Is a multi-touch gesture interface based on a tablet better than a smart-phone for elderly users?

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Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the qualification of any other degree or diploma of a university or other institution of higher learning.

Signature of candidate

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Abstract

With the increasing growth in the elderly population, the health care and social problems of this demographic have become an ongoing concern. Several studies have shown that touch-screen techniques might assist the elderly in their social, recreational and health-related activities. However, little research has been conducted on the most suitable multi-touch screen devices for older users with age-related declines. This study aims to bridge the research gap in the use of touch-screens as a pervasive healthcare aid for the elderly.

This study investigated the effects of age and two multi-touch devices (tablet and smart-phone) on the usability of mobile healthcare tasks. Ten participants (older adults 60-80 years old) performed two types of healthcare tasks: entry tasks and navigation tasks. Usability was assessed by mean task completion rate and errors. After the experiment, participants provided their subjective answers to closed ratings, open-ended questions and semantic deferential on the use of each device. Overall participants found the tablet is easier to use than smart-phone. The number of errors between the tablet and the smart-phone was significantly different for older participants. Consistent with this result, the subjective ratings and comments showed that the participants preferred the tablet to the smart-phone. Participants also achieved a higher completion rate using the tablet than the smart-phone for the input tasks, but not for the navigation tasks. Moreover, the results showed that data entry problems, complexity and poor

visual design, inconsistency of information, loss of cues and accordances and support information, and reduced tactile user feedback are serious consideration when designing interfaces for older users.

Limitations and problems in the research were identified. Based on the results, design recommendations for touch-screen for older adults were suggested. Future research should involve younger participants as a reference group and examine various tasks in a real environment.

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Chapter 1

Introduction

1.1 Background of the Research

According to the UN Population Division, the number of people aged over 65 will approach 2.13 billion by 2050. For the first time in history, the number of older people worldwide is expected to exceed the number of younger people (UNFPA & HelpAge International, 2012). This unprecedented growth in the elderly population is accompanied by age-related health care and social problems (UNFPA & HelpAge International, 2012). Accordingly, the issues resulting from an ageing society have received considerable attention. One approach suggests using Information and Communications Technologies (ICTs) to assist the elderly in their daily lives (Czaja & Lee, 2007). For example, elderly people may complete computer-based tasks (e.g., use pervasive healthcare technologies) for social, recreational and health-related purposes (Caprani, O'Connor & Gurrin, 2012; Czaja & Lee, 2007).

However, according to several age-related studies (Taveira & Choi, 2009; Hooper, 2007; Jayroe & Wolfram, 2012), interacting with a computer system by traditional input devices such as a mouse and keyboard may be difficult for older adults, many of whom are impacted by physical and cognitive decline. Fortunately, other research suggests that these problems might be overcome by touch-screen techniques. For instance, Jayroe and Wolfram (2012) compared the use of desktop computers and an iPad tablet between older and young participants. This study found that although the high sensitivity and non-tactile feedback of the tablet were problematic for elderly participants, this group successfully completed most of the search tasks and expressed a positive attitude towards the new technology. In another comparison study, Murata and Iwase (2005) contrasted the performance with a PC mouse and a touch-panel interface among young, middle-aged, and older people. The time for pointing to the target with touch panel was not significantly different between the groups, but older users were far slower in pointing with the mouse than the younger groups. This earlier study empirically verified that touch-based devices are useful tools for older people (Charness, Bosman & Elliott, 1995).

However, the majority of these studies have compared the use of traditional and touch-screen devices, or individual touch-screen devices by elderly people. To date, the types of multi-touch screen devices that benefit older users with age-related cognitive decline or physical impairments has been little investigated. This study aims to bridge the research gap in the human-computer interactions for pervasive healthcare.

1.2 Motivation

I often ask why elderly people like my grandparents hardly copes with new technology products such as the tablet or smart-phone. Do they not have any willing to use it? "NO", they still have some explicit needs that technologies can fulfill, for example social communication or accessibilities for useful information (Apted, Kay & Quigley, 2006; Doyle, Skrba, McDonnell & Arent, 2010; Lepicard & Vigouroux, 2012). But why the rate of technological devices is low? The reason could be their age-related; physical and mental decline make them hardly adopt new products. Therefore, an appropriate interface is particularly important when the product is to be used by the older adults who are not able-bodied, for example, those affected by cognitive and motor decline. However, to our knowledge, which handhold multi-touch device (tablet or smart-phone) will better assist older people in their generic tasks has yet to be investigated. This knowledge gap provided the motivation for our study. We also hope to create study protocol for further usability testing of elderly adults that will guide future product development.

1.3 The Objectives of the Research

This research seeks answers to the question “is a multi-touch gesture interface for older users better implemented on a tablet or a smart-phone?”

The objective are:

1) to compare older users’ experience of a tablet and a smart-phone, and thereby then identify the most appropriate device for older users.

2) to identify the issues, difficulties and problems encountered during the usability testing and relate them to age-related physical and cognitive disabilities such as reduced attention, manipulation and memory skills.

3) to provide recommendations for development of interfaces that are accessible to elderly users.

To satisfy these objectives, we ask the following questions:

1) “is a touch interface for elderly users better implemented on a smart-phone or a tablet?”

2) “What problems arise during the usability testing and how should we design

interfaces that are accessible to older adults?”

1.4 Structure of the Research

This research consists of six chapters, structured as shown in Figure 1-1.

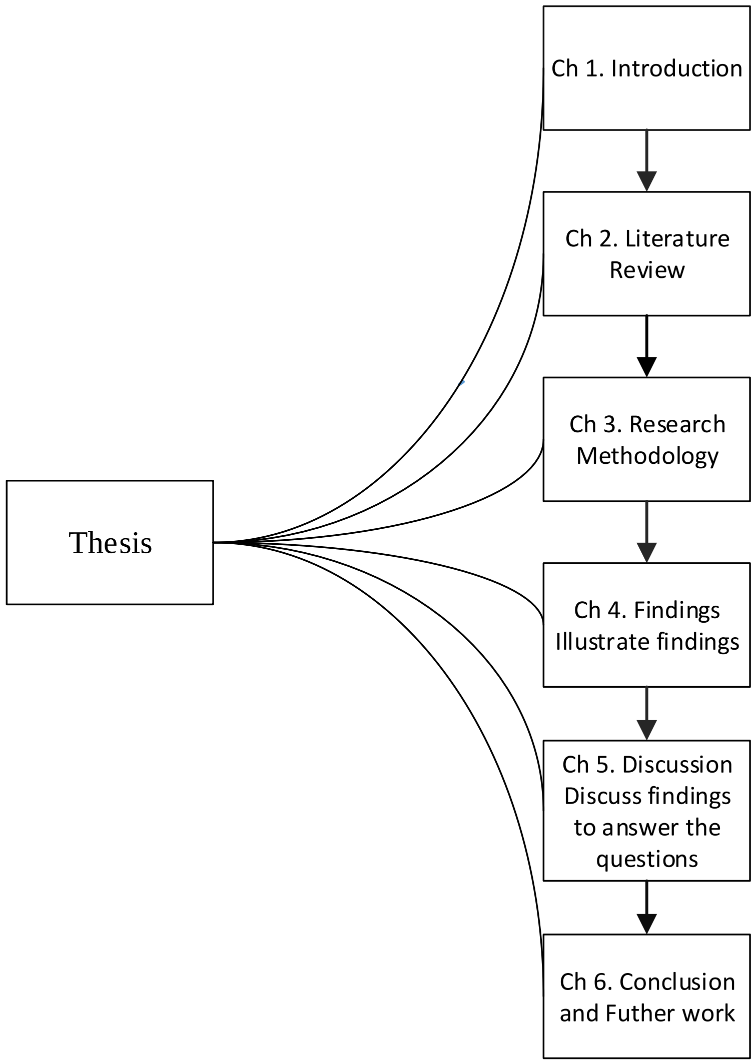


Figure 1.1: Structure of the Thesis

Chapter 1 introduces the background and motivation of the study.

Chapter 2 presents several definitions of older people, before specifying how the term is used in the remainder of this thesis. It then briefly describes the cognitive and physiological changes that accompany the normal ageing process, and the attitudes and anxieties of many older adults towards technology. A model of technology acceptance for older adults is suggested. The chapter concludes with multiple-touch based interactions and its implications for older adults.

Chapter 3 describes the research methodology. Procedures of the usability testing, pilot study, testing methods, participant recruitment, apparatus, and data collection techniques (think-aloud protocol, observation, and questionnaire) are presented here. The data processing, and guidelines for being an effective and unbiased moderator during the testing, conclude this chapter.

Chapter 4 presents the findings of the data obtained from the pre and post test-questionnaires, observation and videos. The findings are summarised at the end.

Chapter 5 discusses the findings and answers the questions posed in Section 1.3.

Chapter 6 draws conclusions, discusses limitations of the research, and proposes recommendations for future study. A full list of references is supplied, and the pre- and post-test questionnaires are detailed in the appendices.

Chapter 2

Literature Review

2.1 Introduction

Across the world, societies are steadily ageing. In 1950, the global older population (age 60 years and over) was approximately 205 million. The number of older people had increased to nearly 810 million by 2012 and is expected to reach 2 billion by 2050 (UNFPA & HelpAge International, 2012) (see Figure 2.1).

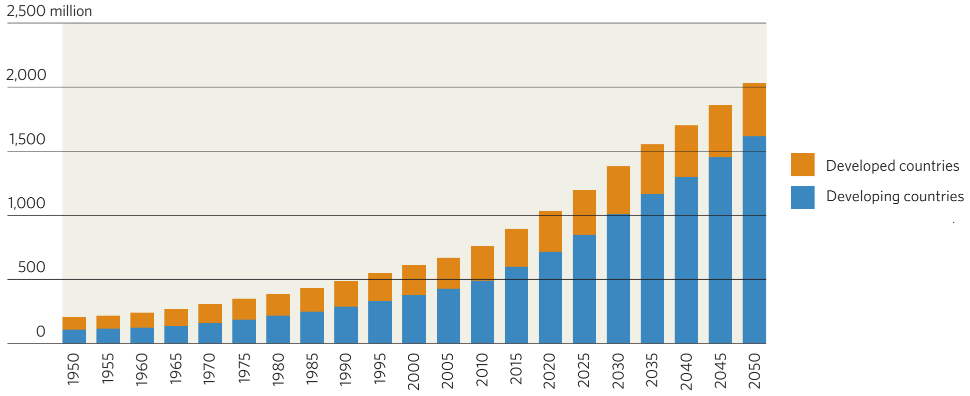


Figure 2.1: Number of People Aged 60 or Over: World, Developed and Developing Countries, 1950-2050 (UNFPA & HelpAge International, 2012)

For example, in New Zealand the number of older persons was projected to increase from half a million in 2005 to 1.33 million in 2051 (Statistics New Zealand, 2006). In the United States the population of 60 year-olds and over expanded from 35 million in 2000 to 41.4 million in 2011, and is projected to double in the interim between 2011 and 2060 (The Administration for Community Living, 2012).

Similar trends have been identified in the European Union (EU). Between 2010 and 2060, the population of 60 years and over will increase in the EU from 87.5 million to 152.6 million, while the number of elderly people (age 80 years and over) is estimated to increase from 23.7 in 2010 to 62.4 million in 2060 (Pench, Gudin De Vallerin, Part & Carone, 2012). In the near future, the ageing of the population is expected to extend to developing as well as developed countries (UNFPA & HelpAge International, 2012). In Africa, 6 percent of the population was 60 years or over in 2012. This population is predicted to increase to 10 percent by 2050 (UNFPA & HelpAge International, 2012). In Asia, the percentage of older people is projected to increase from 11 percent in 2012 to 24 percent in 2050 (UNFPA & HelpAge International, 2012). This unprecedented increase in older populations brings special societal challenges. Among the most urgent global challenges is ensuring adequate quality of life for these members.

Accordingly, the consequences of an ageing society have received increasing attention. One approach is to assist elderly people through touch-based devices. Such as approach requires that technology be adapted to the older adults' knowledge, needs, and abilities, and is attractive to the wants and needs of older users (Sanderson & Scherbov, 2008). If this can be achieved, touch-based technology can successfully contribute to older people's individual well-being, and life quality (Stößel, Wandke & Blessing, 2010). This chapter focusses on the relationship between the elderly and touch-screen technology.

First, we define what is meant by “older user” in the context of this thesis, given that definition of older people differ in different studies (Section 2.2). The numerous cognitive and physiological changes that accompany the normal ageing process are briefly overviewed in Section 2.3. Section 2.4 reviews the attitudes and anxieties held by many older adults towards technology, and Section 2.5 discusses model of technology acceptance for older adults. Computer interaction via touch-screen and its implications for older adults is presented in Section 2.6. The chapter concludes with a discussion on the potential benefits and drawbacks of touch-screen based interaction (Section 2.7).

2.2 How Old Is Older?

How to define “older people” is important to each of us, as all individuals must eventually age. The definition of “older people” has board implications for society and especially for the aged care industries (Wiles, 1987). Thus, a precise definition of older people is essential for this age-related study.

Several definitions of older adults are reported on the literature. A popular way of defining old people is chronological age. According to Hendricks and Hendricks (1976), chronological age is the number of years a person has lived, or the temporal distance from birth. Using this approach, the World Health Organization (2012) defines the threshold of old age as 65 years, and the age at which a person is eligible for the pension. Similarly, the United Nations has selected a chronological age of 60 as the threshold of “older people”, and divides the oldest of these members into the advanced age group (80 years and over) and the “centenarians” (aged 100 years and over) (United Nations. Dept. of Economic and Social Affairs. Population Division, 2010).

When considering the definition of older people in HCI literature, we identified a wide range varying between "above 40" and "above 75" (Wagner, Hassanein & Head, 2010). A study by Hawthorn (2000) suggested that persons over 45 years old should be classified as older people, because age effects become noticeable from the mid forties onward. However, Newell (2008) believed that age-related impairments became evident at 60 years or above.

In addition, several studies have highlighted that being old is more complex that the date of birth may suggest. The meanings and connotations of "old age" differ among countries, societies and cultures (Heller, 2010; Lindley, Harper & Sellen, 2008; Nhongo, 2004). For example, Nhongo (2004) pointed out that the United Nations' chronological definition of older people may entirely unsuited to the various societies and cultures in Africa. Therefore, a chronological age definition of "older people" still lacks a global gold-standard criterion.

Non-chronological approaches to age definition have also been proposed. Neves (2012) suggested four non-chronological indicators for determining older adults: Functional age, Perceived age, Social age, and Cognitive age. Similar categories of age have been proposed in other studies (Barak & Schiffman, 1981; Sanderson & Scherbov, 2008). In their study of population ageing Sanderson and Scherbov (2008) found that advances in health and life expectancy permitted two categorisations of old people; chronologically aged and prospective aged. The latter category includes these with a remaining life expectancy of 15 years or less.

Other researchers have indicated that age is not easily defined in a non-chronological context. A major problem with this approach has been lack of consensus on definition and measurement standards (Barak & Schiffman, 1981). For example, the cognitive age of a person is subjectively inferred from a question such as: "Which age group do you feel you really belong to: twenties, thirties, forties, fifties, sixties, seventies, or eighties?" In other words, the age has been evaluated by unrealistic self-rating scales rather than by any objective measure. Bell (1972) also reported that functional age is difficult to measure through physical assays of blood serum and urine.

In our study, while recognizing the limitations of the chronological indicator, we define an older person as someone with a chronological age of 60 or above (United Nations. Dept. of Economic and Social Affairs. Population Division, 2010). This definition was also influenced by Fisk, Rogers, Charness, Czaja and Sharit (2009), who stated: "If forced to give a number to the question of when a person is an older adult", we would most likely say that older adults are those individuals who are 60 years of age and older".

2.3 Age-related Changes

To date, information communication technologies have focused on younger users (Newell & Gregor, 2001) and therefore risk excluding specific demographics with different needs and requirements, such as older people (Kobayashi et al., 2011; Mitzner et al., 2010). To design interfaces appropriate for use by older people, we must understand the age-related changes in sensation and perception, cognition, and movement control (Fisk et al., 2009).

The remainder of this section discusses how these affect the seeking and processing information, physically reactions to that information, and their implications for interface design targeting elderly users.

2.3.1 Sensory Changes

Sensory input plays an important role in capability to perform a particular activity. This section, we focusses on vision and auditory, because these senses affect user interactions with perceptual systems (Fisk et al., 2009).

2.3.1.1 Visual Impairment

Like many chronic conditions, visual impairment commonly afflicts the older population (Fisk et al., 2009) and inconveniences their daily lifestyle. Vision changes are an important consideration when designing visual display systems for older people because most users interact with devices or applications through a visual interface (Pak & McLaughlin, 2010).

One of the earliest vision impairment is presbyopia, or decline in the eye's accommodation capability. In this condition, the focusing power of the lens is reduced, causing difficulties in near objects viewing (Fisk et al., 2009). Presbyopia usually first appears around age 40. Between the ages of 20 and 70, the near point focus changes from 10 cm to 100 cm (Farage, Miller, Ajayi & Hutchins, 2012). Presbyopia view is illustrated in Figure 2.2; the user's far vision is clear, while the nearby mobile phone appears blurry.

Figure 2.2: Visual Presbyopia (Laservision, 2013)

The loss of visual acuity also impacts on the daily activities of many older adults. Visual acuity refers to the ability to see detail in visual images. Evidence exists that visual acuity declines progressively with age, beginning at 20 years and declining rapidly after age 60. Farage et al. (2012) suggested that small texts and tiny icons require careful consideration when designing interfaces for older people, since those visual elements can hinder the effective interaction between older persons and visual interfaces.

Another visual impairment relevant to interface design is contrast sensitivity, or the ability to distinguish between light and dark regions of an image (Farage et al., 2012). Like presbyopia and lowered visual acuity, reduced contrast sensitivity affects daily activities such as reading, using computers or driving. An example of reduced contrast is shown in Figure 2.3, clearly, low contrast reduces the readability of the text.

Figure 2.3: Simulated Contrast Sensitivity Words

In interface design, low contrast between visual elements should be avoided because it is difficult for old people to perceive and extract information from graphical elements.

Lastly, the age alters the ability of visual searching. Visual searching refers to the ability to focus on a specific item in a scene (Pak & McLaughlin, 2010). The first category of visual search is effortless and requires no of attention. For example, a glowing neon warning sign is easily recognized at night by people of all age groups. By contrast, effortful search is strongly age-dependent, especially when searching is difficult and involves may items. Besides the main visual impairments described above, older people also suffer from changes in illumination, reduced color perception, disability glare (Farage et al., 2012) and several age-related diseases such as macular degeneration (AMD), cataracts, diabetic retinopathy and glaucoma (Jackson & Owsley, 2003).

Fisk et al. (2009) and Farage et al. (2012) have proposed some recommendations for compensating visual impairments. First, the level of illumination of reading surface should exceed 100 cd/m^2 reflected light e.g. white paper. Next, a visual displays should have a high contrast ration (50:1). To maximise contrast, white text should be on a blac background or vice versa. Third, important information should be represented at the long-wavelength end of the spectrum such as red, orange, and yellow. Lastly, using 12 point x-height fonts and serif or almost all fonts are serif or sanserif could be advantageous for the older adult with visual decline.

Collectively, these findings provide broad evidence that vision deteriorates significantly with age, and that deficits become increasingly pronounced as the visual tasks become more challenging. Such findings also can be used to improve the products used by older people.

2.3.1.2 Auditory

Auditory is also subjected to age-related changes. One study by A. C. Davis, Ostri and Parving (1991) indicated that hearing loss begins gradually from 40 years old and accelerates after age 55. By age 55 and or thereabouts, 60 percentage of adults suffer sufficient hearing loss to compromise their quality of life and ability to socially interact.

In addition, as people age, they become less able to hear high-pitched sounds (Fisk et al., 2009; Farage et al., 2012). For example, young people can hear pure tones at frequencies up to 15,000 vibrations per second, whereas the upper hearing threshold of older people may be below 4000 vibrations per second.

To compensate auditory loss in older adults, a high volume sound is necessary (Farage et al., 2012). For example, when older users' make an error while performing a task, warning messages should be administered at 60 dB (conversational speech is 50 dB) to engage their attention. Next, low frequencies (500-2000 HZ) are more effective frequencies (Farage et al., 2012). For instance, older people may better respond to a lower-pitched male voice than high-pitched female voice for older adults. Furthermore, an auditory signal can be combined with other sensory channels, such as vibrations or flashing lights, to convey information to hearing-compromised older people (Farage et al., 2012).

2.3.2 Cognitive Changes

Cognition is broadly divided into fluid and crystallised intelligence. The former involves processing and reasoning components of intelligence and is associated with aptitude for learning (Czaja & Lee, 2007; Pak & McLaughlin, 2010). For example, learning the skills to operate new touch-screen device requires aspects of fluid intelligence. Crystallised intelligence represents the sum knowledge that one has acquired through education and experience. Numerous studies have shown that fluid intelligence such as memory and attention are more relevant to user interface design than crystallised intelligence (Caprani et al., 2012; Czaja & Lee, 2007).

2.3.2.1 Memory

Pak and McLaughlin (2010) described four categories of memory: working memory (the ability to retain information active during a task), semantic memory (the ability to store factual information), prospective memory (the ability to remember a task to be completed in future) and procedural memory (the ability to perform activities using previous skills). However, not all kinds of memory decline with age. For example, semantic memory, which stores information about historical facts and general knowledge, does not appear decline during the normal ageing process (Fisk et al., 2009).

The most relevant memory for interface design is considered to be working memory, by which we remember items while processing or using them. Reduced working memory effects daily activities such as reasoning, problem solving and speech. Unfortunately, working memory does appear to decline with age (Gregor & Dickinson, 2007; Fisk et al., 2009; Farage et al., 2012; Pak & McLaughlin, 2010). For example, selecting the appropriate command in a hierarchical menu to send a message requires this type of memory. A simple way to compensate this decline is to reduce information load and in-memory transformation. This suggestion is support by earlier research (Ziefle, 2010), that has investigated the trade-off between visual density and menu foresight of information presentation in small screen devices for the elderly. The author reported that proper mean orientation is more important than visibility effect for older users.

2.3.2.2 Attention

Attention refers to our limited capacity to process information (Fisk et al., 2009). Depending on the tasks goals, attention can be either selective or divided (Pak & McLaughlin, 2010). During selective attention, we focus on a single item or task (e.g. finding which button to press on a ticket kiosk) while ignoring interferences (e.g. interruptions, bystanders, movement, noise). Divided attention is refers to simultaneous multiple focussing on many items or tasks, or switching attention between tasks (e.g. talking on the phone while watching television). In both situations, older people perform less well than other age groups.

When designing interfaces for the elderly, Fisk et al. (2009) and Pak and McLaughlin (2010) suggested avoiding clutter and minimising non-relevant information that may distract the user's attention, while drawing attention to important elements through another sensory channel (e.g. a flashing light or bright and striking colors).

2.3.3 Motor Control

Motor control refers to the response time and accuracy of movement (Pak & McLaughlin, 2010). The moment of older people are about 1.5 to 2 times slower to movement than those of younger adults (Fisk et al., 2009). Reduced movement speed could effect the task performance of manipulating technology devices, such as double-clicking with a mouse. A good example is double-click action in the Windows operating system, where double-clicking a folder opens a file, while a slow double-click renames the file. Older users could become confused and frustrated if they only want to open a file. To solve this problem, Pak and McLaughlin (2010) suggested minimising the need for double-click in hardware design, and permitting users to either use or abandon a double click.

In addition, in older users, the slow response time is accompanied by reduced ability accurately strike a key (Pak & McLaughlin, 2010). For example, an inadvertently dropped icon returns the icon to its original location requiring the users to restart the task. These small obstacles, experienced by many users of all ages, can especially frustrate users whose accuracy has decline with age. Fortunately, older people can accurately touch a target on a screen, provided the button size and space are appropriate. For a detailed discussion on effective button size and space for older users, the reader is referred to Jin, Plocher and Kiff (2007).

2.4 Attitudes and Anxiety Towards Technology

The attitude towards computer use by older adults has become extensively investigated in recent years, and has yielded conflicting findings. Some researchers have indicated that older adults are afraid or unwilling to use computers. For example, Laguna and Babcock (1997) compared computer anxiety between young and older adults, and reported that older people reacted more negatively towards computers than young people. The results of this study are consistent with other studies, for example, Czaja and Sharit (1998), related age differences in attitudes toward computers to experience with computers and computer task characteristics. They reported that older people are less comfortable and less competent at using a computer.

However, the above results are contradicted by newer studies. For instance, Jayroe and Wolfram (2012), investigated user interaction with iPad tablet technology and desktop computers by older people. They found that, although some features of the tablet technology were not easily mastered by older participants, this group reacted positively to the touch technology, and completed most of the assigned tasks. Similar findings were reported by Piper, Campbell and Hollan (2010), who examined accessibility issues of touch-screen computing experienced by older people and discovered the appeal of touch-screen computing for health care support. In their study, older adults reported that touch-screen computing was less intimidating, less frustrating, and less overwhelming than a traditional computer. In 2006, Apted et al. (2006) researched tabletop photo-sharing application for older people. The participants reported willingness to use the tabletop because it was easily manipulated and the tabletop display was appealing. Piper et al. (2010) and Jayroe and Wolfram (2012), who investigated user interaction with touch-screen technology by older people reported similar findings.

Taken together, it seems that attitudes are related to age, and that older adults are generally less attracted attitudes towards technology than young people. However, innovative information technology (e.g. touch-screen technology), proper encouragement, and clear explanations of technology's benefits, older people could develop the same positive attitudes towards technology as younger generations. Positive attitude towards technology could also be fostered by offering elder users the benefits of its use (Broady, Chan & Caputi, 2010).

2.5 Technology Acceptance by Older People

Although technology acceptance has been widely studied over many years and several models have been proposed, numerous open questions remain (Renaud & van Biljon, 2008; Biljon & Renaud, 2008; Conci, Pianesi & Zancanaro, 2009; Arning & Ziefle, 2007). In particular, technology acceptance among older people, with age-related declines and uncertain attitudes towards new technology is unclear. This section reviews technology acceptance by older people and evaluates the findings as well as limitations of previous studies.

The Technology Acceptance Model (TAM) for predicting acceptance of information technology and usage behaviour was proposed by F. D. Davis, Bagozzi and Warshaw (1989), has been applied in different contexts: World-Wide-Web (Gefen, Karahanna & Straub, 2003; Moon & Kim, 2001), electronic commerce (J. Zhang & Mao, 2008), and telemedicine (Chau & Hu, 2002). TAM posits two primary requisites of computer acceptance: perceived usefulness (PU) and perceived ease of use (PEOU). PU also mediates the effect of PEOU on user behaviour (AT). Together, PU and AT predict the behavioral intention to use (BI), which directly affects actual usage behavior. TAM also assumes some "external variables" such as user differences (cognitive style and other personality variables), system characteristics, and task characteristics. The effects of these variables are fully mediated by PU and PEOU. TAM is a powerful model of acceptance behaviour, but it requires additional variables to better explain the technology acceptance behaviour of older people. For example, cost, which has been neglected in previous studies, is a critical factor influencing the technology acceptance of older people (Kargin, Basoglu & Daim, 2009). Furthermore, ageing is accompanied by changes in perception, cognition, movement, and psychosocial functioning (Fisk et al., 2009; Farage et al., 2012), which are also pivotal in determining an older person's acceptance of technology.

To tackle the limitation of TAM, Biljon and Renaud (2008) proposed the Senior Technology Acceptance & Adoption Model (STAM), which predicts acceptance and user behaviour of mobile phones by older users. STAM considers that older user's acceptance and behaviours are mediated through a temporal process of objectification, incorporation (experimentation and exploration, effected by PU and PEOU), conversion and non-conversion. Biljon and Renaud (2008) excluded attitude as a determining factor in STAM because they considered that attitude towards use was not significantly correlated with other determinants. By combining acceptance factors and with successive, this model explains partially why some older people are reluctant to accept the new technology, and could be useful in modelling the technology acceptance of other demographic groups.

Another model predicting the technology acceptance of older people was proposed by Conci et al. (2009). The authors incorporated factors such as enjoyment, self-actualization, and perceived safety into an extend version of TAM. The key contribution of this study is its distinction internal motivating factors (enjoyment, self-actualization, and perceived safety) and external motivators (mobile phone support, social influence) in mobile phone use. Enjoyment and self-actualization were identified as important critical factors influencing the PU and PEOU. Social influence and supporting were confirmed as significant contributors to mobile phone because they increase the utilitarian value of the device.

In summary, the literature on technology acceptance by older users is far from converging. On the contrary, new models or model extensions are constantly proposed in different contexts, such as healthcare (Holden & Karsh, 2010), education (Muniandy, Ong, Phua & Ong, 2011), mobile phones (Biljon & Renaud, 2008; Wilkowska & Ziefle, 2009; Gelderblom, van Dyk & van Biljon, 2010), and PDAs (Arning & Ziefle, 2007). Although TAM can be adopted to matched contexts and a better understanding of technology acceptance by adding factors, the lack of convergence, consistency, user-specific ability and age-specific limit generalisability limit the applicability of the model.

Moreover, TAM and its extensions are focussed on intention to use, rather than actual use. In contrast, the present study takes an applied perspective, focusing on the actual use of a existing technology by older people. Therefore, the present study cannot be guided by any existing model.

2.6 Touch-screen Based Interaction for Elderly Adults

2.6.1 The Evolution of Touch Interaction

The touch-screen concept was introduced by Johnson in 1965. He conceptualised the touch-screen as an input device to a computer like a keyboard or mouse (Johnson, 1965). Johnson's concept has guided the design of several touch-screen products that have been created. In 1980, XEROX created and commercialised XEROX 5700 Electronic Printing, which could be controlled by simply touching the black and white display

(Nakatani & Rohrlich, 1983). Another commercial example is the point-of-sale (POS), which is now used in retail businesses such as restaurants, bars and supermarkets (Leitão, 2012). A few years later, the first personal touch-screen computer “HP-150” was created by Hewlett-Packard. The HP-150 allows users to operate the system by touching the screen (Hewlett-Packard Development Company, L.P, 2012).

Although such devices have changed the way of communication between users and computers, detecting a single touch event at any one time potentially limits the usability of touch-screen interaction (Leitão, 2012). For example, some useful operations based on multiple gestures, such as zoom in or out, rotation and drag are not available on single touch devices. Another limitation is the operation complexity (Sears, Plaisant & Shneiderman, 1991). For example, a user desiring a wider view of a photograph on a single touch device must proceed through several steps, similar to enlarging a picture on a desktop computer. This task is efficiently performed only if a zoom out feature is available.

Multi-touch technology has rapidly developed to overcome these limitations. In 1982, the University of Toronto’s Input Research Group created the first multi-touch device (Buxton, 2010), which contained a camera placed behind a frosted-glass panel. When single or multiple fingers touched the glass, the camera identified the action as one or more black dots on an otherwise white background, which were identified as a input (Buxton, 2010). Another milestone was the invention of the smart-phone ("Simon") by IBM and Bell South. The Simon operated through two physical buttons, controlling power (on/off) and volume. Current smart-phones which are almost fully controlled by the touch-screen display adopt the same basic design (Buxton, 2010).

In 2007, the Apple iphone appeared on the market. The iPhone is operated by a series of multi-touch gestures, such as the pinch and spread, flick, swipe and drag (Apple, 2013).

Around the same time, the main mobile phone manufactures (HTC, Samsung, and LG) released their own multi-touch products, and development became accelerated by the competition (Leitão, 2012). Besides developing its smart-phones, Microsoft unveiled the Microsoft Surface 1.0 (Tablet) in 2007, which supports multi-touch and multi-users events (Microsoft News Center, 2007). Three years later in 2010, Apple launched another multi-touch screen device (the iPad) with larger screens than smart-phones (Ritchie, 2013). The competition has sparked a touch-screen revolution in which these devices are becoming more available, portable and affordable (Caprani et al., 2012). The technology revolution has also benefited older people who with age-related declines (Umemuro, 2004; Loureiro & Rodrigues, 2011; Annett et al., 2009; Jayroe & Wolfram, 2012; Chung, Kim, Na & Lee, 2010).

The following section evaluates the accessibility of the multi-touch technology to older adults as evaluated in previous studies.

2.6.2 Touch-Screen Based Interaction for Elderly Adults

The development of single/multi-touch technology was briefly indicated in the previous section. Here, we discuss the implications of touch-screen technology for the older user. As stated by Loureiro and Rodrigues (2011) and Jayroe and Wolfram (2012), touch-screen technology offers the potential benefits of ease-of-use, ease of learning and speed, even to special populations such as older users, who may not be familiar with new technology, or who are hampered by age-related problems.

The adequacy of multiple-touch based interaction for older users has been examined in several studies. As mentioned earlier, the ultra-sensitivity and non-tactile feedback of the tablet is problematic for older users. Nonetheless, most older participants successfully completed trial tasks on a tablet, and expressed on a positive attitude to its use (Jayroe

& Wolfram, 2012). Similarly, in a study assessing the usability of two keypad types in numeric entry tasks Chung et al. (2010), the older participants preferred the touch-screen keypad to the physical keypad because of its higher input speed. However, lack of non-tactile feedback is a potential disadvantage of touch-screen devices.

Other research has focussed on the performance of gestures on touch-screens (Lepicard & Vigouroux, 2012; Stößel et al., 2010). This study included user attitude and anxiety, the trade-off between visual density and menu foresight, and sizes and spacing of touch targets most suited to older adults. Stößel et al. (2010) examined the ease at which older people could implement gestures on multiple-touch screen devices. In this study, participants reacted to several displayed arrows with their fingers. Older participants exhibited slower performing, but their accuracy was almost that of their younger counterparts (Stößel et al., 2010). A similar study evaluated the ability of senior citizens to conduct a series of touch-based gestures (Leonardi, Albertini, Pianesi & Zancanaro, 2010). The participants easily implemented and recalled tap and flick gestures, but became confused with the drag gesture. The authors also pointed out that some of the gestures require careful consideration if the interface is to be adopted by elderly users. In particular, 1) performing an action by tapping on the background (rather than an object) was poorly understood and should be avoided, 2) the same object should not respond to both tap and drag gestures; 3) drag gestures should perform in an intuitive manner: if a dragged object is released, it should remain in its dropped position and not return to its initial state; 4) older users readily engage with iconic gestures; and 5) time settings for gestures is extremely important (e.g., time constraints for tap versus a tap and hold).

To investigate whether touch-screen devices could alleviate older people's anxiety in performing computer tasks, Umemuro (2004) evaluated whether older participants could more effectively send email via a touch-screen email terminal or a peripheral input terminal. The touch-screen significantly reduced participants' anxiety towards the touch-screen email terminal, whereas no significant decline in computer anxiety was evidenced in participants using the keyboard-based terminal. Moreover, several studies (Apted et al., 2006; Jayroe & Wolfram, 2012; Piper et al., 2010) have identified uncertain attitude towards multiple touch devices by older users, which can be transformed into positive attitudes by demonstrating the value of the products.

Jin et al. (2007) used three independent variables (button size, button spacing and manual dexterity) to identify the optimal button size and spacing for touch-screen use by older users. They found that larger buttons reduced the reaction time by older participants, and that accurate responses and appeal were maximised at a certain button size (16.21 x 19.05) mm^2. Moreover, increasing the button spacing did not improve the performance; older participants in the study prefered and responded accurately to a spacing of 6.35 mm.

In 2010, Ziefle investigated the trade-off between visual density and menu display of information in small screen devices for elderly users. They found that proper mean orientation is more important than the visibility effect, reflecting the special requirements of older people. Although this study simulated a conventional mobile phone on a touch-based screen and may not directly apply to the touch-screen smart-phones investigated in this study, the results provide guidelines for optimising on information display on small screen smart-phones.

Multi-touch based interactions have also become increasingly adopted in social interaction support, healthcare and wellness support for older people (Doyle et al., 2010; Apted et al., 2006; Leonardi et al., 2010; Piper et al., 2010; Jayroe & Wolfram, 2012). Apted et al. (2006) developed a multi-user, multi-touch, gestural, collaborative digital photograph sharing application for a tabletop that allows older users to create/edit and share digital photographs. The design principles were tailored to this demographic, ensuring easy scalability of interface elements, a focus on learnability and memorability, and reduction of irrelevant elements. This experiment implemented two-hands interaction gestures for resizing, rotating, and copying of pictures were involved in this experiment. All users could learn and use the gestures, but experienced difficulty with more specific gestures. The copy gesture, which requires two-hand cooperation, proved especially problematic for elderly participants.

Healthcare and wellness are other areas in which older people can benefit from touch-screen technology. For instance, in a comparative usability study involving 20 older participants, Piper et al. (2010) explored the accessibility and appeal of multi-touch surface computer as support tools for older adults healthcare. The older adults reported that surface computer was more intuitive, friendly and ease to use than traditional computer for healthcare support and provided positive feedback on the concept. Annett et al. (2009) investigated a multi-touch tabletop, the AIR Touch, as a potential support tool in rehabilitating with older patients with reduced motor functions. During the session, participants executed a set of tasks designed by the therapist, such as painting by number, picture tracing, and drumhab. Participants reported that they would rather use the AIR touch than traditional training programs because the activities and exercises of the AIR touch rehabilitation program were diverse, interesting, and inspired them to maximise their performance. Meanwhile, therapists commented that the system was easy to operate and enabled convenient measurement and recording of patient progress.

2.7 Potential Benefits and Drawbacks of Touch-screen Based Interaction for Elderly Adults

Despite their many benefits highlighted above, multi-touch gesture interface are limited by innate flaws in touch-screen interaction and design errors. This section discusses the advantages and disadvantages of touch-screen technology.

2.7.1 Potential Benefits

Better Visualization

Unlike conventional devices with physical buttons, touch-based devices allow users to control systems through simple or multi-touch gestures by touching the virtual buttons on the display. This design increases the available screen space allowing larger display of visual information. An archetypal example is the Apple iphone (Apple, 2013), which has three buttons: an on /off switch, a volume control, and a home button. Therefore, most of the space is allocated to viewing the information on the display (Stößel et al., 2010). This feature automatically compensates the loss of visual acuity of older adults: buttons are sufficiently large to press, and text is sufficiently large to read.

Direct Interaction

Touch-screen interfaces require little mental effort and are easy to use (Jayroe & Wolfram, 2012; Rogers, Fisk, McLaughlin & Pak, 2005; Caprani et al., 2012; Chung et al., 2010; Murata & Iwase, 2005; Shneiderman, 1991). For example, restoring an item on a conventional device (e.g. cell phones or computers) requires several steps, specifically, the user must open a hierarchical menu and search for the appropriate command using the navigation key. In contrast, clicking the "restore" icon resolves the item in a touch based process. This feature is especially important for older people, who frequently experience decline in their working memory (the ability to retain information during tasks performance) (Fisk et al., 2009). Such memory loss could affect efficiency and comfort of computer use. Touch interaction provides a new connection between older people and computers. As stated by Stößel et al. (2010) and Gabrielli, Bellutti, Jameson, Leonardi and Zancanaro (2008), gesture-based interaction is intuitive even to older people with no prior domain knowledge.

Better and Faster Pointing Device

This point has been verified in comparative empirical studies conducted by (Chung et al., 2010; Murata & Iwase, 2005), who reported that the touch-screen interfaces are applicable for discrete pointing and selection, and that time required to point to a target is age-independent.

Natural User Interface

The Natural User Interface (NUI) described in Blake (2010) allow users to reuse existing knowledge to directly interact with devices. König, Rädle and Reiterer (2009) reported that " the NUI relies on a user being able to carry out natural motions, movements or gestures and let them quickly discover how to control the computer application or to manipulate the on-screen content". These natural interactions are implemented by technologies such as multi-touch and gestural computing (Lepicard & Vigouroux, 2012; Umemuro, 2004; Jayroe & Wolfram, 2012; Annett et al., 2009).

2.7.2 Potential Drawbacks

Lack of Consistency and Standards

As multi-touch devices proliferate in the market, manufactures are striving to develop trademark gestures that will become the future interaction standards (Stößel et al., 2010; Bachl, Tomitsch, Wimmer & Grechenig, 2010). Therefore, the gesture may invokes a particular action, and the action invoked by a particular gesture is not consistent across different platforms (Stößel et al., 2010). For example, in one system, image scale is widely changed by the pinch gesture, but can also be changed by the tap gesture. The tap gesture can also form hyper links to the image, or even unlock the system (Norman & Nielsen, 2010). Users are easily confused by these inconsistent gestures. This situation is aggravated for users with shallower learning curves, such as older users (Fisk et al., 2009).

Loss of Perceived Affordance

A fundamental challenge of multi-touch interfaces is its perceived affordance. Presented with a chair, a user needs no instructions on how to sit on it, because only one action is feasibly available: sit on the flat sector. Therefore, the affordance of how to use a chair is perceived by any user. Multi-touch interfaces, however, appear to lose perceived affordance. For example, when a user want to enlarge or shrink a picture on a touch-screen device, the action is not immediately intuitive because essential cues, such as "+" or "-" on the screen are lacking (see Figure 2.4). This challenge has been investigated in Norman and Nielsen (2010)'s study, who highlighted that not only the lack of clues for specific actions, but also the difficult of discovering these clues by systematically exploring the devices.

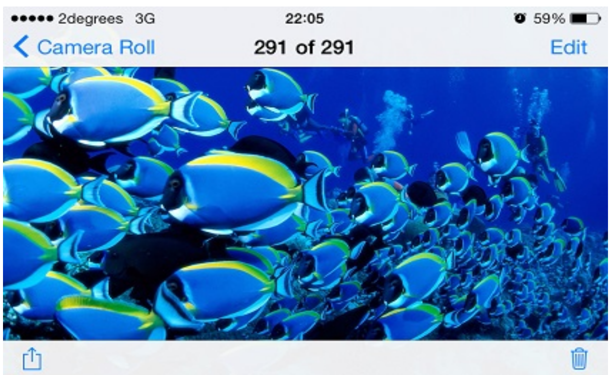


Figure 2.4: Loss of Perceived Affordance

Particularly as their working memory declines, elderly users may easily become lost within the system. If the required gestures are not remembered, the system provides no hints or cues on retrieval of the desired function (Stößel et al., 2010).

Inadvertent Touch

Compared with an indirect input interface such as a mouse, gesture-interaction is subject to accidental activation. This occurs when users inadvertently touch an icon with their wrists or knuckles. Inadvertent touching returns users to the main menu or suddenly removes them from application (Norman & Nielsen, 2010). If the multi-touch screen is over sensitive, and less error tolerant to inadvertent touching, it will present additional difficulty to older users.

The Loss of Tactile Feedback

One of the most discussed and investigated challenges of multi-touch technology is the absence of tactile user feedback (Bachl et al., 2010). On traditional interfaces, users receive immediate feedback such as haptic and sound ("click") from pressing a mouse or a physical keyboard, which is absent in current touch-screen technology. Consequently, users cannot assess whether the gesture is performed at the correct place, time, sequence, speed or pressure (Doyle et al., 2010). Provision of tactile feedback is particularly important for older users, because it both alerts the user to errors and enables learning these errors (Doyle et al., 2010). Once older uses familiarise themselves with a touch-screen device, they feel comfortable using the device.

Thus far, we have reviewed several articles providing various perspectives of touch-screen interfaces for older adults. These studies indicate that touch-screen technology may be successfully deployed to benefit older people. However, previous studies have focused only on specially designed prototypes the devices that are neither portable nor affordable, such as the AIR touch project (Annett et al., 2009), the MobiTable project (Leonardi et al., 2010), and ATM numeric keypads (Chung et al., 2010). To our knowledge, the handhold multi-touch device best suited to the generic needs of older people has yet to be investigated, and form the basis of the present study.

Chapter 3

Methodology

3.1 Introduction

In the previous chapter, we reviewed the relevant literature to acquire a better understanding of 1) what is meant by “older adult”, 2) age-related changes in sensation, cognitive, and psycho-motor skills, and recommended interface designs for older users, 3) attitudes and anxiety of older persons towards technology, 4) technology acceptance by older people, 5) the evolution of touch screen technology, and the benefits and drawbacks in applying this interaction paradigm to older adults. We now describe research methodology employed in this study.

3.2 Methodology for This Study

Two major methodologies that have been applied to usability testing of mobile applications are controlled environment experiments and field studies (Kallio & Kaikkonen, 2005; D. Zhang & Adipat, 2005). In controlled environment experiments, participants are asked to preform a series of specific tasks in a controlled environment where they can focus on the given tasks (e.g. a living room or an office-like area). A field study requires users to use mobile applications in a real context (e.g. a public area or while performing physical body movements such as walking and standing) (Kallio & Kaikkonen, 2005; D. Zhang & Adipat, 2005). Because both methodologies have their benefits and the drawbacks, it is necessary to investigate the pros and cons of each before selecting an appropriate methodology for this study.

Controlled Environment Experiments

Controlled environment testing of usability testing confers several advantages. First, test moderators exert full control over the testing; namely, they define specific tasks and procedures that match the study goals (Kallio & Kaikkonen, 2005). For instance, if the objective of a study is to investigate whether touch-based gestural devices can support older adults in social connecting from their homes, a controlled environment experiment is more suitable than a field study because home environment could be easily simulated in a controlled environment experiment.

Second, interference (e.g. interruptions, bystanders, movement, noise) can be eliminated in a controlled environment.

Third, in the controlled testing environment, observation and verbal data collection techniques are easily employed. Audio and video recorders are also easily deployed to capture participants' actions, emotions, or voice throughout the testing. These collection techniques and apparatuses are less easily utilised in a field study.

Finally, this methodology consumes less time in the data collection phase. The time of each controlled environment experiment session can be half the time of required field studies (D. Zhang & Adipat, 2005).

The major limitations of this methodology are lack of a real environment and various unpredictable interference factors. In a real environment, participants may encounter interferences such as unreliable connection of wireless networks, interruptions, and other factors, which affect real users' performance. In other words, the collected data may be somewhat artificial and less reliable than data collected in the field.

Field Studies:

Field studies offer a real environment in which usability testing meets the desired ecological validity. These conditions are difficult to simulate in a controlled environment experiment (Kallio & Kaikkonen, 2005). Field studies also allow for the interruptions, bystanders, movement, noise, multitasking and other factors that could affect users' performance. Providing a more reliable and realistic dataset than can be obtained in a controlled environment (Kallio & Kaikkonen, 2005).

Nonetheless, this methodology faces several challenges. First, usability testing is not easily conducted in a dynamically changing environment, because it must adequately account for multiple factors, such as time, budget, participants, and testing place (Beck, Christiansen, Kjeldskov, Kolbe & Stage, 2003). Second, a field test may be complicated by more interruptions and unexpected problems than planned (Kallio & Kaikkonen, 2005). Third, interference reduces the applicability of the observation and verbal protocol (D. Zhang & Adipat, 2005).

Kallio and Kaikkonen (2005) and D. Zhang and Adipat (2005) compiled guidelines for selecting an appropriate methodology. The guidelines suggested that controlled environment experiments are more suitable for stand-alone applications, which do not require reliable network connectivity, and when the usability testing evaluates components of mobile applications, such as interface layout, information presentation schemes menu, design menu and link structures, which are not significantly affected by network connectivity, and other interference factors. On the other hand, field studies are appropriate when evaluation application-performance-related issues that are highly depend at on the mobile context, or when user behaviours and attitudes need require study in a natural environment (Kallio & Kaikkonen, 2005; D. Zhang & Adipat, 2005).

Based on above discussion and suggestions, we selected the controlled environment style for the following reasons: First, this research compares ease of use of a tablet and a smart-phone, considering the interface layout, touch screen elements, spacing sizes and text characteristics. The aim is to establish which devices will most benefit elderly users. Following the guidelines proposed by Kallio and Kaikkonen (2005); D. Zhang and Adipat (2005), we decided that the controlled environment experiment was appropriate to our study aims. Second, the limited study time, budget and size of the research team (a single investigator) were also deciding factors in the study methodology.

Third, asking elderly people to participate in a usability testing in a complex real environment exposes them to physical, psychological and emotional risk.

Finally, the researcher lacks adequate experience of conducting usability testing in a real environment. To avoid the impact of unexpected events on the testing, the field study was abandoned.

3.3 Pilot Study

A pilot test was conducted on a 75-year old male on 2nd November, 2013. The goals of the pilot test were two-fold:

1. To detect possible flaws in the measurement procedures (including procedure, time limits, operation of equipment).

2. To identify the best design for the full study.

After the pilot study, a few modifications were made to the task script and apparatus. First, one of the original tasks requested the participant to create an account for FitnessPal using their own email address, we deleted this task from the final study for reasons of privacy, complexity and time. We also simplified the original task script, which contained many detailed instructions of what to do or how to complete the task, because we wanted to test the cognitive ability of older people to use new technology. An adjustable camera rig (Mr Tappy) was added for filming user interactions with the handheld devices from their own viewpoint. The role of moderator in the usability testing was also modified. In the pilot study, the moderator provided too much assistance hindering participant's verbal expressions when stuck in a task. Therefore, we decided that participants should receive assistance only when stuck for 5 minutes or longer.

Through, the pilot study, we evaluated the task script, apparatus, questionnaires and session procedures. The feedback from the pilot study was positive, and the full-scale study could then proceed.

3.4 Testing Method

Various usability testing methods have been adopted in previous researches and publications, each for a slightly different purpose. Rubin and Chisnell (2008, p 27) used the product development life-cycle as a reference for classifying usability testing methods. They identified four classes of usability evaluation methods: exploratory (or formative), assessment (or summative), validation (or verfication), and comparison test, each with different usages.

- Exploratory methods examine product early in the development cycle. The results and conclusions of exploratory methods are used mainly for improving the product's interface prior to final design.
- Assessment is employed either early or midway through the product development cycle. The objective of assessment is to expand the findings of the exploratory test and to document the effectiveness, efficiency, and user satisfaction of a product. Assessment is typically evaluated by task success rate, task completion time, error rate, subjective satisfaction rating, and similar measures.
- The validation test, also called the verification test is usually adopted late in the development cycle and evaluates product usability based on predetermined usability standards or benchmarks.
- The fourth type of usability testing method, comparison, can be integrated with any of the above methods and is not associated with any specific lifecycle phase. This method compares two or more designs, such as interface styles. Its result and conclusions are used mainly for evaluating which product is easier to use and learn, or clarity the benefits and drawbacks of different products.

The object of this study was not to improve or develop a system itself but to test different portable multi-touch devices, and then compares the usability of each product for older users. To meet this objective, we adopted a side-by-side comparison assessment method (Rubin & Chisnell, 2008, p 37) .

3.5 Participant Recruitment

3.5.1 Potential Participants

As defined in the Approval of Auckland University of Technology Ethics Committee Application 13/218 (see Appendix I), the target population of this research was senior adults aged 60-80 years. Participants were expected to have had previous experience with computers and at least basic experience with touch-screen devices. To satisfy these selection criteria, we contacted SeniorNet in Mt Eden, Auckland. SeniorNet could offer the following:

1. SeniorNet is a community training network that supports and motivates older adults (50 years or over) to enjoy and use technology in their daily lives (The Federation of New Zealand SeniorNet Societies Inc, 2011a). It offers a series of courses for older people, ranging from software applications such as word processing, Internet banking and use of Internet protocol for telephone communications (VoIP), to hardware applications such as how to use a computer (Mac or desktop), use of mobile devices (smart-phones or tablets) (The Federation of New Zealand SeniorNet Societies Inc, 2011b). Consequently, most of SeniorNet's members would have previous experience of computers and at least minimal experience of touch-screen devices.

2. Recruiting an adequate number of participants to ensure a representative sample is a major obstacle in volunteer research, because only interested people are willing

to invest their time in study participation. However, we considered that SeniorNet members have already expressed a positive attitude towards on technology in their daily lives and would likely be interested in this study.

3.5.2 Participant Recruitment

Recruitment started at the end of October 2013, and attracted 11 participants. One recruit was assessed in the pilot study, 10 in the full-scale study. We collaborated with SeniorNet in Mt Eden. The club distributed the attached advertisement (see Appendix J), and the participant Information Sheet (see Appendix B) to its members via email. 13 potential participants accepted the invitation. A timetable sheet listing various timeslot options was sent as an attachment with the email. Participants replied by email confirming their timeslots. Of the 13 potential recruits, 11 returned their timesheets. Therefore, the researcher arranged 11 testing session throughout one week and assigned a number to each recruit.

3.6 Apparatus

The apparatus were an iPad (the "large device" with a 9.7-inch, 147.8x197.1 mm multi-touch screen with 768x1024 pixel resoulution, weighing 680 g) running iOS 7 and a Sony (the "small device" with a 3.5-inch, 49.3x74.0 mm multi-touch screen with 640x960 resolution, weighing 101g) running Android. Although the tablet and the smart-phone run different operating systems, they are very similar in terms of interaction. We tested the small devices as representative of smart-phones with similarly sized touch-screens. The large device was deployed because we expected that participants with visual and motor limitations would benefit from larger screen size. To provide a realistic experience of multi-touch devices, MyFitnessPal was adopted as the experimental software. MyfitnessPal is a nutrition and fitness system that assists people to determine their optimal nutrient and caloric intakes (MyFitnessPal, 2014). In 2013, MyFitnessPal was rated the best free mobile program in maintenance, calorie awareness and food variety (Advertiser, 2013).

we recorded the session on video using a custom-built recording system. This system comprised an adjustable camera rig (Mr Tappy), a HD Webcam, and a laptop. One benefit of the system is its budget: the rig cost at economical 80 NZ dollars (the Webcam and the laptop were already owned by the researcher). By contrast, the commercial screen recorder software Morae would have cost 2000 NZ dollars. Moreover, the rig enables easier filming of the interaction with multi-touch devices from the user's viewpoint (see in Figure 3.1). To ensure a comfortable and related body posture while executing the tasks, participants could hold the devices or place them on the table during use.

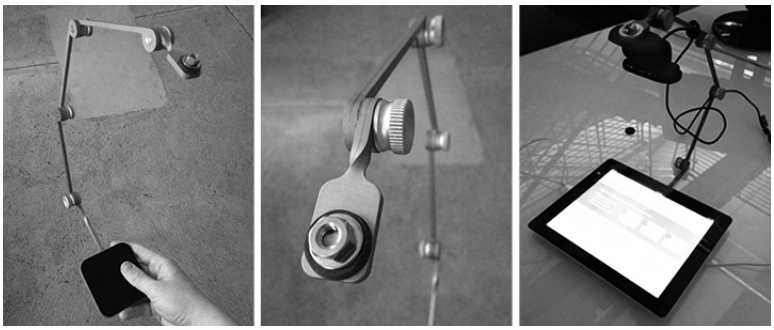


Figure 3.1: Apparatus

3.7 Data Collection

At the beginning of the session, participants were asked to complete the pre-test questionnaires (demographic information). While the participants completed the tasks, the moderator recorded notes on completion rates and the number of errors made during the tasks. Meanwhile, the participants' verbal outputs and interactions with the devices were recorded by the recording system. Having completed their tasks, the participants were required to fill the post-test questionnaire (closed ratings, open-ended questions and semantic deferential). The data collection methods are summarised in Table 3.1. The collected raw data comprised pre- and post-test questionnaires, digital videos, and observation notes. To manage these data, the moderator assigned a unique number to each participant and stored the data together with the numbers and the date of testing.

Method		**Description**	**Results**
Questionnaires	Pre-questionnaire	Demographic Information Section 3.7.1.1	Section 4.2
	Post-questionnaires	Close Ratings Section 3.7.1.1	Section 4.3.1
		Open-Ended Questions Section 3.7.1.1	Section 4.3.2
		Closing Semantic Deferential Section 3.7.1.1	Section 4.3.3
Observation	Observer data collection sheet	Completion Rates Section 3.7.1.2	Section 4.4.1
		The number of errors Section 3.7.1.2	Section 4.4.2
	Video capture	Filming participants' behavior and talk Section 3.7.1.2	Section 4.4.3
Think-Aloud Protocol		Participants' talk Section 3.7.1.3	Section 4.4

Table 3.1: Overview of Collection Methods

3.7.1 Data Collection Techniques

Selecting an appropriate data collection technique is an essential step in research (Marczyk, DeMatteo & Festinger, 2010). First, it is an important integral aspect of research design and methodology. Next, by selecting an appropriate, researches can collect more reliable and valid data for exploring the relationships between various independent and dependent variables, and for answering research questions (Marczyk et al., 2010). The present study adopted three data collection techniques, think-aloud protocol, observation, and questionnaire (see Figure 3.2). These techniques are discussed and compared with other data collection techniques in the following subsections.

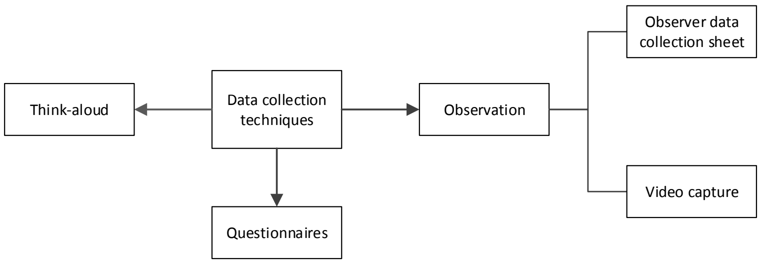


Figure 3.2: Data Collection Techniques

3.7.1.1 Questionnaire

A questionnaire is a printed list of questions that crystallises participants' thoughts on a target or product item. Questions can be either closed and open. Closed questions provide quantitative data, since participants select the most appropriate response from a number of provided alternatives. Open questions offer qualitative data, which is gathered by asking participants to write their answer. The advantage of questionnaires is their rapid, cheap provision of opinion feedback.

In this study, all participants were assigned two questions. Participants first completed a background questionnaire, which provides relevant historical information. Such demographic information assists researchers in understanding the participants' background, experience, attitudes and preferences that may influence their execution on the tasks (Rubin & Chisnell, 2008). The latter consists of two parts: a closed rating for ranking agreement with the statements on the usability criteria of both devices, and some open-ended questions requesting participants to supply reasons for their choices. The semantic differential asks to select the degree to which they agreed with one of two adjective pairs on a 7-point scale (Rubin & Chisnell, 2008, p 197). In closing semantic differential, participants selected a number between the terms such as "Complex" or

“Simple”, “Confusing” or “Clear”,“Unfamiliar” or “Friendly” and other item pairs, depending on their extent of feeling towards the tablet and the smart-phone.

3.7.1.2 Observation

Observation is another efficient way by which researchers gain insight into users behaviours (Marczyk et al., 2010). Observation in usability testing can be either unobtrusive with no intervention, or obtrusive in which test moderators interact with participants. For this research, unobtrusive observation is used, because we wanted the participants to preform their tasks in natural manner and at their desired pace.

The quality of the participant experience is assessed by two usability metrics; completion rates and number of errors. The former was recorded as binary metric (Task Success = 1, Task failure = 0). For evaluating the number of errors, the moderator recorded any unintended action, slip, mistake or omission made by a participant while performing a task. The same error made by the same participant performing the same task was counted in the score error. Both metrics were reported in an observer data collection sheet. Meanwhile, the participants’ interaction with the touch-screen devices and their verbal interjections (Think-aloud protocol) were captured by the recording system. Following the test plan, participants were assisted when they became stuck on a task.

3.7.1.3 Think-Aloud Protocol

The think-aloud protocol is typically adopted in professional usability tests (Molich, Ede, Kaasgaard & Karyukin, 2004; Kallio & Kaikkonen, 2005). This protocol directly captures users’ thoughts while working (Rubin & Chisnell, 2008; Olmsted-Hawala, Murphy, Hawala & Ashenfelter, 2010). It can prove valuable for identifying usability issues in system design and provides the detailed insight into problems encountered during users interactions. (Jaspers, 2009). Think-aloud protocols are of two types; concurrent and retrospective. In concurrent think-aloud evaluations, users are encouraged to speak verbally express their thoughts, feelings and opinions while working on tasks. Granted permission, the researcher can record and analyse users' thoughts and feelings to their thoughts and feelings to assess participants' actual experience of working on a task; how they interpret the items shown on the computer screen; and any problems encountered during the tasks(Ericsson & Simon, 1980; Olmsted-Hawala et al., 2010). Concurrent think-aloud assists researchers to gauge whether the interface matches the natural way of a user's thinking and acting, and to identify where improvement is needed (Kallio & Kaikkonen, 2005).

One disadvantage of this protocol is possible increase in interruption: some participants find the technique unnatural and distracting (Rubin & Chisnell, 2008, p. 243). Moreover, if the experimental variable is the time to task completion, the protocol may be inappropriate because it could significantly slow the user's performance (Rubin & Chisnell, 2008, p. 92).

Retrospective think-aloud is an alternative means of obtaining participants' thoughts (Rubin & Chisnell, 2008). During testing, moderators record notes about issues, questions and concerns raised by participants. At the completion of the test, the moderators discuss the issues related to the participants' recorded. A benefit of this approach is its decreased reactivity during a session. Unlike concurrent method, participants in retrospective think-aloud can fully execute tasks without interruptions (van den Haak, De Jong & Jan Schellens, 2003). Furthermore, retrospective think-aloud does not affect the time required to complete a task, which is beneficial if task completion time is one of the measured variables (van den Haak et al., 2003).

A serious disadvantage of retrospective think-aloud is the time required to review the recording from the beginning. Review consumes more time than the session itself (Rubin & Chisnell, 2008). Also, it also provides participants with the opportunity to modify their thoughts rather than simply express what actually happened and why. For instance, participants may concoct some thoughts to fill memory gaps during later discussion with the moderators (Rubin & Chisnell, 2008; van den Haak et al., 2003).

After comparing both think-aloud protocols, we selected concurrent protocol for the following reasons: First, this study is a small-scale research, and session timing is a limiting factor. If retrospective think-aloud was used, the session time might extend to beyond one hour, increasing the difficulty of recruiting participants and arranging the testing time. Next, measuring time to task completion is not evaluated in this study. A more important concern issue is that participants may easily forget specific events that occurred during the session. In particular, the subjects of this study are over 60 years old, and their memories may be in varying states of decline. Therefore, for the purposes of this study, concurrent is more appropriate than the retrospective think-aloud protocol.

3.8 Data Processing

Almost all studies, quantitative or qualitative, require some form of data collection, entry, and summary (Marczyk et al., 2010, p 199). Data provides the information by which researchers describe phenomena, predict events, identify and quantify the differences between conditions, and establish the effectiveness of interventions. Therefore data processing requires careful attention. An appropriated data processing technique protects the confidentiality and security of personal data. Clearly, data processing is an important step in research.

Typically, data processing involves compiling, summarizing and analysing data, enabling researchers to remove clutter and observe larger trends and patterns (Rubin & Chisnell, 2008, p 246). Compiling data refers to placing the collected date into a data collection sheet so that patterns become obvious. After compilation, the data is transformed from the data collection sheet onto summary sheets. By gathering the data, researchers obtain basic information on the testing procedure; what participants did well and where they lacked competently. These aggregated data also allow researchers to detect differences in the performance of different groups, such as young and elderly, or differences in the performance of different products. Analysing date refers to interpreting the data using statistical procedures (descriptive statistics and inferential statistics) and examining the relationships between variables (causal relationships). From the analysed data, the researcher answer the questions posed. The data processing in this research followed above three steps.

The procedures for each of these steps are summarised below:

Step 1: All the data collected were recorded in a data collection sheet. At the end of each session day, the moderator transferred the handwritten notes into a Microsoft Word file. A digital video file (.wmv file) that recorded the staring and ending time of each session, errors made by each participant, and each participant's spoken thoughts were transcribed to another Word file.

Step 2: The collected data were divided into performance data and preference data. Performance data were collected from the video file and the observer data collection sheet (ODCS), calculated in Microsoft Excel and expressed in percentage, mean and mix format. Preference data were extracted from spoken thoughts, the pre-test questionnaires, and the post-test questionnaires. For limited-choice questions, individual questions and rankings were summed and the average scores compared for each item. For open-questions and think-aloud responses, all questions and all answers provided by participants were grouped into meaningful categories. For example, the summation of all positive and negative references to a particular screen or particular section of a Word file section.

Step 3: All the data sets were collated in tables, where they were compared, grouped, and summarised by statistical procedures. This step is explained in more detail in the following chapter.

3.9 Being An Effective and Unbiased Moderator

The test moderator plays a critical role in usability testing, being ultimately responsible for preparing the test documents and scripts, participant arrangements and apparatus prior to testing, greeting the participants and obtaining informed consent from them (Snyder, 2004; Rubin & Chisnell, 2008, p. 45). During the test, the moderator must monitor the participants throughout their tasks, collect data, assist and probe. Especially, when participants become stuck on a task, assistance should be available so that participants can proceed to the next task (Rubin & Chisnell, 2008, p. 47). After the test, the moderator must collate the data collection, and ensure that testing is consistent with the test objectives (Rubin & Chisnell, 2008, p. 47).

Because *“an ineffective moderator can negate the result and even waste much of the preliminary preparation work”* (Rubin & Chisnell, 2008, p. 52), Snyder (2004) suggested that a moderator should act *"like a duck –serene on the surface, but paddling like heck underneath”*, and the best moderators should have *“a lot in common with an orchestra conductor”*. Moreover, Barnum (2010) suggested that moderators should develop a “to-do” lists for themselves, reminding them pg their responsibilities before, during and after each test session. Based on the check-list in Barnum's book, we have developed an own "to-do" lists for this test.

3.10 Tasks

To provide a realistic experience on multi-touch devices, we simulated a pervasive healthcare system on a tablet and a smart phone through a graphical user interface in this testing. The experiments were scheduled in a controlled, quiet meeting room at Senior net. Although set up as a laboratory, our environment could not provide all laboratory facilities. We decided to concentrate only on the tasks requiring tap and swipe because they are the most essential to operate a touch-screen device (Leitão, 2012). In addition, we also aimed to maintain each test session limited to 60 minutes. We found in our pilot test, that the participant began feeling anxious and tired when session became too long. Therefore, we considered it best to limit our study to a small, but essential, set of tasks to be studied. The task scripts are provided in Appendix E.

3.11 Procedure

In this study, ten participants were involved each in an individual session. Prior to the tasks, participants reviewed the session sheet (see Appendix A) and the participant sheet (see Appendix B). After reviewing the sheets, the participants were asked to sign the consent form (Appendix C), indicating that they had agreed to the conditions of the experiment and allowed the moderator to turn on the web camera. The camera recorded their voices and behaviours while preforming the tasks.

Next, the participants were asked to complete a pre-test questionnaire (demographic questionnaire) given in Appendix D. This questionnaire included multi-touch experience-based questions, preferred multi-touch devices and attitude towards on the devices, as well as the age, gender and educational background of each participant.

Once participants had completed the demographic questionnaire, they were assigned a task script (see Appendix E). Participants were asked to perform the tasks first on the tablet and then on the smart-phone in a single session. As mentioned in the previous section, participants executed two types of tasks (input and navigational) were executed by the participants. For input tasks, the participants were required to locate the healthcare application on the screen and then log into the application. After logging in, the participants were asked to create a fitness profile for themselves. In navigation tasks, the participants were required to find the desired function through the main menu. For example, they were asked to locate the scan barcode function that scans a food item and returns its major nutrients; calories, fat, protein, fibre and cholesterol. Participants then synchronized their fitness profiles and obtained major nutrients to the MyFitnessPal.com account, using the synchronization function. Meanwhile, the moderator encouraged the participants to thinkaloud while working on the tasks and recorded their behaviours and thoughts by a web camera. The completion rates and number of errors made during the tasks were recorded and logged in an observer data collection sheet (see Appendix H).

Finally, participants were required to complete the post questionnaire. The questionnaire consisted of a close rating accompanied by open ended questions (see Appendix F) and a closing semantic deferential (see Appendix G). In the closing rating, the participants were asked to rate the utility task achievement and ease of use of the devices, and state the reasons for their ratings in open ended questions. In the closing semantic deferential, participants were required to select the number that best matched their experience of

"Complex" or "Simple", "Confusing" or "Clear","Unfamiliar" or "Friendly", and other items to consolidate their thoughts about the tablet and the smart-phone. A flowchart of the assessment procedure is provided in Figure 3.3.

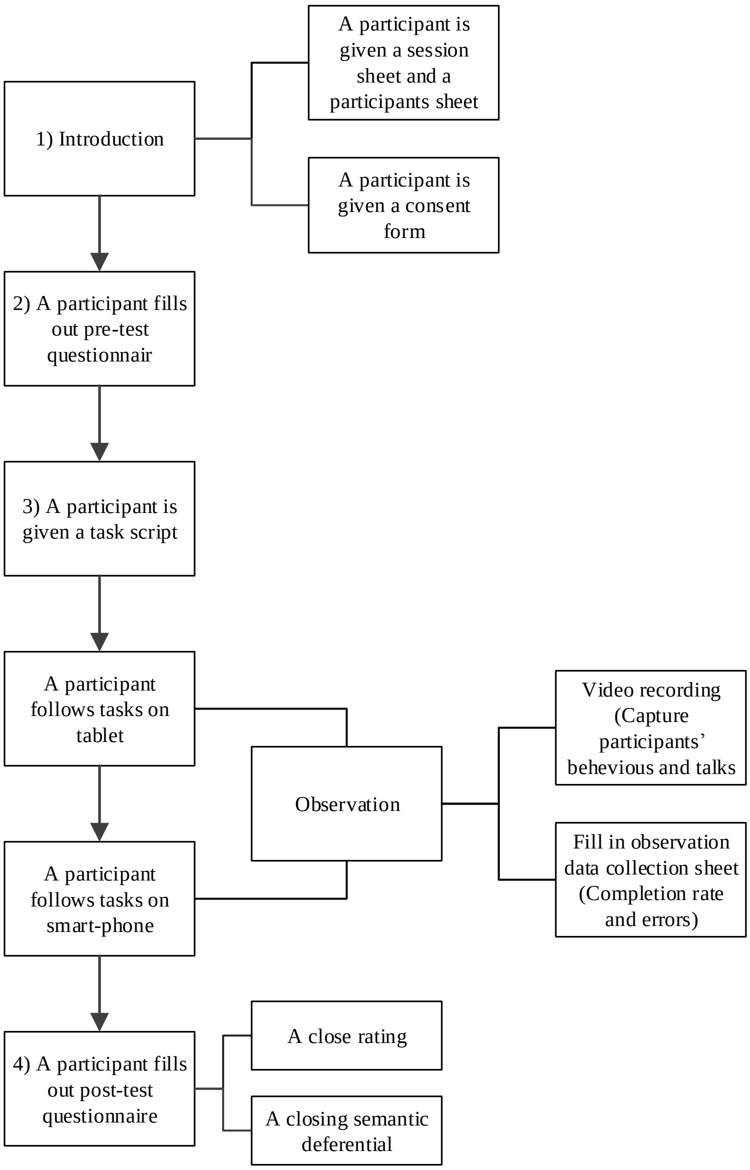


Figure 3.3: Flowchart of the Assessment Procedure (60 minutes)

In summary, this chapter has reviewed the relevant methodologies, research methods and collection methods. After reviewing, we adopted the controlled environment experiment as the methodology and side-by-side comparison assessment as the usability testing method in this study. Data are provided from questionnaires, observations and a concurrent think-aloud protocol. This chapter also presented the procedures of the session, participants recruitment, apparatus and data processing, as well how to be an effective and unbiased moderator.

Chapter 4

Findings and Analysis

4.1 Introduction

The chapter represents the findings of the research in four sections as shown below:

- 4.2 Pre-test Questionnaire
- 4.3 Post-test Questionnaire
    - 4.3.1 Part A - Closing Ratings
    - 4.3.2 Part B - Open-ended Questions
    - 4.3.3 Part C - Closing Semantic Deferential
- 4.4 Observation
    - 4.4.1 Completion Rates
    - 4.4.2 Number of Errors
    - 4.4.3 Video Recording
- 4.5 Concurrent Think-Aloud

4.2 Pre-test Questionnaire

Each participant was asked three demographic questions and seven questions about their previous experience with multi-touch devices. The pre-test questionnaire is shown in Appendix D. The percentage and number of the participants are indicated by the following symbols.

- **%:** Percentage of participants who selected an answer to a question;
- **# :** Number of participants who selected an answer to a question.

4.2.1 Age, Gender and Education Status of Participants

The participants ranged from 65-79 years old (average age: 71.9 years old). Therefore, all participants met the pre-specified age criterion (at least 60 years of age). Seven participants obtained high school diploma and two have bachelor degrees. The remaining participants gained no qualifications. The sex ratio of the participants was 6:4 (female and male).

4.2.2 Participant's Experiences

Attitude towards Multi-Touch Devices (Q4, Q5, Q6)

As shown in Table 4.1, 60% of participants own their own multi-touch device, but all of the participants have previously used multi-touch devices through the computer courses offered at SeniorNet. Regarding attitude towards multi-touch device, 60% (6) participants were comfortable with the devices, the remaining 40% (4) are neutral towards them. Notably none of the participants ticked the disagree or strongly disagree options, implying that no participant held a negative attitude towards on multi-touch devices. Referring to the preferred type of multi-touch devices, all participants would rather possess an iPad than a smart-phone.

Question 4: Do you own a multi touch device?		
	Yes	**No**
	% (#)	**% (#)**
Participants	60% (6)	40% (4)

Question 5: Do you feel comfortable using multi-touch devices?					
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
	% (#)	**% (#)**	**% (#)**	**% (#)**	**% (#)**
Participants	20% (2)	40% (4)	40% (4)	0% (0)	0% (0)

Question 6: What types of multi-touch devices do you prefer?		
	Tablet (iPad, Surface, etc.)	**Smart phone (iPhone, HTC, etc.)**
	% (#)	**% (#)**
Participants	100%(10)	0% (0)

Table 4.1: Responses to Q4, Q5, and Q6

Previous Experience with Mobile Application on Multi-Touch Devices (Q7)

Table 4.2 summarises the various activities that participants had previously performed on multi-touch devices. All four activities had been performed in equal proportion. Half of the participants had received emails on the touch-screen devices, and half had used touched devices to electronic calendar, conducting on-line banking or remind of an appointment.

Question 7: Do you have experience with multi-touch decides?	
	Participants % (#)
Receiving e-mails	50%(5)
Electronic calendaring	50%(5)
Online banking	50%(5)
Reminder	50%(5)

Table 4.2: Responses to Q7

Time Spent Using Multi-Touch Devices in One Week (Q8)

Table 4.3 below summarises the time expenditure per week on multi-touch devices. 50% (5) of the participants spent less than one hour per week on them, and 20% (2) used them for 1-2 hours. The remaining participants 30 % (3) do not use the devices on a weekly basis.

Question 8: How many hours do you use a multi touch device in a week						
	$<$1hr	1≤2hrs	3≤5 hrs	6≤8 hrs	≥8 hrs	NA
	% (#)	% (#)	% (#)	% (#)	% (#)	% (#)
Participants	50% (5)	20% (2)				30% (3)

Table 4.3: Responses to Q8

Managing Health Care with Multi-Touch Devices (Q9)

Managing health care with touched devices includes tracking food intake and calorie consumption, obtaining wellness tips, checking symptoms to common ailments, and finding doctors and scheduling appointments. All participants expressed willingness to use the devices to manage their health status (see Table 4.4). This result accords with earlier research documented in Section 2.4, which indicated that older users can develop positive attitude towards technology if the technology delivers benefits (Broady et al., 2010).

Question 9: Are you willing to use mobile healthcare apps for managing your health care?					
	Tracking food intake	Tracking calorie consumption	Obtaining wellness tips	Checking symptoms for common ailments	Finding doctors and scheduling appointments
	% (#)	% (#)	% (#)	% (#)	% (#)
Participants	100% (10)	100% (10)	100% (10)	100% (10)	100% (10)

Table 4.4: Responses to Q9

To sum up, although not every participant owns a multi-touch device, all participants had performed various activities by touch-screen through the courses offered by SeniorNet. The majority of participants expressed positive attitude towards the multi-touch devices, as evident from Tables 4.1 and 4.4. Moreover, over 70 % of the participants use these devices on a weekly basis. Prior to testing, all participants considered that a tablet better suited their needs than a smart-phone.

4.3 Post-Test Questionnaire

The post-test questionnaire of closing ratings comprise of three ratings and three statements for both of the tested multi-touch devices. Ranking was performed on a 5 point Likert scale (see Appendix F). The Part A of the questionnaire reported overall feedback from the participants after using the devices. The data were analysed in Excel, and the findings are presented in Section 4.3.1. To interpret the tables, the following labels were assigned.

- **%:** Percentage of participants who rated a question;
- **T:** Tablet
- **S:** Smart-phone

4.3.1 Part A-Closing Ratings

The percentages of participants who rated each multi-touch device as useful, able to accomplish tasks and ease of use are listed in Table 4.5. 80% of the participants strongly agreed that the tablet was a useful device. The remaining 20% agreed that the tablet was a useful device, and no participant rated the tablet as neutral or unhelpful. On the other hand, 20% of the participants (10% strongly agreeing and 10% agreeing) rated the smart-phone as useful. Of the remaining 80%, 20% of the participants neither agreed nor disagreed, 40% strongly disagreed and 20% disagreed. In task performance, 70% of the participants (30% strongly agree and 40% agree) considered that they could perform all expected tasks on the tablet, while 20% participants disagreed. The remaining 10% of participants rated the tablet as neutral. 70% of participants recorded that they could not accomplish the tasks using the smart-phone, 30% of participants recorded otherwise. Regarding ease of use of the multi-touch devices, 80% participants rated “strongly agree and agree” for the tablet, while only 20% assigned those ratings to the smart-phone.

Level of Agreement	**Strongly agree**		**Agree**		**Neither agree nor disagree**		**Disagree**		**Strongly Disagree**	
Participants	**%**		**% (#)**		**% (#)**		**% (#)**		**% (#)**	
Devices	**T**	**S**	**T**	**S**	**T**	**S**	**T**	**S**	**T**	**S**
Useful	80%	10%	20%	10%	0%	20%	0%	40%	0%	20%
Accomplishing tasks	30%	10%	40%	20%	10%	0%	10%	60%	10%	10%
Ease of use	60%	10%	20%	10%	20%	20%	0%	40%	0%	20%

Table 4.5: Comparison of Closing Ratings between the Tablet and the Smart-phone

4.3.2 Part B-Open Ended Questions

The following are some qualitative combined findings from the open-ended questionnaire responses concerning the tablet and the smart-phone. The findings are grouped into positive and negative findings.

The positive impressions of the tablet are mainly attributable to its larger display, which enlarges the font size, keyboard, and finger size icons so that they are easily seen by users (see Table 4.6). Because of the enlarged display, some participants believed that the tablet was more comfortable to visualise and operate, and they could accurately strike the keys. Even P6 demonstrated a desire to learn use of the tablet. At the same time, the tablet received some negative comments. P10 pointed out that the lack of information prevented users from achieving their tasks. Similar comments were expressed by P3, P5 and P6. Second, despite the larger display size of the tablet, some control-buttons are too small for participants with wide fingers. Third, the speed of scrolling when changing dates, location and similar items is too fast. The layout of the buttons or icons proved another obstacle for some participants.

Positive Impressions

- “I like this tablet because of its big screen, big letters, easy application.” - P2
- “Larger keyboard, finger remedy size Icons. Similar to computer visual.” - P3
- “Because of its size, it is more comfortable to see and operate - P5
- “I think I could learn to use this gadget” - P6
- “Keyboard large enough to strike accurately” - P8

Negative Impressions

- “Icons or signs are not clear where to go further” - P5
- “More time needed, practice and knowledge needed.” - P3
- “Not knowing how to use it” - P6
- “Speed of scrolling on changing dates, location. etc too fast” - P8
- “ Lack of information to get tasks achieved“ - P10
- “Too small control. Back, home, edit button badly placed for my fat finger.” - P3
- “I want need to be taught.” - P6
- “Some of the icons had to find or touch” - P10

Table 4.6: Open-Ended Responses for the Tablet

The impressions of the smart-phone were mostly negative. P4 stated that “personally, I find it is ok”. A similar comment was provided by P5: “I think that this smart-phone is very convenient and keeps you in contact with other, allows you to find your way show photos wherever you go”. In fact, both participants had had at least one years experience with a smart-phone. On the other hand, P7 considered that the only benefit of the smart-phone is that it can be carried in the pocket.

The smart-phone received more negative comments than positive comments in. Some participants (P2, P3, P6, P8, and P9) noted that the sizes of letters, digits, and keyboard were main obstacles when using the smart-phone. Moreover, due to the small-size of the display, all operations were very difficult. For example, P5 required ample time to perform tasks, and the small scale of the device was problematic for his shaky hands. Another issue was the ambiguity of the signs, P2 commented that “the signs do not clarify where to go”. Furthermore, the smart-phone was disadvantaged by the layout issue; namely, difficult program layout (P3).

Positive Impressions

- “I think that this smart-phone is very convenient and keeps you in contact with other, allows you to find you way show photos wherever you go.” - P5
- “..., only good to carry in pocket.” - P7
- “I am sure it would be easy to use if playlist using it”
- “Personally I find it is ok” P4

Negative Impressions

- “Small letters, small digits” - P2
- “At first, I need a glasses.” - P3
- “Too difficult to read” - P6
- “Keyboard too small” - P8
- “Size of keys too small“ - P9
- “Too small control. Back, home, edit button badly placed for my fat finger.” - P3
- “Signs are not clear to go.” - P2
- “Layout of program difficult, find keyboard a mystery” - P3
- “The fact that everything is so small, so you take a lot of time to do things and it is bad when you are a bit shaky. Also you need good light to see everything properly.” - P5
- “Not for elderly user” - P3
- “All operation are very difficult.” - P9

Table 4.7: Open-Ended Responses to the Smart-phone

4.3.3 Part C-Closing Semantic Deferential

The participants were asked to use the closing semantic deferential to rank their experiences with both multi-touch devices. Similarly to Section 4.3, the collected data were analysed in Excel. The findings are presented in here.

The mean response to the tablet evaluations is generally greater than 1 (the midway point is 0). This indicates that the participants reacted favourably to the tablet. The ratings for "High tech", "Reliable", "Professional", "Safe", "Durable", "Attractive", and "Quality" were not significantly different between the tablet and smart-phone. However, the tablet received many positive assessments such as "Simple", "Ease of use", "Friendly", "I like", and "Clear", and the mean responses for these items were greater than 1.

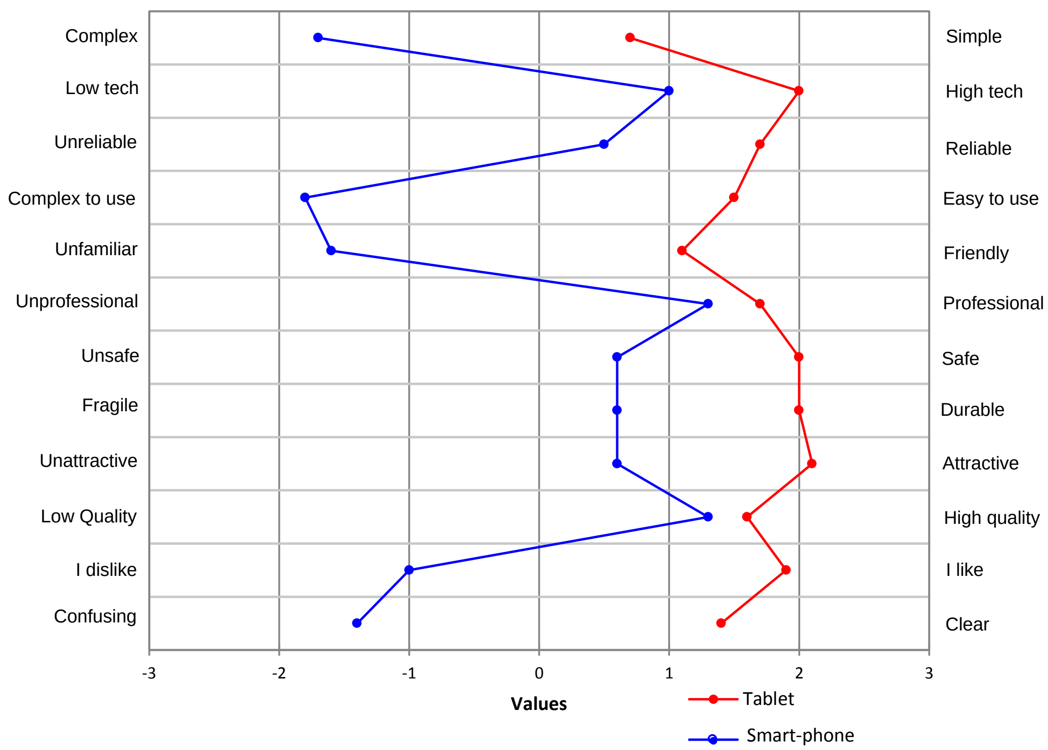


Figure 4.1: Closing Semantic Deferential

4.4 Observation

A separate observer data collection sheet (ODCS) was completed by the moderator while each participant was preforming the given tasks. As mentioned in Section 3.8, the findings were drawn from the raw data that recorded in ODCS and in the digital video files.

4.4.1 Completion Rates

The completion rate of task 1 was significantly different the smart-phone and the tablet. From Figure 4.2 we observe that 80% of the participants completed task 1 using the tablet, versus 40% using the smart-phone. However, the completion rates of tasks 2, 3 and 4 were statistically the same for both devices. The proportion of participants who completed task 2 using the tablet and the smart-phone was 85% and 79% respectively. All participants failed task 3, and only 20% participants completed task 4, regardless of device.

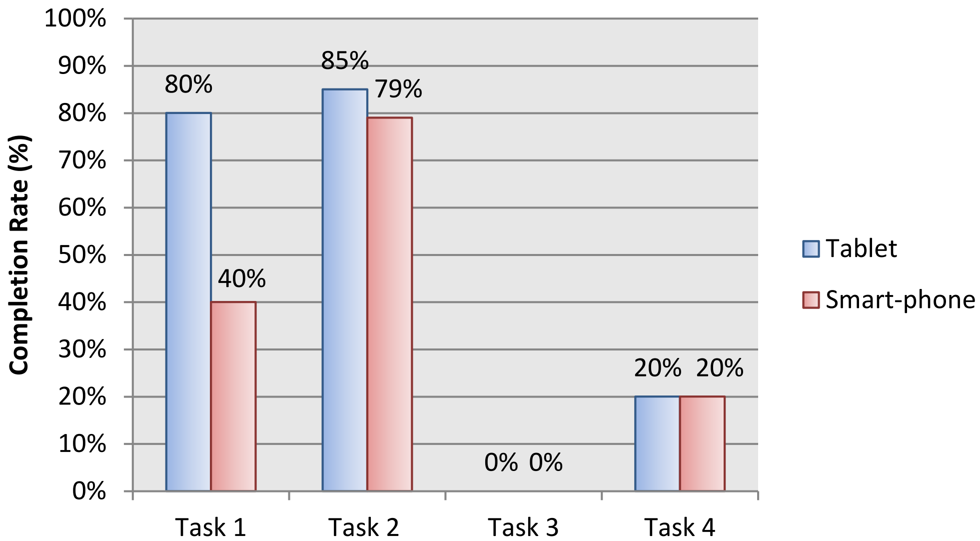


Figure 4.2: Completion Rates (Tablet vs Smart-phone)

4.4.2 The Number of Errors

From Figure 4.3 we observed that the participants made fewer errors when using the tablet than using the smart-phone, regardless of task. For example, when using the tablet to complete task 1, participants made a total of 13 errors, versus 62 when using the smart-phone. Similarly, the number of errors was much lower when participants performed task 2 with the tablet than with the smart-phone. The participants also made fewer errors in tasks 3, and 4, when using the tablet than using the smart-phone.

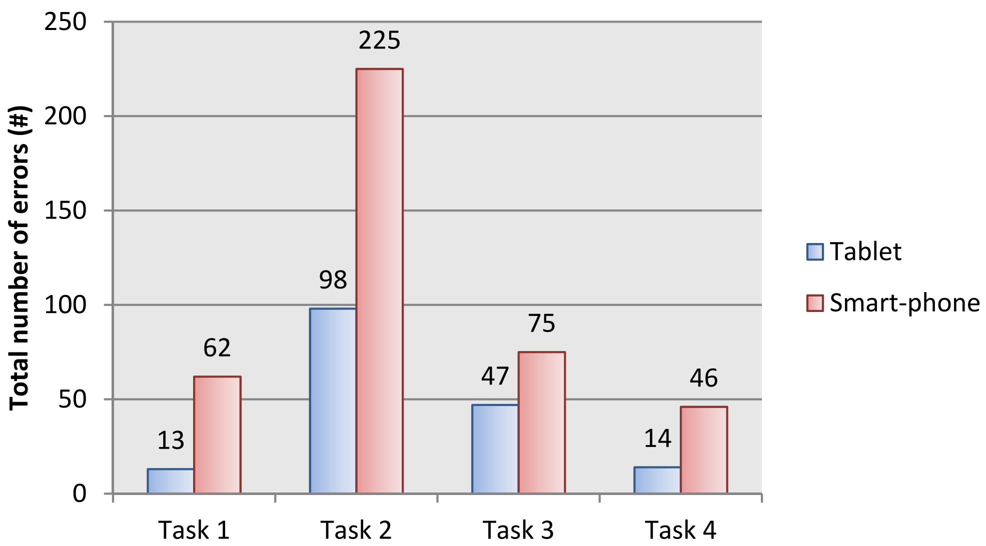


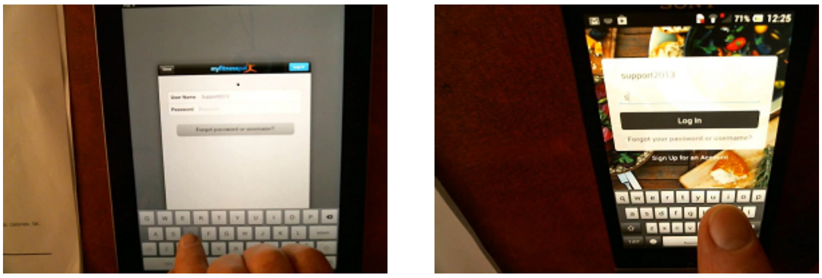
Figure 4.3: Total Number of Errors (Tablet vs Smart-phone)

4.4.3 Video Recording

As mentioned in Sub-subsection 3.7.1.2, the video recoding was conducted to capture the participants' behaviours and verbal expressions to identify any usability problems encountered during the sessions. After analysing the 10 recordings, we categorised the problems into five types as discussed below:

1) Data Entry Problems:

- Compared to the tablet, the participants experienced difficulty tapping small targets present on the smart-phone. For example, on the smart-phone, the participants frequently tapped the keys adjacent to the target keys on the virtual keyboard (see Figure 4.4).



(a) Tablet (b) Smart-phone

Figure 4.4: Virtual Keyboard Size (Tablet vs Smart-phone)

- The participants reported difficulty with moving the cursor to a specific position in the text input area.
- Switching between alphabets and Arabic digits was also problematic for the participants, some of the participants did not know how to perform this activity.
- The speed of scrolling input also degraded users' experience of inputting data onto multi-touch interfaces.

2) Complexity and Poor Visual Design:

- The participants often became lost on the screen and became confused by the various elements on the screen (see Figure 4.5).

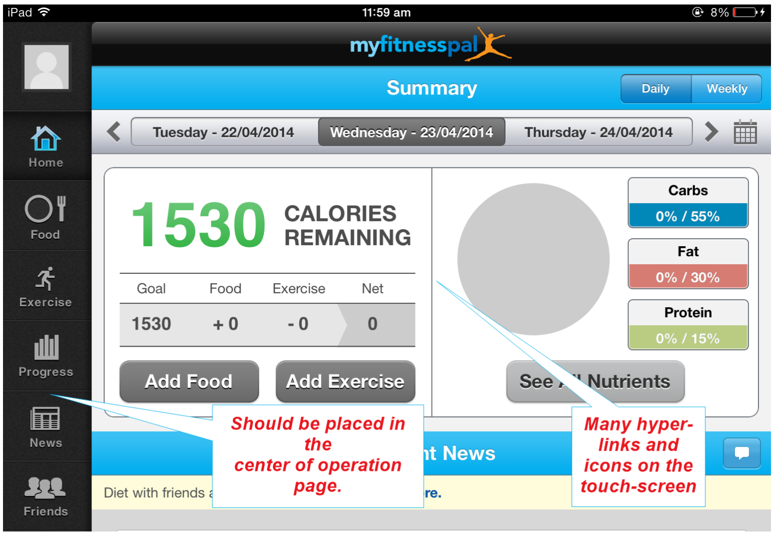


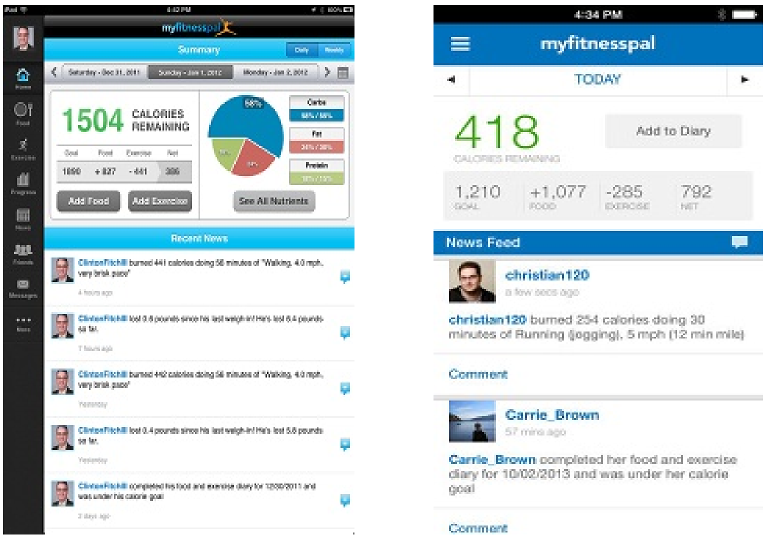
Figure 4.5: Complexity and Poor Visual Design Interface on Tablet

- The participants could not locate the main menu on the screen (see also Figure 4.5).
- The participants did not understand some of the labels appearing next to icons on the screen (see Figure 4.6).

Figure 4.6: "No meaningful icon" Label Appearing on Smart-phone

3) Inconsistency of Information

- The inconsistent interfaces between the tablet and the smart-phone caused concern for the older users evaluated in this study. The participants expressed difficulty in adopting to a new interface (see Figure 4.7)



(a) Tablet (b) Smart-phone

Figure 4.7: Inconsistent Interfaces between the Tablet and the Smart-phone

4) Loss of Cues and Notifying information

- Both devices lacked some useful navigation features and means of conveying information. Some participants complained that the navigational structure was unclear and that they frequently became lost.
- Neither device provided an error notice when a mistake was made.

5) Tactile User Feedback

- The absence of tactile user feedback is a serious consideration. Some participants touched the screen and failed to elicit a response.

4.4.4 Concurrent Think-Aloud Protocol

The participants were encouraged to think aloud during the testing sessions. Their spoken words were recorded and captured as video data. From the spoken data, we identified specific types of problems associated with both devices.

Tablet:

1) Data Entry Problems: some common verbalisations were *"the bigger letters are not only better for eyes, also for understanding. If the letter is bigger, I can read them in a better a way, quickly, easily" "I like multiple choices input rather than direct input and scrolling input methods" "I am looking for the numbers on the keyboard"*.

2) Complexity and Poor Visual Design: e.g. *"Do I have to go to the Face book to login." "I am looking for something like barcodes"*

3) Navigation:

For example *"where is the back button on this" "I am looking for the icon for the task 2, but I couldn't find it" "Food item doesn't give me the key to scan the barcode" "I am completely lost here" "I didn't realized that there is a rear facing camera of the tablet"*.

4) Support Information:

For instance *"there should be a help message which shows how to scan the barcode"*.

Smart-phone:

1) Data Entry Problems: some common verbalisations were *"The keyboard is too small" "where is the keyboard to enter numbers" "it is quite difficult to enter the letters and numbers with the tiny keyboard" "This should be more accurate of scrolling input"*.

2) Complexity and Poor Visual Design: e.g. *"How am I supposed to know what the signal means" "The icons are too small to read"*.

3) Navigation: *"I am looking for the icon for this task" "I did not realize that the sync icon is hidden"*

4) Inconsistency of Information: e.g. *"I didn't realize that the scan barcode button is under the dairy option. It used to be under the food option on the iPad"*

5) Tactile User Feedback: e.g. *"I think I pressed the setting option but did not see that" "The password is on the screen, when I touched the screen, noting happened"*.

To summarise, this chapter has presented the findings of the data collected from the pre-questionnaire, and parts A, part B and part C in the post-questionnaire, as well as the observer date collection sheet, video recordings and the concurrent think-aloud protocol. In the pre-questionnaire, all participants expressed more positive attitudes towards the tablet than the smart-phone. Participants reported similar attitudes in the post-questionnaire.

Analysis of the observational data collection sheet revealed that overall, participants achieved better performance using the tablet interface than the smart-phone interface. However, the enhanced performance was limited to the input tasks, performance on the navigational tasks was device-independent.

The video recordings and concurrent think-aloud protocol provided suggestions for improvement in both devices. Participants expressed problems with data entry, complexity and poor visual design, navigation, inconsistency of information, and lack of support information and tactile user feedback.

Chapter 5

Discussion

5.1 Introduction

This chapter presents the key conclusions drawn from this project. It is divided into two sections. Section 5.2 discusses the research question 1, and Section 5.3 answers the research question 2.

5.2 Threats to validity

In this study, we used an iPad (the "large " device running iOS) and a Sony smart-phone (the "small" device running Android). Although the tablet and the smart-phone run different operating systems, both devices basically work in the same way. Therefore, the participants do not need to use different type of interaction (swipe etc.). The sequence of testing the devices may be seen as another threat to validity. However the participants all had previous experience of tablet and/or smart-phones, so that the novelty of the interaction method was minimal.

5.3 Answering Research Question 1

"Is a multi-touch gesture interface for elderly users better implemented on a smart-phone or a tablet?"

This research investigates whether interfaces can be rendered easier to use, learn, and recall for older users when implemented on a tablet rather than a smart-phone. To answer this question, we compared the smart-phone and tablet as interfaces between older adults. Overall a multi-touch gesture interface was more effective for elderly users when implemented on a tablet than a smart-phone.The number of errors made by the elderly participants significantly differed between the two devices. In subjective ratings and comments, the participants showed their preference to the tablet over the smart-phone. This result is consistent with an earlier study by Caprani et al. (2012) who reported that elderly users generally prefer items which are larger on the screen, making them easier to see and easier to select accurately.

In next section, the findings from Section 4.2, Section 4.3 (closing ratings - Part A, open ended questions - Part B, and closing semantic deferential - Part C) and Section 4.4 are discussed in detail.

5.3.1 Subjective Ratings and Comments

The findings from the pre-test and post-test questionnaire reveal that the participants rated the tablet more highly than the smart-phone. All participants reported that they would rather own a tablet than a smart-phone (Questions 6 in the pre-test questionnaire). This result is consistent with the results of the post-questionnaires. For example, 80% participants assessed the tablet as useful versus 20% participants who evaluated the smart-phone as useful. 70% of the participants expected to perform all allocated tasks on the tablet, while only 30% participants expected to complete all tasks using the smart-phone. Furthermore, 80% of the participants rated the tablet as easy to use, whereas only 20% participants could easily manipulated the smart-phone.

Similarly, the closing semantic deferential also revealed that the participants more favourable attitude towards the tablet than towards the smart-phone. For example, the participants assigned more ratings of “Simple”, “Easy to use”, “Friendly”, “I like” and “Clear” to the tablet than to the smart-phone. Participants also explained their preference for the tablet in open ended questions. The tablet was mainly preferred for its larger screen size, rendering it comfortable to see and operate for some participants. In particular, participants could accurately strike the keys and links on the tablet.

By contrast, “small” size of the smart-phone is almost certainly the main usability limitation for older users. For example, P2, P3, P6, P8, and P9 complained that the small size of letters, digits and keyboard on the smart-phone screen increased the difficulty of operating this device. The author considers that appropriate screen size is an important consideration for elderly users, especially for those with visual impairments. This idea is supported by Leitão (2012) who reported that older users generally prefer bigger targets and separated by spacing. Small texts and tiny icons can prevent older people from effectively interactions with a visual system (Farage et al., 2012) .

However, several negative comments regarding tablet use are worthy of attention. For example, some participants remarked that “while completing some tasks, I often did not know how to reach a specific function”. In fact, the lack of support and unclear instructions were responsible for the low completion rates in tasks 3 and 4 for both devices (see Figure 4.2). This results highlights navigation as another important factor in developing touch-screen devices for the older age group, and is consistent with an earlier study by Ziefle (2010) who identified that visibility and orientation as prominently important factors of information presentation. However, especially for elderly users, a proper navigation setup may be more important than visibility.

We also noticed a difference between participants' rankings and their achievement when actually performing tasks. Subjective ratings may not provide an accurate usability measure because users tend to give generous scores even when they experiencing marked difficulty with a design. In addition, users are frequently poor judges of their own performance (Nielsen & Loranger, 2006). Thus, to strengthen analysis and draw appropriate conclusions, we must evaluate the observer data collection sheet. This is achieved in the next section.

5.3.2 Completion Rates and Number of Errors

Among the participants, completion of task 1 was significantly higher when performed with the tablet than with the smart-phone (80% versus 40%; see Figure 4.2). The high success rate of the tablet is likely imperturbable to its larger size, enabling easy manipulation by the older participants. Supporting this idea, Jin et al. (2007) reported that user performance is enhanced by larger target and spacing. The completion rates of task 2 are also interesting. As indicated Figure 5.1, participants successfully completed the input subtasks of task 2 on both devices, but struggled with the navigational subtask 1. These results suggest that participants have effectively learned the input task by preforming task 1. Similarity, Jayroe and Wolfram (2012) and Loureiro and Rodrigues (2011) who reported that touch-screen devices are easy of use and learn, even by older users who are unfamiliar with new technology or experience age-related problems.

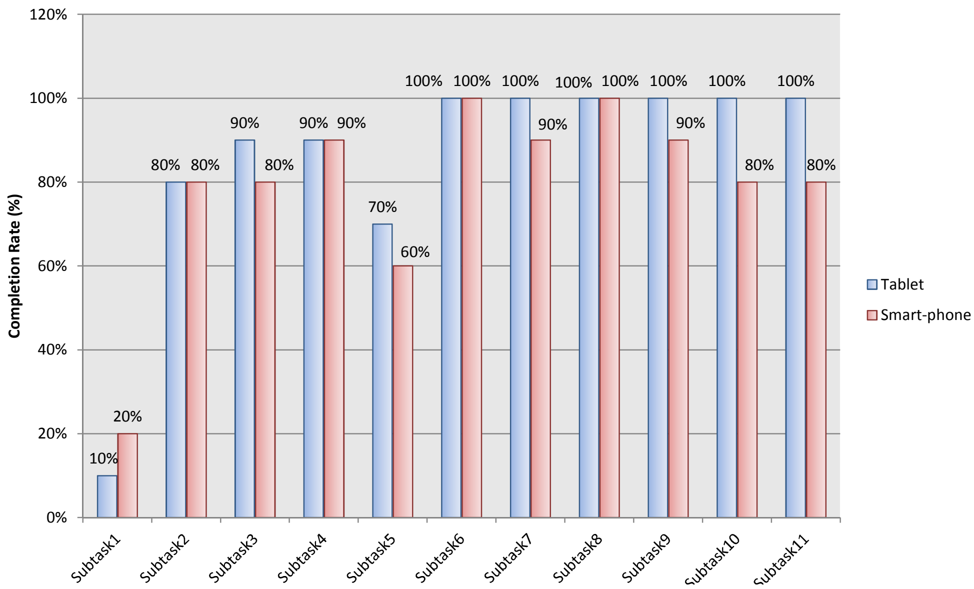


Figure 5.1: Task 2 Completion Rate

However, those claims that touch-screen devices are easily learned and manipulated by older adults were only partially supported by this study. Figure 4.2 in Section 4.4.1 reveals that all participants failed task 3, and that only 20% participants completed task 4, regardless of device. Therefore, our participants could not successfully complete navigation tasks on touch-screen devices. It appears that input tasks are easier to implement and learn than navigation tasks, at least in this study. As mentioned in subsection 5.3.1, the navigation issue should be considered as at least important as visual effects.

The total number of errors was higher when participants used the smart-phone than when they used the tablet. For example, in tasks 1, the number of errors was almost five times less when performed with the tablet than with the smart-phone (see Figure 4.3). Figure 5.2 compares the number of errors in tablet and smart-phone use in task 2 broken into its constituent subtasks. All subtasks were more easily performed with the tablet than the smart-phone, but the most remarkable effects are seen in subtasks 4, 5, 6, 7, 9, 10, and 11.

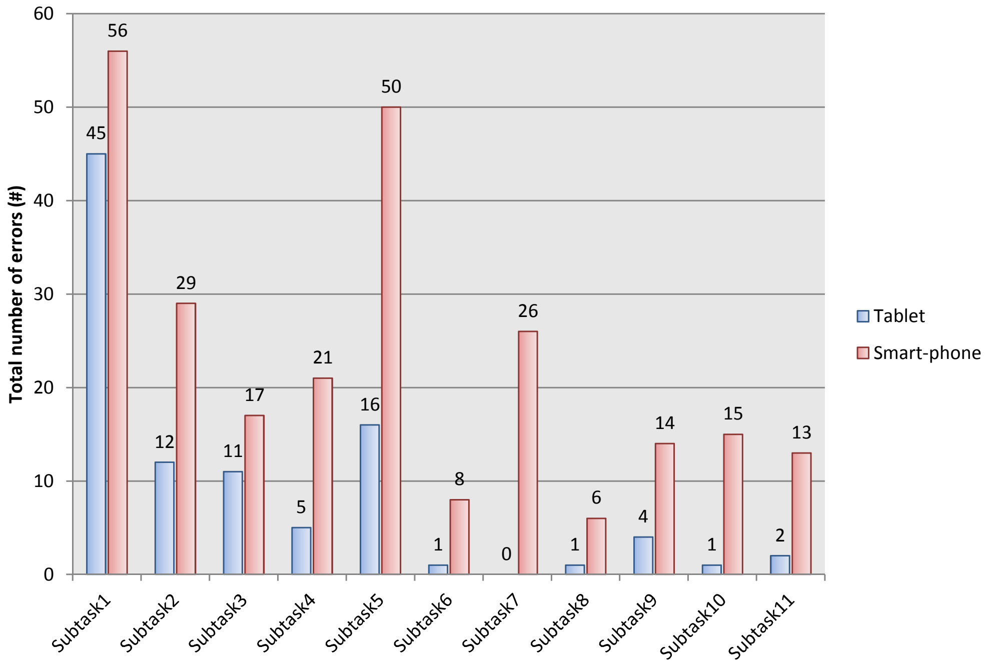


Figure 5.2: Task 2 Errors

The author considers that text and digits are more easily seen and input to the larger display screen of the tablet. More specifically, the participant could more easily and accurately strike the virtual keyboard on the tablet, thereby minimising their typographical inadvertent touching errors.

Moreover, disorientation in the menus of devices was a frequent problem, especially for older users or those with few computer-related skills. At the first glance, the problem appears to be related to be visibility and readability (Omori, Watanabe, Takai, Takada & Miyao, 2002), but was found to be also related to the cognitive aspect of information display, that is, users orient themselves by how the information is presented.

In this study, the menu functions on both devices are organized in a hierarchical tree structure. To locate the desired function in deeper menu levels, participants needed to decide at each point which of the alternatives likely leads to the goal. If more menu items could presented at any one time, the participants could effectively locate the desired function. However, we observed that because screen space on the smart-phone is strictly limited, some menu items are hidden in deeper menu levels or at the bottom of the screen (see Figure 5.3). Consequently, the participants lacked guidance on reaching the desired function and became lost in the menu, clicking the screen at random, such disorientation may have accounted for the high error rate when using the smart-phone to perform tasks 3 and 4. As stated by Phiriyapokanon (2011), a clear navigational structure not only reduces the complexity of application and errors, but also reduces attention load, and thereby improves product usability for older users.

Figure 5.3: Hidden Menu Items on the Smart-phone Interface

5.4 Answering Research Question 2

"What problems arise during the usability testing and how should we design interfaces that are accessible to older adults?

Combination the findings of the open-ended questions, concurrent think-aloud protocol and video recordings, we categorised the usability problems into five types: data entry problems, complexity and poor visual design, inconsistency of information, lack of cues and support information, and lack of tactile feedback. This result is supported by Norman and Nielsen (2010) and Stößel et al. (2010) who reported similar usability problems that are needed to be considered when designing the older user experience of multi-touch interfaces.

Data Entry Problems:

Tapping small targets was identified as a major problem when using the smart-phone. Participants frequently failed to tap the proper key or icons on the smart-phone's virtual keyboard. Some participants reported that the letters, digits, and keyboard on the smart-phone were so small that all operations were rendered difficult for them.

Second, some participants reported difficulty moving the cursor to a specific position in the text input area on both devices. Unlike a computer mouse, the target zone of the cursor is one pixel. Targeting a specific single pixel with a finger is nearly impossible (Bachl et al., 2010).

Third, the speed of the scrolling input degraded user experience of inputting data to multi-touch interfaces. The participants needed several attempts before obtaining the correct numbers. This is because the movements of aged people are approximately 1.5 to 2 times slower than those of younger adults (Pak & McLaughlin, 2010).

Lastly, as reported by Norman and Nielsen (2010) gesture-interaction is far more prone to accident activation than input interfaces such as a mouse since gesture interaction responds to inadvertent touching by wrists or knuckles. In this study, inadvertent touching was a common source of error on both devices. For example, when one participant was editing a unit preference, inadvertent touching caused unexpected pop-up of a message box.

To resolve the above, we proposed several recommendations. First, we suggested that larger target (finger-sized) can be used on smart-phones (Dandekar, Raju & Srinivasan, 2003; Anthony, 2012) when designing interfaces for older users. This idea is supported by (Anthony, 2012; Park, Han, Park & Cho, 2008) who reported that the number of errors decreased as the touch target size increased. In addition, when such targets are manipulated by older users, haptic output and/or auditory tones should be provided as the appropriate feedback to confirm interaction (Koskinen, Kaaresoja & Laitinen, 2008; Hoggan, Brewster & Johnston, 2008; Hoober & Berkman, 2011; Lee & Zhai, 2009).

Regarding to the speed problem in the scrolling input method, Pak and McLaughlin (2010, p 96) suggested that users could alter the response time of scrolling input in the operating system settings, provided that they first understand this relatively advanced feature.

Unintentional touching is another limitation of touch-screen devices. To solve this problem, IBM (2011) has installed a new and unique feature called "Unintentional Touch" on its products. It allows users to select the appropriate sensitivity for the touch panel. Users can choose among light (only very light touches are rejected), medium (light touches are rejected), hard (light and medium touches are rejected). Although this feature may not directly apply to the touch-screen devices investigated in this study, it provide potential guidelines when designing interfaces for older users. In addition, a "Back" or "Undo" button would allow user to recover from inadvertent activations, such as accidental selections, or checking of boxes (Norman & Nielsen, 2010).

Complexity and Poor Visual Design:

The usability of both devices was restricted by complexity and poor visual design. Complexity was introduced by hyper-links and icons on the touch-screen, which frequently overwhelmed and disoriented participants. Thus, simplicity is an important consideration when designing interfaces for older users. Supporting this idea, Fisk et al. (2009) and Pak and McLaughlin (2010), highlighted the need to avoid clutter and non-relevant information that may distract older users from their task. Moreover, reducing the number of options can compensate the reduction of elderly user's working memory and also reduce their responding time in preforming tasks.

Regarding to poor visual cues, we observed that the main menu located at left of the screen was largely ignored by the participants. To alleviate such problems, we propose a high contrast ration (50:1) on the interfaces of the touch-devices for elderly users. Maximum contrast is provided by on a background, or vice versa. Second, important elements such as menus, icons or links should be presented in bright or striking colours such as like red, orange and yellow to draw attention from users.

The lack of intuitive symbols is another visual limitation of touch-screen devices. Replacing words with symbols as navigation tool or buttons may be appropriate for inherently small devices such as smart-phones, but if these symbols lack meaning, they create additional usability problems. During the testing, some participants reported that they ignored obscure symbols on the smart-phone device. Such obscure symbols should be avoided when designing interfaces for elderly users. Finally, 12-point x-height fonts and serif or sand serif font types are recommended for older adults with visual declines (Fisk et al., 2009).

Inconsistency of Information

Inconsistency between the tablet and the smart-phone is especially problematic to elderly users. Some participants reported becoming confused by different layout, label-text, and icons on the tablet and the smart-phone. For example, in task 3, the participants were required to scan the barcode of a food item. First, they needed to find the barcode scanning function in deeper menu levels of each device. However, the required deeper menus were labelled "Food" on the tablet, and "Diary" on the smart-phone. This lack of consistency complicates learning process for users, especially for older users because different knowledge is required for two or more similar devices (Stößel et al., 2010).

Lack of Cues and Support Information

As stated in Subsection 5.3.2, navigational problems are important and require serious attention when displaying information in touch-screen devices to older users. A clear structure of navigational not only reduce the error rate and the complexity of applications, it also reduces the attention load, and improves product usability. For example on the tablet, the main page of MyPalFitnessis crowded with many attention points and links to another pages, requiring more cognitive switching than some older users can accommodate. As mentioned in the literature review (Gregor & Dickinson, 2007; Fisk et al., 2009; Farage et al., 2012; Pak & McLaughlin, 2010) loss of working memory among older adults effects many daily cognitive activities such as reasoning, problem solving and speech. Thus, we recommend that the reduction of information load and in-memory transformation to compensate navigational problems for elderly users.

Second, usability could be improved for elderly users by installing wizards that simplify complex tasks. In task 3, the participants were required to locate the barcode scan function in a deeper menu, and then click the button to begin the scan. If supporting information such as wizards appeared, we anticipate the user performance would improve.

Lack Tactile User Feedback

Unlike traditional interfaces, for example, a keyboard that controls a mobile phone, users receive haptic and acoustic feedback ("press") on whether the finger contacts at the correct place, time, sequence, and speed, and with the right pressure. Such feedback is lost on touch-screen interfaces (Doyle et al., 2010; Stößel et al., 2010; Bachl et al., 2010). In this study, the participants commented that *"I think I pressed the setting option but did not see that" "The password is on the screen, when I touched the screen, nothing happened"*, these experiences are related to pressing an incorrect place on the touch-screen. If provided with vibrational and acoustic feedback on whether they had located the correct part of the touch-screen interfaces, users could correct their mistakes unaided. This idea has been approved in several studies (Koskinen et al., 2008; Hoggan et al., 2008; Lee & Zhai, 2009), indicating the tactile feedback can improve performance and decrease error rates. Moreover, vibration and acoustic feedback could be combined with other sensory channels, such as message or flashing lights to better convey information to older people with audition impairments (Farage et al., 2012).

To summarise, this chapter answered the two research questions proposed at the beginning of this thesis, based on the findings reported in chapter 4. Referring to question 1; Overall, the older participants achieved better performance using the tablet than the smart-phone. The participants made significantly fewer errors when using the tablet. The subjective ratings and comments showed that the participants preferred the tablet to the smart-phone. However, while input significantly improved by use of the tablet, navigational tasks were poorly implemented in both devices.

Regarding question 2, this, highlighted several pertinent problems with touch-screen devices. The most serious concerns in both devices are data entry problems, complexity and poor visual design, inconsistency of information, lack of cues and support information, and lack of tactile feedback. Having identified these problems, the author proposed recommendations for improving the interaction between older users and touch-screen devices.

Chapter 6

Conclusion and Future Study

6.1 Conclusion

In this study, the participants preformed several tasks on a tablet and a smart-phone and evaluated the usability of both devices in the questionnaires. Overall the participants achieved higher task performance on the tablet than on the smart-phone interface. This result was attributable to the improvement in input tasks; Performance on the navigational tasks was not significantly different between the devices. We identified navigation as a serious consideration when designing interfaces for older users.

Overall this study has achieved both objectives stated in the original proposal submitted by the researcher, first, that interface is easier to use, learn and remember for older adults when implemented on a tablet than on a smart-phone. Second, that recommendations could be established once the difficulties and problems encountered by participants during testing became known. These recommendations will assist the design of touch-screen interfaces for elderly users, especially when re-designing smart-phones for an ageing population.

6.2 Future Study

Our research revealed that a tablet can make interfaces easier to use, learn and remember for older adults. However, in navigation tasks, the tablet preformed as poorly as the smart-phone. In this context, it would be interesting to redesign the application, and repeat the test, adopting optimal input methods, a clear navigational structure of navigation and good visual icons.

Second, a health survey (SF-36) (see Appendix K) should also be used to categorise user types in future study. Irwin and Sesto (2012) evaluated performance and touch characteristics of individuals with and without a movement disorder during a reciprocal tapping touch screen task. They found that timing and error rate were affected by motor control disabilities, those with movement difficulties had less accuracy with aiming and a longer deceleration phase. The result of this study is consistent with other studies such that of K. B. Chen, Savage, Chourasia, Wiegmann and Sesto (2012) who compared touch screen performance by individuals with and without motor control disabilities. These findings highlight the need for study to examine varying health status of participants as presence and type of disability may affect some touch characteristics. Also, more investigation is needed to understand the trends and problems we encountered. Are they cause by physical and cognitive disabilities such as attention and memory loss related to aging?

Third, during the study each participants performed two types of tasks that required tap and swipe gestures. Our results showed that older adults were in fact able to quickly learn how to employ tap and swipe to the tasks. However, it would be interesting to assess the learnability of the other gestures that seems to be more complex in further study, such as pinch and spread, tap and hold and double hold.

Fourth, as mentioned in section 2.5, the literature on touch-screen technology acceptance by older users is far from converging. Therefore, we would like to conduct face to face semi-structured in-depth interviews with older users to reveal reasons behind the behaviours and the perceptions that drive touch-screen devices usage. 15 constructs in Table 6.1 as potential factors which could impact the adoption of touch-screen devices usage will be examined. Then the strength of the factors will be computed based on the frequency of comments of each user about the specific factors.

Table 6.1: Constructs and related publications

Construct	*Publication*
Attitude	Bouwman, Carlsson, Molina-Castillo and Walden (2007)
Content	Patrick Rau and Chen (2006)
Cost	Kargin et al. (2009)
Enjoyment	Conci et al. (2009)
Ease of use	Conci et al. (2009)
Simplicity	Fife and Pereira (2005)
Experience	Renaud and van Biljon (2008)
Innovativeness	Gelderblom et al. (2010)
Mobility	Fife and Pereira (2005)
Profession	Scheepers, Scheepers and Ngwenyama (2006)
Social factors	Conci et al. (2009)
Speed	Gelderblom et al. (2010)
Technology	Czaja et al. (2006)
Time-efficiency	K. Chen and Chan (2011)
Usefulness	Wilkowska and Ziefle (2009)
Visual factors	Hsu, Lu and Hsu (2007)

Fifth, although performing usability testing in a controlled environment is certainly less demanding than testing in a real environment, where the workload and interference factors are typically higher, a real environment provides the desired ecological setting that is difficult to simulate in a controlled environment experiment Kallio and Kaikkonen (2005). Therefore, field data might be more reliable and realistic than those collected in a controlled environment experiment.

Finally, regarding the use of concurrent think-aloud protocol in this study, we must consider the limited contribution of the participant's verbalisations to the findings (identified usability problems). We observed that during the testing, most participants remained silent despite being constantly encouraged to talk. Perhaps they did not want to be disturbed by the moderator. Therefore, the methodology could be redesigned to adopt a retrospective think-aloud protocol, enabling participants to preform tasks in their natural manner and at their desired pace.

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Appendix A

Session Introduction

“Thank you for your interest in this research study. My name is Peng Wang. May I have your signed consent form, please? Thanks “During the rest of the session, I’ll be working from a script to ensure that my instructions to everyone who participates in the study are the same.

“I’m here to investigate whether a multi-touch gesture interface based on a tablet is better than a smart phone for elderly users.

“During the session, I will ask you to use a tablet and a smart phone to complete a series of tasks and will observe you while you do them. As you do these things, please try to do whatever you would normally do.

“Please try to think out loud while you’re working. Just tell me whatever is going through your mind. Please know that we’re not testing you, and there is no such thing as a wrong answer. By doing this, you are helping us to understand which multi touch devices are better for elderly users. “The whole session will take about 45 minutes. “Do you have any questions before we begin?

Appendix B

Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced:
14/06/2013

Project Title:
Is a multi-touch gesture interface based on a tablet better than a smart phone for elderly users?

An Invitation
Thank you for your interest in this research study. My name is Peng Wang. I'm here to investigate whether a multi touch gesture interface based on a tablet is better than a smart phone for elderly users. This study will be published as part of my college degree requirements.

If you agree to participate in the study, we will arrange a location and time for a 45 minute research session. During the session, I will ask you to use a tablet and a smart phone to complete a series of tasks and will observe you while you complete them. You will also be requested to complete a health status questionnaire and a background questionnaire. Please note that all roles are voluntary and you can withdraw at any time prior to the completion of data collection.

What is the purpose of this research?
The purpose of this research is to examine whether, by adopting multi-touch gestures on a multi-touch screen device, pervasive healthcare systems can make interfaces easier to use, learn and remember for older adults.

How was I identified and why am I being invited to participate in this research?
The researched is targeted at older people aged 60- 80 years from different working and educational backgrounds. Participants should also have pervious experience with computers and the internet and at least basic experience with touch-screen devices.

What will happen in this research?
If you agree to participate in this study, you will use a tablet and a smart phone to complete a series of tasks and will be observed while you complete them. First, you will be requested to complete a background information questionnaire and health status questionnaire. You will then perform three categories of tasks on a tablet and a smart phone. The selected task categories are representative of multi-touch devices usage, and involve sign up tasks, daily caloric intake tasks and calories remaining tasks. After completing the tasks, you will be requested to complete a closing rating and a final questionnaire.

What are the discomforts and risks?
There is no foreseeable risk of harm or discomfort in this research. However, you may feel tired toward the end of the session.

What are the benefits?
Older people face unique challenges in interfacing with the pervasive healthcare systems on which they may depend. By participating in this research, you will gain the opportunity to trial tablets and smart-phones and related medical technologies, indicate their advantages and disadvantages, and suggest improvements and new functions that might be adopted in the future. In addition, the researcher will gain valuable practice in the design and implementation of real research.

How will my privacy be protected?

1. You will be fully informed about the nature of the research
2. The records will be kept safely and will be deleted after 10 years.

What are the costs of participating in this research?
You will spend about 45 minutes completing the task.

What opportunity do I have to consider this invitation?
You will be given one week to decide whether to accept this invitation.

How do I agree to participate in this research?
You will receive a consent form during the session introduction.

Will I receive feedback on the results of this research?
The result of this research will be sent to you via e-mail.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Dave Parry, dave.parry@aut.ac.nz, 921 9999 ext 8918.

Concerns regarding the conduct of the research should be notified to the Acting Executive Secretary of AUTEC, Madeline Banda, ethics@aut.ac.nz , 921 9999 ext 8316.

Whom do I contact for further information about this research?
Researcher Name: Peng Wang

Researcher Contact Details:
Researcher Name: Peng Wang E-mail: nonplussed424@msn.com Mobile: 0211089095

Project Supervisor Contact Details:
Project supervisor: Dr Dave Parry E-mail: dave.parry@aut.ac.nz Work phone: 921 9999 ext 8918

Approved by the Auckland University of Technology Ethics Committee on type the date final ethics approval was granted, AUTEC Reference number 12/218

Appendix C

Consent Form

Consent Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project title: Is a multi-touch gesture interface based on a tablet better than a smart phone for elderly users?

Project Supervisor: Dr Dave Parry

Researcher: Peng Wang

- I have read and understood the information provided about this research project in the Information Sheet dated _______
- I have had an opportunity to ask questions and to have them answered.
- I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.
- I agree to take part in this research.

- I wish to receive a copy of the report from the research (please tick one): Yes No

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....
....

Date:............

Approved by the Auckland University of Technology Ethics Committee on 14 October 2013 ***AUTEC Reference number*** 13/218

Appendix D

Demographic Questionnaire

Background questionnaire

Name: ____
Location: ____

General Information

1. Gender

   A. _____ Female
   B. _____ Male

2. Age Group

   A. 60-64
   B. 65-69
   C. 70-74
   D. 75-79
   E. 80+

Education

1. Please tick the highest educational level you have achieved.

   A. _____ Doctorate / Professional (PhD, MD, etc.)
   B. _____ Graduate School (Master, etc.)
   C. _____ University / College (Bachelors, etc.)
   D. _____ Community College (Associates, etc.)

E. _____ High School
F. _____ None of above

Multi-touch device experience

1. Do you feel comfortable using multi-touch devices?

A. _____ Strongly agree
B. _____ Agree
C. _____ Neutral
D. _____ Disagree
E. _____Strongly disagree

2. What types of multi-touch devices do you prefer?

A. _____ Tablet (iPad, Surface, etc.)
B. _____ Smart phone (iPhone, HTC, etc.)

3. Do you own a multi touch device?

A. _____ Yes
B. _____ No

4. In a typical week, how many hours do you use a multi touch device?

A. _____More than eight hours a day
B. _____Six to eight hours a day
C. _____Three to five hours a day
D. _____ Less than one hour a day
E. _____I rarely or never use a multi touch device

5. Do you send or receive e-mails from multi-touch device?

A. _____Always
B. _____Often
C. _____Sometimes
D. _____Seldom

6. Do you have experience with mobile apps such as electronic calendaring, online banking and reminder with multi-touch devices ?

   A. _____Yes

   B. _____No

7. Are you willing to use mobile healthcare apps for managing your health care? With these apps, you can:

   - Find doctors and schedule appointments
   - See lab results
   - Compare prices on drugs and medical services
   - Obtain wellness tips
   - Obtain routing medical advice and check symptoms for common ailments

   A. _____Yes

   B. _____No

Appendix E

Tasks for Tablet and Smart-phone

Tasks (Tablet)

Sign in and Edit profile tasks

1. Please find the application "MYFitnessPal" and Log in
2. Please find "Fitness Profile" and change its unit preferences which are in accordance with the list below:
   - Current Weight (KG)
   - Goal Weight (KG): 70
   - Starting Weight (KG): 80
   - Height: 180 cm
   - Gender: Female
   - Date of Birth: 12/12/1983
   - How Active Are You? Lightly Active
   - Country: New Zealand
   - Time Zone: Auckland
   - Zip/Postal Code: 1644

Daily caloric intake tasks

1. Please scan the barcode of a food item, to track all major nutrients: calories, fat, protein, fibre and cholesterol.
2. Please sync the all local changes.

Tasks (Smart-phone)

Sign in and Edit profile tasks

1. Please find the application "MYFitnessPal" and Log in
2. Please find "Fitness Profile" and change its unit preferences which are in accordance with the list below:
   - Current Weight (KG)
   - Goal Weight (KG): 70
   - Starting Weight (KG): 80
   - Height: 180 cm
   - Gender: Female
   - Date of Birth: 12/12/1983
   - How Active Are You? Lightly Active
   - Country: New Zealand
   - Time Zone: Auckland
   - Zip/Postal Code: 1644

Daily caloric intake tasks

1. Please scan the barcode of a food item, to track all major nutrients: calories, fat, protein, fibre cholesterol.
2. Please sync the all local changes.

Appendix F

Closing Ratings

Closing Ratings (Tablet)

Please rate these statements from 1 (strongly disagree) to 5 (strongly agree) by circling your choice.

1. I thought the tablet was useful.

Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly Agree

Why or why not?

2. I can perform all expected tasks on a tablet.

Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly Agree

What obstacles prevented you from achieving your tasks?

3. Overall, the tablet was easy to use.

Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly Agree

Why or why not?

Closing Ratings (Smart-phone)

Please rate these statements from 1 (strongly disagree) to 5 (strongly agree) by circling your choice.

1. I thought the smart-phone was useful.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

Why or why not?

2. I can perform all expected tasks on the smart-phone.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

What obstacles prevented you from achieving your tasks?

3. Overall, the smart-phone was easy to use.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

Why or why not?

Appendix G

Closing Semantic Deferential

Closing Semantic Deferential (Tablet)

Using the rating sheet below, please circle the number that most closely matches your feelings about the tablet.

Simple	3	2	1	0	1	2	3	Complex
High tech	3	2	1	0	1	2	3	Low tech
Reliable	3	2	1	0	1	2	3	Unreliable
Easy to use	3	2	1	0	1	2	3	Complex to use
Friendly	3	2	1	0	1	2	3	Unfamiliar
Professional	3	2	1	0	1	2	3	Unprofessional
Safe	3	2	1	0	1	2	3	Unsafe
Durable	3	2	1	0	1	2	3	Fragile
Attractive	3	2	1	0	1	2	3	Unattractive
High quality	3	2	1	0	1	2	3	Low Quality
I like	3	2	1	0	1	2	3	I dislike
Clear	3	2	1	0	1	2	3	Confusing

Closing Semantic Deferential (Smart-phone)

Using the rating sheet below, please circle the number that most closely matches your feelings about the smart-phone.

Simple	3	2	1	0	1	2	3	Complex
High tech	3	2	1	0	1	2	3	Low tech
Reliable	3	2	1	0	1	2	3	Unreliable
Easy to use	3	2	1	0	1	2	3	Complex to use
Friendly	3	2	1	0	1	2	3	Unfamiliar
Professional	3	2	1	0	1	2	3	Unprofessional
Safe	3	2	1	0	1	2	3	Unsafe
Durable	3	2	1	0	1	2	3	Fragile
Attractive	3	2	1	0	1	2	3	Unattractive
High quality	3	2	1	0	1	2	3	Low Quality
I like	3	2	1	0	1	2	3	I dislike
Clear	3	2	1	0	1	2	3	Confusing

Appendix H

Observer Data Collection Sheet

Confidentiality Disclaimer: The collected raw information will be de-identified data and may be used in the thesis and subsequent publications.

Observer's Name: Peng Wang

Date:

Participant Number:

Errors and Completion Tasks (Tablet)

Sign in and Edit profile tasks

1. Please find the application "MYFitnessPal" and Log in
   Errors:
   Success__ Failure __
2. Please find "Fitness Profile" and change its unit preferences which are in accordance with the list below:
   Errors:
   Success__ Failure __
   - Current Weight (KG)90
     Errors:
     Success__ Failure __
   - Goal Weight (KG): 70
     Errors:
     Success__ Failure __
   - Starting Weight (KG): 80
     Errors:
     Success__ Failure __

- Height: 180 cm
  Errors:
  Success__ Failure __
- Gender: Female
  Errors:
  Success__ Failure __
- Date of Birth: 12/12/1983
  Errors:
  Success__ Failure __
- How Active Are You? Lightly Active
  Errors:
  Success__ Failure __
- Country: New Zealand
  Errors:
  Success__ Failure __
- Time Zone: Auckland
  Errors:
  Success__ Failure __
- Zip/Postal Code: 1644
  Errors:
  Success__ Failure __

Daily caloric intake tasks

1. Please scan the barcode of a food item, to track all major nutrients: calories, fat, protein, fibre cholesterol.
   Errors:
   Success__ Failure __
2. Please sync the all local changes.
   Errors:
   Success__ Failure __

Errors and Completion Tasks (Smart-phone)

Sign in and Edit profile tasks

1. Please find the application "MYFitnessPal" and Log in
   Errors:
   Success__ Failure __

2. Please find "Fitness Profile" and change its unit preferences which are in accordance with the list below:
   Errors:
   Success__ Failure __

   - Current Weight (KG)90
     Errors:
     Success__ Failure __
   - Goal Weight (KG): 70
     Errors:
     Success__ Failure __
   - Starting Weight (KG): 80
     Errors:
     Success__ Failure __
   - Height: 180 cm
     Errors:
     Success__ Failure __
   - Gender: Female
     Errors:
     Success__ Failure __
   - Date of Birth: 12/12/1983
     Errors:
     Success__ Failure __
   - How Active Are You? Lightly Active
     Errors:
     Success__ Failure __
   - Country: New Zealand
     Errors:
     Success__ Failure __
   - Time Zone: Auckland
     Errors:
     Success__ Failure __
   - Zip/Postal Code: 1644
     Errors:
     Success__ Failure __

Daily caloric intake tasks

1. Please scan the barcode of a food item, to track all major nutrients: calories, fat, protein, fibre cholesterol.
   Errors:
   Success__ Failure __

2. Please sync the all local changes.
   Errors:
   Success__ Failure __

Appendix I

Approval for AUTEC Ethical Application 13/218

AUTEC
SECRETARIAT

14 October 2013

Dave Parry
Faculty of Design and Creative Technologies

Dear Dave

Re Ethics Application: **13/218 Is a multitouch gesture interface based on a tablet better than a smart phone for elderly users?**

Thank you for providing evidence as requested, which satisfies the points raised by the AUT University Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 14 October 2016.

As part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online throughhttp://www.aut.ac.nz/researchethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 14 October 2016;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/researchethics. This report is to be submitted either when the approval expires on 14 October 2016 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this. If your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply there.

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,

Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Peng Wang nonplussed424@msn.com

Appendix J

Advertisement

Are you interested in using Tablets (e.g. Ipads) or Smart-phones (e.g. Iphones) to help manage your health?

We are investigating whether older people (60+) find it easier to use healthcare applications on smart phones (for example iPhones or Samsung Galaxy) or tablet devices (such as Ipads or Galaxy tablets).

We would like 60 minutes of your time for you to try out some applications on both a smartphone and a Tablet, and answer some questions about your health status and how easy (or difficult) it was to use each device.

We are testing the devices- not you! This is part of a master's student project, supervised by Dr. Dave Parry, form Auckland University of Technology.

If you would like to participate – please contact:

Masters student: Peng Wang E-mail: nonplussed424@msn.com Mobile: 0211089095
Or
The Project supervisor: Dr Dave Parry E-mail: dave.parry@aut.ac.nz Work phone: 921 9999 ext 8918

Appendix K

SF-36(tm) Health Survey

SF-36(tm) Health Survey

Instructions for completing the questionnaire: Please answer every question. Some questions may look like others, but each one is different. Please take the time to read and answer each question carefully by filling in the bubble that best represents your response.

Patient Name: ____

SSN#: ______________________________________ Date: ______________________________________

Person heling to complete this form: ____

1. In general, would you say your health is:

- ❑ Excellent
- ❑ Very good
- ❑ Good
- ❑ Fair
- ❑ Poor

2. Compared to one year ago, how would you rate your health in general now?

- ❑ Much better now than a year ago
- ❑ Somewhat better now than a year ago
- ❑ About the same as one year ago
- ❑ Somewhat worse now than one year ago
- ❑ Much worse now than one year ago

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf?
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

c. Lifting or carrying groceries.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

d. Climbing several flights of stairs.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

e. Climbing one flight of stairs.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

f. Bending, kneeling or stooping.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

g. Walking more than one mile.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

h. Walking several blocks.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

i. Walking one block.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

j. Bathing or dressing yourself.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

a. Cut down the amount of time you spent on work or other activities?
☐ Yes ☐ No

b. Accomplished less than you would like?
☐ Yes ☐ No

c. Were limited in the kind of work or other activities
☐ Yes ☐ No

d. Had difficulty performing the work or other activities (for example, it took extra time)
☐ Yes ☐ No

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

a. Cut down the amount of time you spent on work or other activities?
☐ Yes ☐ No

b. Accomplished less than you would like
☐ Yes ☐ No

c. Didn't do work or other activities as carefully as usual
☐ Yes ☐ No

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
- ❑ Not at all
- ❑ Slightly
- ❑ Moderately
- ❑ Quite a bit
- ❑ Extremely

7. How much bodily pain have you had during the past 4 weeks?
- ❑ Not at all
- ❑ Slightly
- ❑ Moderately
- ❑ Quite a bit
- ❑ Extremely

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

- ❑ Not at all
- ❑ Slightly
- ❑ Moderately
- ❑ Quite a bit
- ❑ Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks.

a. did you feel full of pep?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

b. have you been a very nervous person?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

c. have you felt so down in the dumps nothing could cheer you up?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

d. have you felt calm and peaceful?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

e. did you have a lot of energy?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

f. have you felt downhearted and blue?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

g. did you feel worn out?

- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

h. have you been a happy person?

- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

i. did you feel tired?

- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

- ❑ All of the time
- ❑ Most of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

11. How TRUE or FALSE is each of the following statements for you?

a. I seem to get sick a little easier than other people

- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

b. I am as healthy as anybody I know

- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

c. I expect my health to get worse

- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

d. My health is excellent

- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false