Research on Smart Phone Interfaces for the Elderly Based on Ergonomics

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Abstract. To improve the usability of products, this thesis discusses about mobile phone interface designs which are more consistent with the elderly’s using habits. Based on a comprehensive analysis of the elderly’s physiological perception functions, the thesis first lists all factors that affect the design of smart phone interfaces. Guiding the interface design with methods targeted at clients’ experience, it puts forward designing principles from the perspectives of information structure, visual design and interactive design. Cooperating the elderly’s demand preferences, it masters design thinking from the macroscopic perspective to explore optimal interface design for the elderly. In the grand context of informatization, this thesis systematically analyzes and researches the characteristics of specific group to find out the relations between the elderly’s smart mobile phones and the human-machine interactive design. It aims at putting forward effective methods of designing optimal user interfaces for the elderly’s smart phones.

1. Introduction

1.1. Research Objectives

Based on analyzing and discussing human-machine ergonomics and users’ using habits, the thesis first points out diverse problems in current mobile phones designed for the elderly and studies how the elderly’s physiological characteristics, psychological features and operation habits affect the design of mobile phone interfaces. Based on reasonably arranging the positions, layout and size of virtual operation buttons, the dimension scale of words and the allocation of interface colors, the thesis introduces how to improve and beautify the mobile phone interface to improve the feasibility and practicability of products. The thesis aims to find out how to design an interface that allows users to operate the mobile phone more easily and freely, improve the error-tolerance space and lower the rate of faulty operations.

1.2. Research Contents

A product is used by humans and all of its functions should be designed based on meeting people’s using demands and habits. The humane principles of a product include product practicability, usability and economical efficiency. As the elderly have special requirements, the design of smart phone interface for them should give more consideration to their using habits, physiological factors and psychological characteristics to meet their demands. In this precondition, the thesis analyzes and researches the application of human-machine ergonomics to designing mobile phone interfaces. Based
on combining research results with the design of mobile phone interface, it aims to improve the problems in current products and draw conclusions for optimal designs.

2. Concepts of Human-machine Interaction and Smart Phone Interface

2.1. Concept of Human-machine Interaction
As an overlapping discipline, human-machine ergonomics studies the interactions between humans, machines and environment through multi-disciplinary knowledge on psychology, physiology, biomechanics and engineering. Essentially speaking, it is the science that aims to improve humans’ operating performances and safety in the system and respects humans’ psychological and physiological preference demands. The core of developing ergonomics in the future lies in human-machine interactions. It is thus indispensable to analyze how ergonomics affects the interactive design of products. The human-machine interactive design is a science that studies the interactive relations between the system and clients[1]. In order to solve the contradictions between people and artificially-made products, the design and manufacturing of machine operation and control systems should meet people’s capacities. Similarly, the design and manufacturing of smart phone products should consider multiple factors, including the product weight, modeling design, button layout, color matching and feeling of gripping. In addition, designers should find out whether users have comfortable sensual experience, whether buttons have a suitable size, whether the display is readable and whether fonts can be identified easily based on human-machine ergonomics. More importantly, designers should give full consideration to the comfort, operation experience, identification efficacy and using smoothness of human-machine interaction. Generally speaking, a scientific design not only improves users’ experience, but also enhances the operability of smart phones for the elderly.

2.2. Overview on Interactive Interface of Smart Phones for the Elderly
As global population aging becomes increasingly severe, the aging industry will be the biggest economy in the future. The interaction based on real human-machine interactive interfaces of smart phones with touch screens is more suitable to people’s operation habits. This interactive operation is not only suitable for young people, but also helps to popularize smart phones among the elderly. Compared with common users, the elderly have bigger demands for smart phones with good user experience. Despite this, all mobile phone brands generally add complex product functions, lengthen stand-by time and beautify the image in product development to enhance their brand characteristics and competiveness and attract users’ attention. As a result, the smart phone market faces the tendency of increasingly distinctive product positioning, including business mobile phones, women’s mobile phones and beauty mobile phones. Although the market also provides smart phones especially designed for the elderly, the function interfaces of such mobile phones do not make reasonable classification based on the elderly’s real demands(see Figure 1). Instead, current interface design remains superficial, including enlarging the font size and the button size or adjusting the volume. Faced with complex yet useless functions, the elderly are at a loss when it comes to operation. The fundamental reason for such a failure is that the product R&D does not analyze the objective demands of client hierarchy and design concepts fail to be effectively converted into design and R&D achievements. To solve the problems existing in the design of smart phone interfaces for the elderly, designers should first face the complex smart phone market, base on ergonomics, improve the elderly’s smart phone using experience with client-centered designing concepts and improve the interface design for the elderly.
3. Research and Design Practice of Smart Phone Interfaces for the Elderly Based on Human-Machine Ergonomics

3.1 Analysis of the Elderly’s Physiological and Psychological Characteristics

With gradual degeneration of physical functions, the elderly’s sensual functions decline, including visual sense, auditory sense and tactile sense. Such a decline and their lifestyle severely affect how the elderly use smart phones. Only when an interface design is based on mastering the foundation of functional changes can the product be better used by users.

The research on psychological and physiological changes is one of the means that effectively solves the elderly’s difficulties of using smart phones directly and effectively. Generally speaking, the physiological and psychological changes faced by the elderly include the changes in visual sense, auditory sense, tactile sense, learning capacity and memory[2].

3.1.1 Visual sense: As people grow old, their lens become increasingly hardened and ciliary muscle has declining functions, which cause the adjustment function of visual system to decline. It is from about 40~45 years old when people have significantly declining visual functions and difficulties in short-distance reading. According to the description of Jon Hendricks, nearly 20% of the elderly aged over 65 years old fail to have the CAV of 20/40. In fact, the short-distance vision of the elderly is only about 20/70 (see Figure 2), which severely affects the elderly’s capacity of operating products and brings much inconvenience to their life[3]. Moreover, the elderly’s papillary dilation is less than 2/3 of that when they were young. The clouding of lens makes it more likely for the elderly to have glare and the yellowish lens causes eyes to filter blue light. As a result, the elderly’s capacity of identifying blue and green light is about 25%~40% lower than that of young people. With the advancement of ages, people’s sensitivity towards visual comparison lowers. Given consideration to such changes, designers should make adequate comparison when setting the target color and background color.

3.1.2 Auditory sense: The auditory sense starts aging when humans turn 55. Generally speaking, people aged over 70 cannot hear the sounds with the frequency of above 4,000 HZ and their hearing function basically does not work when it comes to the sound of 8,000 HZ. They can barely hear the sounds of lower than 1,000 HZ (see Figure 3)[4]. Due to the degeneration of auditory functions, the elderly have hearing barriers and their failure of obtaining information severely affects their capacities of cognition, response and learning. To improve the functional loss of hearing, designers should adopt low-frequency voice reminder, clear music and high altitude displacement to enhance the visual stimulation to the elderly.

![Figure 1. Categories of mobile phones for the elderly](image1)

![Figure 2. Changes in visual sensitivity towards objects along with aging ty](image2)

![Figure 3. Changes in visual sensitivity static](image3)
3.1.3 Learning capacity: The elderly’s acceptance of new things is determined by their learning capacities. Generally speaking, the elderly need to spend more time learning a new skill because they have slow reactions and informational transmission caused by the aging functions of brain. In addition, their response speed will also decrease by about 20%~30%, which apparently results in frequent slow operations. Due to the degenerated capacity of understanding and memory, the elderly have declining problem-solving capacity, logic reasoning and understanding although their understanding capacity remains the same. It is thus necessary to design a smart phone interface with easily-understood and simple operations for the elderly to lower their learning difficulties. In addition, the elements which the elderly are interested in and familiar with should be analyzed precisely to better inspire the elderly’s learning initiative[5].

3.1.4 Memory: According to a scientific analysis, humans start to experience a gradual loss of memory at the age of 45 and face a dramatic decline after turning 70. Therefore, declining memory is another significant characteristic of the elderly. Its characteristics are as follows: The memory capacity is significantly declined; have good understanding and memory, yet significantly declined mechanical memory; prominent slow-down of memorization speed and decline of short memory; good long-term memory yet significantly declined short-term memory.

It is also non-negligible that the elderly, who have declining visual and auditory functions, may have wrong operations because of erroneous tactile feelings. The most important body part of operating a mobile phone is finger. Due to bone aging and physiological degeneration changes, the elderly’s finger joints lead to an increasing rate of operation errors. These physiological characteristics determine that the mobile phone interface designs for the elderly should follow scientific human-machine ergonomics theories. Due to declining physiological functions, the elderly have weaker capacity of adapting to different environments. The sense of frustration further results in negative sentiments and makes the elderly reject new things. The longer people enjoy negative sentiments, the weaker their acceptance capacity will be. In order to narrow down the distance between the elderly and modern scientific products, the design of mobile phone interface should lower the costs for the elderly to learn how to operate mobile phones. According to relevant data[6], the difficulty of operating the interfaces of hi-tech products severely affects the elderly’s psychological anxiety. The occurrence of hi-tech scientific anxieties requires the interface design of smart phones to be as simple as possible to boost the elderly’s interest and confidence.

3.2 Research on Client Objectives of Smart Phone Interface Design for the Elderly

3.2.1 Appeal of the Elderly for Smart Phone Interfaces. Due to their uniqueness, different users have distinctive demands for mobile phone interfaces. According to the data concluded from survey on users’ using habits(see Table 1), objectives and behaviors, users’ basic motivations are different. However, an in-depth research shows the elderly use smart phones to receive information from the outside world and have communications. The fundamental reason is that the elderly are defying their aging, which forces them to expect a more convenient lifestyle. Although the elderly with different lifestyles have different demands, they have basically the same appeal regarding smart phone interfaces: (1) basic demands, including psychological demands, security and social sense of belonging; (2) spiritual demands that represent values. For instance, the elderly have highly similar appeal for cultural and entertainment activities. The key to meeting core demands lies in designing the interface of mobile phones from the perspective of their appeal.
Table 1 Analysis of common appeal of the elderly

| Appeal Type             | Appeal Contents                                                                                                                                 |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Emotional Demands       | The communication page should accentuate information of families, relatives and friends; The dynamic page should accentuate the news of families, relatives and friends; The mobile phone should have an album memory function; |
| Visualized Demands      | Large fonts, large pictures, coordinated colors, aesthetical interface elements, simplified client interface and moderate light.                   |
| Usability Demands       | Simple operation, easy information inquiry, simple functions, good feedback to operation and moderate page turning speed                          |
| Fundamental Function    | Video phone, voice phone, send voice information and send text information                                                                     |
| Additional Function     | News feeds, software update, position sharing, radio FM, convenient networking, no advertisement, shopping mall and memo reminder              |

3.2.2 Research on the User Objectives of Smart Phone Interfaces for the Elderly. Based on analyzing clients’ appeal, the author concluded comprehensive client demands. When designing a smart phone product that meets the vast elderly’s demands, designers should abandon the wrong conventional logic of providing a wide range of functions to accept more clients. Instead, designers should carry out a specific survey of clients’ objective demands first and then make a special and individual design to accept vast users successfully. In addition, the decisions and designing of auxiliary products should be based on a detailed analysis and research on the elderly’s objectives, behaviors and opinions. Moreover, client-oriented designing concepts help designers to meet clients’ objective demands by setting up a client model[7]. Essentially speaking, the client model is the designer’s systematic knowledge system about clients. It is helpful to design the appearance, human-machine interface, environment, pictures, text and information of a product[8]. The elderly’s physical characteristics is taken as the basis for objective research. Designers should analyze clients’ thinking model, make conclusion and analysis of relevant data through network research and conversation research, set up a client model with objectives and excavate the elderly’s expectation objectives.

Based on in-depth analysis of the objective model with different level of demands, the thesis finds out the objective demand design for the elderly is based on their uniqueness (see Figure 4), such as the degeneration of physical functions and declining understanding capacity. The interface of smart phones for the elderly should be designed according to the color match, functional layout, interactive elements and practicability to meet the objective demands of inexperienced senior users. The elderly prefer to obtain accurate information by institutional means and tend to choose interface designs with simpler interactions and lower learning costs. It is because such designs boost their learning confidence. The design should thus avoid the barriers and difficulties brought by complex operations that force the elderly to give up using smart phones.
3.3 Strategies and Paths of Designing Smart Phone Interfaces for the Elderly

3.3.1 Information architecture: As the indispensable bone of a product, good information architecture helps users to obtain information accurately and efficiently. The designer should conclude a clear, accurate, simplified, non-redundant, scientifically-classified, reasonably-structured, shallow and narrow information architecture based on the elderly’s behavioral habits, visual identification capacity and learning capacity. This information architecture then guides clients in subsequent operations to obtain the final objective information. The shallow and narrow information architecture is a light-weight information arrangement of public thinking model, which helps the brain to process information. For instance (see Figure 5), the address book commonly used by clients is arranged following the alphabetic order of letters to make it convenient for users to search for target information fast. Regarding receiving information through smart phones, the elderly face a significantly heavier burden than young users. A direct, clear and framework-relationship design is more suitable for the elderly’s thinking model and should shift the interface by the easiest means within the information architecture.

3.3.2 Interface visual design: The elderly’s eyes face the degeneration of physiological functions, including the loss of adjustment capacity and lowered visual acuity. Given consideration to this fact, the color of pictures on the mobile phone interface should adopt warm colors with a strong contrast, high pureness, high brightness and hues to avoid the difficulties of identifying colors brought by allocating with short-frequency colors. Only in this way will the design be more consistent with the elderly’s cognitive habits. It is also necessary to avoid the color combination of the same hues and particularly the color system which the elderly can hardly identify, including blue and green. As different colors have distinctive color natures, only highly-identified color match can improve information comparison[9]. Of course, excessive emphasis over vision may result in visual fatigue. It is thus necessary for the interface design to analyze the hierarchies of key information zones scientifically and reasonably, as well as guide and operation reading through different characteristics of colors. (see Figure 6)
It is recommended to adopt large fonts for the smart phones designed for the elderly. The elderly have restricted visual acuteness and the optimal font should be ≥18. To reduce visual interference and enhance visual attention, designers generally choose sans serif Western fonts, such as Helvetica and boldfaces, for titles. Regarding the words of contents, Song typeface and Times New Roman typeface are suitable choices. With the development of modern smart phone, the phone screen also has an increasingly large size. Generally speaking, the mainstream size is about 3.5~5.5 inches. Although the large screen makes up for the elderly’s defects in visual recognition, it also lowers the convenience of using smart phone. It is thus recommended to make a phone size about 4.6 inches to combine visual effect, portability and the convenience of single-hand operation. With the popularity of designing concept with no rim and tangible button, it meets the optimal size and improves both portability and operability.

3.3.3 Interactive design: Combining with the interface design principle put forward by Ben Shneiderman[10], the interactive design of smart phone interfaces for the elderly should follow the principles of simplicity, consistency, reducing memory burden, avoiding mistakes and attaching importance to feedback. It is necessary to combine the functional layout of subjects, decrease functional choices and design corresponding functions for each icon. This decreases learning costs, lowers the rate of wrong operation and achieves efficient interaction between the elderly and mobile phones. Apart from avoiding multiple page shifts, designers should adopt a clear menu operation and offer effective feedback to users in operation. It not only allows clients to learn efficiently, but also boosts their confidence. Taking the icon feedback of smart phones for the elderly for instance, designers should make information feedback to enlarge the size of icons, change colors and make vibrations to avoid the loss of focus in interactive and help the elderly to use smart phones. In addition, interactive behavior may simulate the habitual operations in real life through interactive behaviors, such as the page-turning interaction, to lower the difficulty of using and memorization.

“It is crucial to know customer demands in product design. Only by determining customer demands can products meet different objective clients’ demands and ensure successful product design.” [11] Combining with the comprehensive analysis of designing strategies mentioned above, the thesis advocates designing smart phone interfaces for the elderly based on client’s experience. In actual design architecture of smart phones for the elderly, process analysis and optimized design are commonly used. Based on human-machine ergonomics, the thesis concludes and analyzes the methods of designing interface for smart phones, puts forward normalizing the designing of interface elements, decreases the designs of input operations and improves the methods of designing interface operation feedback. It is necessary to give full consideration to the factor that the elderly have declining body-adjustment functions. In this way, the design will effectively meet the elderly’s psychological and physiological demands for smart phone interfaces, solve the product deficiency in sub-divided market and meet the elderly’s life and spiritual demands.
4. Conclusions
This thesis concludes the strategies of designing smart phone interfaces that meet the elderly’s using habits and demands. Based on the feedback information of the elderly, it provides effective psychological guarantee to the elderly. Based on human-machine ergonomics, it researches the smart phone interface for the elderly. Through the analysis of the elderly’s unique psychological and physiological characteristics, the thesis studies the elderly’s acceptance of smart phone interfaces and the problems in actual design. With client-centered design concepts, it analyzes the information structure, visual design and interactive design and mobile phone interface to eventually optimize the functions of products for the elderly. Technological development exerts profound impact on the living environment and lifestyle of the elderly. It is thus necessary to attach more importance to the elderly consumption group and create a friendly product interaction environment for the elderly. This not only meets the elderly’s growing demands for spiritual culture, but also plays an effective role in guiding the research on humane product designs.

References
[1] Wikipedia: Human-machine interaction. https://zh.wikipedia.org/wiki/%E4%BA%BA%E6%9C%BA%E4%BA%A4%E4%BA%92
[2] Leshan Li. Human-Machine Interface Design [M]. Beijing: Science Press, 2004
[3] Jiayue Wang. Research on Humane, Emotional and Smart Interaction of Product Design for the Elderly [D]. Shandong: Shandong Polytechnic University, 2008
[4] Hongen Pei. Analysis of the Auditory Function Characteristics of the Elderly[J]. Journal of Audiology and Speech Pathology, 2001
[5] Kathleen M. Galotti. Cognitive Psychology [M]. Edition 3. Translated by Guohong Wu. Shaanxi: Shaanxi Normal University Press, 2005
[6] Bin Zhang & Peilun Rao. How Cognition Aging Affect the Interaction Validity between the Elderly and Smart Furniture [J]. Journal of Shenzhen University of Science and Technology, 2007, 24(02): 127~131
[7] Qiuhi Wang. Analysis of Elderly’s Behaviors and Designing Strategies for Barrier-free Products [J]. Journal of Beijing Institute of Technology, 2009(11):57-61
[8] Rahmati A, Zhong Lin. Human-battery interaction on mobile phones[J]. Pervasive and Mobile Computing, 2009, 5(5):465-477
[9] Zhi Yang. Overview on the Research on Words, Colors and Layout Design for the Elderly [J]. Decoration. 2012(05): 86-87
[10] Jones M. Marsden G. Mobile Interaction Design[M]. Printed and bound in Great Britain by Bell&Bain, Glasgow, 2006
[11] Ge Ding and Hongyun Xiong. Research on the Interactive Design of the Medium-aged and Elderly Based on Smart Mobile Terminals [J]. 2014. 11