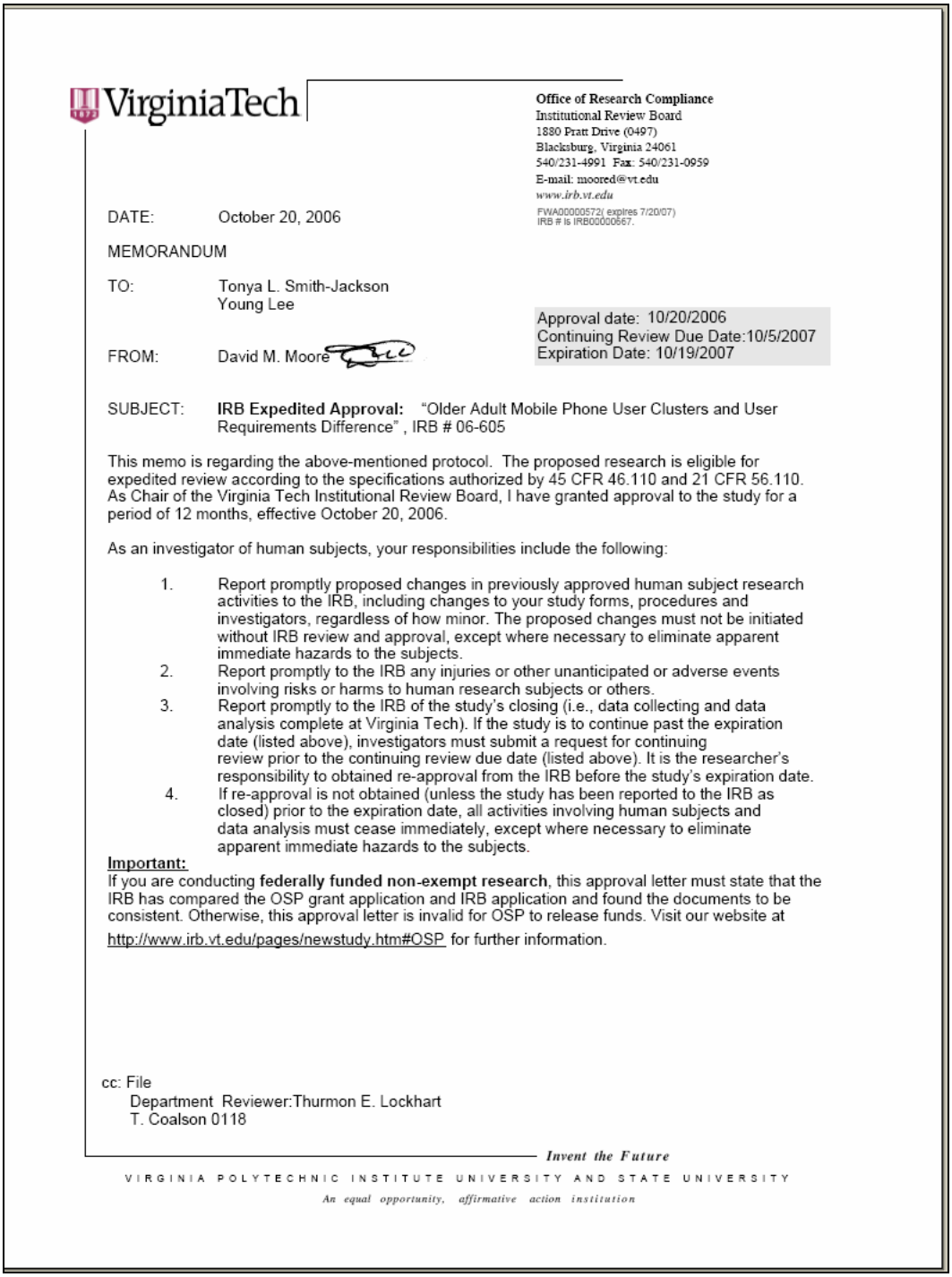
- Giles county senior center: 1320 Wenonah Ave, Pearisburg, VA 24134
- Radford recreation center: 619 Second Street Radford, Virginia 24141
- Warmhearth retirement communities: 2603 Warm Hearth Drive, Blacksburg, VA 24060
- Christiansburg recreation center: 1600 N Franklin St Christiansburg, VA 24073
- Blacksburg recreation center: 725 Patrick Henry Drive Blacksburg, VA 24060
- Roanoke recreation center: 3738 Brambleton Ave. Roanoke, VA 24018
- Bailey's senior center: 5920 Summers Lane Falls Church, VA 22041
- Franconia-Springfield senior center: Springfield Fire House 6300 Beulah Street Alexandria, Virginia 22310
- Groveton Senior Center:8350 Richmond Hwy., 3rd floor, Ste 325 Alexandria, VA 22309
- Herndon senior center: 873 Grace Street Herndon, VA 20170
- Hollin Hall senior center: 1500 Shenandoah Road Alexandria, VA 22308
- James Lee Community Center: 2855-A Annandale Road Falls Church, Virginia 22042
- Lewinsville senior center: 1609 Great Falls Street McLean, VA 22101
- Lincolnia senior center: 4710 North Chambliss St. Alexandria, VA 22312
- Little River Glen senior center: 4001 Barker Court Fairfax, VA 22032-1366
- Lorton senior center: 7722 Gunston Plaza Lorton, VA 22079
- Pimmit Hills senior center: 7510 Lisle Avenue Falls Church, VA 22043-1099
- Sully senior center: 5690 Sully Road Centreville, VA 20120
- Wakefield recreation center: 8100 Braddock Road Annandale, VA 22003
- AARP local chapter meeting: Blacksburg, Radford, Giles country, Floyd county, Eureka (Salem, VA), Southwest Roanoke Valley, Franklin County,

2) Online communities

- Seniornet.org: http://www.seniornet.org/
- Seniorliving at about.com: http://seniorliving.about.com/

- New River Valley today: http://www.nrvtoday.com/
- SeniorTech: http://www.seniortech.us/

Appendix C. IRB approval (Study 1)



VirginiaTech

Office of Research Compliance
Institutional Review Board
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax: 540/231-0959
E-mail: moored@vt.edu
www.irb.vt.edu
FWA00000572(expires 7/20/07)
IRB # Is IRB00000667.

DATE: October 20, 2006

MEMORANDUM

TO: Tonya L. Smith-Jackson
Young Lee

FROM: David M. Moore

Approval date: 10/20/2006
Continuing Review Due Date:10/5/2007
Expiration Date: 10/19/2007

SUBJECT: **IRB Expedited Approval:** "Older Adult Mobile Phone User Clusters and User Requirements Difference" , IRB # 06-605

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective October 20, 2006.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtained re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Important:
If you are conducting **federally funded non-exempt research**, this approval letter must state that the IRB has compared the OSP grant application and IRB application and found the documents to be consistent. Otherwise, this approval letter is invalid for OSP to release funds. Visit our website at http://www.irb.vt.edu/pages/newstudy.htm#OSP for further information.

cc: File
Department Reviewer:Thurmon E. Lockhart
T. Coalson 0118

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An equal opportunity, affirmative action institution

Appendix D. Bivariate correlations between variables measured in Study 1

Variable	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
X1:ownership	1.00														
X2:Useful	0.24**	1.00													
X3: Ease of use	0.10	0.35**	1.00												
X4: Pleasure	-0.05	0.29**	0.46**	1.00											
X5: Satisfaction	0.07	0.46**	0.65**	0.50**	1.00										
X6: Feature wish	-0.02	0.27**	0.08	0.20*	0.06	1.00									
X7: Computer use	0.15	-0.08	0.00	0.01	-0.17*	0.14	1.00								
X8: Internet use	0.21**	0.01	-0.02	-0.05	-0.11	0.12	0.91**	1.00							
X9: Email use	0.15	-0.02	-0.03	-0.03	-0.17*	0.09	0.94**	0.95**	1.00						
X10: Age	-0.04	-0.05	-0.02	-0.13	0.10	-0.18	-0.29**	-0.29**	-0.30**	1.00					
X11: Gender	0.00	-0.04	0.16*	-0.01	0.10	0.06	0.11	0.14	0.09	0.00	1.00				
X12: Education	0.12	0.04	-0.01	-0.01	-0.10	0.14	0.43**	0.48**	0.47**	-0.13	0.31**	1.00			
X13: income	0.14	0.02	-0.02	-0.07	-0.12	0.11	0.43**	0.43**	0.44**	-0.21*	0.24*	0.56**	1.00		
X14: Residence	-0.08	0.03	-0.02	-0.18	-0.02	-0.02	-0.18*	-0.13	-0.18	-0.07	0.10	-0.03	0.01	1.00	
X15: Clusters	-0.31**	-0.43**	-0.25**	-0.34**	-0.18*	-0.50**	-0.11	-0.13	-0.11	0.36**	-0.08	-0.10	-0.18*	0.01	1.00

*: $p<0.05$

**: $p<0.01$

Appendix E. IRB approval (Study 2)

VirginiaTech

Office of Research Compliance
Institutional Review Board
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax: 540/231-0959
E-mail: moored@vt.edu
www.irb.vt.edu
FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: April 6, 2007

MEMORANDUM

TO: Tonya L. Smith-Jackson
Young Lee

FROM: David M. Moore

Approval date: 4/6/2007
Continuing Review Due Date:3/22/2008
Expiration Date: 4/5/2008

SUBJECT: **IRB Expedited Approval:** "Older Adult Mobile Phone User Clusters and User Requirements Differences (Study 2)" , IRB # 07-206

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective April 6, 2007.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtained re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Important:
If you are conducting **federally funded non-exempt research**, this approval letter must state that the IRB has compared the OSP grant application and IRB application and found the documents to be consistent. Otherwise, this approval letter is invalid for OSP to release funds. Visit our website at http://www.irb.vt.edu/pages/newstudy.htm#OSP for further information.

cc: File
Department Reviewer:Thurmon E. Lockhart
T. Coalson 0118

Appendix F. Informed consent form for Study 2

INFORMED CONSENT FORM

Title of Project: Older adult mobile phone user clusters and user requirements differences
Principal Investigator: Tonya L. Smith-Jackson, Ph.D., Young Seok Lee

PURPOSE OF PROJECT

This study will examine older adults' mobile phone usage and identify types of mobile phone users in the senior population. Also, user needs and user requirements will be captured to facilitate developing mobile phones that are useful and usable for older adults.

PROCEDURE

In this project, you will participate in an interview that will ask your mobile phone usage and likes and dislikes about your phone. Also, you will be shown a new mobile phone, and your reaction to the phone will be asked. **All interview sessions will be videotaped to support data collection.**

RISKS

Participation in this project does not place you at more than minimal risk of harm.

BENEFITS

You will be compensated for your participation, and you will be given information to contact the principal investigator to get information about the outcomes of the study. You will also benefit from knowing that you have participated in worthwhile research that has immediate and positive applications to the design of mobile phones.

CONFIDENTIALITY

The information gained in this research project will be kept strictly confidential. At no time will the researchers release the results of the study to anyone other than individuals working on the project without your written consent. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

You will be identified only by a 3 digit study code. Data will be stored securely and will be made available only in the context of research publications and discussion. No reference will be made in oral or written reports that could link you to the data nor will you ever be identified as a participant in the project.

We will use digitized portions of the videos of the interview sessions. However, faces will be blurred or obscured so that you cannot be identified. However, your voice as well as your hands may be used to present specific issues requiring design attention. If you feel uncomfortable with the display of your hands and voice to other groups, please indicate on the second page.

COMPENSATION

You will be compensated at the rate of $10 per hour for participation in this research.

FREEDOM TO WITHDRAW

You are free to withdraw from this study at any time without penalty.

PARTICIPANT'S PERMISSION

I have read and understand the Consent Form and conditions of this project. I have had all questions answered. I hereby acknowledge the above and give my voluntary consent:

_____ _____
Subject signature Date

PARTICIPANT'S PERMISSION TO USE EXCERPTS FROM VIDEOTAPED SESSIONS (FACES WILL BE OBSCURED OR BLOCKED)

I have read and understand the manner in which videos will be used for subsequent presentation of information related to this study. I understand that my face will not be identifiable because it will be obscured or blocked. I understand that my hands and voice will be presented as relevant to the operation of cell phones. I grant permission to researchers to present this information as necessary in the manner described on this form.

_____ _____
Subject signature Date

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury, I may contact:

Young Seok Lee_____ 540-808-8843/ yolee10@vt.edu
Investigator(s) Telephone/e-mail

Tonya L. Smith-Jackson, Ph.D 540-231-4119/ smithjack@vt.edu
Faculty Advisor Telephone/e-mail

Thurmon E. Lockhart, Ph.D 540-231-9088/ lockhart@vt.edu
Departmental Reviewer Telephone/e-mail

David M. Moore 540-231-4991/ moored@vt.edu
Chair, Virginia Tech Institutional Review Board for the Protection of Human Subjects Telephone/e-mail
Office of Research Compliance
1880 Pratt Drive, Suite 2006 (0497)
Blacksburg, VA 24061

VT IRB – This document is valid from 6 April 2007 to 5 April 2008

Appendix G. Background information sheet for Study 2

Interview template

Participants' information

Participant #:
Age: Gender:

Computer use:

I am comfortable with using a computer.

1 ---------- 2 ---------- 3 ---------- 4 ---------- 5
Strongly agree Agree Neutral Disagree Strongly disagree

I feel confident in my ability to use my mobile phone.

1 ---------- 2 ---------- 3 ---------- 4 ---------- 5
Strongly agree Agree Neutral Disagree Strongly disagree

Phone model: Phone carrier: Phone picture:

Phone ownership for a cell phone:

Phone ownership for the current cell phone:

Appendix H. Interview script for Study 2

INTERVIEW SCRIPT

Introduction and informed consent **[5 mins]**

Thanks for your participation. I am Young S. Lee. I am a graduate student in ISE department at Virginia Tech, and I am doing my dissertation research to improve the design of cell phones for senior users.

I understand that you are a current cell phone user. Today, I am going to ask you to tell me about how you use your phone, what you like and dislike about your phone. I believe that any technology including a cell phone must be designed to meet users' needs and wants. In the current market, there are many cell phones that are designed well but also there are many designed badly for seniors. So, today, from this interview, I am looking for good examples or bad examples of cell phone design for seniors. Therefore, your critique will be very important. In the middle of the interview, I am going to ask you to do one task for me to understand how you use your phone more. Later on, I will show you a new phone and I will ask questions about the phone. Again, your critique will be really helpful.

Sometimes, I will ask the same questions multiple times through the interview. I would like to let you know that is my intention to help you think about different things, and that is not from my lack of attention.

This interview will take about one hour, and I will record our interview to support data analysis because I cannot take notes everything you said during the interview. This video camera will be used mainly to record our conversation but sometimes I will use it to capture your phone. I have already left a mark that this camera is aiming at, so please hold your phone around the mark during the interview.

As I said before, you will be paid $10 an hour for your time and you are free to withdraw at any time. Do you have any questions regarding this study?

Also, please feel free to stop me at any time if you need to take a break or get refreshments, etc.

[Give participant Informed Consent form. Read form to them, not word for word, but review main sections]
[Have participant sign 2 copies. One copy for them to keep, one copy for us to file].

Do you have any questions regarding the Informed Consent form?

Ok, First, I'd like to confirm your background information before we get started. [Compare demographic information with the survey form they filled out]. Demographic information

includes:

Age, gender, education, phone ownership, phone model, service carrier, and computer usage

Session 1: Interview with participants' mobile phone [45 mins]

1) Experience when purchasing a phone
Can you tell me about your experience when you bought this phone?

[Probes while listening]
How did you get this phone? Did you buy it yourself? Where? What made you choose this phone particularly?

2) Phone usage and their experience with their phone
Now, let us talk about how use this phone. Can you tell me about your mobile phone use?

[Probes while listening]
How frequently do you use your phone?
Do you carry your phone every time and everywhere you go?
What feature of your phone do you use frequently?
What do you like about your phone?
What do you not like about your phone?
Did you find your phone easy or difficult? Can you tell me why?

3) Task: saving a phone number
Ok, from now on, I am going to ask you to show me how you use your phone. I am going to ask you to save my phone number and my name into your phone, and I am going to ask you some questions about that. Is that ok with you? Again, I am not evaluating you. I am evaluating your phone. I believe that you cannot use it, it is a bad design.

[Interviewer observe participants' behavior]
[probes after task performance]
Do you see any problems with your phone while saving my number?
Do you have any suggestions on how to improve the problem?

4) Learning how to use the phone
Let us talk about how you learn about your phone? How did you learn how to use your phone after you bought it.

[Probes]
Do you use the user manual that came with the phone?
What made it easy or difficult to use?

Session 2: Interview using a prototype [10 mins]

I am going to show you a new phone model. Recently, this phone has not been released to the U.S. U.S. market yet.
[Interviewer provide a quick demonstration of features]
[Probes]
What are your impressions of this phone?
What do you think about these features? Do you think they are useful or not useful for you?
Would you use this phone?
What are your first impressions of this phone design?

Session 3: Wish lists

Let us talk about an ideal phone for you. What kind of phone would you like to have? Can you simply explain what it would be like?

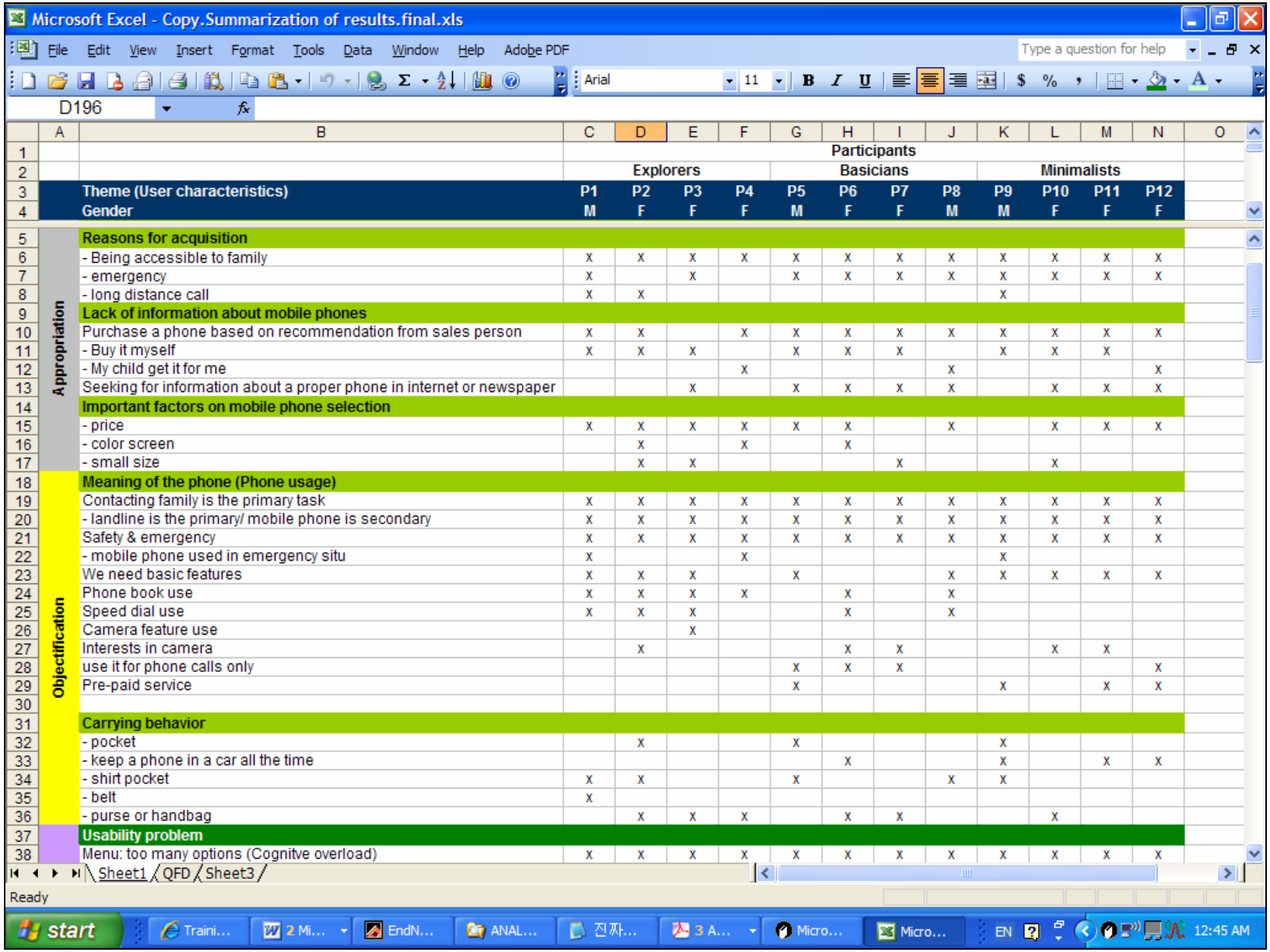
This is the last question for you today. Let's pretend that resources and technology are no object. Now, if you could have anything you wanted to be able to do with your phone, what would it be, and what would it be like?

[End of the interview]
Thank you very much for your participation and valuable information. Here is the compensation for your time. I need your signature here. Thank you very much again for your time.
Do you have any question for me about your phone? If you don't know a certain thing, maybe I can take a look and tell you how to do it.

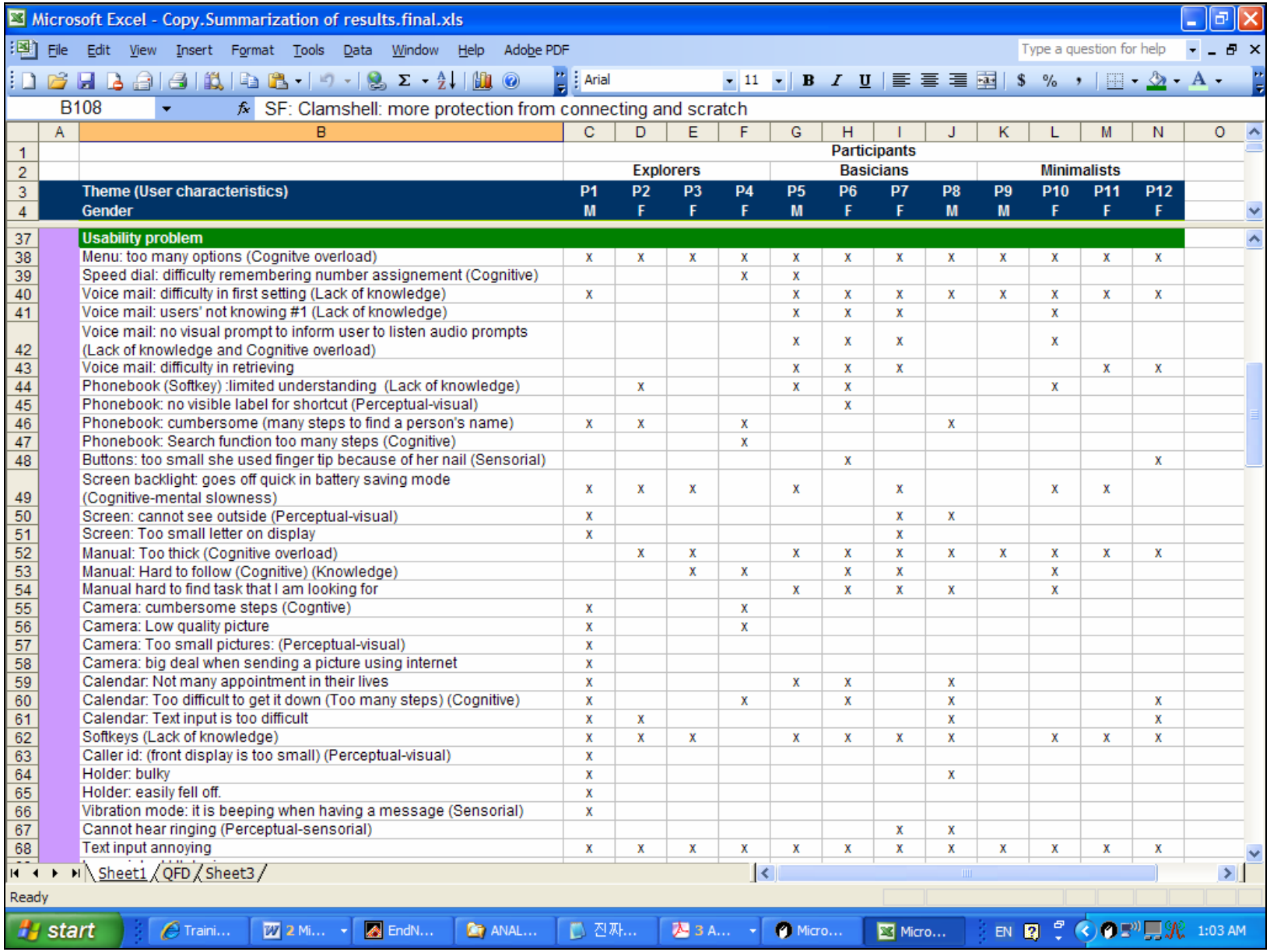
Appendix I. Prototype used in Study 2

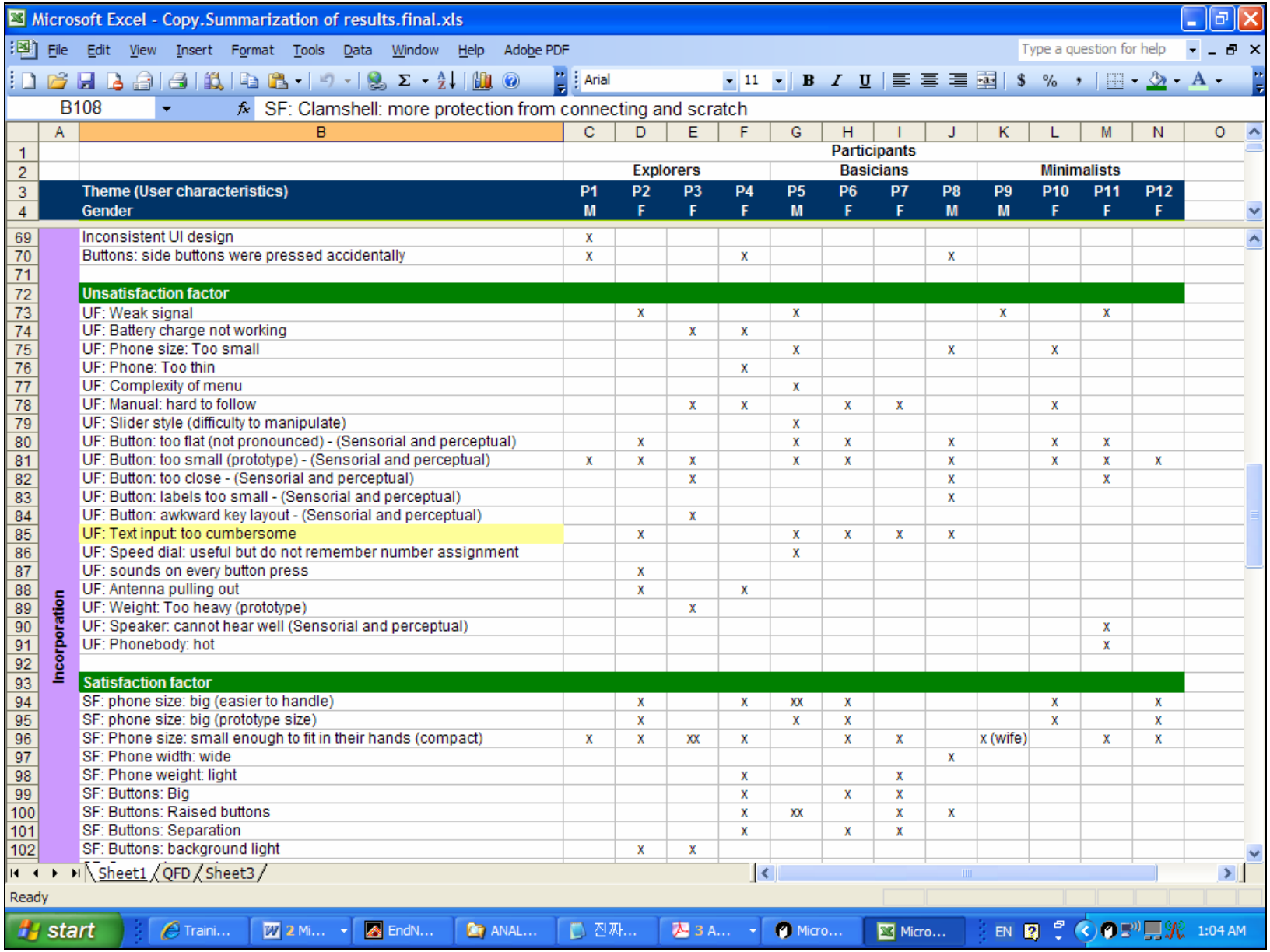
Model	Name	LG KG920 GSM 5MP Camera phone
Size	Dimensions	108 x 50 x 18 mm
	Weight	138g
Display	Type	TFT, 256K colors
	Size	240 x 320 pixels
Features	Vibration	Yes
	SMS	Send / Receive
	MMS	Send / Receive
	Camera	5 MP, 2560 x 1920 pixels, autofocus, video(VGA), flash
	Java	Yes
	Games	Yes
	Clock	Yes
	Alarm	Yes
	Calculator	Yes
	To-Do list	Yes
	T9	Yes
	Music	MP3/AAC/WMA/3GP player
	Standby	Up to 180 hours

Appendix J. Matrix tables for across-case contrasts and pattern clustering



		Theme (User characteristics)	Participants											
			Explorers				Basicians				Minimalists			
		Theme (User characteristics)	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
		Gender	M	F	F	F	M	F	F	M	M	F	F	F
	Appropriation	**Reasons for acquisition**												
		- Being accessible to family	x	x	x	x	x	x	x	x	x	x	x	x
		- emergency	x		x		x	x	x	x	x	x	x	x
		- long distance call	x	x							x			
		Lack of information about mobile phones												
		Purchase a phone based on recommendation from sales person	x	x		x	x	x	x	x	x	x	x	x
		- Buy it myself	x	x	x		x	x	x		x	x	x	
		- My child get it for me				x				x				x
		Seeking for information about a proper phone in internet or newspaper			x		x	x	x	x		x	x	x
		Important factors on mobile phone selection												
		- price	x	x	x	x	x	x		x		x	x	x
		- color screen		x		x		x						
		- small size		x	x				x			x		
	Objectification	**Meaning of the phone (Phone usage)**												
		Contacting family is the primary task	x	x	x	x	x	x	x	x	x	x	x	x
		- landline is the primary/ mobile phone is secondary	x	x	x	x	x	x	x	x	x	x	x	x
		Safety & emergency	x	x	x	x	x	x	x	x	x	x	x	x
		- mobile phone used in emergency situ	x			x					x			
		We need basic features	x	x	x		x			x	x	x	x	x
		Phone book use	x	x	x	x		x		x				
		Speed dial use	x	x	x			x		x				
		Camera feature use			x									
		Interests in camera		x				x	x			x	x	
		use it for phone calls only					x	x	x					x
		Pre-paid service					x				x		x	x
		Carrying behavior												
		- pocket		x			x				x			
		- keep a phone in a car all the time						x			x		x	x
		- shirt pocket	x	x			x			x	x			
		- belt	x											
		- purse or handbag		x	x	x		x	x			x		
		Usability problem												
		Menu: too many options (Cognitve overload)	x	x	x	x	x	x	x	x	x	x	x	x


Microsoft Excel - Copy.Summarization of results.final.xls
File Edit View Insert Format Tools Data Window Help Adobe PDF
Type a question for help
Arial 11
B108
SF: Clamshell: more protection from connecting and scratch
Participants
Explorers
Basicians
Minimalists
Theme (User characteristics) P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12
Gender M F F F M F F M M F F F
Usability problem
Menu: too many options (Cognitve overload) x x x x x x x x x x x x
Speed dial: difficulty remembering number assignement (Cognitive) x x x
Voice mail: difficulty in first setting (Lack of knowledge) x x x x x x x x x x
Voice mail: users' not knowing #1 (Lack of knowledge) x x x x
Voice mail: no visual prompt to inform user to listen audio prompts (Lack of knowledge and Cognitive overload) x x x x
Voice mail: difficulty in retrieving x x x x x
Phonebook (Softkey) :limited understanding (Lack of knowledge) x x x x
Phonebook: no visible label for shortcut (Perceptual-visual) x
Phonebook: cumbersome (many steps to find a person's name) x x x x
Phonebook: Search function too many steps (Cognitive) x
Buttons: too small she used finger tip because of her nail (Sensorial) x x
Screen backlight: goes off quick in battery saving mode (Cognitive-mental slowness) x x x x x x x
Screen: cannot see outside (Perceptual-visual) x x x
Screen: Too small letter on display x x
Manual: Too thick (Cognitive overload) x x x x x x x x x
Manual: Hard to follow (Cognitive) (Knowledge) x x x x x
Manual hard to find task that I am looking for x x x x x
Camera: cumbersome steps (Cogntive) x x
Camera: Low quality picture x x
Camera: Too small pictures: (Perceptual-visual) x
Camera: big deal when sending a picture using internet x
Calendar: Not many appointment in their lives x x x x
Calendar: Too difficult to get it down (Too many steps) (Cognitive) x x x x x
Calendar: Text input is too difficult x x x x
Softkeys (Lack of knowledge) x x x x x x x x x x
Caller id: (front display is too small) (Perceptual-visual) x
Holder: bulky x x
Holder: easily fell off. x
Vibration mode: it is beeping when having a message (Sensorial) x
Cannot hear ringing (Perceptual-sensorial) x x
Text input annoying x x x x x x x x x x x x
Sheet1 QFD Sheet3
Ready
start
Traini... 2 Mi... EndN... ANAL... 진짜... 3 A... Micro... Micro... EN 1:03 AM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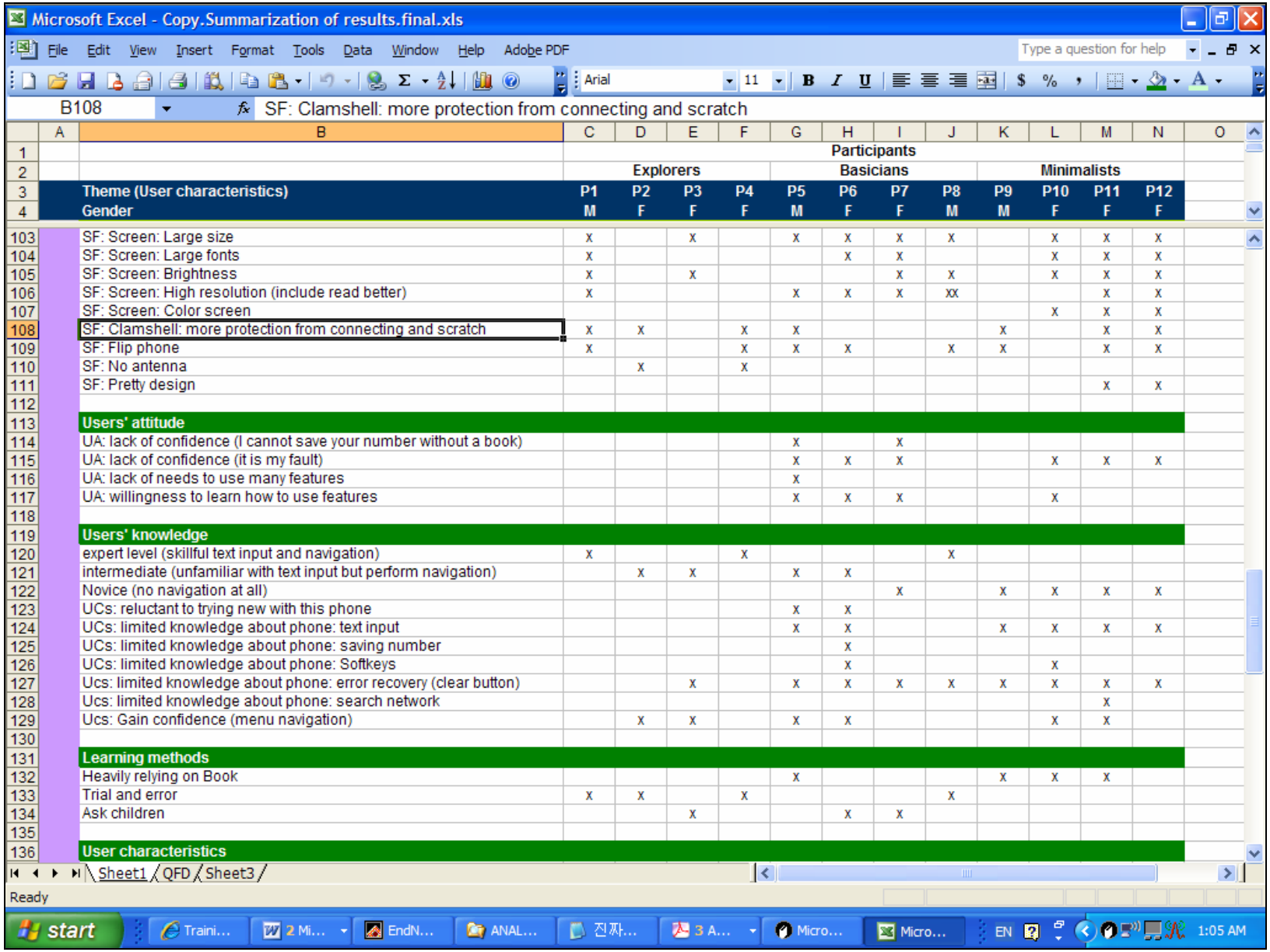
File Edit View Insert Format Tools Data Window Help Adobe PDF
Type a question for help
Arial 11
B108
SF: Clamshell: more protection from connecting and scratch
Participants
Explorers Basicians Minimalists
Theme (User characteristics) P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12
Gender M F F F M F F M M F F F
Incorporation
Inconsistent UI design
Buttons: side buttons were pressed accidentally
Unsatisfaction factor
UF: Weak signal
UF: Battery charge not working
UF: Phone size: Too small
UF: Phone: Too thin
UF: Complexity of menu
UF: Manual: hard to follow
UF: Slider style (difficulty to manipulate)
UF: Button: too flat (not pronounced) - (Sensorial and perceptual)
UF: Button: too small (prototype) - (Sensorial and perceptual)
UF: Button: too close - (Sensorial and perceptual)
UF: Button: labels too small - (Sensorial and perceptual)
UF: Button: awkward key layout - (Sensorial and perceptual)
UF: Text input: too cumbersome
UF: Speed dial: useful but do not remember number assignment
UF: sounds on every button press
UF: Antenna pulling out
UF: Weight: Too heavy (prototype)
UF: Speaker: cannot hear well (Sensorial and perceptual)
UF: Phonebody: hot
Satisfaction factor
SF: phone size: big (easier to handle)
SF: phone size: big (prototype size)
SF: Phone size: small enough to fit in their hands (compact)
SF: Phone width: wide
SF: Phone weight: light
SF: Buttons: Big
SF: Buttons: Raised buttons
SF: Buttons: Separation
SF: Buttons: background light
x (wife)
Sheet1 QFD Sheet3
Ready
start
1:04 AM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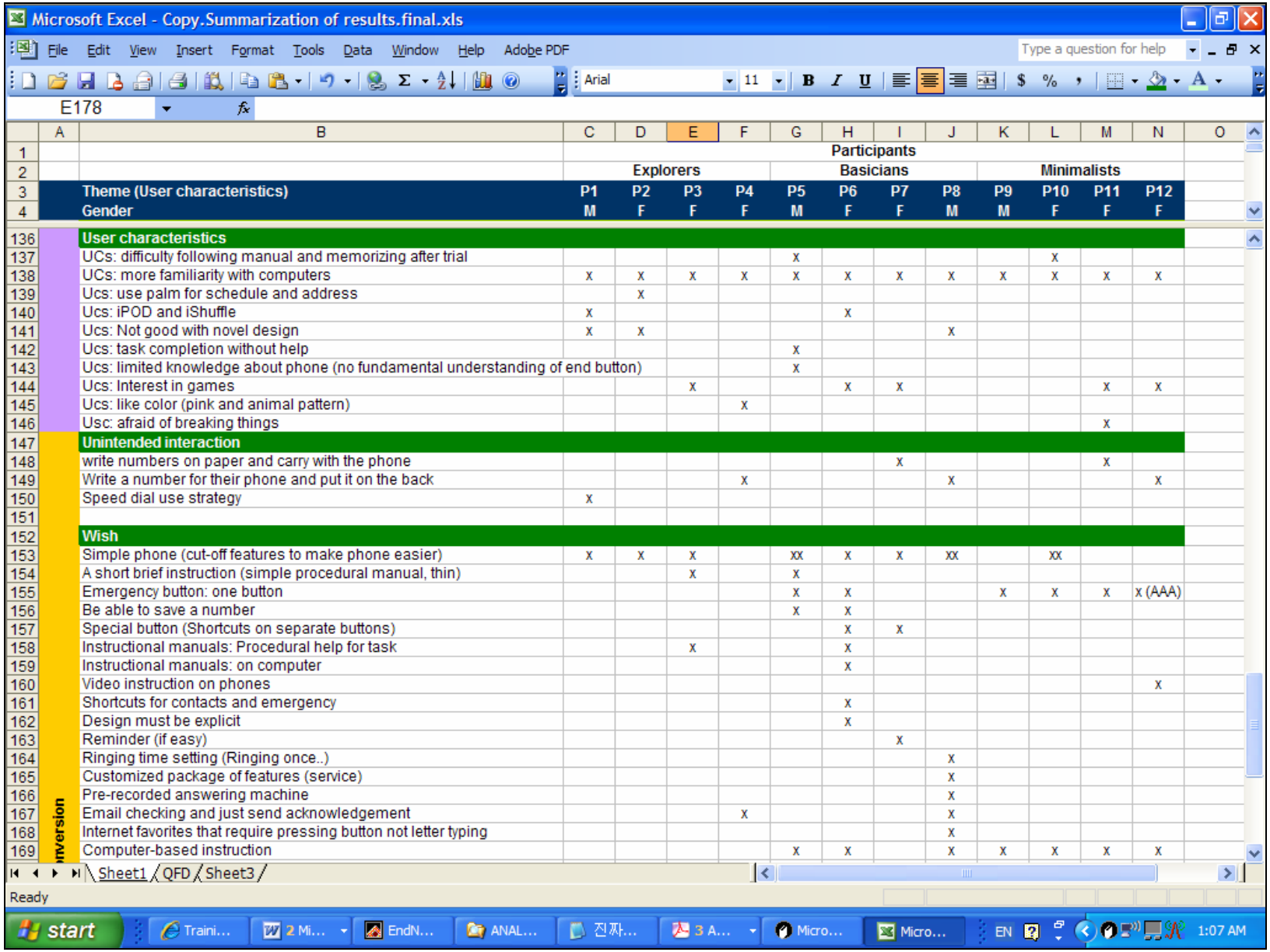
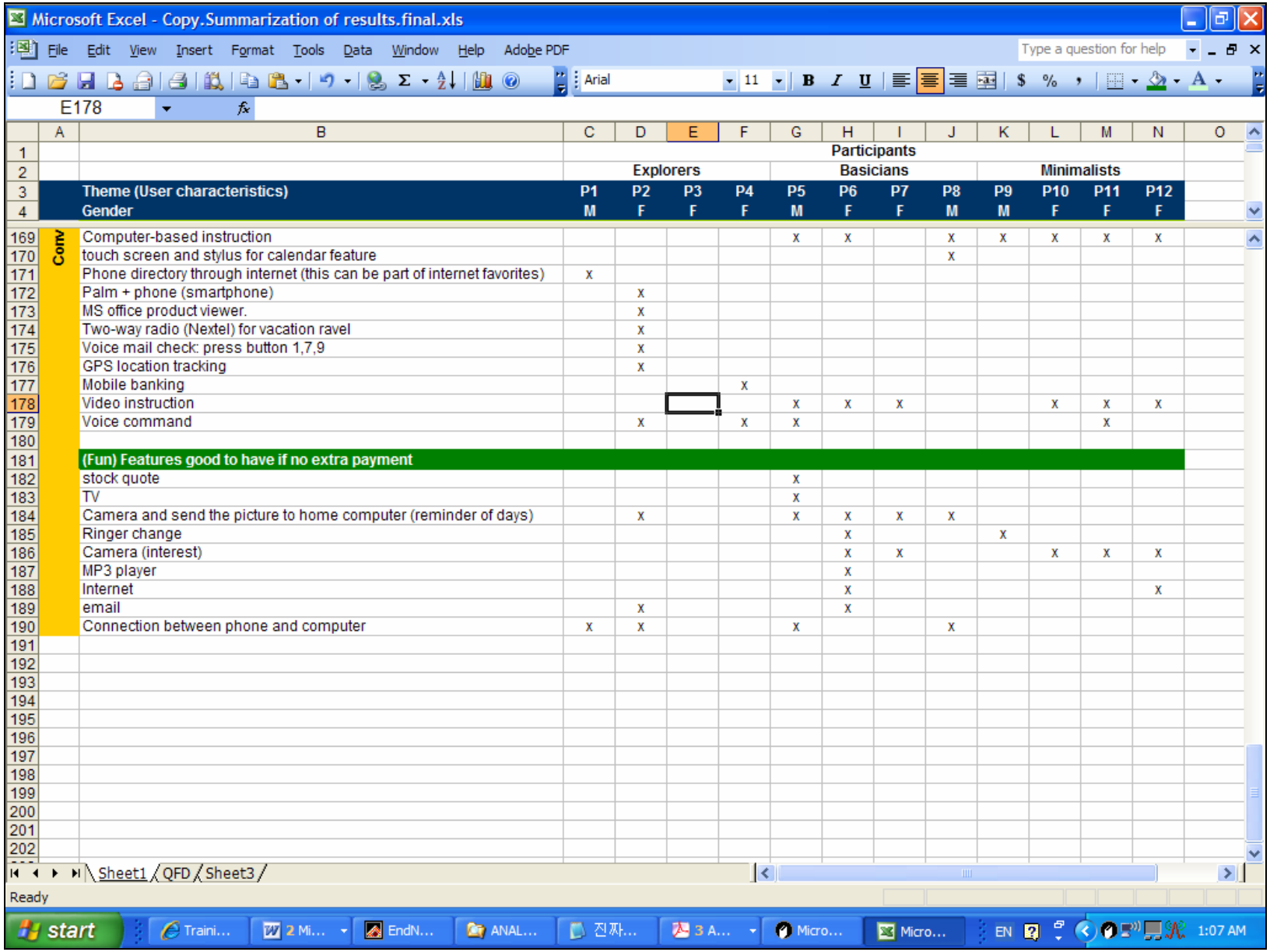
File Edit View Insert Format Tools Data Window Help Adobe PDF
Type a question for help
Arial 11
B108
SF: Clamshell: more protection from connecting and scratch
Participants
Explorers
Basicians
Minimalists
Theme (User characteristics) P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12
Gender M F F F M F F M M F F F
SF: Screen: Large size x x x x x x x
SF: Screen: Large fonts x x x x x
SF: Screen: Brightness x x x x x x
SF: Screen: High resolution (include read better) x x x x x x xx x x
SF: Screen: Color screen x x x
SF: Clamshell: more protection from connecting and scratch x x x x x x x x
SF: Flip phone x x x x x x x x x
SF: No antenna x x x
SF: Pretty design x x
Users' attitude
UA: lack of confidence (I cannot save your number without a book) x x
UA: lack of confidence (it is my fault) x x x x x x x
UA: lack of needs to use many features x
UA: willingness to learn how to use features x x x x
Users' knowledge
expert level (skillful text input and navigation) x x x x
intermediate (unfamiliar with text input but perform navigation) x x x x x
Novice (no navigation at all) x x x x x x x
UCs: reluctant to trying new with this phone x x
UCs: limited knowledge about phone: text input x x x x x x x
UCs: limited knowledge about phone: saving number x
UCs: limited knowledge about phone: Softkeys x x
Ucs: limited knowledge about phone: error recovery (clear button) x x x x x x x x x x
Ucs: limited knowledge about phone: search network x
Ucs: Gain confidence (menu navigation) x x x x x x x
Learning methods
Heavily relying on Book x x x x x
Trial and error x x x x x
Ask children x x x x
User characteristics
Sheet1 QFD Sheet3
Ready
start
1:05 AM


Microsoft Excel - Copy.Summarization of results.final.xls
File Edit View Insert Format Tools Data Window Help Adobe PDF
Type a question for help
Arial 11
E178
Participants
Explorers Basicians Minimalists
Theme (User characteristics) P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12
Gender M F F F M F F M M F F F
User characteristics
UCs: difficulty following manual and memorizing after trial
UCs: more familiarity with computers
Ucs: use palm for schedule and address
Ucs: iPOD and iShuffle
Ucs: Not good with novel design
Ucs: task completion without help
Ucs: limited knowledge about phone (no fundamental understanding of end button)
Ucs: Interest in games
Ucs: like color (pink and animal pattern)
Usc: afraid of breaking things
Unintended interaction
write numbers on paper and carry with the phone
Write a number for their phone and put it on the back
Speed dial use strategy
Wish
Simple phone (cut-off features to make phone easier)
A short brief instruction (simple procedural manual, thin)
Emergency button: one button
Be able to save a number
Special button (Shortcuts on separate buttons)
Instructional manuals: Procedural help for task
Instructional manuals: on computer
Video instruction on phones
Shortcuts for contacts and emergency
Design must be explicit
Reminder (if easy)
Ringing time setting (Ringing once..)
Customized package of features (service)
Pre-recorded answering machine
Email checking and just send acknowledgement
Internet favorites that require pressing button not letter typing
Computer-based instruction
nversion
Sheet1 QFD Sheet3
Ready
start
1:07 AM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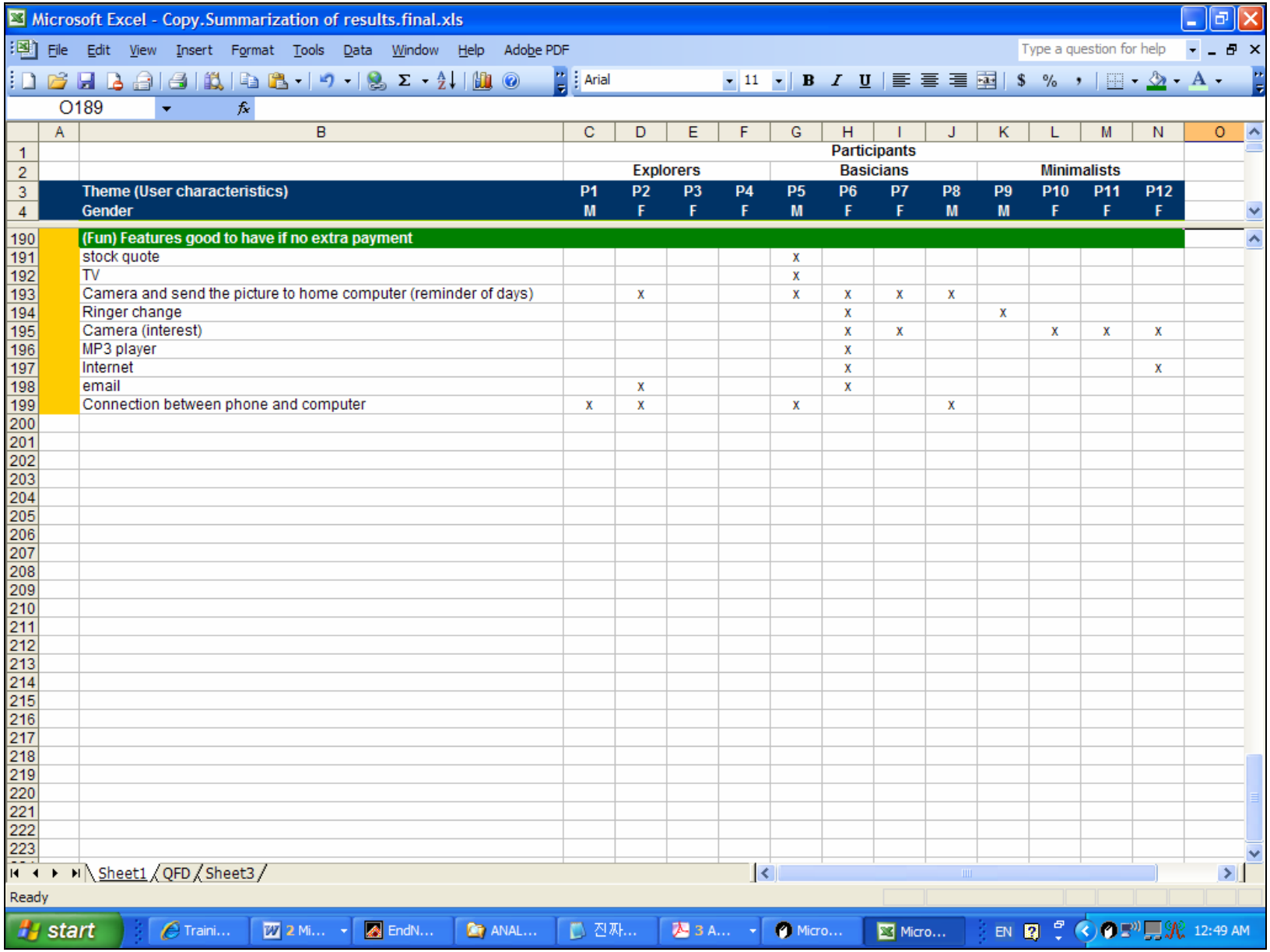
Arial 11
E178
Participants
Explorers Basicians Minimalists
Theme (User characteristics) P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12
Gender M F F F M F F M M F F F
Conv
Computer-based instruction
touch screen and stylus for calendar feature
Phone directory through internet (this can be part of internet favorites)
Palm + phone (smartphone)
MS office product viewer.
Two-way radio (Nextel) for vacation ravel
Voice mail check: press button 1,7,9
GPS location tracking
Mobile banking
Video instruction
Voice command
(Fun) Features good to have if no extra payment
stock quote
TV
Camera and send the picture to home computer (reminder of days)
Ringer change
Camera (interest)
MP3 player
Internet
email
Connection between phone and computer
Sheet1 QFD Sheet3
Ready
start
1:07 AM


Microsoft Excel - Copy.Summarization of results.final.xls
File Edit View Insert Format Tools Data Window Help Adobe PDF
Type a question for help
Arial 11
O189
Participants
Explorers Basicians Minimalists
Theme (User characteristics) P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12
Gender M F F F M F F M M F F F
(Fun) Features good to have if no extra payment
stock quote x
TV x
Camera and send the picture to home computer (reminder of days) x x x x x x
Ringer change x x
Camera (interest) x x x x x
MP3 player x
Internet x x
email x x x
Connection between phone and computer x x x x x
Sheet1 QFD Sheet3
Ready
start
Traini... 2 Mi... EndN... ANAL... 진짜... 3 A... Micro... Micro...
EN
12:49 AM

Appendix K. Features desired by participants in Study 2

Feature	Descriptions
Profile	● One touch profile change: a feature to change between profiles by one key press ● Customized profiles a feature to allow users to set a customized profile. For example, users are allowed to set a profile where a phone will ring once when someone calls and turn it into the silence mode. Another profile suggested is a meeting profile where a phone takes a message immediately after a pre-recorded message "sorry, I am in a meeting now. Please leave a message".
Two way radio feature	● Two-way radio communication when they travel
Email	● Email checking and send an acknowledgement. Participants did not want to type letters using a mobile phone. They just wanted to check email and send back an acknowledgement.
Smartphone feature	● Calendar: a feature to save an appointment ● Touch screen and stylus pen ● Microsoft product readers: A feature to view Microsoft office files (.xls and .doc)
Mobile Internet	● One-touch Internet favorites: a feature to connect to websites that users set. Favorite sites that participants were interested in were: phone directory (yellow page), stock market watch, and local weather ● Mobile banking system: a feature to check balance of bank accounts

Appendix L. User requirements

Appendix L-1. User requirements in hardware design

* Note: Priority was determined by consensus between three researchers. Priority was presented as quick reference tools to prioritize design specifications or usability testing.

Categories	Sub-categories	User requirements	Description	Priority
Phone	Phone type	Clamshell phone type	● All participants preferred a clamshell phone type for two reasons: 1) It gives more protection from accidental key press and scratch. 2) It can contain a larger display and buttons while it keeps the overall phone size small. ● The slide phone type was not desirable since it was difficult for (male) older adults to open. ● The candybar type was not desirable since it does not provide a secure feeling from accidental connection and scratch	High
	Phone size	Large but portable phone size Not too thin phone size	● The phone size needs to be large enough to handle easily, but small enough to fit in users' hands. Too small or thin phones were not preferred by participants since they do not provide a secure feeling, and it makes all other UI components too small. ● Potential gender difference on the phone size preference was found: ■ Males preferred a thinner and wider phone since they keep a phone either in their shirt pocket or on the belt clip. Prototype size (Width 50mm, thickness: 17mm)	High

			was desirable. ■ Females preferred the relatively thick and narrow phone size since they keep a phone in their purse or handbag. The prototype width (50mm) was the maximum acceptable width. The thickness (17mm) of the prototype was acceptable but a thicker size could be better.	
	Phone weight	Light weight phone	● The phone weight was not identified as a big concern for users, but a heavy phone causes fatigue in users' hands. ● Participants felt the weight of the prototype (130 g) is slightly too heavy.	Low
Button	Button size	Large button	● Large button size is preferred by all participants. ● Small buttons caused double actions since participants pressed wrong buttons. ● Button size of prototype (width: 7mm, height: 4 mm) was considered too small by participants.	High
	Button protrusion	Pronounced buttons	● Button protrusion must be sufficient to allow users orientation on the key pad. ● Too flat buttons were not accepted well by users.	High
	Button separation	Separated buttons	● Key separation must be sufficient to allow use by older adults who have somewhat lower motor control without major difficulties. ● Navigation button separation is critical since most usability	High

			problems were found here. ● Cluttered buttons caused users to press wrong buttons during phone operation.	
	Button background light	Backlit buttons	● Button background light is necessary for use in dark circumstances.	Moderate
	Button labels	Clear and large button labels	● Labels on buttons must be large enough for older adults.	Moderate
	Soft keys	Softkeys labeled differently	● Two softkeys should be labeled differently for novice users to distinguish from one another. ● Numerous usability problems arose because softkeys did not have any label except a period mark.	High
Display	Screen size	Large screen	● The large screen was preferred by users because it was easy to read text and icons. ● The screen size of the prototype (width: 34 mm, height: 55mm) was preferred by every participant.	High
	Screen resolution	High resolution	● A screen with high resolution was preferred by users because it provides high quality readability of icons and letters on screen.	Moderate
	Letter size on screen	Large fonts	● Letters on screen must be large enough for older adults to read	High
	Screen contrast	High contrast screen (no shaded background)	● The display should provide high contrast to allow high readability of text on the screen. ● Black on white or white on black was preferred (by males).	Moderate

			• A shaded background with colors on screen interfered with users' reading of icons and labels. • Colorful display was preferred by female participants due to the better aesthetics rather than usability.	
	Screen brightness	Bright display	• Screen must be bright enough for older adults to read letters comfortably. • Users complained they cannot read the display under sun light. • Brighter screen was preferred by users.	High
	Screen backlight	Increased display backlight duration	• Screen backlight must remain on for more than one minute. • Screen backlight disappeared quickly (usually after 10 seconds) due to the default battery saving mode, which caused additional usability problems. Older adults need to take more time to read menu options during navigation.	High
	Sub-display	Large sub-display on front face of phone	• Sub-screens used to display time and caller ID must be large enough for older adults to read it without wearing glasses. • Sub-screens were too small for users to read without glasses, and subsequently they were not used.	Moderate
Sound	Speaker loudness	Increased range of loudness of speaker	• The maximum range of speaker loudness should be extended for older adults with minor hearing loss. • Some participants with hearing loss could not hear well from the speaker on the phone.	High
Vibration	Vibration	Increased strength of	• Male users tended to carry their phone on a belt clip but	Low

	strength	vibration	sometimes missed a call when it was on vibration mode because they could not feel it. ● Users with minor hearing loss preferred a strong vibration due to the difficulty of hearing a phone call.	
Antenna	Antenna	Removal of antenna or durable antenna	● Antenna must be removed or designed to be more durable. ● Older adults often spend time with their grandchildren. It is often that the antenna was pulled out and broken while being played with by their grandchildren. ● Male older adults tend to keep a phone in their shirt pocket. The antenna that sticks out of the body does not fit into men's shirt pocket	Medium
Battery	Detachment	Easy Attachment and removal	● Battery attachment and removal must be easy and should require only minimal force	Low
	Charge	Easy battery charge	● Battery charge must be easy in attachment and removal. ● There must be a (visual) alert to indicate charge completion.	Low
	Heat	No heat in use	● Users reported dissatisfaction due to heat from battery	Low

Appendix L-2. User requirements in software design

Categories	User requirements	Descriptions	Priority
Essential basic features	Easy access to these features is required by one button press	Easy access to the following features is required: ● Call/receive ● Phonebook ● Speed dial ● Emergency button ● Volume control ● Voice message checking ● Profile change (ringer mode vs. vibration mode) ● Caller ID	High
My telephone number	Easy access to their phone number	● Easy access to user's phone number should be easy. ● 10 out of 12 participants put a paper that shows their phone number on the back side of phone to refresh their memory.	High
Phonebook	Easy access to the phone book	● Minimize the steps to save a phone number. ● Due to the diversity among clusters, different requirements were set: ■ Explorers: a better search function needs to developed ■ Basicians and minimalists: the phonebook feature should be on the initial screen, so when users turn on the phone, the contact list should be shown on the screen with the speed dial number, or develop a new hardware mechanism that allows users to use a paper-version phonebook.	High
Speed dial	Reminder of the number assignment	● Phone must allow user to change speed dial number allocation easily. ● Older adults do not remember what number to press to call someone. This information should be visible on surface. ● Provide a sticker to put on each number for minimalists.	High
Voice mail	Easy setting	● The use of voice mail was extremely difficult because there is no instruction on the manual. It just stated "follow the system prompts". The instruction for the detailed voice mail setting must be provided by service carriers when users purchase a phone. ● Most participants did not use this feature although it was perceived to be useful. They faced a problem in the first use	High

		because some service carriers required users to change the personal option. This mandatory step must be removed.	
	Easy retrieving	● Users were not aware of the shortcut (#1) to the voice mail. This must be shown in the quick reference manual. Color coding may be needed. ● After users connected to the voice message system, users were not informed that they had to listen and follow the voice prompts. Text-based prompts should be displayed on screen, or voice prompts must be dictated in the text format.	High
	Visual prompt	● After users selected the voice message checking option in the menu, users did not know when to listen to voice prompts. A textual (visual) prompt needs to accompany the voice prompts.	Medium
Text input	Easy text input Voice command	● Most users consider it difficult to type letters on mobile phones. Users wished to have a dictation system that converts users' voice to text formats. Also users need a feature to synchronize with computers because all participants were familiar with computers.	Medium
Emergency button	GPS location tracking system on a separate button	● Three features were suggested by users: ■ Use a separate button and color code (yellow or red) ■ GPS location tracking system ■ Voice note feature: a new feature that users can leave a note for others. It can be implemented in a communication network, for example 5-1-1. It can be used in an emergency situation if users leave a list of allergic substances. It can also be used for a note in case users lost their phone and somebody picks it up.	High
Customization	Consistent profile	Users complained that the phone beeps in vibration mode when it receives a message. In this case, the vibration needs to be applied to all features.	Low
Caller ID	Large fonts	Some participants could not read the caller ID because the font size was too small. Fonts and display must be large enough.	Low

Appendix L-3. User requirements in external and service components

Categories	**User requirements**	**Priority**
Instruction manual	Due to the diversity among users, instruction manuals should be developed in a variety of formats. Three versions of manuals are recommended: ● A full manual: a paper book that include every feature of the phone. It must include an index and table of contents. Each of title must be designed with users' language. Do not use technical jargon (e.g., follow the system prompt) ● A quick reference manual: one-page reference that shows brief procedures for basic features (phonebook, speed dial, volume control, voice message checking). This must begin with a brief introduction of softkey use, text input, and error recovery. ● Multi-media manual: A video-based instruction manual that include hands-on practice. This must be played on computers.	High
Accessories	● Minimalists usually keep a phone in their car. A phone holder in the car along with battery charge should be designed and advertised. ● Males tend to carry their phone using a belt clip. A rigid belt clip should be designed to hold a phone securely.	Low
Web-based information resources (Service component)	● Participants showed their familiarity with the internet, and they considered the internet as an information resource. They also considered a peer review as credible information. Therefore, a web-based information resource where older adult users can share their experience with various mobile phones must be offered. ● Regular emails to explain features of mobile phone should be sent to older adults.	High

Vita

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EDUCATION

Ph.D.	Industrial and Systems Engineering (Human Factors option), 09/2007, GPA:3.78/4.0 Virginia Polytechnic Institute and State University, Blacksburg, Virginia Dissertation Title: *Older adults' user experiences with mobile phones: Identification of user clusters and user requirements* Dissertation Advisor: Tonya L. Smith-Jackson, Ph.D.
M.S.	Industrial and Systems Engineering (Human Factors option), 08/2003, GPA:3.91/4.0 Virginia Polytechnic Institute and State University, Blacksburg, Virginia
M.S.	Industrial Engineering, 02/2001, GPA: 4.36/4.5 Seoul National University of Technology
B.S.	Industrial Engineering, 02/1999, GPA: 3.56/4.5 Seoul National University of Technology

RESEARCH EXPERIENCE

Summer Intern (05/2006 – 08/2006)	Motorola Human Interaction Research Labs - Conducted data analysis for paper prototype evaluation for innovation center design - Conducted user studies and captured user requirements for a dictation system in mobile devices - Developed dictation system prototypes for further user testing
Research Assistant (09/2005 – 05/2006)	"Individual Differences in End-User Programming for Web Applications", funded by National Science Foundation - Conducted literature review and online-survey and laboratory experiments to test potential factors affecting end-user programming performance for web applications * Employer: Department of Computer Science at Virginia Tech
Lead Researcher / Research Assistant (05/2005 – 10/2005)	"Needs Analysis and Requirements Acquisition for Inclusive Design of Cell Phones: United Kingdom and Germany", funded by Toshiba Corporation of Japan - Developed focus group scripts and questionnaires - Trained a German moderator of focus groups - Directed product interactive focus groups in Germany and United Kingdom - Conducted content analysis and critical incidents analysis - Generated user requirements and design recommendations on usability and accessibility features for cell phones in German market. * Employer: Assessment and Cognitive Ergonomics (ACE) Lab/Human Computer

Interaction (HCI) Lab at Virginia Tech, 05/2005 – 10/2005

Research Assistant (01/2005 – 05/2005)
"Sensemaking in Team Environments", funded by Army Research Office
- Conducted extensive literature review on sensemaking, shared-mental model, and team-based decision making process.

* Employer: ACE Lab at Virginia Tech/ Center of Excellence for Battlefield Capability Enhancements at North Carolina A&T State University,

Lead Researcher/ Research Assistant (02/2004 – 12/2004)
"Design, Testing, and Verification of the Cellular Phone Navigation System", funded by Toshiba Corporation of Japan
- Conducted user interviews and focus groups to elicit mental models
- Designed and developed medium-fidelity working prototypes of menu system of mobile phone using Macromedia Flash MX (Action script)
- Conducted laboratory-based usability tests
- Conducted statistical quantitative data analysis using SAS and qualitative data analysis
- Developed user requirements and design recommendations for intuitive navigation systems of cell phones

* Employer: ACE/HCI Lab at Virginia Tech

Research Assistant (09/2002 – 08/2003)
"Usability Inspection, Testing, and Evaluation of Cell Phone User Interfaces", funded by Toshiba Corporation of Japan
- Administered focus groups and conducted laboratory-based usability tests
- Conducted statistical quantitative data analysis using SAS and qualitative data analysis
- Generated user requirements and design recommendations for inclusive design of cell phones

* Employer: ACE/HCI Lab at Virginia Tech

Research Assistant (09/1999 – 05/2001)
"Visualization of Forging Processing Using Virtual Reality", funded by Ministry of Science & Technology in Republic of Korea.
- Designed and implemented a web-based interactive virtual press using Java EAI (External Authoring Interface) and VRML (Virtual Reality Markup Language) to visualize forging operation on the web

* Employer: Computer Aided Manufacturing Lab at Seoul National University of Technology, Korea

PUBLICATIONS

Referred Journal Papers

- Lee, Y. S., Hong, S. W., Smith-Jackson, T. L., Nussbaum, M.A., and Tomioka, K. (2006) Systematic evaluation methodology for cell phone user interfaces, Interacting with Computers, 18 (2), pp. 304-325.
- Lee, Y. S., Peres, M. A., and Rosson, M. B. Effects of gender and associated individual differences on end-user web application development performance, International Journal of Human Computer Studies, * *submitted.*
- Lee, Y.S. and Smith-Jackson, T.L. Effects of screen size on reading from a desktop computer and comparison with reading from a handheld computer. **a journal paper manuscript in progress*

Referred Conference Proceedings

- Lee, Y. S. (2007) A survey of mobile phone usage by older adults, Proceedings of the 51th Annual Human Factors and Ergonomics Conference, **to appear.*
- Basapur, S., Xu, S., Ahlenius, M., and Lee, Y. S. (2007) User expectations from dictation on mobile devices, Proceedings of the 12th International Conference on Human-Computer Interaction (HCII '07), **to appear.*

- Lee, Y.S., Jhangiani, I., Smith-Jackson, T.L. and Nussbaum, M.A., and Tomioka, K. (2006) Design considerations for accessible mobile phones, Proceedings of the 50th Annual Human Factors and Ergonomics Conference, San Francisco CA, October 2006.
- Ryu, Y.S., Lee, Y.S., Smith-Jackson, T.L. and Nussbaum, M.A., and Tomioka, K. (2006) User centered design and testing methods for the development of the menu system for mobile phones, Proceedings of the 50th Annual Human Factors and Ergonomics Conference, San Francisco CA, October 2006.
- Lee, Y.S., Ryu, Y.S., Smith-Jackson, T.L., Shin, D.J. Nussbaum, M.A., and Tomioka, K. (2005) Usability testing with cultural groups in developing a cell phone navigation system. Proceedings of the 11th International Conference on Human-Computer Interaction (HCII '05), Las Vegas NV, July 2005.
- Lee, Y.S., Smith-Jackson, T.L., Nussbaum, M.A., Tomioka, K. and Bhatkhande, Y. (2004) Use of product-interactive focus groups for requirements capture and usability assessment. Proceedings of the 48th Annual Human Factors and Ergonomics Conference. New Orleans, LA, September 20-24, pp. 2461-2465.
- Lee, Y.S. and Smith-Jackson, T.L. (2004) Effects of screen orientation and margin on reading with a handheld computer. Proceedings of the 48th Annual Human Factors and Ergonomics Conference. New Orleans, LA, September 20-24, pp. 946-950.

Magazines & Posters

- Lee, Y.S., Soh, B.S., and Kim, H.N. (2005) I-SPEAK-TO-THEE: Online-language learning environment. Project poster session presentation, International Education student conference: Education without Borders 2005, Abu Dhabi, United Arab Emirates, February 19-21, 2005.
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Technical Reports

- Smith-Jackson, T.L., Nussbaum, M.A., Lee, Y.S., Jhangiani, I. (2006) "Needs Analysis and Requirements Acquisition for Inclusive Design of Cell Phones: United Kingdom and Germany", Technical report prepared for Design Center, Toshiba Corporation of Japan, February 26, 2006.
- Smith-Jackson, T.L., Nussbaum, M.A., Lee, Y.S., Yang, H.C., Ryu, Y.S., and Shin, D.J. (2004) "Design, testing, and verification of the cellular phone navigation system", Technical report prepared for Design Center, Toshiba Corporation of Japan, December 29, 2004.
- Smith-Jackson, T.L., Nussbaum, M.A., Lee, Y.S., Bhatkhande, Y, and Hong, S.W. (2003) "Usability inspection, testing, and evaluation of cell phone user interfaces", Technical report prepared for Design Center, Toshiba Corporation of Japan, November 10, 2003.

CERTIFICATE and TRAINING

- Certificate in Basics of Supply Chain Management of CPIM (Certified in Production and Inventory Management) from APICS (American Production and Inventory Control Society), 03/1999
- Manufacturing Training Course for CNC Lathe, Milling, Virtual Reality Robot and CIM, Denford Professional Training & Development Centre, Brighouse, West Yorkshire, United Kingdom, 08/1999

AWARDS and HONORS

- Information and Telecommunication National Scholarship Recipient by the Ministry of Information and Communication, Republic of Korea, 08/2001 – 08/2005
- Honorable mention, Poster session presentation, I-SPEAK-TO-THEE: Online-language learning environment, International Education student conference: Education without Borders 2005, Abu Dhabi, United Arab Emirates, February 19-21, 2005.
- Excellent Academic Record Scholarship, Seoul National University of Technology, 09/2000
- Excellent Academic Record Scholarship, Seoul National University of Technology, 03/2000
- Excellent Academic Record Scholarship, Seoul National University of Technology, 03/1997

PROFESSIONAL SKILLS

Professional skills	User centered design process in product development cycles ● Acquisition of user requirements (survey, focus groups, user interview skills) ● Rapid prototyping techniques using Macromedia Flash ● Laboratory-based usability testing and evaluation ● Experimental design and statistical data analysis ● Qualitative data analysis (e.g., content analysis)
Programming languages	VRML(Virtual Reality Markup Language), Macromedia Flash Actionscript, Java, HTML, JavaScript, ASP, C#
Software	Macromedia Flash, Dreamweaver, MS office products, Visual Studio.NET, JBuilder, Cosmo-World, VRT(Virtual Reality Toolkit), Pro/ENGINEER, Atlas.ti
Statistics packages	SAS, JMP, and SPSS

ASSOCIATIONS and ACTIVITIES

- Lab manager & systems administrator, Assessment and Cognitive Ergonomics Lab/Human Computer Interaction Lab, Virginia Tech, 09/2005 - Present
- Member, Human Factors and Ergonomics Society (HFES), 2002 - Present
- Member, Product Design Technical Group under HFES, 2004 - Present
- Member, The Usability Professional's Association, 2004 - Present
- Mentor, Graduate student mentorship program, HFES Virginia Tech Student Chapter, 2003 - Present

RESEARCH INTERESTS

User centered design in consumer product development cycles, requirements engineering, mobile product's contents and user interface design and evaluation, computer supported collaborative learning, vehicle user interface design, digitizing education (e.g., Electronic books and Distance learning), usability, industrial application of virtual reality for training.

REFERENCES

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