Holistically Understanding the User Model of the Elderly People While Using Mobile Phones

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Abstract. This paper tried to understand the problems encountered by the elderly while using mobile phones through their user mental models. The purpose was to show the different dimensions of the discrepancies between user and designers models regarding mobile phones. Protocol analysis, structural hinting, and coaching methods were applied in the usability test. The results showed the different levels of operational problems of mobile phones, including physical, perceptual, functional, and conceptual. The problematic scripts of mobile operation, therefore, can be systematically categorized. Finally, conceptual misunderstanding of mobile phones should receive more attentions than the physical features of mobile phones to form a holistic perspective toward understanding the usability of mobile phones

1 Introduction

People of modern society living longer have gradually changed the demographics of the population, and elderly people have become a large group in society as well as essential users of mobile phones. As modern communication has been drastically improved by the advantages of mobile phones, it is very often to see they cannot even operate the basic functions. Mobiles companies and phone designers tend to focus on teenagers, and mistakenly categorize elderly people into the entry-level group that only requires basic functions in hope that without modifications entry-level mobiles can fulfill their need. Similar, when picking up gifts for elderly parents, people tend to choose the mobile phone with big screen and buttons without other considerations. This study explored the user model of the elderly people to understand their real needs when using mobile phones in order to reveal the problematic thoughts regarding senior mobile consumers.

Most literatures discussed the usability of electronic devices for elderly users in terms of decline of physical performance and a slower reaction time. The improved physical features of these devices increased the operation performance of elderly users a great deal, and our understanding of their physical ergonomics. With the progress and diversity of electronic products, large size screens and handwritten devices enabled elderly users operate cell-phones effectively.

In 2001, NTT DoCoMo Inc., the biggest Japanese telecommunication company, interviewed 300 male and female cell/PHS phone users in their sixties to understand mobile phones being increasingly popular among the elderly [1]. This survey re-

ported nearly 70% considered mobile phones essential for enjoying their lives. Interestingly, they indicated that mobile phones should be easier to use. As mobile phones incorporate more functions, the elderly found themselves unable to keep up with technological advances. Their comments regarding mobile phone development primarily required single function units for calls only and enhanced operational ease for mail and other additional functions.

While bigger buttons made navigation easier, older users actually faced a more complex problem in terms of understanding how mobile services were structured. When the forms of mobile phones are getting more stylish, it's a problem if you cannot perceive the correct operations of the interface, such as where the button is for dialing. Similarly, the complex hierarchy of a phone's menus increases the difficulty to navigate through a phone's functions as memory declines, since it places a high demand on remembering a sequence of actions [2].

The phenomenon seemed to suggest a diversity of problems occurred when the elderly operated mobile phones. Operational misusability of elderly users did not only result from physiological performance but also cognitive misunderstanding. Most design-related research has been done in the physical ergonomics of elderly welfare and usability of user interface, but there is still limited research applying cognitive ergonomics of elderly users in mobile phone design. The design of mobile phones, therefore, remains unsatisfactory. We speculated their operational misusability resulted from both physiological performance and importantly cognitive misunderstanding. Applying the mental model proposed by Johnson-Laird [3] and Norman [4], we hypothesized the mismatch between the user's and designer's mental models causes the hindrances of using mobile phones. The inability of elderly people to understand the fundamental concepts in mobile phones and the deterioration in cognitive capacities to operation further exacerbated the situation. The purpose of this study was to establish a primary model, comprising a set of characteristics of the cognitive process through which elderly users utilize mobile phones. Through the models, we can understand more about the discrepancies of mental models between designers and the elderly from a holistic perspective.

2. Ageing, Cognition, and Computer-based Tasks

A previous study of elderly computer users found that older adults usually face larger difficulties than younger adults in learning and using new computer applications [5]. Their learning process is longer. They need more time to solve different tasks, to handle large information spaces, to sort out task-relevant information, and to deal with complex information. Some of the age-related differences related to performance with computers could result from the cognitive functions declining with age [6]. It is needed to understand which age-sensitive cognitive functions play an important role in different computer-related tasks, so we can compensate for this age-related decline using better interface design in mobile phone design. According to the definition of Gregor, Newell, Zajicek [7], this study focused on *Fit older people,* who do not appear to be disabled, nor consider themselves disabled, and the age-related cognitive decline existed. For the cognitive decline in relation to navigation in electronic

environments, Sjölinder's research provided an extensive review in terms of processing speed, attention and working memory, memory, and spatial ability [8].

Human cognition is described as human information processing, involving related processes of acquisition and processing of information. These processes include perception, perception-based knowledge, memory, problem-solving, expertise, decision-making, and use of language [9]. Processing speed has been shown associated with ages; increased age contributes to slower responses and longer reaction times [10]. This processing speed decline could be also explained by other age-related cognitive differences as well as attention and working memory. In computer-related tasks, this processing speed affected older adults in finding information, keeping track of where information is, and sorting out relevant information.

When people attend to information for conducting tasks, different levels of attention are required for allocation and directing of cognitive resource. Research showed that the age-related differences in performing cognitive tasks increase during dual task conditions [11]. The increased memory demands in attention switch result in older adults performing slowly when switching between different tasks. Working memory is an integrated system for holding and manipulating information during the performance of complex cognitive tasks. It consists of a central executive with two subsystems of the phonological loop and visuo-spatial sketchpad [12]. The increase of cognitive demands contributes to the age-related decline of working memory. It becomes more difficult for older adults performing an on-going task demanding integrating old and new information and processing simultaneously. Both attention and working are required in filtering out irrelevant information for a certain task. Older adults weaken in attention, working memory, and this inhibition mechanism, and, therefore, amount of task-irrelevant information increases in working memory. Tardieu & Gyselinck [13] investigated whether the use of multimedia information presentation increases the demands on working memory or decreases it by providing opportunities to use different subsystems of working memory. It suggests multiple sources of information could be beneficial when the information sources are integrated and using different components of working memory.

The long-term memory processes includes learning, storage, and retrieval, and human memory is categorized into semantic memory, episodic memory, procedural memory, perceptual representation system, and prospective memory [14]. Episodic memory is more affected by age so that contextual information is more exposed to age-related differences [10]. In terms of mobile phone, function keys and remembering a command in the menu place large demands on memory recall, and long output message performs similarly.

Spatial abilities are cognitive functions that enable people to concern relations and orientation of objects in space. Vicente & Williges [15] has shown that spatial abilities influence computer use, such as searching in hierarchical file system. Spatial abilities also decline with increasing age [16]. When people engage in learning spatial relations, landmark knowledge, route knowledge, and survey knowledge are distinguished [17]. Older adults have lowered performance abilities on landmark and route knowledge than younger adults, and the survey is the most difficult spatial information to acquire and to use for older adults since it demands both storage and processing simultaneously. It has been suggested survey knowledge is related to computer-based tasks because they need spatial abilities to create a mental model of an envi-

ronment to navigate in. Therefore, 2D visual hierarchies with all levels visible and linear structures were more efficient in supporting older adults with lo spatial abilities.

Besides there declines of cognitive functions, physical decline and motivation may also contribute to age-related differences in performance of computer-related tasks. The decline in psycho-motor skills and motor speed make it difficult to perform computer-based data entry [18], for example, moving mouse to the right spot, clicking on mouse at the right spot, and double clicking. In terms of small devices such as mobile phone, the closer buttons are placed together the harder older adults can press the correct buttons at the right time [19]. For most mobile phone, both the texts in the display and on the buttons are too small for older adults.

3. Method

A usability test surveying the operations of mobile phones with the participation of elderly people was applied to observe their cognitive processes and frustration occurrences. According to the characteristics of senior citizen and our experimental experience, the final method was composed of protocol analysis, structural hinting, and coaching method in order to maximum both the quality and the quantity of our experimental data, Figure 1.

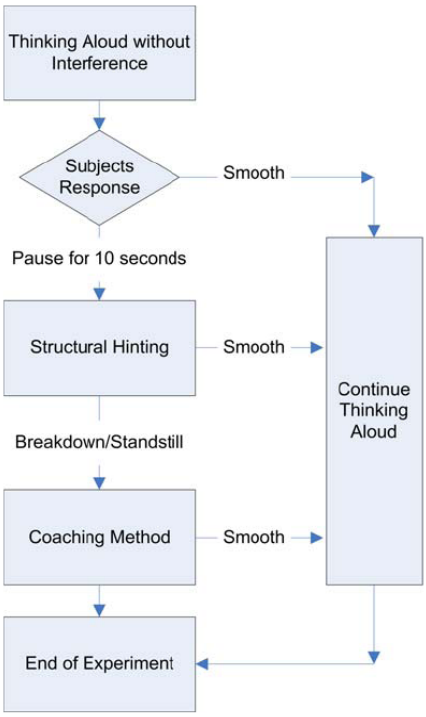

Fig. 1. The procedure of experiment

Protocol analysis was originally proposed by Ericsson & Simon [20] to explore the human problem-solving process. In recent years, it has been broadly applied in usability test in human-computer interface (HCI) studies. Subjects were required to speak out their thoughts while operating the target devices. Experimenters analyzed the utterances of their thinking aloud, protocol, to research the cognitive process. Nielsen [21] indicated that protocol analysis was the qualitative method of usability test aiming at examining the operational problems and cognitive misunderstanding. The richness of protocol was valuable to the understanding of HCI [22].

Structural hinting was applied in the process of protocol experiments to encourage subjects to verbally express their thinking processes when the elderly encountered operational problems and paused for 10 seconds. The hinting was not to direct the subjects' reaction but to guide them to solve the problem by proposing appropriate questions related to HCI. If the experimental process still encountered a breakdown or a standstill, coaching method was then applied [21]. The experimenter would provide the correct procedures to the subjects, and listened to their responses. The procedure of the experiment was established.

The situation determining a standstill were incorrect operations for a long time and expressing of frustration, and that of a breakdown was pause for a long time and giving up. The structures of hinting questions and coaching steps were based on Norman's execution-evaluation cycle [4]. If proceeding smoothly after questions or coaching, the experimental process continued with protocol analysis.

The tasks for the experiment were replying the missed call, calling an answered call again, and taking a picture. Both of them were the most fundamental and essential functions of mobiles and the last one is the basic function for mobile phone with camera. The selection criteria are bigger screen, larger button, ordinary layout of keypad, and basic camera function, all of which are devised for elderly users. As a result, several similar mobile phones from dominant brands were selected, including Motorola E398, NOKIA 6610i, Sony Ericsson K300i, and BenQ M315. All four mobiles have home menus of icon selections GUI and detail settings on menu-driven basis. The Nokia, however, does not have a matrix home menu that shows nine functions at once. The hierarchical location of operating our three tasks, replying a missed call, calling an answered call again, and taking a picture, were different in the mobiles. For example, one's replying a missed call lies in the top level of the operational hierarchy and other lie in the second level.

Before the experiment, three mobile were selected except of the mobile that the users were most familiar with or currently used. The interpretations of the results were generalized to older adults' metal model on the use of cell phone whose operations are foreign to them. User manuals were given and advised to use.

In most literatures, elderly means an individual who will be age 60 or older by the end of the month. In reality, the definition is relatively ill-defined since it does not include the performance of physical, physiological, and psychological functions. Subjects of this series of study ranged from 45 to 75 and have the experience of using mobile phones for at least 1 year. With a total number of 39, we disregarded the data of subjects who's age does not fall into the range of 45 to 60 and is illiterate to form

an more interesting group for observation. In the end, 30 subjects individually provided a video recording of the operational process and a concurrent protocol.

The nature of the protocol was different from other protocol analysis. The elderly subjects could not usually report the process of correct operation even with proper warm-up, training, and reminding in terms of methodology. Therefore, the retrospective protocol was taken after an operational mistake occurred and the experimenter asked about what went wrong in the process. Consequently, the protocol was more like descriptions of problematic operation of the subject.

4. Results

The results were presented as problematic scripts, including the detailed operational procedure, situations and discussions. Among them, common problems of mobile phones for elderly were found. Based on Norman's conceptual model and the cognitive literature review in section 2, we found that the problematic scripts could be categorized into four different levels that imply a cognitive process in which a stimulus of mobile phone goes from the external world to the internal world of the elderly and vise versa.

The four cognitive levels were physical, perceptual, functional, and conceptual. The physical referred to the physical attributes of the mobile phones, including shapes, colors, textures, and sizes. The perceptual referred to the visual-spatial relationships of the appearance of the mobile phone, including arrangements of buttons and the alignment between screens and buttons.

Fig. 2. The keypad of Sony Ericsson-Z200

The functional relates to functional references mapped between visio-spatial features/relationships on the mobile and the meanings and functions they represented. For example, the center square of the keypad of Sony Ericsson-Z200 represents four-directional selection and confirmation buttons, Figure 2. The conceptual represented the various functions of mobile phones, their concepts, operational procedures and the service they can provide, for example, SMS message and how to use SMS message.

The problematic scripts of operational processes were represented by these four levels and their inter-linked relationships. The physical and perceptual levels reveal the external physical problems of mobile phone design, while the functional and conceptual levels revealed the internal cognitive misunderstanding of the elderly

users about the mobile phone. These four levels were the discrepancies between user and designer models and generated usability problems while the elderly operated mobile phone. The conceptual model for understanding the user model of the elderly people while using mobile phones was produced, Figure 3.

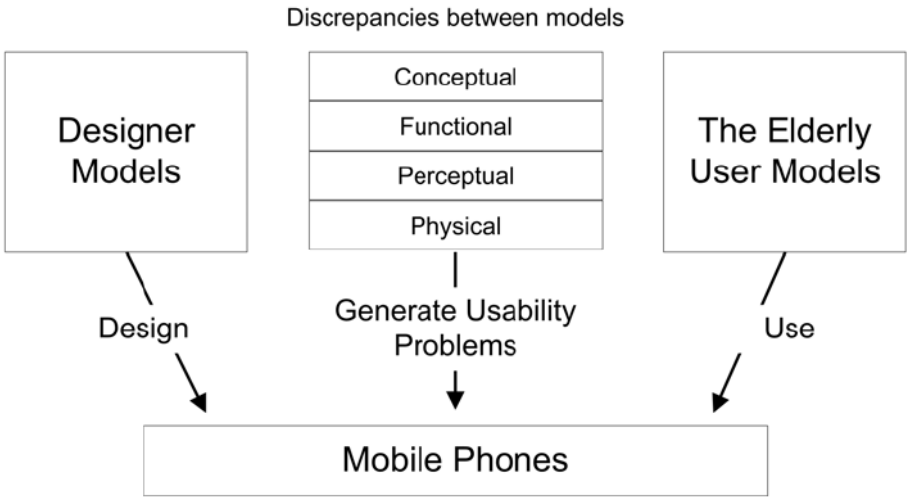

Fig. 3. The discrepancies between models

Table 1 shows the coding table of subject 15 in the task of calling an answered call again. The problematic scripts of operational processes were represented with error number and its corresponding coding.

Table 1. The coding table of subject 15 in the task of calling an answered call again.

Subject Number: 15 Mobile: Nokia 6610i Task: calling an answered call again		
Error	**Operational Process**	**Coding**
1	Read the user manual about calling an answered call again. Press the left arrow key and mistakenly enter the message function. Be confused because the subject did not understand the functions could be switched continuously like a circle.	Conceptual
2	Stuck while the mobile in stand-by mode	Conceptual
3	While in answered call list press the wrong button in an attempt to call the number	Physical

In terms of abovementioned model, the problems found in the operational processes of mobile phone could be systematically categorized into a table, Table 2. The most interesting result was conceptual misunderstanding created many problems and frustration for the elderly. Some fundamental concepts applied in the design of mobile phones alienated the elderly users who were not familiar with these ideas, for example the hierarchical menu. Some problems crossed two levels. For example, a soft key without a label created a perceptual confusion, and the its mapping with

changeable displayed functions also did. However, soft key and hierarchy were commonly applied in the entry-level mobile phones that were proposed to be used by senior citizen.

Table 2. Systematic organization of the operational problems of mobile phones

Physical	Perceptual	Functional	Conceptual
■ Small Button Size ■ Small Display Font Size ■ Short Distance between Buttons	■ The Operational Directions of Buttons ■ The Buttons without Labels	■ Soft Keys (one key representing multiple functions according to the display) ■ Comprehension of the Icons	■ Using the Mental Model of a Traditional Phone ■ Hierarchical Structure of the menu ■ Automatic Wizards ■ The Meaning of Missed Call

5. Conclusions

For most consumers, designers, and market persons, the problems of mobile phones for the elderly were mostly physical and external. Therefore, we could found the mobile phone for the elderly were equipped with extra large keys, a wider size, but similar underlying functions. Our results indicated that for elderly mobile phone users, even with more than one year experiences, misconception of basic operations and functions still existed. Therefore, the discrepancies between the users and design models hindered senior citizen to use mobile phones pleasantly.

The physical and perceptual problems were easy to perceive and correct in terms of mobile design, while the functional and conceptual were not. Given the situation that designers cannot use soft keys and hierarchical menus in their mobile design, what kind of mobile could be produced. If with some initial learning about these concepts, to what extend we can apply these concepts. With the emphasis shifted to functional and conceptual problems, more possibility regarding to the mobile phone design emerged and more usability problems of mobile phones could be reduced for the elderly. Therefore, a holistic perspective of understanding the mobile usability for elderly people was formed, including lower physical and perceptual levels to higher functional and conceptual levels.

In conclusion, this study provided a method to observe the elderly while using mobile phones. The primitive results are as follows. First, many operational problems occurred due to cognitive aspects of ergonomics. Second, not age but the familiarity with underlying concepts of mobile phones represented the meaning of “elderly” users of mobile phone. Third, the results of this study provided realistic scenarios to abridge the gap between the users and designer mental models. The functional and conceptual aspects of mobile design should be the focus on understanding the user model of the elderly people while using mobile phones.

The future study will be focusing on how to facilitate the learning process when elderly people use mobile phones in the hope that the current technology of commu-

nication could benefit elderly people more with our better understanding of their user models of mobile phones.

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