A questionnaire survey on usage of and requirements for touchscreen interfaces among the Japanese visually impaired population

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Abstract: With the spread of touchscreen computers, the accessibility of touchscreen interfaces for the visually impaired population should also be ensured. Although some of this population have an interest in the technology and own touchscreen computers, their usage conditions and computer requirements have not been investigated. Specifically, the following questions concerning this population's use of touchscreen computers remain unanswered. What kinds of inconveniences have they experienced when using them? What kinds of functions do they require? Why do some members of this population avoid using touchscreens despite their interest in them? In order to develop and spread a user-friendly interface for visually impaired people, it is necessary not only to study their ability to access touchscreen computers, but also to investigate the current situation pertaining to these devices with regard to this population. In this report, our objective is to demonstrate visually impaired people's usage conditions and their requirements of touchscreen interfaces, such as smartphones and tablet computers. These issues are investigated through a questionnaire survey whose subjects were visually impaired Japanese people. Some of the results indicated that: most visually impaired people would like to use touchscreen computers; most owners used their touchscreens by means of screen readers, regardless of their visual condition; and dynamic and stable tactile feedback can be effective.

Keywords: Questionnaire survey, Touchscreen interfaces, Visually impaired people

1. Introduction

Smartphones and tablet computers have recently become popular in the sighted population. According to the recent news in Japan, the ratio of smartphone subscriptions continues to increase [1-3]. Due to the expectation of the rapid penetration of the visually impaired population by touchscreen computers, the accessibility of suitable touchscreen interfaces should be ensured. Although some visually impaired people are interested in and use touchscreen interfaces, how they use them and what they require from touchscreen interfaces remains unclear. This fact leads to an insufficient amount of information about these devices being distributed among visually impaired people. As a result, unfortunately, many visually impaired people regard these interfaces as unavailable to them.

In order to obtain visual information from current touchscreen computers, visually impaired people need to use accessibility applications, such as screen readers and screen magnifiers. Low-vision users can identify a target position with their remaining visual sense by utilizing a screen magnifier, while totally blind people can do so by using their auditory and tactile senses to use screen readers such as VoiceOver on iOS devices [4] and TalkBack on Android devices [5]. Examples of the problems related to these accessibility applications are that the localization of screen readers on touchscreen computers until August 2012 was inadequate, explanatory expressions (called "Shosaiyomi" in Japanese) have not been implemented in the VoiceOver utility on iOS devices, and Android smartphones cannot vocalize Japanese sentences. This situation might mean that at least

the Japanese visually impaired population requires an improvement in these accessibility functions. A recent update of iOS 6 in September 2012 provided a Japanese-specific version of this function. Further, Document Talker, which has been released by Create System Kaihatsu, can be installed on Android touchscreen computers to provide this function [6]. Thus, the accessibility environment for visually impaired people is improving gradually. However, manipulation using accessibility software is different from normal manipulation, and the amount of specialized learning materials and the provision of lecture courses for touchscreen computers are insufficient, especially those catering to the totally blind population. As a result, unfortunately, many visually impaired people regard these interfaces as unavailable to them. To ensure that accessible touchscreen computers for the visually impaired will become prevalent, it is necessary to investigate the specific conditions of the interaction between the visually impaired and touchscreen computers. What kind of shortcomings do visual impaired users find in their interaction with touchscreen computers, and what kind of functions do they need in their touchscreen computers?

In this report, our objective is to demonstrate the visually impaired population's usage of touchscreen interfaces, such as smartphones and tablet computers, and what they require from them. These issues are investigated through the questionnaire described in Section 2. After the results are presented, the current interaction situation is discussed in Section 3.

2. Method

2.1. Participant

One hundred and forty visually impaired persons (100 males and 40 females), comprising students of a university and personnel belonging to NPOs for ICT penetration among visually impaired people, participated in this investigation. Fig. 1 shows the age group and the disability grade (in Japanese standards) of the participants. The sample was composed mainly of middle-aged people, as compared to Watanabe's research [7]. The disability of 54.3% of the participants was 1st grade, and of 30.7 %, 2nd grade (1st grade: people whose summation of binocular corrected visual acuity is less than 0.01; 2nd grade: people whose summation is 0.02–0.04.).

2.2. Questionnaire outline

The questionnaire items were originally written in Japanese, and were translated by the authors. The objective of the questionnaire was to collect the following data:

1) The individual characteristics of the participants: age, gender, disability condition, history of training for daily living, etc.

2) The usage conditions of traditional cell phones: current model, in-use accessibility functions, desired functions, etc. In this study, a traditional cell phone is defined as a mobile phone comprising a display and a hardware keyboard.

3) The usage conditions of personal computers: current OS, in-use accessibility functions, etc.

4) The usage conditions of touchscreen computers, such as smartphones and tablet computers: current model, location and situation of usage, in-use applications, and accessibility functions, etc. In this study, a touchscreen computer is defined as a mobile device that does not have a hardware keyboard.

5) Other opinions or reflections.
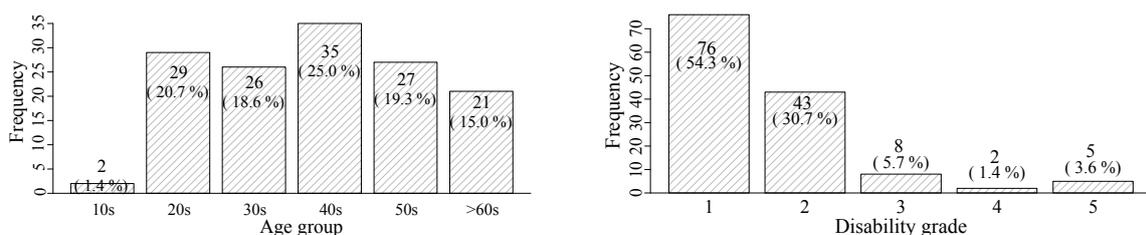
Fig.1. Participants according to age-group (left) and disability grade (right)

The questionnaire items were determined through a discussion among the authors (including a totally blind person) with reference to Watanabe's study [7] and MHLW's census [8]. The questionnaire items numbered fifty-four. The questionnaire was distributed in a computer-based electronic text file format, by e-mail. The participants filled the questionnaire on their own computer, and returned it to the authors. Approval of the survey questionnaire was obtained from the Tsukuba University of Technology Ethics Board, and all participants had consented to participate in the survey. This survey was conducted from 2011.12 to 2012. 2.

3. Results and discussion

3.1. Individual characteristics

36.4% of participants reported that they were totally blind, while 52.1% of participants reported that they could not read visually. The cross tabulation table of disability condition and questionnaire items is analyzed in the following sections. To define the participants' disability condition, two considerations were used: reported visual condition and visual reading ability.

The number (ratio) of participants who used traditional mobiles, personal computers, and touchscreen computers, such as smartphones and tablet computers, was 134 (95.7 %), 139 (99.3 %), and 18 (12.9%), respectively. A cross tabulation table of visual reading ability and the usage condition of ICT devices is presented in Table 1, which shows that the ratio between participants who could read visually and had touchscreen computers was greater than that between participants who were totally blind and had touchscreen computers. The participants who did not have smartphones and tablet computers (122 persons) consisted of 96 (78.6%) who had never touched them and 19 (15.6%) who had touched them but did not own them (the remaining participants did not answer this question).

3.2. Usage conditions of traditional mobile phones

Almost all the participants (95.7 %) owned traditional mobile phones. This result indicates that the participants in this study used mobile phones more than those in Watanabe's investigation [7]. Fig. 2 shows the use frequency of applications installed on the mobiles. No significant difference was found among the disability grade, the reported visual condition, and the visual reading ability, using Fisher's exact test. Most of the participants used the phone call and e-mail functions, and the clock/alarm. The item "other" included barcode reader, pedometer, map, address book, calculator, camera, music player, infrared data communication, and mobile wallet applications, and navigation applications based on GPS.

The rate of accessibility functions in use on mobile phones is presented in Table 2. Most totally blind or partially visually impaired participants tended to use auditory assistive software, such as a screen reader, or visual assistive software, including a font magnification or color configuration application, respectively. These findings are very similar to those of Watanabe's investigation [7].

Table 1. Cross tabulation table. Columns: Visual reading ability of participants. Rows: Usage status of ICT devices, such as mobile phone, personal computer, and touchscreen computer.

		Able to read visually	Unable
Mobiles	In Use	54	73
	Not in use	7	0
	($p = 0.02 < 0.05$, Fisher's exact test)		
Personal computer	In use	59	73
	Not in use	1	0
	($p = 0.53$, Fisher's exact test)		
Touchscreen computer	In use	12	5
	Not in use	48	68
	($p = 0.04 < 0.05$, Fisher's exact test)		
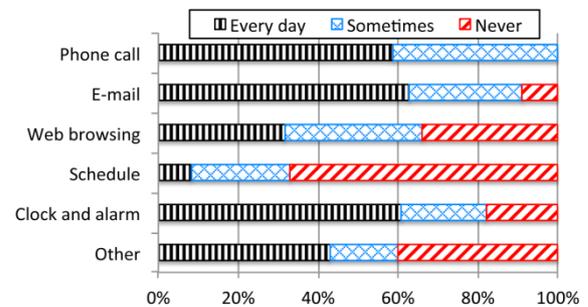
Fig. 2. Use frequency of each application installed on mobile phone

Table 2. Cross tabulation table. Columns: Reported visual condition of participants. Rows: Accessibility functions in use on mobile phones.

		Partially blind	Totally blind
Screen reader	In use	59	49
	Not in use	20	1
		($p < 0.01$, Fisher's exact test)	
Font magnification	In use	50	1
	Not in use	29	49
		($p < 0.01$, Fisher's exact test)	
Color config	In use	34	0
	Not in use	45	50
		($p = 0.02 < 0.05$, Fisher's exact test)	

Table 3. Cross tabulation table. Columns: The reported visual condition. Rows: Usage condition of accessibility applications.

		Partially blind	Totally blind
Screen reader	In use	70	48
	Not in use	13	0
		($p = 0.01$, Fisher's exact test)	
Screen magnifier	In use	37	0
	Not in use	33	48
		($p = 0.01$, Fisher's exact test)	
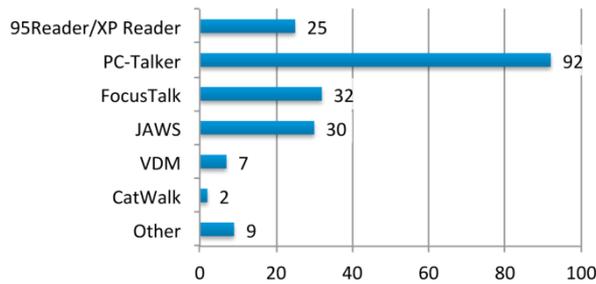
(a) In-use rates of Japanese screen reader for all participants
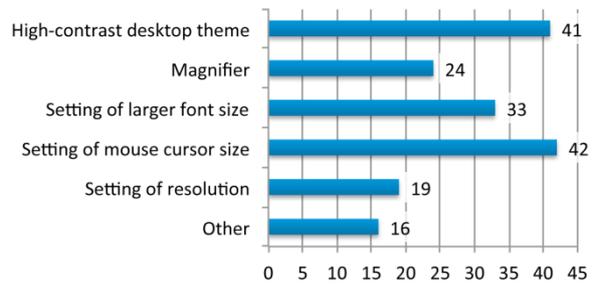
(c) Partially visually impaired participants' in-use support applications preinstalled. on Windows
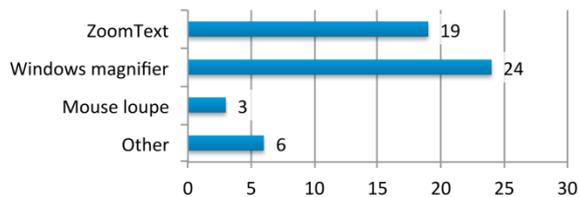
(b) Partially visually impaired participants' in-use screen magnifiers

Fig. 3. Participants' in-use accessibility applications

3.3. Usage conditions of personal computer

All the participants who owned personal computers used the Microsoft Windows program. Ninety-five and seventy-one participants used Windows XP and 7, respectively. Only three persons concurrently used Mac OS X, all of whom were partially visually impaired.

The number of in-use screen readers is shown in Fig. 3 (a). The tendency to use screen readers did not differ significantly between totally blind and partially visually impaired participants. However, the number of partially visually impaired participants who did not use any screen reader applications was significantly more than that of totally blind, as shown in Table 3. On the other hand, none of the totally blind participants used screen magnifier applications. Figures 3 (b) and (c) show the number of in-use screen magnifiers and in-use Windows user-support applications in the partially visually impaired group. These results indicate that not all partially visually impaired participants used a screen magnifier: some customized the GUI of their personal computers.

3.4. Usage conditions of smartphones and tablet computers, and participants' reasons for not using them

Table 4 shows the participants' experience in using touchscreen computers. No significant difference in usage experience was found in relation to the participants' reported visual ability. In Table 5, it can be seen that there is no significant difference in the willingness of participants who did not have touchscreen computers to use them in relation to their reported visual ability. Table 5 shows that 50.0% of the participants wanted to use this kind of the computer. Their reasons for not using touchscreen computers, shown in Table 6, indicate that some participants who did not want to use a touchscreen computer may be satisfied with traditional mobile phones. This cross tabulation table also indicates that a significant number

Table 4. Use experience of touchscreen computers

	Partially blind	Totally blind
No use experience	60	39
Experienced but not in possession	15	8
In possession	15	4
($p = 0.20$, Fisher's exact test)		

Table 5. Willingness to use touchscreen computer

	Partially blind	Totally blind
Strong	15	7
Moderate	14	14
Not very strong	11	5
None	3	6
Do not know	17	8
($p = 0.14$, Fisher's exact test)		

Table 6. Reason for not using touchscreen computers

		Partially blind	Totally blind
Flat touchscreen w/o buttons	Checked	14	9
	Unchecked	18	9
($p = 0.77$, Fisher's exact test)			
No information about functions	Checked	8	6
	Unchecked	24	12
($p = 0.53$, Fisher's exact test)			
No knowledge of screen readers	Checked	8	5
	Unchecked	24	13
($p = 1.00$, Fisher's exact test)			
No knowledge of screen magnifiers	Checked	3	1
	Unchecked	29	17
($p = 1.00$, Fisher's exact test)			
Satisfied with current mobile	Checked	18	9
	Unchecked	14	9
($p = 0.77$, Fisher's exact test)			
I need buttons like hardware keyboard	Checked	6	9
	Unchecked	26	9
($p = 0.03 < 0.05$, Fisher's exact test)			
Other	Checked	4	3
	Unchecked	28	15
($p = 0.69$, Fisher's exact test)			

Fig. 4. Touchscreen computers owned by participants
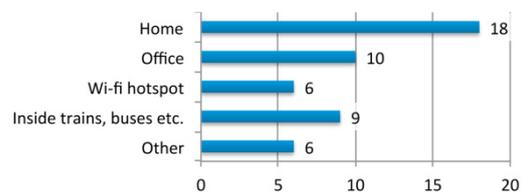
Fig. 5. Places where participants used their touchscreen computers

of totally blind people, in particular, would like touchscreen mobiles to have buttons as hardware keyboards that enable users to give feedback by pressing or not pressing them.

Figures 4 and 5 show what kind of touchscreen computer the participants owned and the places where they used it, respectively. Three of the participants or the others were totally blind or partially visually impaired, respectively. Seven of the participants owned multiple devices. No significant difference in the place where the computer was used and in ownership was observed between the two reported visual conditions ($p > 0.05$, Fisher's exact test). All and half of the participants selected home or inside public transportations as the place where they used the computer, respectively.

Fig. 6 shows the applications that the participants used. The participants mainly used the phone call, e-mail, music player, and browser functions. No remarkable difference in applications used was observed between the stationary and moving conditions. However, in the case of the navigation application, more participants selected the stationary rather than the moving condition. This result may reflect the fact that partially visually impaired people investigate barrier-free information mainly in advance of moving to their destination, according to our previous study [9].

According to the responses concerning in-use accessibility applications, shown in Fig. 7, approximately half of the visually impaired participants used their touchscreen computer by means of their visual sense. This may be because most of the participants who answered this question were partially visually impaired. They also used a screen reader; this result is not surprising because, for example, approximately 75% and 84% of partially visually impaired participants also used screen reader applications on mobile phones (as shown in Table 2) or personal computers, respectively (as shown in Fig. 3(a)).

According to Fig. 8, which shows the participants' need for tactile feedback from the interface of touchscreen computers, most of the participants considered this function to be necessary. They indicated that desirable tactile feedback functions include a guide to the display frame/center of the display and the locations of targets, such as icons and buttons, and that detachable hardware buttons for application shortcuts etc. For teaching people to use a touchscreen computer, a fixed guide to the display frame or the center of the display may be easily available and would be effective. The authors are now testing an
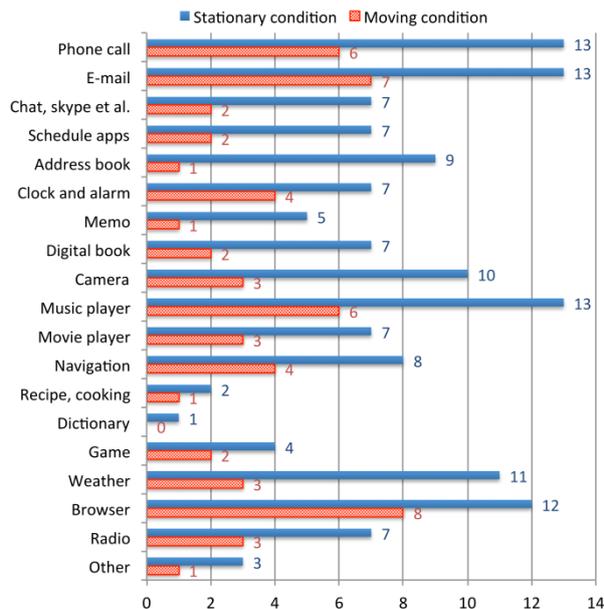
Fig. 6. Applications used by participants on their touchscreen computer
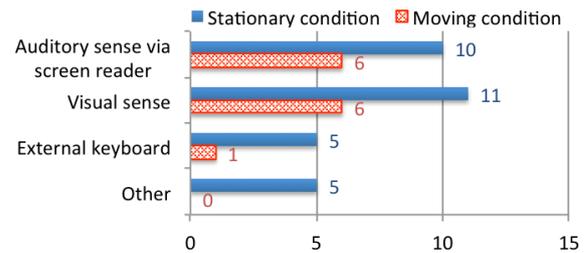
Fig. 7. Accessibility applications used by participants on their touchscreen computers
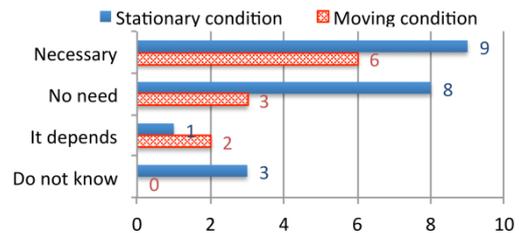
Fig. 8. Need for tactile feedback from touchscreen computers

easily detachable sheet with a tactile guide for training sessions for people who are totally blind. The results will be reported in the future.

3.5. Other opinions or reflections

Some participants reported that they only found out about the existence of accessibility functions for touchscreen displays that would enable them to use a computer through answering this questionnaire. This indicates that some visually impaired people have preconceived ideas about touchscreen computers that can be corrected. At least, if visually impaired people received just a brief explanation of accessibility functions or are notified about their availability, their motivation to use them might be effectively promoted.

4. Conclusion and future work

To demonstrate how touchscreen interfaces, such as smartphones and tablet computers, are used by visually impaired people, and what this population requires of them, a questionnaire survey was carried out. The results indicated the following:

1) 95.7 % and 99.3 % of the participants owned a traditional mobile phone and personal computer, respectively. This result indicates that the participants in the survey reported in this article may generally be more interested in using these devices than has previously been reported. However, in this participant group, only 12.9% of the participants owned a touchscreen computer. No significant difference in the possession of a computer was observed between totally blind and partially visually impaired participants.

2) Some participants who did not want to use a touchscreen interface may be satisfied with a traditional mobile phone. A significant number of the totally blind participants would like touchscreen mobiles to have buttons like a hardware keyboard that would enable them to give feedback by pressing or not pressing them.

3) With respect to accessibility functions, half of the participants who used a touchscreen computer employed a screen reader, regardless of their reported visual condition. All the totally blind users employed a screen reader.

4) Most of the participants regarded tactile feedback to be a necessary function, according to the summary of participants' need for tactile feedback from touchscreen computers. Their opinion indicated that not only dynamic but also stable

tactile feedback could be effective. Stable tactile feedback hardware includes a guide fixed to the display frame or center of the display.

5) Even brief information about accessibility functions can probably promote visually impaired people's use of touchscreen computers.

Future work will involve the development and evaluation of systematic learning materials and methods for visually impaired people, especially totally blind people.

Acknowledgement

References

[1] http://consult.nikkeibp.co.jp/consult/news/2012/0726sp/ (in Japanese) (date last viewed: 2012/12/03)

[2] http://jp.en.nielsen.com/site/documents/SPImr-jun12_FINAL.pdf (date last viewed: 2012/12/03)

[3] http://www.impressrd.jp/news/121120/kwp2013 / (in Japanese) (date last viewed: 2012/12/03)

[4] VoiceOver - apple, http://www.apple.com/accessibility/voiceover/ (date last viewed: 2012/12/03)

[5] TalkBack, https://play.google.com/store/apps/details?id=com.google.android.marvin.talkback
     (date last viewed: 2012/12/03)

[6] http://www.createsystem.co.jp/dtalkerAndroidSDK.html (date last viewed: 2012/12/03)

[7] T. Watanabe, H. Nakgaoka, M. Miyagi, K. Minatani, "User Survey of Screen Readers, the Internet, and Mobile Phones 2007," The National Institute of Special Education, 2007. Web: http://vips.eng.niigata-u.ac.jp/ PCUserSurvey/Survey2007/ Survey2007En.html (date last viewed: 2012/12/03)

[8] Census of disabled people in 2006 (this translated title was prepared by the authors).
     http://www.mhlw.go.jp/toukei/saikin/hw/shintai/06/index.html (date last viewed: 2012/12/03).

[9] T. Miura, K. Yabu, S. Ikematsu, A. Kano, M. Ueda, J. Suzuki, M. Sakajiri, T. Ifukube, "Barrier-free Walk: A social sharing platform of barrier-free information for sensory/physically-impaired and aged people," *IEEE Int. Conf. Syst. Man Cybern. 2012*, 2012: 2921-2926.

[10] T. Miura, H. Matsuzaka, M. Sakajiri, and T. Ono, "Usages and demands to touchscreen interface: a questionnaire survey in Japanese visually impaired people," *IEEE Int. Conf. Syst. Man Cybern. 2012*, 2012: 2927-2932.