Touchscreen Text Entry Methods Used by Blind and Low Vision Users

Analysis of ICT User Survey 2017

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Abstract A survey was conducted on the use of ICT devices by blind and visually impaired people. Of the 303 respondents, 180 (59.4%) used feature phones (*keitai*), 161 (53.1%) used smartphones, 64 (21.1%) used tablets, and 285 (94.1%) used personal computers. The usage rate of smartphones doubled, and that of feature phones decreased by about 20%. The higher the age was, the higher the usage rate of feature phones and the lower that of smartphones became. The text entry methods on touchscreens with a screen reader varied greatly between blind and low vision people and between smartphones and tablets. Vision aid apps such as for GPS navigation and object recognition were used by more than half of the blind smartphone users.

Key words: Blind, Low Vision, Smartphone, Tablet, User Survey, Text Entry.

1. Introduction

Information and Communication Technology (ICT) devices have enabled blind and visually impaired people to obtain and communicate information by themselves. With these devices, users can read a variety of books and documents whenever they like without relying on sighted persons, whereas traditional human support such as braille description and audio recording takes a month or more for transformation to be completed¹⁾.

Traditionally, personal computers (PCs) have been playing a leading role in providing blind and visually impaired people with access to mainly text information. Recently, however, smartphones and tablets are taking over this role²⁾. They not only give access to text information and the Internet but also have functions and apps for speech recognition, image recognition, GPS navigation, and others that enable blind and visually impaired people to live high-quality, independent lives. As these devices are handy, blind and visually impaired people can utilize them whenever and wherever they

want to. However, blind users have difficulty operating touch interfaces since these devices have no tactile cues²⁾. Thus, not only blind and visually impaired people and their supporters but also other stakeholders such as smartphone and tablet makers, marketers, carriers, and administrative officers are showing an interest in the usage of these devices. With this background, we decided to carry out a new survey on the use of ICT devices by blind and visually impaired people. The following is what we wish to make clear out of this survey.

- Latest usage rate of smartphones and tablets
- Age-related differences in usage rate
- Usage differences between blind and low vision
- Latest share of each device
- Text entry methods on touchscreens
- Usage rate of vision aid apps

Among these findings, this paper focuses on text entry methods on touchscreens since this was the biggest issue for blind and visually impaired users in our previous survey²⁾.

2. Related Surveys

The first ICT blind user survey in Japan that focused on smartphones and tablets may be the one conducted by Matsuzaka from November 2011 to February 2012³⁾. The same research group carried out two more surveys in 2012 and 2013 to explore how touchscreens were used by blind people⁴⁾. Nikkei BP Consulting Inc. carried out a survey on the use of the Internet by blind and visu-

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ally impaired people from October to November 2014⁵⁾. The results showed how blind and visually impaired people used the Internet by means of PCs and smartphones. The authors had previously conducted four ICT user surveys on visually impaired people, one each in 2000, 2002, 2007, and 2013. Among them, the 2013 survey revealed the usage rate and the advantages and drawbacks of smartphones and tablets statistically²⁾.

Globally, WebAIM (Accessibility In Mind) has done seven screen reader user surveys from 2008 to 2017⁶⁾. The high frequency of survey conduction and the variety of respondents from all over the world are remarkable.

3. Survey Procedure

The survey was contracted to a non-profit organization “Turtle” whose main activity is to help visually impaired people in seeking and keeping their careers⁷⁾. They disseminated the questionnaire to about 50 mailing lists to which visually impaired people belonged. The respondents answered to the questionnaire by writing a reply message and sending it to the Turtle. For descriptive questions, they wrote the answers in the next line to the question or in the bracket following the question, and for closed-end questions by placing an arbitrary symbol such as a circle in front of the choice they chose. The survey started on February 20, 2017 and ended on March 20, 2017.

The questionnaire first asked about the respondents’ profiles and whether they used feature phones, smartphones, tablets, and PCs. If they used one of them, then they were instructed to move on to the following parts where they were asked to describe the model(s) and accessibility features in use, purposes of the use, Web sites they browsed from each device, conveniences, and inconveniences they faced while using them. As for smartphones and tablets, text entry methods and learning methods were asked about in addition. The number of questions on respondents’ profiles was five, three on the usage of ICT devices in general, seven on feature phone usage, and nine on each of smartphone, tablet, and PC usage along with a few sub-questions. Most of the questions in the current survey were the same as those in the previous survey except for the detailed questions as to text entry methods.

This survey was reviewed by the Ethics Committee of Niigata University and conducted with the permission of the President (permission number: 2016-0026).

4. Respondents

The total number of valid respondents was 303. This number was smaller than that of the 2013 user survey by just one²⁾. As the mailing lists in which the questionnaire was circulated were mostly the same as in the previous survey in 2013, it is presumable that the respondents in 2017 survey may overlap those in 2013 greatly. However, we cannot confirm it because the personal information of the respondents such as name, address, and e-mail address was removed before we receive the responses. The 303 respondents comprised 190 men (62.7%) and 113 women (37.3%) ranging in age groups from teens to 80 years or older (Fig. 1). Those in their fifties were the biggest age group with 76 respondents (25.1%) followed by the forties (65 respondents, 21.5%) and the sixties (54 respondents, 17.8%).

Two hundred and seven (68.3%) were registered as grade 1 visually impaired persons, 68 (22.4%) as grade 2, and 23 (7.6%) as grades 3 through 6. Four persons were not registered as visually impaired, and the status of one was unknown. The Japanese Law for the Welfare of Physically Disabled Persons classifies visually impaired people into six grades and people with grades 1 and 2 disabilities are considered severely impaired.

Among grade 1 respondents, 92.3% stated that they could not read nor write print. This ratio declined as the degree of disability decreased, 32.4% for grade 2 and 0% for grades 3 through 6 (Fig. 2). A survey conducted by a research group in University of Tsukuba on the students attending schools for the blind has shown the relationship between their visual acuity and the letters they use: When their visual acuity is 0.02 or less than that, the usage rate of normal (printed or written) letters declined sharply and that of Braille rose accordingly⁸⁾. Persons whose visual acuity of both eyes is 0.02 to 0.04 are classified as disability grade 2. Thus, it is reasonable that the grade 2 respondents in our survey included both people who could read and write print and people who could not. Hereafter, we refer to the respondents who could not read nor write print “blind people” and those who could read and write as “people with low vision.” The survey data were categorized into these two user groups and compared with each other.

5. Usage of ICT Devices in General

Among the 303 respondents, 180 (54.9%) used feature phones, 161 (53.1%) smartphones, 64 (21.1%) tablets, and 285 (94.1%) PCs.

Fig. 1 Age distribution of respondents.

Fig. 2 Ratio of blind to low vision respondents by disability grade.

Fig. 3 Usage of ICT devices.

5.1 Usage Difference between Blind and Low Vision

The usage rate data were classified in two user groups: blind and low vision (Fig. 3). Four χ^2 tests showed no significant difference between blind and low vision people in the usage rate of feature phones and smartphones ($\chi^2(1) = 1.57$ and 0.47 , respectively), whereas significant differences were found in the use of tablets and PCs ($\chi^2(1) = 25.1$ and 12.8 , $p < 0.05$, respectively). The same p value was used hereinafter.

When compared with the 2013 survey results²⁾, the usage rate of smartphones doubled for both blind and low vision people. The usage rate of tablets doubled for low vision people but grew by only 1.4 times for blind people. In contrast, the usage rate of feature phones decreased by 20% for both blind and low vision people. The usage rate of PCs by blind people kept as high as nearly 100%, whereas that by low vision people dropped by 7.4%.

5.2 Usage Difference by Age Group

Prior to the investigation of age difference, the difference in the ratio of blind to low vision people was tested among age groups. From teens to the seventies, the ratio of blind people ranged from 55.6% to 77.1%. A χ^2

test showed no significant difference in the ratio of blind to low vision people among age groups ($\chi^2(6) = 4.54$. Since the size of the age group of 80s and older was as small as three people, it was excluded from the test.). Thus, in the investigation of age difference, the data of both blind and low vision people were summed up by age group.

Figures 4 (a) to (d) show the usage rate of four types of ICT devices by age group. Apparently, the older the respondents were, the higher the usage rate of feature phones became (Fig 4 (a)). In contrast, the younger the respondents were, the higher the usage rate of smartphones became (Fig 4 (b)). Age group differences were not noticeable for tablets and PCs. Statistical analysis proved these phenomena. Four χ^2 tests showed significant differences by age group in the usage rate of feature phones and smartphones ($\chi^2(6) = 47.1$ and 48.4 , respectively), whereas no significant age difference was found in the use of tablets and PCs ($\chi^2(6) = 5.25$ and 6.40 , respectively).

6. Smartphone Usage

This chapter describes the responses from 161 (111 blind and 50 low vision) users to questions on smartphone usage.

6.1 Models

The smartphone models being used by the respondents are shown in Fig. 5. The most popular models were various Apple iPhones with 102 (91.9% of the 111) blind and 40 (80.0% of the 50) low vision users. “Raku-Raku (easy to use) Smartphones” from Fujitsu, which are equipped with a speech output function, were used by only six blind respondents, a very small number compared with the 102 for iPhones. Android devices were used by 14 respondents and 9 of them were people with low vision. Five respondents listed two devices or more, two respondent’s devices were not identified, and one did not answer this question. Thus, the summed up numbers in Fig. 5 do not equal the number of total users.

6.2 Accessibility Features

Usage rates of accessibility features differed greatly between blind and low vision users (Fig. 6). Most (99.1%) of the 111 blind smartphone users used speech output (screen reader), and only 7 (6.3%) used visual aids. In contrast, most (90.0%) of the low vision users used visual accessibility features such as Large Text (70.0%), Zoom (68.0%), and Invert Colors (40.0%). It is worth noting that 24 low vision users (48.0%)

Fig. 4 Usage rate by age group.

Fig. 5 Popular smartphone models.

Fig. 6 Accessibility features used on smartphones.

Fig. 7 Overlapping of accessibility feature usage on smartphones.

6.3 Text Entry Methods

The questions on the text entry methods on smartphones were in three parts. First, respondents were asked which hardware or software they were using. The result was that software keyboards were used by about 90% of both blind and low vision users. As for blind users, voice input and hardware keyboards also had high usage rates, 53.2% and 35.1%, respectively (Fig. 8).

Second, the keyboard users were asked about the type of keyboard. Among 95 blind users of software keyboards, more than half were using the QWERTY keyboard and Japanese numeric keypad (61.1% and 55.8%, respectively) (Fig. 9, 11). In contrast, among the 45 low vision users of software keyboards, 75.6% were using the Japanese numeric keypad, and the usage rate of the QWERTY keyboard was as low as 40.0%. The usage rates of the *Hiragana* keyboard were low for both blind and low vision users. This could be because of the small key pitch (the distance between the centers of two neighboring keys) of the keyboard, which has 50 keys, nearly twice that of the QWERTY keyboard.

When a screen reader is turned on, touch gestures for selecting and entering text change from the norm. In normal mode, a single-tap gesture enters a character. However, in screen reading mode, a single tap gesture has the role of making a touched key a candidate and saying that key aloud. To enter that key, a “double-tap” or “split-tap” gesture is required. Double-tap involves tapping one key two times quickly. Split-tap involves holding a key with one finger and tapping the screen with another finger. Among 110 blind users of screen readers, the number of split-tap users was the topmost (49 users, 44.5%), and that of double-tap users was the second most (45 users, 40.9%). However, their difference was small. The number of users of touch input

used speech output along with visual aids (21 users) or speech output only (3 users) (Fig. 7).

Fig. 8 Text entry methods used on smartphones.

Fig. 9 Software keyboards used on smartphones.

Fig. 10 Character selection gestures used on smartphones.

Fig. 11 Japanese numeric keypad.

mode was half of that of split-tap users, and the number of users of double-tap & flick was half of touch input users. Since the number of low vision users of screen readers was as small as 24, a comparison of the users of each gesture for selecting characters was not meaningful.

The low vision users who did not use a screen reader used the flick input (20 users, 76.9% of 26 non screen reader users) and toggle input methods (11 users, 42.3%).

6.4 Apps

We presented 26 kinds of apps and had the respondents select and check the apps they were using and write down the names of the apps if possible. In this subsection, we focus on the use of four kinds of vision aid apps that were originally developed for blind and visually impaired people and two standard apps, camera and photo viewer, as they are quite useful for low vision users as vision aids.

Out of the four kinds of apps, GPS and object identifier apps were used by more than half of blind smart-

Fig. 12 Vision aid apps used on smartphones.

Fig. 13 Popular tablet models.

phone users (GPS apps were used by 61 users (55.0%) and object identifier apps by 63 users (56.8%), Fig. 12). Color identifier and light detector apps had fewer users than these. Despite this, it was confirmed that they were used by blind people. Only GPS apps were used by many low vision users (22 users, 44.0%).

Camera and photo viewer apps were used by most of the low vision users of smartphones (camera was used by 41 users (82.0%) and photo viewer by 36 users (72.0%)). Although camera apps were used by more than half of the blind users of smartphones (65 users, 58.6%), photo viewer apps were used by only one-third of them (36 users, 32.4%).

7. Tablet Usage

This chapter describes the responses from 64 (29 blind and 35 low vision) users to questions on tablet usage.

7.1 Models

The tablet models being used by the respondents are shown in Fig. 13. The most popular models were various Apple iPads with 23 (79.3% of the 29) blind and 28 (80.0% of the 35) low vision users. Other devices used by more than one respondent were iPod touch and NEC Lavie Tab. Five respondents listed two devices or more, and one did not answer this question. Thus, the summed up number in Fig. 13 does not equal the number of total users.

7.2 Accessibility Features

Regarding the usage of tablets, the usage rates for accessibility features differed greatly between blind and low vision users too (Fig.14). The shapes of the graph in Fig. 14 bore a close resemblance to those in Fig. 6.

Fig. 14 Accessibility features used on tablets.

Fig. 15 Text entry methods used on tablets.

Fig. 16 Software keyboards used on tablets.

7.3 Text Entry Methods

The questions on the text entry methods on tablets were the same as those on smartphones. For both blind and low vision users, software keyboards, voice input, and hardware keyboards were the top three text entry methods on tablets (Fig. 15). The usage rates of these methods for low vision users were close to those on smartphones. In contrast, the usage rates of software keyboards and voice input for blind users were roughly 20% lower than those on smartphones (Fig. 8). This means that fewer blind people were using multiple text entry methods on tablets than on smartphones. No one used handwriting on tablets. Two blind people used “touch braille input” of PC-Talker, a Windows screen reader.

For both blind and low vision users, the QWERTY keyboard was the most used keyboard on tablets with 20 blind users (100%) and 24 low vision users (75.0%) (Fig. 16). A striking difference from smartphones was the low usage rates of the numeric keypad for both blind and low vision users.

The touch gesture for selecting characters that was used by the most blind users on tablets was double-tap (15 users, 55%) (Fig. 7), different from that on smartphones (split-tap, Fig. 10). Among low vision users, touch input was the most common gesture for selecting characters (8 users, 50.0%).

Fig. 17 Character selection gestures used on tablets.

Fig. 18 Vision aid apps used on tablets.

7.4 Apps

The usage rates of the six apps that were introduced in the chapter on smartphone usage are shown in Fig. 18. Camera and photo viewer apps were used by nearly half of low vision users (15 (42.9%) and 17 users (48.6%), respectively). However, the number of users of the four vision aid apps was low, less than nine users. The numbers of blind users who used the four apps and camera and photo viewer apps were as low as seven or less.

8. Discussion

On the basis of the survey results, let us discuss the questions posed in Introduction.

8.1 Device Usage Rate

The latest usage rate of smartphones demonstrated an increase in smartphone and decrease in feature phone usage rates from 2013 to 2017. These phenomena were not peculiar to the lives of blind and visually impaired people but were the same for general (sighted) people. As for the mobile phone usage of sighted persons, NTT docomo's starting to handle the iPhone was the biggest reason for the turnaround in the usage rates of smartphones and feature phones⁹⁾. As for blind and visually impaired people, the September 2014 release of iOS 6, which, for the first time on smartphones, adopted *Sho-saiyomi*, which are Kanji explanatory expressions¹⁰⁾, pushed up the usage rate of smartphones. Our two surveys in 2013 and 2017 accurately observed this transition from feature phones to smartphones.

8.2 Age-Related Differences in Usage Rate

High usage rates of smartphones among younger generations and those of feature phones among older gener-

ations were observed. These phenomena were also the same for sighted people¹¹⁾.

Similarly, the phenomenon that the younger the users are, the higher the usage rate of new devices had been observed when feature phones (called as mobile phones at that time) prevailed among visually impaired people¹²⁾.

8.3 Usage Differences between Blind and Low Vision

Significant differences were found in the use of tablets and PCs between blind and low vision. As for tablet usage, it is because tablets are useful for people with low vision as vision aid (see Fig.18) whereas tablets are too large to use for blind people¹³⁾.

8.4 Latest Device Shares

For both smartphone and tablet usage, devices from Apple Inc. were the most popular. This is because the accessibility features in iOS are ample and satisfactory for blind and visually impaired people¹⁴⁾. If there is a certain number of users of specific products, the convenience of being able to ask questions on the use of these products would lead to an additional increase in the number of users of these products.

The same phenomenon had been observed when the “Raku-Raku Phones” series feature phones from Fujitsu that had special accessibility features such as voice output and large letters were dominant among visually impaired users¹²⁾.

8.5 Text Entry Methods on Touchscreen

Text entry on touchscreens without tactile cues is the biggest challenge for blind and visually impaired people²⁾. The present survey made clear how they were dealing with this challenge in detail; text entry methods on touchscreens varied greatly between blind and low vision people and between smartphones and tablets. Most of the low vision smartphone users were using Japanese numeric software keyboards. This usage is identical to that of sighted people. In contrast, high usage rates of voice input and hardware keyboards by blind smartphone users were noticeable. These users mainly used QWERTY and numeric keyboards at the same rate. The usage rates of each gesture for selecting characters when using screen readers were determined for the first time.

In the meantime, we are carrying out an experiment in which text entry speeds with a screen reader on a smartphone are being measured with various keyboards and character selection methods as conditions¹⁵⁾. The results of this experiment as well as the present survey

Table 1 Key pitches of different keyboards on smartphone (iPhone 6) and tablet (iPad mini).

Keyboard	Direction	Key pitch [mm]	
		Smartphone	Tablet
Japanese numeric	Horizontal	11.5	9.8
	Vertical	8.3	8.4
QWERTY	Horizontal	5.85	10.7
	Vertical	8.45	10.25
Hiragana	Horizontal	-	8.55
	Vertical	-	8.0

results would be very useful for ICT instructors who teach blind people how to use smartphones.

On tablets, QWERTY was the most-used keyboard for both blind and low vision users. This would be because the wider key pitches than on smartphones allow users to select keys precisely. The horizontal and vertical key pitches of the Japanese numeric keypad, QWERTY keyboard, and Hiragana keyboard (only for tablets) on the most popular smartphone model, iPhone 6, and on the most popular tablet model, iPad mini, are shown in Table 1. It was interesting that the character selection gestures used by more than half of the blind users were different from those on smartphones. How the size of a device changes the character selection gestures to be used is worth being investigated in the future.

8.6 Usage Rate of Vision Aid Apps

GPS navigation and object recognition apps were used by more than half of the blind smartphone users. In addition to this, color recognition and light detection apps were used by about one-third and one-fifth of the blind smartphone users. These figures show the usefulness of these vision aid apps for blind people. However, fewer blind people used these apps on tablets. This suggests the superiority of smartphones in terms of portability and usability over tablets. In comparison, the numbers of low vision users of these vision aid apps were quite low except for GPS navigation. Instead, nearly half of low vision smartphone users used camera and picture apps. Some functions of these apps would be playing the role of zooming and color-inverting vision aids.

9. Conclusion

An ICT user survey was conducted to investigate usage by blind and low vision people. The findings can be utilized as a basis for developing new easier-to-use text entry methods, vision aid apps, and mobile devices and for designing new accessibility policies.

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