The Study of the Blind's Mobile Communication Interface

盲人行動溝通介面之研究

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Abstract

This study has gathered relevant literature on the physiological and psychological characteristics of the visually impaired individuals in order to develop a basic theoretical framework for the research and to clearly define the research objectives. For methodology, the research is carried out in two stages. In the first stage, a field interview with the fully blind users is conducted in order to gain a basic understanding of the current state of cell phone use by the visually disabled. In the second stage, a simplified thinking aloud experiment is performed, in which the subjects are asked to voice out their actions, thoughts, and concerns while operating a cell phone. The process is recorded using a video camera in order to facilitate a video/audio protocols analysis. The tape is also provided to a group of experts for heuristic evaluation, in order to understand the specific difficulties and problems that the visually disabled may encounter with cell phone use.

The research findings reveals that the blind subjects, even those who had never used a cell phone before, can dial numbers correctly, which indicates the importance of product standardization. This study hopes to establish the human factor considerations for cell phone design for the visually impaired users in order to provide product designers an important guideline for developing new cell phone models, thereby improving the man-machine interfaces of cell phones for blind users and increasing the overall well-being of people suffering visual disabilities.

摘 要

綜觀國內外人因設計領域的文獻報告，鮮少有探討關於視障者人因的研究主題，設計師在這種參考資料缺乏的情況下進行產品設計，自然無法考慮到最佳之視障者操作介面，其結果輕則可能造成視障者操作上之不便，嚴重則可能導致視障者生命安全之危害。

本研究首先就視障者之生理及心理特性蒐集相關文獻報告，以做爲研究進行之理論基礎並界定出研究目標。而研究之方法主要分成二個階段進行：第一階段爲實地訪談，訪談對象爲全盲的視障者，主要是爲了初步瞭解視障者使用行動電話的現況分析；第二階段則爲實施「簡化邊說邊做法」(Simplified thinking aloud)的實驗，請受測的視障者進

行行動電話手機操作的邊說邊做，利用攝影機加以記錄後針對影片內容進行影音回溯，並由專家進行啓發式評估，藉以瞭解視障者於使用手機時所可能遭遇的困難與不便。

本研究結果發現盲人即使使用不曾操作過的行動電話，也均能正確撥號，這個結果顯示出標準化的重要性。希望根據研究結果可建立出適合視障者使用的行動電話人因設計準則，以提供產品設計師於開發新型行動電話手機時的重要依據，進而改善視障者使用行動電話時的人機介面，增進視障者的生活福祉！。

Key words: visual disability, mobile communication interface, simplified thinking aloud, video/audio protocols analysis

關鍵詞：視障者、行動溝通介面、簡化式邊說邊做法、影音回溯分析

I. Introduction

There are about 43 million persons in the United States alone report some type of function limiting disability (Sheppard, 1989). India is the second most populous country in the world. According to the investigation, it is estimated that 23.5% of the world's blind population lives in India. Further, there is every possibility that the situation is going to get worse (Ravi Thomas, Padma Paul, Gullapalli N Rao, Muliyil, Annie Mathai, 2005) At present, the blind population in Taiwan has reached 40,000, who, except a visual disability, are not much different from the ordinary people. If government institutions can care more about the visually disabled and give extra consideration to the use characteristics of those with a visual disability in the planning of public construction projects and provide the disabled a living environment free of obstacle, the visually challenged will be able lead a life as independent and autonomous as that enjoyed by ordinary people.

Since 1960s, Western countries have been actively promoting equal access to buildings, facilities, activity venues, and transportation means of the handicapped and those with mobile disabilities. This wave of movement to remove obstacles of mobility for disabled individuals is thus called the movement for building an obstacle-free environment. The United Nations even proclaimed 1981 as the International Year of Disabled Persons and raised several themes such as equal opportunity and total participation to help create a worldwide trend of caring for disabled persons.

The R.O.C. Government also promulgated the Disabled Persons Welfare Enforcement Rules in April of the same year to ensure a full and equal access to all facilities and public places for the disabled. In other words, a barrier-free environment has been attached high priority in Taiwan government policies. (Ju-Hung Jeng, 2001)

Since the visually impaired persons cannot see things with their eyes as normal people, their mobile communications interface operations are tremendously limited. With the advancement of technology in recent years, mobile communications devices are becoming smaller, smarter, and with greater function. (Kuo-Jui Chang,2002) Normally, an ordinary cell phone user receives feedback for his phone operations through the screen, which however is totally useless as a feedback channel for the visually disabled users. Therefore, the visually disabled users are indeed in great need of a valid, proprietary mobile communications interface.

II. Experimental Method and Procedures

This study mainly adopts the field interview, simplified thinking aloud, and video/audio protocols analysis methods for experimentation. First of all, a field interview is conducted with the seven fully-blind subjects to obtain a preliminary understanding of the current state of cell phone use among the visually disabled. The result is then used for the design of the simplified thinking aloud experiment in the second stage, during which, the subjects are to operate a cell phone according to instructions. The whole process including the image and the sound is recorded by a video camera, and the mental model and problem-solving process of the subjects while operating the cell phone is also recorded through the simplified thinking aloud technique. After the experiment, the video/audio protocols revealed in the recorded data are then timed, coding, and analyzed.

A. Field interview

Field interview is a method of gathering empirical data through face-to-face interviews given by the researcher to research subjects according to a predetermined outline or procedure on the topic of research.(Shao-Hsun Chang,1999)

It has several advantages, which include: 1) Flexibility; the method helps the researcher to obtain better first-hand data. 2) Survey scope extendibility; the method yields higher rate of return. 3) Complex question workability; the method allows in-depth investigation into more complex issues. 4) The method provides an opportunity for observation of the interviewee's nonverbal behaviors, which is useful for data evaluation. 5) The method offers high levels of control over the interview process. 6) Interviewers with proper training can manage all sorts of different situations.

B. Simplified thinking aloud

The thinking aloud method on the other hand has long been used in psychological studies, and has been gradually applied to man-machine interface evaluation. The major downside of this method is that it does not offer enough information for quantitative measurement. However, it allows the researcher to obtain very detailed small data about the user, which can be based upon for qualitative analysis.(Nielsen, Jakob, 1993)

Berry and Broadbent applied a write-down method for users to jot down how they face and carry out a specific task in their study and found that the thinking aloud method is 9% faster than the write-down method in terms of the time required for experimentation.(Berry & Broadbent, 1990) They held the view that language expression not only reinforces the concept about task demands among the users, but also helps them work more efficiently. In another research study, it is found that between the two groups of users operating different file systems, the error rate of think-aloud users is only 20% of that of quiet users. In addition, the think-aloud users work twice as fast as the quiet users.(Wright & Converse, 1992)

C. Video / audio protocols

The video/audio protocols are particularly valuable when it comes to situations in which test users have little control because it can retrieve information from each and every test user. The most obvious disadvantage of this method is that each test requires at least twice as long.

D. Data Analysis

1. According to the structure of questionnaire design, field interview can be further divided into the following:

* Structured interview: Interviews that follow a fixed questionnaire design.

* Non-structured interview, e.g. focus interview and in-depth interview.

* Quasi-interview: An interview form between structured and non-structured interview.

This study adopts a structured field interview, with the questionnaire design including basic information of the interviewee and a structured current status survey.

2. In the simplified thinking-aloud experiment, this study first developed the test tasks and then asked the respondents to proceed with the test tasks step-by-step as required, and to speak out their reasons and thoughts while operating the cell phone, which was recorded by the experimenter for later analysis of users' inner thoughts. This method allows the experimenter to observe the interaction between the user and the interface and to analyze the reasons behind certain user movements. Such observations are important for the experimenter to pinpoint the specific elements of users' operation errors.

3. Video/audio protocols involve two separate tasks of data recording and analysis. The recorded data includes verbal records and response records, while the analysis mainly involves verbal data encoding analysis.

The analysis of the recorded verbal data of the experiment requires a coding system, C.O.P.E., which involves four major categories of conceptual, operational, perceptual, and evaluation (Chen, 2001). This study aims to investigate the interface characteristics of blind users when operating a cell phone and defines its own verbal analysis encoding system for the purpose of the research, the D.M.O.T. system, which stands for doubt, movement, observation, and try respectively. It is hoped that through the coding technique, the qualitative verbal data can be quantified to facilitate analysis, in order to understand the operational difficulties that visually disabled users may face during their first use of an unfamiliar cell phone.

III. Results

A. Field Interview Results

This study interviewed 7 fully-blind massagists at You-ming Massage Center in Tainan. The interview results including the background information of the interviewees and the major content of the interviews are summarized below:

1. Basic information

a. *Average age:* 42.

b. *Gender distribution:* 4 males; 3 females.

c. *Recreational activities:* The result shows that "listening to music" is the most frequent leisure activity of the respondents, totaling 6 person-times, followed by listening to news (3 person-times), listening to audio books (1 person-time), playing musical instruments (1 person-time), and playing blowing (1 person-time).

This author has conducted a similar field interview with the fully-blind students at the Taichung School for the Blind, in which, listening to music was also listed by the interviewees as their favorite hobby.

In addition, some special education scholars (Wan & Chih, 1991) also conducted a survey on the frequent pastime activities of visually disabled persons. According to their survey, the majority of the visually disabled spent most of their leisure time listening to music, listening to radio broadcasts, and reading audio books, which together accounted for 226 person-times, or 28.3% of the total respondents under survey. This shows that listening to music and radio stations are the major leisure activities among the blind.

d. *Education background:* Most of the respondents only has elementary school education (3 persons), followed by junior high school education (2 persons), vocational high school education (1 person), and two-year junior college education (1 person).

e. *Braille reading ability:* Among the respondents, 5 persons are equipped with Braille reading skills, while the other 2 cannot read Braille characters correctly. A further interview reveals that the two massagists unable to read Braille characters are both non-congenitally blind.

f. *Difficulty with ordinary home phone use:* All the interviewees expressed that they do not have problem using home phones. This may have to do with the fact that they have been used the phone for so many times that they have become familiar with it. Other possible explanations for the comparatively easy use of home phones include large-size press-buttons, simple functionality, and limited amount of press-button selection.

2. Current Status Survey

a. Q: Do you currently use a cell phone?

A: All 7 respondents use cell phone at the time of survey.

b. Q: What is the brand name and model of the cell phone that you use currently?

A: Nokia cell phones are used by 2 respondents; Motorola, 4; and Acer, 1. On product model, no two respondents use the same type of cell phone model.

c. Q: What was the main consideration when you purchased this cell phone?

A: 4 respondents answered "price" as their main consideration, 2 answered "recommendations by friends and relatives, and 1 answered "recommendations by the salesperson at the retail store". This results shows that most of the blind people select their cell phone by its pricing, not its operability. This explains why many of these users have encountered difficulties and committed errors with cell phone operations after purchase.

d. Q: What are the most frequently encountered difficulties with cell phone use?

A: The difficulties most frequently encountered by the visually disabled users under survey include the following: "cannot check the status of cell phone signals", "cell phone functions are too complex and complicated", "cannot read the number of an unanswered call", "cannot read short messages", "buttons are too small and the connection is slow", "often dial the wrong number", "cannot tell the function mode of the cell phone, and thus cannot make a phone call successfully".

e. Q: In order for the visually disabled to use cell phones more smoothly, what are the things do you think that existing cell phones most need to improve on?

A1: Function simplification: Existing cell phone functions are highly complicated. Even sighted people can have hard time successfully operating a cell phone. Therefore, it is necessary for cell phone designers to simplify the operation process and to retain only the essential functions. This will be one of the main considerations that future cell phone designers should bear in mind when developing new cell phones for the blind.

A2: Adding voice function: For instance, unanswered calls and short messages can be delivered through voice.

A3: Adding raised dots: The most commonly seen raised dots on the cell phone keyboards are the only one on the number 5 key. All other commonly used press-buttons are lacking tactile marks for recognition.

A4: Voice information for function selection: Visually disabled users often press the function key by mistake, which often results in dial failure or setup problems. Therefore, many visually disabled

people are asking for voice hints for function selection, and hope that through voice information, they will be able to learn the function mode at the time of use.

A5: Increasing cell phone volume: People tend to believe that because of their loss of visual ability, the blind will become stronger with other senses through the "compensation effects". However, in one of the studies conducted by this author, the sighted subjects demonstrated a far smaller average threshold of audibility in their right ear for pure tone testing than their fully-blind counterparts from the School for the Blind. In other words, physiologically, the hearing organs of the blind do not become superior to those of sighted because of the compensation effect of human senses. Therefore, reasonably adjusting cell phone volumes will definitely have positive effect on blind users who do not have the necessary visual input.

A6: Enlarging button sizes: In the pursuit of slimness and lightweight, the easiness in use has been compromised in modern cell phone design. According to the human-factor measurement data, press-buttons in square or round shape are the most appropriate and the size of the buttons is most ideal within the range of 12mm to 30mm. In order to ensure that the cell phone does not become too bulky and difficult to carry, it is suggested that the button size adopt the minimum value of the recommended human-factor reference data.

A7: Raising the press-buttons: The visually disabled persons usually use their fingertip pulp to locate the correct number key. Therefore, insufficient height of press-buttons will affect the dialing efficiency and accuracy of the visually disabled. Excessively high press-button design on the other hand will make the product too bulky and is conducive to pressing of wrong keys, and excessively long pressing movements.

A8: Adding feedback for pressing movements: The visually disabled require a sound or a mechanical response as feedback to make sure that they have completed the pressing movement correctly.

f. Q: Please dial 0953-095198 and then press the call button. (This experiment uses a Nokia cell phone provided by the researcher).

A: Only one who uses another model of Nokia cell phone managed to complete the task. The subject was able to complete the dial and connection movement successfully because he has used a Nokia phone before. The experiment result shows that there is a lack of consistency in the front panel design between cell phones of different brands and thus users' past experience with cell phone of other brands cannot apply.

B. Simplified Thinking-aloud Procedure

1. Test Task Establishment

The field interview in the first stage reveals that the cell phone use of visually disabled people is much limited to making and answering phone calls. Other cell phone functions are rarely used by users with visual disabilities. Since the operations involved with phone call answering are very simple, the visually disabled users do not encounter any difficulty with it. On the contrary, given their visual disability, the blind can easily commit an error with dialing and call connecting. In order for subsequent usability comparison, this study has established the test task flow of call connecting from a cell phone (see Figure 1), or the standard call-connecting procedure, for identifying and comparing the operation characteristics with cell phone use of the blind subjects under experiment. The designated test tasks of this experiment are shown in Figure 1.

Turn on → Dialing → Sending → Talked over → Turn off

Figure 1. Test task flow of call connecting from a cell phone

2. Simplified Thinking-aloud Experiment

In this stage, the experiment is designed to record the mental model and behavioral characteristics of the visually disabled when using cell phone. The thinking-aloud method is applied to help reveal the mental model hidden inside the subjects and the movement analysis method is then used to identify the behavioral traits of each individual and the specific factors causing operational difficulties.

The thinking-aloud experiment uses an Acer phone and a Nokia phone, of which the Acer phone is of the flip-lid model (see Figure 2) while the Nokia phone is of a standard model (see Figure 3). The purpose of using two different models for testing is to ensure greater objectivity with data collection.

This experiment is conducted in a place with no external interference. First of all, the experimenter briefed the subjects the experiment content and then the subjects are required to perform the designated test tasks using two different models of mobile phones. The entire process of subjects' operating the cell phones including the complete video and audio data is recorded.

Figure 2. Acer G530

Figure 3. Nokia 8250

C. Video/Audio Protocols Analysis

1. Video/Audio Protocols Records

The researcher first observes closely both the verbal speech and responses of the subjects on the recorded film of the experimentation in the previous stage, and then summarizes the data under two categories of "Verbal Records" and "Response Records" in Table 1 and identifies the parts with poor use interface, and finally measures the time required for completing the test tasks of the 5 subjects in various stages.

Table 1. The record of the test tasks of the 5 subjects in various stages.

Record / Step	Record of verbal speech	Record of responses	Record of operational time	Complete the assigned tasks?
Step a-1	Abridge	Abridge	5sec, 4sec, 3sec, 5sec, 6sec	Yes(5) No(0)
Step a-2	Abridge	Abridge		Yes (0) No (5)
Step a-3	Abridge	Abridge	22sec, 30sec, 26sec, 28sec, 25sec	Yes (5) No (0)
Step a-4	Abridge	Abridge		Yes (0) No (5)
Step a-5	Abridge	Abridge		Yes (0) No (5)
Step a-6	Abridge	Abridge	5sec, 5sec, 4sec, 6sec, 5sec	Yes (5) No (0)
Step b-1	Abridge	Abridge		Yes (0) No (5)
Step b-2	Abridge	Abridge	15sec, 20sec, 18sec, 17sec, 21sec	Yes (5) No (0)
Step b-3	Abridge	Abridge		Yes (0) No (5)
Step b-4	Abridge	Abridge		Yes (0) No (5)
Step b-5	Abridge	Abridge	2sec, 4sec, 3sec, 2sec, 3sec	Yes (5) No (0)

2. Video/Audio Protocols Analysis

This study utilizes the D.M.O.T. verbal analysis encoding system, which stands for doubt, movement, observation, and try respectively.

It is hoped that through the coding technique, the qualitative verbal data can be quantified to facilitate analysis, in order to understand the operational difficulties that visually disabled users may face during their first use of an unfamiliar cell phone. (see Table 2)

Table 2. The result of D.M.O.T encoding system.

Item / Step	Novice' result of vebal analysis	Average of operational time	Remarks
Step a-1	O(2) M(5)	4.6 sec	
Step a-2	D(7) O(6) T(10)	※	Not yet finished
Step a-3	M(5)	26.2 sec	
Step a-4	D(5) O(6) T(12)	※	Not yet finished
Step a-5	D(6) O(7) T(11)	※	Not yet finished
Step a-6	O(3) M(5)	5 sec	
Step b-1	D(8) O(8) T(12)	※	Not yet finished
Step b-2	M(5)	18.2 sec	
Step b-3	D(6) O(7) T(14)	※	Not yet finished
Step b-4	D(8) O(9) T(13)	※	Not yet finished
Step b-5	M(5)	2.8 sec	

IV. Discussion

This study uses its self-designed encoding system to codify and analyze the verbal and observation records of the subjects and derives from Table 1 the verbal analysis results as shown in Table 2, with the figures within the parentheses denoting the number of occurrence of the behavior described by a specific code. The above analysis results have led to some initial findings: In performing such tasks as "switching on the power", "sending a call", and "ending a call", the blind subjects have encountered high levels of difficulties. Even after repeated trials, they still failed to operate correctly. The dialing process on the other hand can be completed by all subjects, and they can eventually manage to dial correctly. This proves that as long as the keyboard arrangement is standardized, even when they have not used the phone before, the visually impaired people can still complete basic functional operations without a problem. The power switch design on the other hand varies with the brand and type of cell phone. Hence, none of the subjects were able to press the correct power switch at the first time of use and relied on the experimenter to tell them the exact location of the power switch.

As can be seen from Table 2, the average time required for completing the dialing task on a Nokia cell phone is 18.2 sec and 26.2 sec on an Acer cell phone. The huge difference can be explained by the fact that the height of the raised buttons of the two types are different. The rather flat press-buttons of Acer phones thus largely limits the dialing speed of blind users, who rely mainly on their tactile sense for key pressing. The operation time analysis chart is shown in Figure 4.

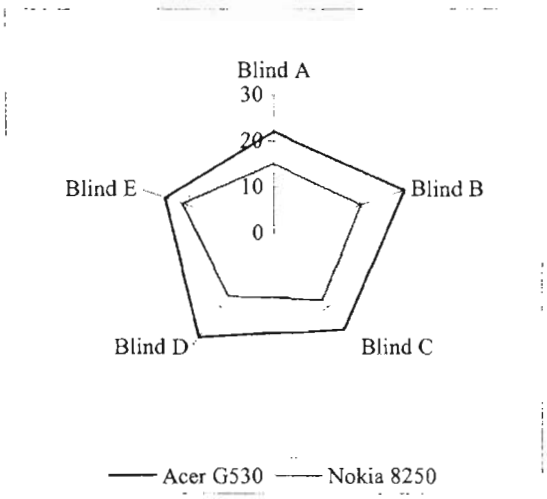

Figure 4. The operation time analysis chart.

V. Conclusions

This study finds that when using a cell phone, the blind people demonstrate high levels of familiarity with the number keys. In the experiment, 5 subjects achieved 100% accuracy rate with dialing regardless of phone brands and models. This highlights the importance of product standardization for the visually disabled. The experiment also shows that Nokia cell phones have better operability with key pressing function. For the subjects to complete dialing of a 10-digit phone number on a Nokia handset takes only 18.2 sec on average, as opposed to 26.2 sec on an Acer handset. This different mainly has to do with the height of the raised buttons of the two phones. On the Acer phone for instance, the bottom half of each single press-button is cut off to almost the same level of the panel. This presents a serious difficulty to the visually disabled users because they rely on the tactile sense of their fingertips to locate and identify different press-buttons. Thus it requires a longer time for them to dial a number on an Acer phone.

The visually impaired persons have very high expectations towards the voice function, and are hoping that more daily-life products will be added a voice function. For instance, a voice dialing phone, voice hints for incoming calls, and short messages delivered through voice. In the future it is likely to even develop a more human-friendly voice recognition and operation interface by incorporating the information technology or other specialized technologies to ensure easy operations for the blind population.
The most commonly used function keys on a cell phone include "power", "call", "end", and "delete" keys. If these function keys can be standardized as the number keys, the visually disabled users will be able to make phone calls as easily as sighted users with any type of phone at the first time of use.

According to the field interview, the main consideration of the blind people when purchasing a cell phone is "price". Among the interviewees, no one was using a cell phone with a voice function. But the voice function of the cell phone was useful for the blind. Therefore for future, cell phone manufacturers should strive to develop mid- to low- priced voice dialing handsets to attract customers with visual disabilities.

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