筑波大学 情報学群 情報メディア創成学類

卒業研究論文

携帯情報端末のタッチパネルにおける
アイズフリーな片手かな文字入力方式

深津 佳智

指導教員　志築 文太郎　三末 和男　田中 二郎

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Abstract

We present a single-handed and eyes-free Japanese text input system on touch screens of mobile devices. At first, we conducted an preliminary experiment to investigate pointing accuracy in single-handed and eyes-free. From this result, we found that users can point with accuracy the screen which was divided into 2 $\times$ 2. Based on this result, to enable eyes-free typing with accuracy, the system uses *kana* letter input based on 2-stroke input. First users perform flick operation for consonant input, and then vowel input similarly. We conducted a user study to measure the accuracy of input, subjective impression of the system, and recall rate of input phrases. Participants' error rates of input ranged from 2.4% to 14.8%, and the grand mean of error rates was 7.8%. Recall rates ranged from 83.3% to 100%, and the grand mean of recall rates was 94.8%.

Contents

List of Figures

Chapter 1

Introduction

The character input on touch screens of mobile devices is carried out using software keyboards. Because of the following two issues resulting from a touch screen property, eyes-free input on touch screens is difficult. First, lack of haptic feedback requires users' visual attention [YT09]. Second, it is difficult for users to tap keys finely because of "fat finger problem" [SRC05], that causes false input.

On the other hand, Karlson et al. [KB06, PKB06] stated that the vast majority of users want single-handed interaction with mobile devices, e.g., when a single hand is occupied. Moreover, as Yi et al. showed [YCFZ12], there are some situations where users do want to use their mobile devices while continuing to talk with others, whereas such overtly use of mobile devices is socially inappropriate (e.g., for replying to emergent messages they received).

To explore the above issues, we built a single-handed and eyes-free Japanese *kana* text input system for touch screens on mobile devices. Specifically, our system, No-look Flick, is designed to meet the following purposes:

Taking personal memo in a social situation
: Our system allows users to take memo without interrupting one's talk in a meeting or a class by enabling users to input texts under the desk because the system requires only a single hand for text input and can be used in eyes-free. In addition, in situations where users must look forward (e.g., at walking, or waiting at a stoplight), users can take memo with visual attention forward.

Protection of peeping at the screen
: Using our system, users can input texts with the display turned off. Thus, users can prevent input texts being peeped by others in the environment where there are many people (e.g., on terribly overcrowded trains in Japan). In addition, users can type with single hand even if the other hand is occupied (e.g., hanging on a strap on trains).

These purposes involve unique challenges in designing text input system:

- Some subtle tactile feedback could be used. In contrast, the design should avoid adopting any visual and audible feedback, since such types of feedback hinder the system from being used in a social situation.

- Because our purposes are to realize taking personal memo in a social situation and protection of peeping, the main goal in designing our text input system is to make users recall their personal memo afterward, rather than to make users to input their memo fast or accurately.

In this thesis, we present a single-handed and eyes-free Japanese *kana* text input system on touch screens of mobile devices. As the first step in designing such system, we conducted an preliminary experiment to investigate pointing accuracy in eyes-free on touch screens of mobile devices. Based on the result of this experiment, we designed No-look Flick. Then, we implemented this system as an iOS application which works on iPhone 4. We conducted a user study to measure the accuracy of recalling input text with a questionnaire about subjective impression of the system.

The findings of this research are:

- On the mobile device with touch screens used in this study, which is generally used, users can point the screen with accuracy in eyes-free under the condition where the screen is divided into a 2×2 grid.

- Users can input texts in single-handed and eyes-free on touch screens of mobile devices accurately enough for taking personal memo.

This thesis is organized as follows. In Chapter 2, we present the related works. In Chapter 3, we explain the preliminary experiment for investigating pointing accuracy in eyes-free. In Chapter 4, we introduce our text input system which is designed based upon two preliminary experiments. In Chapter 5, we explain evaluation of our system. In Chapter 6, we discuss the result of the evaluation. Lastly, in Chapter 7, we present the conclusions and future work.

Chapter 2

Related Work

Our No-look Flick builds on the following two areas of prior work.

2.1 Accessibility Technology

Many researchers proposed eyes-free text input system for visually-impaired. Mobile Messenger for the Blind [SA07] is a messaging system on mobile devices that has 9 software keys; each key has 3-4 letters. Users input letters by multi-tap with text-to-speech provided as feedback. No-look Notes [BBAE10] is a text input system on mobile devices that uses multi-touch input and audio feedback. No-look Notes significantly outperformed VoiceOver [APP], which Apple offers for accessibility of visually impaired, in terms of speed, accuracy, and user preference. BrailleTouch [FSR11] is a text entry system with 6 software keys which represents braille with audio feedback. Similarly, [MBB12] and [AWPL12] adopted braille techniques. For users who are familiar with braille, these braille based system are efficient because their key layout is easy to be memorized. However, these systems for visually impaired rely on audio feedback. In contrast, our system uses only subtle tactile feedback for supporting situationally-impaired, e.g., those who want to take personal memo in a social situation.

Some researchers proposed text input systems for situationally-impaired. PocketTouch [SHB11] enables eyes-free multi-touch input with capacitive touchscreen on the back of a smartphone detecting finger-strokes through fabric, allowing users to input without taking the device out of their pocket. However, PocketTouch requires auxiliary hardware. In contrast, our system applies exiting mobile devices without any additional equipment, enabling users to use our system on their own devices by only installing the application. Jain et al. [JB12] proposed a bezel-based text input system with high accuracy in double-handed and eyes-free. While this system is designed for two-handed usage, our system is designed for single-handed usage in contrast.

2.2 Gesture-based Text Input

Our research relates gesture-based text input because gesture based input can be applied to touch screens of mobile devices, which can detect gesture strokes. Castellucci et al. [CM08] compared Unistroke to Graffiti; these are stylus-based text input systems. Graffiti uses free-form gestures resembling the handwritten Roman alphabet, increasing user's learnability. Unlike Graffiti, Unistrokes [GR93] does not closely resemble to Roman alphabet. However, Unistrokes uses a simple single-stroke gesture, showing better results of entry speed and error rate in the longitudinal study. These stylus-based techniques can be applied to touch screens of mobile devices because they also can be input by fingers [TM09, TM10]. Bragdon et al. [BNLH11] showed that mark-based gestures is better than free-form gestures in terms of input speed and accuracy, and is preferred by users. EdgeWrite [WMK03] is a single-stroke and stylus-based text input system for motor impaired. EdgeWrite uses physical edges, and users stroke along 4 edges and 2 diagonals to input. Most of the strokes are resemble to Roman alphabet, increasing user's learnability. EdgeWrite is applied to a various devices (e.g., joysticks, touchpads) [WMAL04]. However, no evaluation in eyes-free has been reported in these studies. In contrast, we evaluated our system in eyes-free.

Chapter 3

Preliminary Experiment: Pointing Accuracy in eyes-free

We conducted a preliminary experiment to investigate pointing accuracy on touch screens of mobile devices in eyes-free to get insights into the system design.

3.1 Participants

10 participants (9 male and 1 female) ranging in age from 21 to 24 took part in the experiment as a volunteer. Their career of using mobile devices with touch screens ranged from 0 to 84 months ($mean = 21.9$, $SD = 23.3$).

3.2 Procedure

We located a laptop computer on a desk (Apple MacBook Pro which has 13 inches of screen size). We asked the participant to sit down on a chair and hold a mobile device with a touch screen (Apple iPhone 4S which has 3.5 inches of screen size) with single hand (Figure 3.1). Since all participants were right-handed, the participants held the mobile device with their right hand. We mirrored the screen of the mobile device to the laptop using Reflection [1]. We also asked the participant to place the hand with the mobile device under the desk not to look at the mobile device's screen, and to look at the laptop's screen.

When a participant touched any position of the mobile device's screen, an experiment started, and a gray rectangle (hereafter target) was shown on the mobile device (and on the laptop by mirroring). When the participant saw the target on the laptop, he or she pointed the corresponding position on the screen of the mobile device. Regardless of the success or failure of the pointing, next target was shown when he or she touched the screen. A beep was played when the screen is touched to promote the participant to perform the next trial.

We divided the screen into a 2×2, 3×3, 4×4, and 5×5 grid (screen conditions), and showed a target in a grid (Figure 3.2) in each trial. The same targets were shown 4 times in a randomized

[1] Reflection `http://www.reflectionapp.com/`

order. (e.g., when the screen condition was 2×2, targets were shown 4 times $\times$ 4 areas = 16 times.) Each screen condition was shown in a randomized order. As a result, target was shown 216 times (4 times $\times$ (4+9+16+25) areas) per participant. A participant took about 10 minutes to complete this experiment. For each trial, we recorded the tapped positions.

Figure 3.1: An experiment environment.

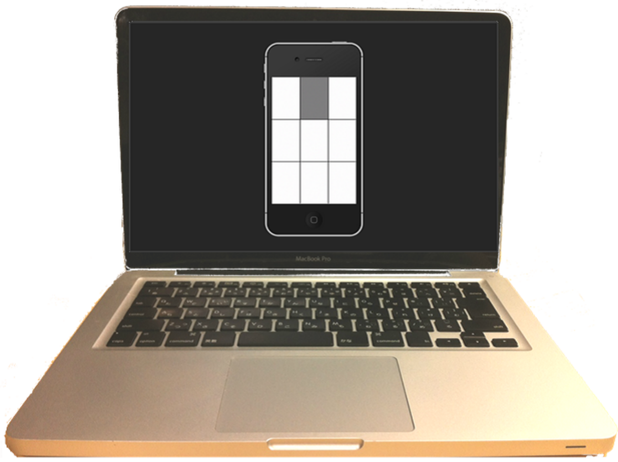

Figure 3.2: An example of a target shown on the laptop when screen condition is 3×3.

3.3 Result and Analysis

We calculated a pointing accuracy, as the percentage that divided the number of successful pointing by the number of the total pointing. The pointing accuracy of each screen condition is shown in Table 3.1.

From this result, when the screen condition is 2×2, one can point a grid accurately in eyes-free. Figure 3.3 shows all the pointed positions of all participants in 2×2 screen condition. In this figure, blue points represent the pointed positions and the centers of a gray circle represent the centroid of pointed positions for each target.

Note that the centroid of pointed positions tend to deviate from the centers to the lower, and that these points in the right-side targets tend to deviate from the centers to the right. Also note that the rightmost points among blue points in the left-side targets locate near the vertical boundary and leftmost points among blue points in the right-side targets locate far right from the vertical boundary.

Table 3.1: Pointing accuracy for each screen condition.

screen condition	pointing accuracy
2×2	100.0%
3×3	83.1%
4×4	57.5%
5×5	48.5%

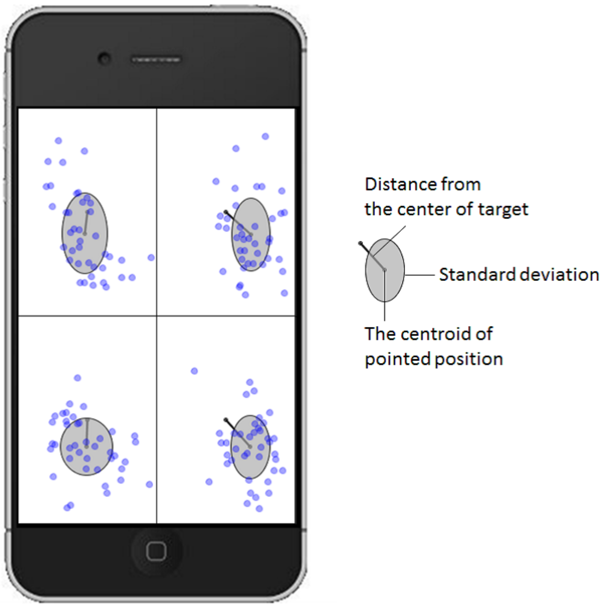

Figure 3.3: Distribution of pointed positions.

Chapter 4

No-look Flick: Japanese Text Input System in Eyes-free

Based on the insights from the preliminary experiment, we designed No-look Flick, the Japanese text input system.

4.1 Japanese Syllabaly

In this section, first of all, we describe the method of Japanese text input. Japanese text consists of *kana* and *kanji*. *Kana* are phonetic characters, and *kanji* are Chinese characters. In most of Japanese text input systems, firstly, a user input words with *kana*. Then, the input system shows possible candidates with *kanji* corresponding to the input words with *kana*; the user select a candidate from them (*kana-kanji* conversion).

In our system, users input only *kana* because they cannot choose *kanji* from candidates in eyes-free. In addition, taking personal memo with phrases which consist of only *kana* is casual in daily life, because such phrases make sense enough and writing *kanji* is time-consuming (one *kanji* requires 12.2 strokes on average, one *kana* requires 2.8 strokes on average).

Table 4.1 shows the Japanese syllabary. Most *kana* can be transcribed into a consonant and a vowel (e.g., "く" can be transcribed into 'K' and 'u'). Some of *kana* letters can be changed to the corresponding voiced letters, p-sound letters, and small letters (hereafter special letters) by being added a symbol (e.g., '*' in voiced letters). Namely, a special letter can be transcribed into a consonant, a vowel, and a symbol (e.g., "ぐ" can be transcribed into 'K' and 'u', and '*'). Therefore, we adopted 2-stroke input in most cases, and 3-stroke input for special letters.

4.2 Key Layout and Input Method

Figure 4.1 shows key layout of No-look Flick. We locate two consonant keys and one vowel key on the touch screen.

A user inputs one *kana* letter by 2 strokes: the first is a flick for inputting its consonant of the *kana* letter, the second is a flick for inputting its vowel. If the user inputs consonants twice or

Table 4.1: Japanese syllabary. (‘K*’ can be transcribed into combination a consonant ‘K’ and a symbol ‘*’, and can be transcribed ‘G’ in a phonetic alphabet. The same applies to the other voiced letters, p-sound letters, and small letters.)

Vowels	Consonants																		
												Voiced letter				P-sound	Small letter		
	A	K	S	T	N	H	M	Y	R	W	-	K*(G)	S*(Z)	T*(D)	H*(B)	H**(P)	A˜	Y˜	T˜
a	あ	か	さ	た	な	は	ま	や	ら	わ		が	ざ	だ	ば	ぱ	ぁ	ゃ	
i	い	き	し	ち	に	ひ	み		り			ぎ	じ	ぢ	び	ぴ	ぃ		
u	う	く	す	つ	ぬ	ふ	む	ゆ	る			ぐ	ず	づ	ぶ	ぷ	ぅ	ゅ	っ
e	え	け	せ	て	ね	へ	め		れ			げ	ぜ	で	べ	ぺ	ぇ		
o	お	こ	そ	と	の	ほ	も	よ	ろ	を		ご	ぞ	ど	ぼ	ぽ	ぉ	ょ	
-											ん								
-											ー								

more successively, the last consonant is adopted. If the user inputs a vowel before inputting any consonant, any *kana* letter is not input. When finishing the input of these 2 strokes, one *kana* letter is input, and a vowel key changes to a key for a special letter. At this time, by inputting the key for a special letter, the user can change the *kana* letter to its voiced letter, its p-sound letter, or its small letter. Namely, the user inputs a voiced letter, a p-sound letter, or a small letter by 3 strokes. The user can backspace by swiping the screen from the right edge to the left edge.

Whenever a *kana* letter is input (i.e., after a vowel is input, after a *kana* letter is changed to its special letter), the user is given a tactile feedback by a vibration. Similarly, whenever backspacing is performed, the same tactile feedback is given.

Figure 4.2 shows the state transition diagram for accepting a *kana* letter. In this figure, “special input” means input of a symbol for a voiced letter, a p-sound letter, or a small letter. Vowel input 1 means input of a *kana* letter which cannot be changed to a voiced letter, a p-sound letter, or a small letter. Vowel input 2 means input of a *kana* letter which can be changed to the special letters. Specifically, Vowel input 1 includes letters of ‘N’ row, ‘M’ row, ‘R’ row, and ‘W’ row. Vowel input 2 includes letters of ‘A’ row, ‘K’ row, ‘S’ row, ‘T’ row, ‘H’ row, and ‘Y’ row.

Figure 4.3a shows input of “も”, which is transcribed into a consonant ‘M’ and a vowel ‘o’. It is input by 2 strokes. Figure 4.3b shows input of “じ”, which is transcribed into a consonant ’S’ , a vowel ‘i’, and a symbol ‘*’. It is input by 3 strokes.

4.3 Design Principle

To realize single-handed and eyes-free input with accuracy, we adopted the following design principles:

2 × 2 key layout

From the result of the preliminary experiment, we found that the participants can point accurately in single-handed and eyes-free when the screen condition is 2×2. This implies that the number of keys should be equal to or less than four for this size of touch screen devices. In addition, we found that their pointed positions tend to deviate from the center to the lower.

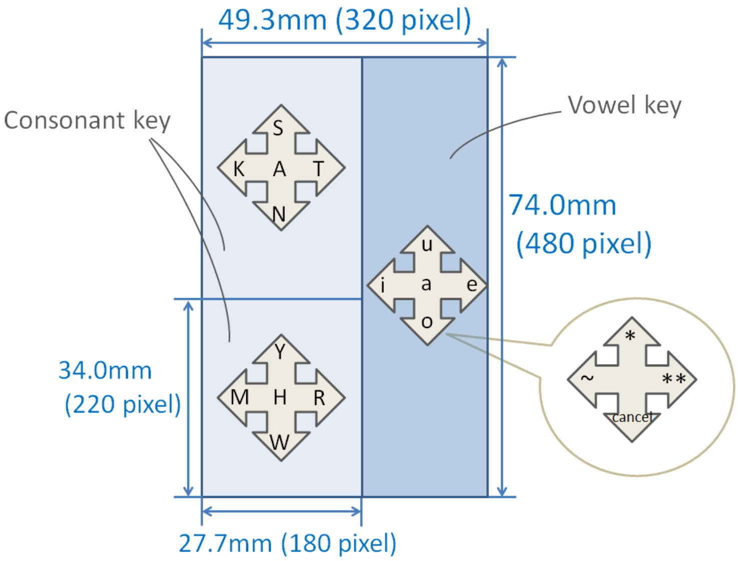

Figure 4.1: Key layout. (These keys are not displayed on the screen on the mobile device.)

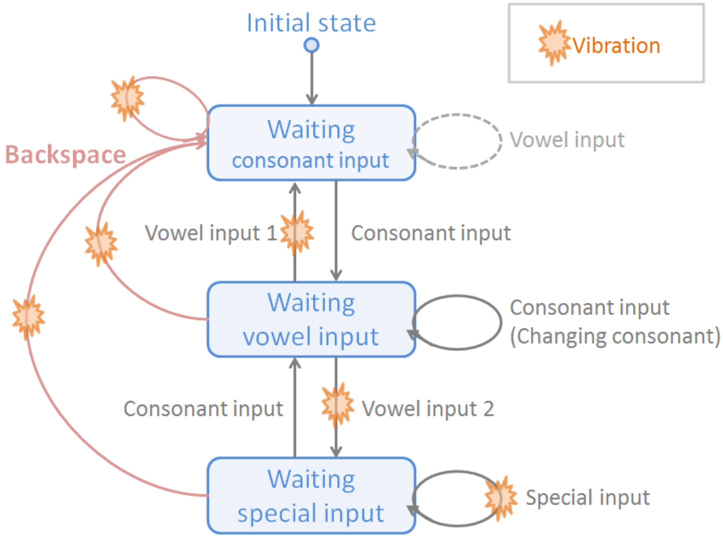

Figure 4.2: State transition diagram for accepting a *kana* letter.

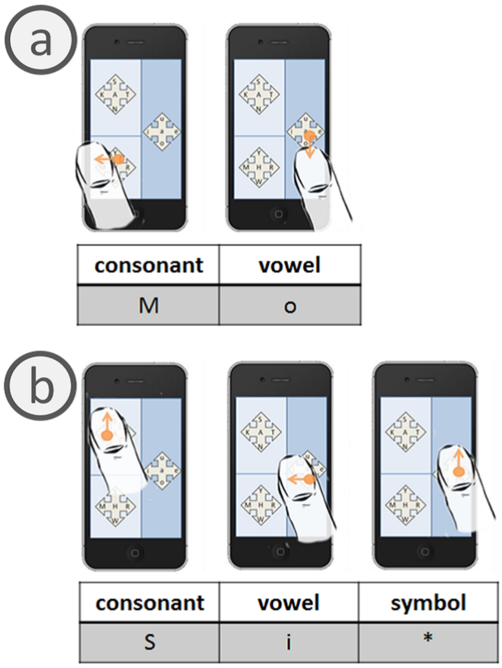

Figure 4.3: (a) an example of inputting a *kana* letter by 2 strokes (“ も ” in this case), (b) an example of inputting a *kana* letter by 3 strokes (“ じ ” in this case).

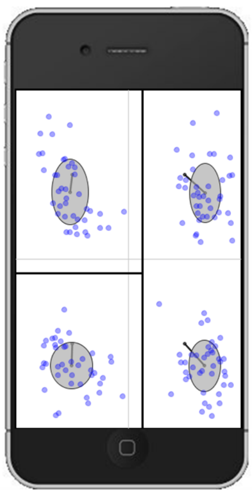

Figure 4.4: Distribution of pointed positions and boundary lines of the keys.

Based on this result, we decided boundary lines of the keys as the black solid lines shown in Figure 4.4. Moreover, to realize the *kana* letter input system, it is necessary to be able to input the Japanese syllabary including a voiced letters, p-sound letters, and small letters, which are 81 letters in total, while minimizing the number of the keys to realize accurate input in eyes-free. Therefore, we adopted four-directional flick input. Using flick input, users can input 5 kinds of letters per key by tapping it or by flicking from its center to one of four direction (left, forward, right, and downward).

Separation of consonant input and vowel input

We separated consonant keys from a vowel key. This design allows users to retype a consonant as many times as they want before inputting a *kana* letter. If there were not this retyping function, users have to delete a consonant when users find that they mistyped a consonant. However, the deletion of a vowel can be confused with the deletion of a letter, making it difficult for users to grasp the number of letters deleted under the condition where user cannot see what they typed. Therefore, this separation is effective in avoiding such confusion.

Near-edge interaction

We designed the gesture for backspacing to start and end at the edge of the screen, similar to Bezel Swipe [RT09], whose starting position of operation locates the edge of the screen. Our design is based on the fact that near-edge interaction can be operated accurately even in eyes-free [JB12, BNLH11]. In addition, the design prevents conflict with the flick operation for inputting a *kana* letter.

Tactile feedback

Whenever a letter is input or deleted, a vibration is given, letting users grasp that a letter is input or deleted. Specifically, a tactile feedback by a vibration is given in the timing shown in the state transition diagram of Figure 4.2. When inputting the first stroke which input only a consonant, a vibration is not given. When inputting the second stroke, the third stroke, or backspace, a vibration is given.

Chapter 5

Evaluation

We implemented a prototype of No-look Flick, and conducted a user study to measure the accuracy of input, subjective impression of the system, and recall rate of input phrases.

5.1 Participants

12 participants (10 male and 2 female) ranging in age from 21 to 23 took part in the experiment as volunteers. None took part in the preliminary experiment. Whereas 11 participants were right-handed, 1 participant were left-handed. All participants usually used right hand for operation of mobile devices. 6 participants had never used flick input before.

5.2 Experimental Design

5.2.1 Apparatus

We implemented the prototype of No-look Flick as an iOS application in Objective-C that operates on iPhone 4 (iOS 5.1).

5.2.2 Tasks

As a trial, a participant input a short phrase with right hand with looking at the paper that illustrates the key layout with a short phrase to input such as the one shown in Figure 5.1 (hereafter the test paper). When a researcher presented the test paper, a participant started input. After finishing the input, a participant said “Finished.” as end signal. A participant carried out this trial under the 3 posture conditions (sitting, standing, walking). One carried out the trials 8 times per posture. As a result, each participant carried out the trials 24 times in total (8 times $\times$ 3 postures).

5.2.3 Posture Conditions

Based on the scene where the use of this system is assumed, we designed the following 3 posture conditions:

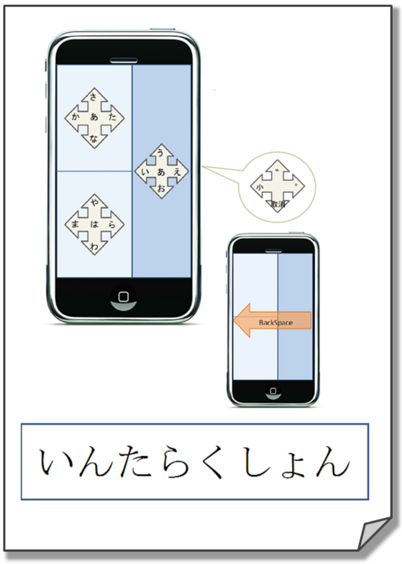

Figure 5.1: The test paper that illustrates the key layout with a short phrase to input. (“いんたらくしょん” means “Interaction” in Japanese. This phrase is a reminder indicating to check some papers in the proceedings of a symposium called Interaction.)

Sitting posture (Figure 5.2a)
A participant sat down on the chair and input the phrases with holding the mobile device under the desk. A researcher presented the test papers by putting them on the desk.

Standing posture (Figure 5.2b)
A participant stood in front of the wall and input the phrases with the hand holding the mobile device near one’s waist. A researcher presented the test papers by putting them on the wall.

Walking posture (Figure 5.2c)
A participant input the phrases while walking behind a researcher. We designed this posture condition by referring to [GFW12, NJ12]. A researcher presented the test papers by carrying them with the clipboard on his back.

5.2.4 Procedure

Participants went through the following procedure:

(1) Explanation
A participant was explained the input method and the procedure of the experiment. The participant was also explained that the posture conditions are designed by assuming the scenes where the system is used, and was asked to input with attention to accuracy rather than speed.

(2) Practice
A participant used the prototype in the practice mode (Figure 5.3a) freely for 10 minutes. In

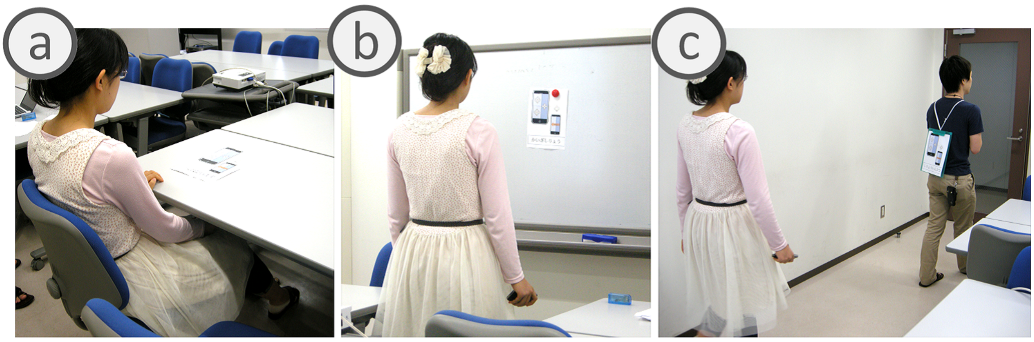

Figure 5.2: (a) sitting posture, (b) standing posture, (c) walking posture.

the practice mode, the prototype shows input letters on the upper area of the screen, making the participant to see whether he or she can use the prototype correctly or not. In this step, a participant could ask the researcher questions about the way to use the prototype if any. The participant was asked to check if he or she can input ‘W’ row, voiced letters, p-sound letters, and small letters because they are mistakable. The participant was also asked to check if he or she can input in eyes-free by inputting his or her name without looking at the screen.

(3) Measurement

Under the 3 posture conditions (sitting, standing, walking), a participant input phrases (24 phrases in total) with the prototype in the measurement mode (Figure 5.3b). In the measurement mode, the prototype shows nothing on the screen. Presentation order of the 3 posture conditions were counterbalanced.

(4) Questionnaire

A participant answered a questionnaire about the impression of the system.

(5) Recall

Later than 48 hours after the measurement, a participant read his or her own input phrases, and recalled the presented phrases.

5.2.5 Short Phrases

Based on the following criteria, we prepared 24 short phrases (Appendix F.1) consisting of 6-8 characters:

- Exhaustively including the letters which users can input with this system.
- Being the short phrases which seem to be input in the scene where the use of this system is assumed.

One example is “ぎゅうにゅうかう”, which means “Buy milk.” in Japanese. This phrase is a reminder indicating to buy some milk for cooking. Another example is “れぽーとしめきり”, which means “deadline of report.” This phrase is a reminder indicating to finish a report as the deadline draws near.

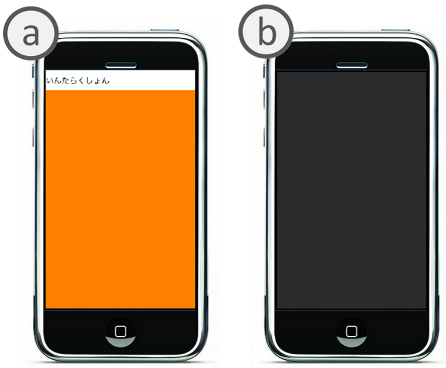

Figure 5.3: (a) the screen of the practice mode, (b) the screen of the measurement mode.

5.2.6 Questionnaire

It has 3 questions (Appendix E). A participant was asked to score accuracy of input in Question 1 and easiness of memorizing in Question 2 with a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) and to write the reason of each score. In Question 3, a participant was asked to write freely about good points, points that should be refined, and impression of the prototype.

5.3 Results

We analyzed the error rate of input, the error rate of recall, and questionnaire.

5.3.1 Results of Measurement and Recall

We calculated the error rate of input, the percentage that the total number of the letters which were wrong (i.e., the ones which were not input, and the ones which were input unnecessarily) divided by the total number of the letters in the presented phrases. We also calculated the error rate of recall, the percentage that the total number of the phrases which were wrong divided by the total number of the phrases (i.e., 24 in this experiment). Figure 5.4 shows the error rate of input and error rate of recall per participant (A-K), and Figure 5.5 shows the error rate of input per posture condition.

We classified the errors. Figure 5.6 shows the number of errors per error type. Figure 5.7 shows the number of errors per error type on each posture. The classification of error is shown below:

Upside consonant key error (Upside)
Wrongly input letters due to mistyping the downside consonant key instead of the upside consonant key (e.g., mistyping “み” instead of “き”).

Downside consonant key error (Downside)
Wrongly input letters due to mistyping the upside consonant key instead of the downside consonant key (e.g., mistyping “き” instead of “み”).

Flick error (Flick)
Wrongly input letters by wrong flick input (e.g., misyping “き” instead of “く”).

Lack of letter error (Lack)
Letters which were not input.

Surplus of letter error (Surplus)
Letters which were input unnecessarily.

The mean input speed of letters was 21.9 cpm (characters per minute), and ranged from 17.5 cpm to 29.8 cpm.

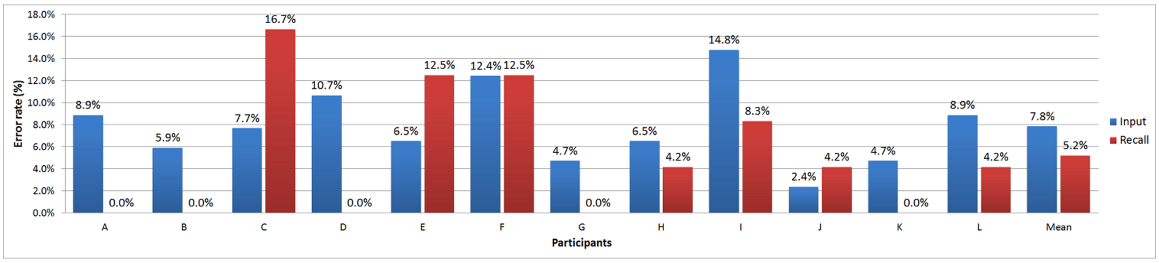

Figure 5.4: Error rate per participant.

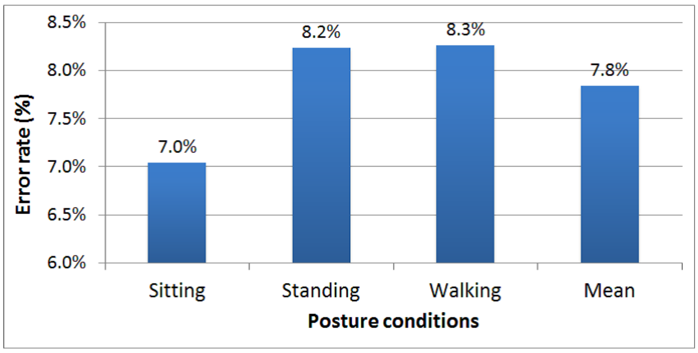

Figure 5.5: Error rate per posture condition.

5.3.2 Results of Questionnaire

Table 5.1 shows results of questionnaire. The mean score of Question 1 was 3.2, and that of Question 2 was 3.4.

Table 5.1: Results of questionnaire [people].

	Evaluation				
	1	2	3	4	5
Question 1	0	4	2	6	0
Question 2	1	2	1	7	1

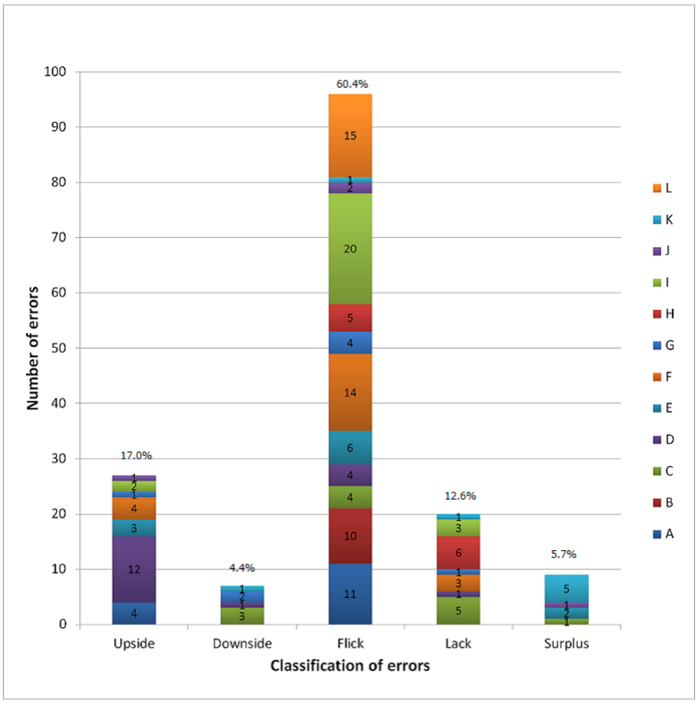

Figure 5.6: Number of errors per error type.

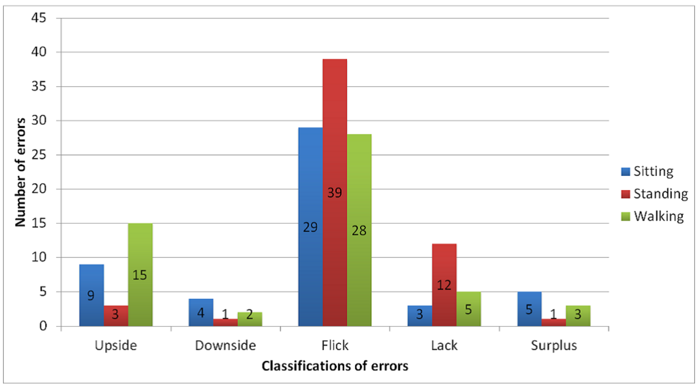

Figure 5.7: Number of errors per error type on each posture.

Chapter 6

Discussion

The grand mean error rate of input was 7.8%. The lowest error rate among all participants was 2.4%. The highest error rate among 3 posture conditions was 8.3% in walking posture. This result was consistent to [SR10], which also showed reduction of accuracy in walking.

Upside consonant key error occupied 17.0% of all errors. Downside consonant key error occupied 4.4% of all errors. As shown Figure 5.6, the two errors tended to occur exclusively by each participant. Holding position of mobile devices by each participant might influence this tendency. The total number of these error was 34, and the total number of inputting a consonant was 2035. Thus, error rate of inputting a consonant was 1.7% ($34 \div 2035 \times 100$). In addition, 4 participants commented "The small number of keys was good to type in eyes-free." Although we evaluated only consonant input, our key layout was effective in typing on eyes-free in terms of pointing accuracy.

Flick error had the largest number of errors among classified error types; it occupied 60.4% of all errors. 7 participants commented "Flick direction of W row and Y row was confusing." on the questionnaire (Question 1). Participant A and F told that they mistook flick direction of 'W' row after the measurement. That might influence the increase of flick error. We think this kind of mistake will be improved to some extent by getting used to our input method. On the other hand, participant's actual flick direction might be different from participant's imaginary flick direction because in eyes-free he or she could not look at one's finger movement. We would like to investigate flick input accuracy in eyes-free since there might be some tendency of difference between flick input under visual condition and that under non-visual condition; this might be the insight to reduce flick errors.

Lack of letter error occupied 12.6% of all errors. Surplus of letter error occupied 5.7% of all errors. When participants backspace, these error was increased. Although the number of these errors was relatively low, some valuable comments were gathered in the questionnaire. 5 participants commented "You should adopt a different vibration for each type of input (input a consonant, input a vowel, and input backspace).", and 4 participants commented "I was afraid I would mistype because I couldn‘t see input letters." To enable users to grasp one's input, we plan to modify our implementation to use a different pattern of the vibration for each type of input.

The grand mean error rate of recall was 5.2% (about 1.2 phrases out of 24 phrases were wrong). 5 participants recalled all phrases correctly. In contrast, participants frequently failed to recall the phrases which had two or more wrong letters or which lacked two or more letters (e.g., mistyping

“やすゅーす” instead of “やさいじゅーす”). Lack of letters are mainly caused by backspace. Therefore, just showing the letters which was deleted by backspace and backspace characters might be improve the recall rate.

Note that participant D whose error rate of input was 10.7% (the third worst error rate) recalled all phrases correctly. For example, the participant mistyped “どよ**つ**のみ**な**い” instead of “どようのみかい” (“DoYo*T*uNoMi*N*aAi” instead of “DoYoAuNoMiKaAi” in alphabet). Namely, although there are two wrong letters, the participant could recall this phrase correctly. In addition, some participants commented “I could guess the correct phrase from the consonant or the vowel.” when the recall step finished. Namely, participants tend to recall phrases correctly when a consonant or a vowel is correct even if a letter is wrong. This result suggests that our design principle “separation of consonant input and vowel input” was successful. This result also have possibility of enabling computers to predict the correct phrase from user’s phrase containing wrong letters. Similarly, pointed positions and flick trajectories also helps this.

The mean input speed of letters was 21.9 cpm. These input speed are not so high relative to prior study, although in this study we asked to input with attention to accuracy rather than speed. In contrast, 4 participants commented “It is easy to memorize because it is similar to exiting flick input.”, and 3 participants commented “If I get used to this key layout, I think I can type with high speed.” in the questionnaire. We plan to conduct a longitudinal study to evaluate the input speed and its learning effect.

Chapter 7

Conclusions and Future Work

We have presented No-look Flick, the Japanese text input system for eyes-free typing on screens of mobile devices to take a personal memo. We implemented this system as iOS application, and evaluated the accuracy of input, recall rate of input phrases, and impression of the system. As a result, in the scene where the use of the system is assumed, enough accuracy of input and recall rate of input phrases were provided. Although our approach leverages a Japanese property, whose *kana* letter has a vowel and a consonant, our design principle for eyes-free text input is applicable for other languages.

On the other hand, we found the issue that it is hard for users to grasp a letter inputting and becomes afraid whether they can input accurately. In future work, we first improve the system as discussed in the previous section, then implement the system for left-handed users. We also plan to conduct a longitudinal study to evaluate the input speed and its learning effect.

Acknowledgements

I would like to acknowledge the solid support provided by many people in this research.

Professor Buntarou Shizuki, my thesis supervisor, assisted me in a variety of ways including precise direction, rewarding discussion, and procurement of experimental equipment. Professor Jiro Tanaka and Professor Kazuo Misue, also my supervisor, gave me many advice and suggestions regarding this research. Professor Shin Takahashi also gave me helpful feedback in the presentation practices. I would like to express my sincere gratitude to those professors.

I am also grateful to all the members of IPLAB, Interactive Programming Laboratory, for giving me many advice and helping me in my experiments; total number of people who participated my experiments was 28. Moreover, we supported each other as good friends.

Mr. Yohei Ikawa of Meiji university organized the text entry battle in WISS 2012, 20th Workshop on Interactive Systems and Software. I was motivated by the discussion of the researcher in the same field and developed through friendly competition. Mr. Kazutaka Kurihara of AIST, National Institute of Advanced Industrial Science and Technology, hosted the battle. I am deeply grateful to them.

Lastly, I would like to thank to my parents, my friends, and all those who helped me out before now.

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Appendix A

Procedure of the Preliminary Experiment

実験の流れ

文責：深津佳智

<はじめに>

本日は、実験にご協力いただき、誠にありがとうございます。本実験の目的は、携帯端末の画面を見ずにどの程度の大きさのボタンを押すことが可能かを調べることです。

<実験の流れ>

1. 実験タスクを行っていただきます。
2. アンケートにお答えいただきます。

<実験タスクについて>

ノート PC に、iPhone4S と同様の画面が提示されます。この画面に灰色の矩形が提示されます。iPhone4S を机の下で持った状態において、この矩形をなるべく早く、正確にポインティングしてください。

なお、タップ時にはタップ音が鳴り、タップされたことが確認できるようになっています。

Appendix B

Consent Form and Questionnaire in the Preliminary Experiment

iPhone4S におけるポインティングタスク時の

データ収集およびアンケートのお願い

文責：深津佳智

この度は実験にご協力いただき、ありがとうございます。

□ 本調査の目的は、携帯端末のタッチパネルを用いたポインティングタスクを行っていただき、その入力データを取得することです。

□ 実験中に、写真および動画の撮影を行う場合がありますが、これは実験の様子を撮影するために行い、その写真および動画を発表において利用する場合は、本人の確認を得た上で、研究目的においてのみ利用いたします。

□ この実験によって得られたデータは、個人が特定できないように処理いたします。

□ 実験への参加は、協力者の自由意思によるものであり、実験への参加を随時拒否・撤回することができます。

□ 学内外において発表する論文に実験内容を利用することがありますが、いかなる場合においても協力者のプライバシーは保全されます。

平成　　年　　月　　日

所属＿＿＿＿＿＿＿＿＿＿　署名＿＿＿＿＿＿＿＿＿＿

説明者　所属　情報学群 情報メディア創成　署名＿＿＿＿＿＿＿＿＿＿

実験に関するアンケート

文責：深津佳智

1. 年齢、性別、利き手についてお答えください。

   年齢：＿＿歳　　　性別： 男・女　　　利き手：右・左

2. 普段使用しているスマートフォン等のタッチパネル付携帯情報端末の種類についてお答えください。（複数回答可）

   （例：iPhone4S, docomo Galaxy SⅡ, iPod touch, なし）

   ＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

3. 普段、上記の携帯情報端末の操作に用いる手についてお答えください。（複数回答可）

   右・左・両手

4. 上記の携帯情報端末の利用歴はどのくらいですか？

   ＿＿＿年＿＿＿ヵ月

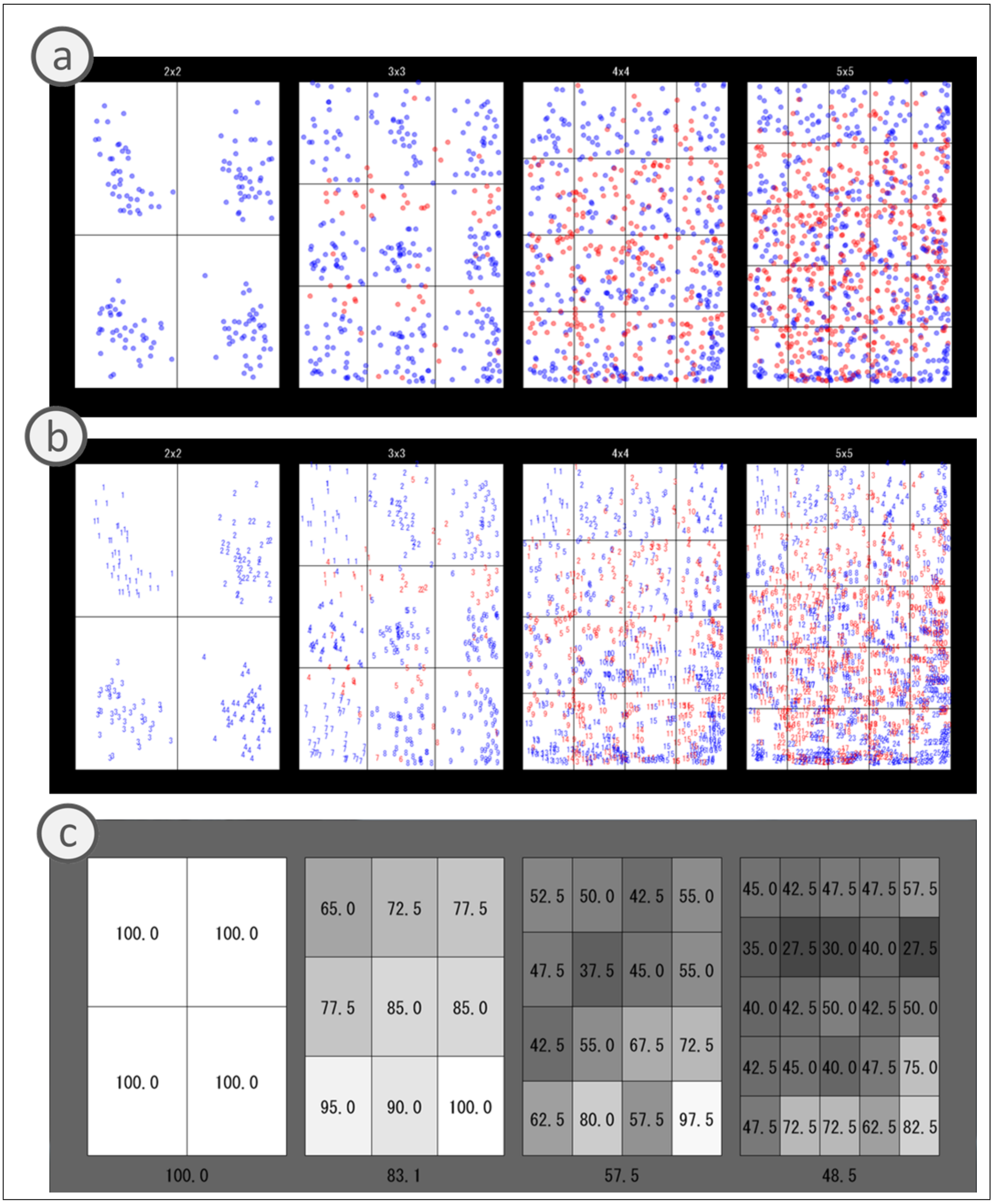
アンケートは以上になります。ご協力ありがとうございました。

Results of Questionnaire

Participant	Age	Sex	Handedness	Kind of mobile devices for daily use	Handedness in using mobile devices	Career of using mobile devices (month)
A	21	M	R	docomo Xperia	R	36
B	24	M	R	au IS06	R	84
C	23	M	R	none	none	0
D	22	M	R	Xperia Arc	R	18
E	23	M	R	iPhone 4S	R	27
F	23	M	R	Xperia NX	R	6
G	22	M	R	Galaxy S3, ipod touch	R, Both	12
H	23	M	R	iPhone 4	R, L, Both	21
I	23	M	R	Arrows X	R	1
J	24	F	R	iPhone 4S	R, L, Both	14

Appendix C

Detailed results of the Preliminary Experiment


a
2x2
3x3
4x4
5x5
b
2x2
3x3
4x4
5x5
c
100. 0 100. 0
100. 0 100. 0
100. 0
65. 0 72. 5 77. 5
77. 5 85. 0 85. 0
95. 0 90. 0 100. 0
83. 1
52. 5 50. 0 42. 5 55. 0
47. 5 37. 5 45. 0 55. 0
42. 5 55. 0 67. 5 72. 5
62. 5 80. 0 57. 5 97. 5
57. 5
45. 0 42. 5 47. 5 47. 5 57. 5
35. 0 27. 5 30. 0 40. 0 27. 5
40. 0 42. 5 50. 0 42. 5 50. 0
42. 5 45. 0 40. 0 47. 5 75. 0
47. 5 72. 5 72. 5 62. 5 82. 5
48. 5

Appendix D

Procedure of the Evaluation

実験の流れ

文責：深津佳智

<はじめに>

本日は、実験にご協力いただき、誠にありがとうございます。本実験は、スマートフォンにおいて、アイズフリーかつ片手でかな文字入力を行うためのシステムを使用し、文字入力精度と使用感を検証するための実験です。

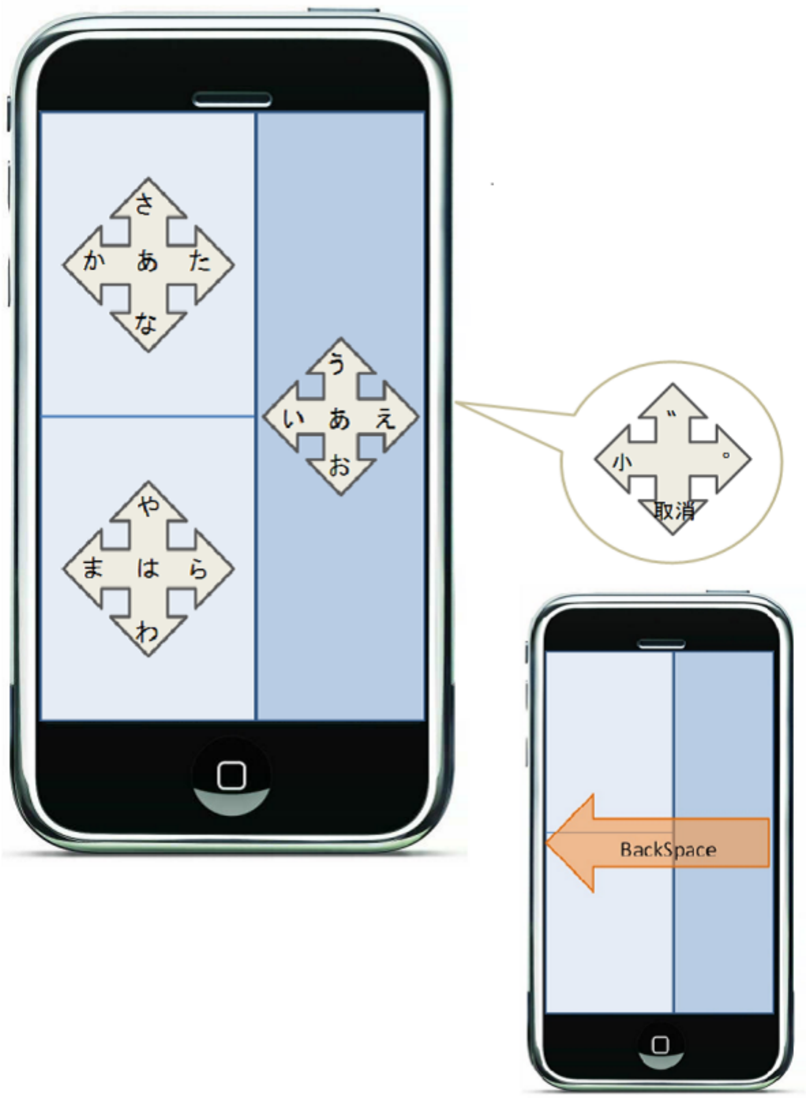
<システムの操作説明>

次ページの図が本文字入力システムのキー配置図となっています。

本システムでは、2回のフリック操作によってかな文字の入力を行います。まず、左側のキーをフリックし、子音入力を行います。次に、右側のキーをフリックし、母音入力を行うことにより、かな文字が入力されます。この際、バイブレーションにより、文字が入力されたことが通知されます。なお、子音入力の前に母音入力を行っても文字は入力されません。つまり、1文字のかな文字を入力するためには、必ず、子音を入力した後に、母音を入力するという 2 回のフリック操作を行うことになります。濁音化、半濁音化、小文字化は、この2回のフリック操作に続けて、再度、右側のキーをフリックすることで行います。文字を消去するためには、画面の右端から左端へスライド操作してください。

<実験の流れ>

1. 10 分ほど自由に入力を行い、操作に慣れていただきます。(操作について不明な点がある場合は、質問してください。)
2. 3 つの条件（座り、立ち、歩きの 3 つ。行う順番はこちらが指定します。）において、それぞれ、短文を 8 つ入力していただきます。キー配置図と短文の書かれた紙を見ながら入力することができます。(なお、速く入力することよりも正確に入力することに注意して入力してください。)
3. アンケートにお答えいただきます。



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取消
BackSpace

Appendix E

Consent Form and Questionnaire in the Evaluation

iPhone4 におけるかな文字入力システム使用時の

データ収集およびアンケートのお願い

文責：深津佳智

この度は実験にご協力いただき、ありがとうございます。

- ☐ 本調査の目的は、深津の研究「携帯情報端末のタッチパネルにおけるアイズフリーな片手文字入力システム」を行うにあたり、作成した文字入力システムを、iPhone4 端末上にて使用していただき、その入力データを取得することです。

- ☐ 3 つの状態（座る、立つ、歩く)において、作成した文字入力システムを使用し、指定した文字列を入力していただきます。

- ☐ 実験中に、写真および動画の撮影を行う場合がありますが、これは実験の様子を撮影するために行い、その写真および動画を発表において利用する場合は、本人の確認を得た上で、研究目的においてのみ利用いたします。

- ☐ この実験によって得られたデータは、個人が特定できないように処理いたします。

- ☐ 実験への参加は、協力者の自由意思によるものであり、実験への参加を随時拒否・撤回することができます。

- ☐ 学内外において発表する論文に実験内容を利用することがありますが、いかなる場合においても協力者のプライバシーは保全されます。

平成　　年　　月　　日

所属＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿　署名＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

説明者　所属　情報学群 情報メディア創成　署名＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

実験に関するアンケート

文責：深津佳智

1. 年齢、性別、利き手についてお答えください。

年齢：＿＿歳　　性別： 男・女　　利き手：右・左

2. 普段使用しているスマートフォンの機種は何ですか？

（例：iPhone4S, docomo Galaxy SⅡ）

＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

3. 普段、日本語入力を行う際に用いる手についてお答えください。（複数回答可）

右・左・両手

4. スマートフォンの利用歴はどのくらいですか？

＿＿年＿＿ヵ月

5. フリック入力の利用歴はどのくらいですか？

＿＿年＿＿ヵ月

6. 普段、携帯情報端末において利用している日本語入力方式は何ですか？（複数回答可）

1．　フリック入力
2．　QWERTY キーボードを使用したローマ字入力
3．　トグル打ち
4．　ベル打ち
5．　その他（　　　　　　　　　　）

1/2

7. 本文字入力システムを使用して、かな入力が正確に行えると思いましたか？

（とても思う） 5・4・3・2・1 （全く思わない）

理由

8. 本文字入力システムのキー配列は覚えやすかったですか？

（とても覚えやすい） 5・4・3・2・1 （とても覚えにくい）

理由

9. 本文字入力システムについて、良かった点、改善すべき点、感想をご記入ください。

良かった点
改善すべき点
その他・感想

アンケートは以上になります。ご協力ありがとうございました。

2 / 2

Results of Questionnaire

Participant	Age	Sex	Handedness	Kind of smartphones for daily use	Handedness in using mobile devices	Career of using smartphones (month)	Career of using flick input (month)	Text input method on mobile devices for daily use	Accuracy of input	Easiness of memorizing	Error rate (%)	Recall rate (%)
A	21	M	L	iPhone 4	R	25	25	Flick, QWERTY	2	4	8.9	100
B	22	M	R	Galaxy S2	R	12	0	QWERTY	2	2	5.9	100
C	21	M	R	none	R	0	0	Toggle	4	1	7.7	83.3
D	21	F	R	none	R	0	0	Toggle	4	3	10.7	100
E	23	M	R	DIGNO	Both	24	0	QWERTY	2	2	6.5	87.5
F	23	M	R	iPhone 4S	R, Both	12	12	Flick, QWERTY	4	4	12.4	87.5
G	22	M	R	IS05	R	18	18	Flick	4	4	4.7	100
H	21	M	R	iPhone 4S	R	12	12	Flick	3	4	6.5	95.8
I	22	M	R	iPhone 4S	R	1	1	Flick	4	4	14.8	91.7
J	22	M	R	none	R	0	0	Toggle	2	4	2.4	95.8
K	22	M	R	iPhone 4	Both	27	12	Flick, QWERTY	3	4	4.7	100
L	22	F	R	none	R	0	0	Toggle	4	5	8.9	95.8

Appendix F

Short Phrases Typed in the Evaluation

Table F.1: 24 short phrases typed in the evaluation.

ID	Phrase	Phrase in alphabet	Number of characters	Number of strokes
1	ぎゅうにゅうかう	Ki*Yu˜AuNiYu˜AuKaAu	8	19
2	あしたかいぎ	AaSiTaKaAiKi*	6	13
3	れぽーとしめきり	ReHo**WeToSiMeKiRi	8	17
4	かいぎしりょう	KaAiKi*SiRiYo˜Au	7	16
5	しりょういんさつ	SiRiYo˜AuAiWuSaTu	8	17
6	すいどうだい	SuAiTo*AuTa*Ai	6	14
7	ごごきゅうこう	Ko*Ko*KiYu˜KoAu	7	17
8	あしたはやすみ	AaSiTaHaYaSuMi	7	14
9	びでおへんきゃく	Hi*Te*AoHeWuKiYa˜Ku	8	19
10	ろんぶんよむ	RoWuHu*WuYoMu	6	13
11	どようのみかい	To*YoAuNoMiKaAi	7	15
12	れんしゅうなし	ReWuSiYu˜NaSi	7	15
13	あさってしめきり	AaSaTu˜TeSiMeKiRi	8	17
14	いんたらくしょん	AiWuTaRaKuSiYo˜Wu	8	17
15	かいぎりまいんだ	KaAiKi*RiMaAiWuTa*	8	18
16	さぼてんにみず	SaHo*TeWuNiMiSU*	7	16
17	すけじゅーる	SuKeSi*Yu˜WeRu	6	14
18	せんたくものほす	SeWuTaKuMoNoHoSu	8	16
19	ろくがよやく	RoKuKa*YoYaKu	6	13
20	ぺっとぼとる	He**Tu˜ToHo*ToRu	6	15
21	かんとりーまあむ	KaWuToRiWeMaAaMu	8	16
22	やさいじゅーす	YaSaAiSi*Yu˜WeSu	7	16
23	あるみほいる	AaRuMiHoAiRu	6	12
24	ごめんなさい	Ko*MeWuNaSaAi	6	13

Appendix G

Detailed results of the Evaluation

Table G.1: Result of participant A.

ID	Presented phrase	Transcribed phrase	Number of errors
13	あさってしめきり	あさってしめきり	0
23	あるみほいる	あるみほいる	0
8	あしたはやすみ	あしらはやすみ	1
15	かいぎりまいんだ	かいぎりまいんだ	0
21	かんとりーまあむ	かんとりーまあむ	0
3	れぽーとしめきり	れぽーとしめきり	0
7	ごごきゅうこう	ごごきゅうこう	0
11	どようのみかい	どようのみかい	0
2	あしたかいぎ	あしたかいぎ	0
1	ぎゅうにゅうかう	ぎゅうをゅうかう	1
17	すけじゅーる	すけじゅーる	0
5	しりょういんさつ	しりょういわあつ	2
22	やさいじゅーす	やさいじゅーす	0
9	びでおへんきゃく	びでおへわきゃく	1
10	ろんぶんよむ	ろわぶわよむ	2
12	れんしゅうなし	れわしゅうなし	1
19	ろくがよやく	ろむがよやく	1
6	すいどうだい	すいどうだい	0
14	いんたらくしょん	いわたらくしょわ	2
18	せんたくものほす	せわたくもわほす	2
24	ごめんなさい	ごめわなさい	1
4	かいぎしりょう	かいぎしりょう	0
20	ぺっとぼとる	ぺっとぼとる	0
16	さぼてんにみず	さぼてわにみず	1

Table G.2: Result of participant B.

ID	Presented phrase	Transcribed phrase	Number of errors
24	ごめんなさい	ごめんなさい	0
12	れんしゅうなし	れんしゅうなし	0
19	ろくがよやく	らくがよやく	1
15	かいぎりまいんだ	かいぎりまいんだ	0
13	あさってしめきり	あさってしまきら	2
7	ごごきゅうこう	ごごきゅうこう	0
18	せんたくものほす	さんたくものほす	1
4	かいぎしりょう	かいぎしりょう	0
23	あるみほいる	あるみほいる	0
3	れぽーとしめきり	らほーたしめきり	3
6	すいどうだい	すいどうだい	0
2	あしたかいぎ	あしたかいぎ	0
8	あしたはやすみ	あしたはやすみ	0
10	ろんぶんよむ	ろんぶんよむ	0
9	びでおへんきゃく	びでおはんきゃく	1
5	しりょういんさつ	しりょういんさつ	0
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
21	かんとりーまあむ	かんとりーまあむ	0
14	いんたらくしょん	いんたらくしょん	0
20	ぺっとぼとる	ぺっとぼとる	0
11	どようのみかい	どようのみかい	0
22	やさいじゅーす	やさいじゅーす	0
16	さぼてんにみず	さぼたんにまず	2
17	すけじゅーる	すけじゅーる	0

Table G.3: Result of participant C.

ID	Presented phrase	Transcribed phrase	Number of errors
13	あさってしめきり	あさってしめきり	0
14	いんたらくしょん	いんたらくしょん	0
16	さぼてんにみず	さぼてんにみず	0
8	あしたはやすみ	あしたはやすみ	0
24	ごめんなさい	ごめんなさい	0
18	せんたくものほす	せんたくものほす	0
5	しりょういんさつ	しりょういんさつ	0
2	あしたかいぎ	あしたかいぎ	0
17	すけじゅーる	けしすねる	4
20	ぺっとぼとる	ぺっととる	1
23	あるみほいる	あるみほいる	0
11	どようのみかい	どようのみかい	0
4	かいぎしりょう	かいぎしりょう	0
19	ろくがよやく	ろぬがよやく	1
15	かいぎりまいんだ	かいぎりまいんだ	0
6	すいどうだい	すいどうだい	0
3	れぽーとしめきり	おーとしめきり	2
22	やさいじゅーす	やしいじゅーす	1
21	かんとりーまあむ	かんとりーまあむ	0
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
9	びでおへんきゃく	びでおへんきゃく	0
12	れんしゅうなし	れんしゅうはなし	1
10	ろんぶんよむ	ろんゆんよむ	1
7	ごごきゅうこう	ごきうこう	2

Table G.4: Result of participant D.

ID	Presented phrase	Transcribed phrase	Number of errors
8	あしたはやすみ	あしたはやすみ	0
15	かいぎりまいんだ	かいぎりまいんだ	0
21	かんとりーまあむ	かんとりーまあむ	0
17	すけじゅーる	すくじゅーる	1
3	れぽーとしめきり	れぽれとしめきり	1
24	ごめんなさい	ごめんなさい	0
9	びでおへんきゃく	やでおへんきゃく	1
6	すいどうだい	すいどうだい	0
10	ろんぶんよむ	ほんぶんよむ	1
22	やさいじゅーす	やさいやゅーゆ	2
12	れんしゅうなし	れんやゅうわや	3
14	いんたらくしょん	いんたらくしょん	0
20	ぺっとぼとる	ぺっとぼろる	1
2	あしたかいぎ	あやらかいぎ	2
16	さぼてんにみず	さぼれんにみず	1
7	ごごきゅうこう	ごごきゅうこう	0
18	せんたくものほす	んたくものおす	2
13	あさってしめきり	あさってしめきり	0
4	かいぎしりょう	かいぎやりょう	1
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
5	しりょういんさつ	しりょういんさる	1
19	ろくがよやく	ろくがよやく	0
11	どようのみかい	どようのみかい	0
23	あるみほいる	はるみほいる	1

Table G.5: Result of participant E.

ID	Presented phrase	Transcribed phrase	Number of errors
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
4	かいぎしりょう	かいぎしりょう	0
7	ごごきゅうこう	ごごきゅうこう	0
12	れんしゅうなし	れんしゅうなし	0
11	どようのみかい	どようのみかい	0
16	さぼてんにみず	さぼてんにみず	0
23	あるみほいる	あるみほいる	0
6	すいどうだい	すいどうつい	1
14	いんたらくしょん	いんたらくしょん	0
19	ろくがよやく	ろくがよやく	0
21	かんとりーまあむ	かんとりーまあむ	0
9	びでおへんきゃく	びでおへんきゃく	0
17	すけじゅーる	ゆめやゆをんる	6
10	ろんぶんよむ	ろんふんよむ	1
13	あさってしめきり	あさってしめきり	0
15	かいぎりまいんだ	かいぎしやまいゆだ	3
22	やさいじゅーす	やさいじゅーす	0
24	ごめんなさい	ごめんなさい	0
18	せんたくものほす	せんたくものほす	0
5	しりょういんさつ	しりょういんさつ	0
20	ぺっとぼとる	ぺっとぼとる	0
8	あしたはやすみ	あしたはやすみ	0
2	あしたかいぎ	あしたかいぎ	0
3	れぽーとしめきり	れぽーとしめきり	0

Table G.6: Result of participant F.

ID	Presented phrase	Transcribed phrase	Number of errors
16	さぼてんにみず	さおれわにみゆ	4
1	ぎゅうにゅうかう	くゅうにゅうかう	1
11	どようのみかい	ようのみかい	1
20	ぺっとぼとる	ぺっとぼとる	0
6	すいどうだい	すいうだい	1
15	かいぎりまいんだ	かうぎりまいわだ	1
4	かいぎしりょう	ないぎしりょう	1
9	びでおへんきゃく	びでおへわきゃく	1
24	ごめんなさい	こめわなさい	2
2	あしたかいぎ	あしたかいきぎ	1
21	かんとりーまあむ	かわとりーまあむ	1
7	ごごきゅうこう	ごごきゅうこう	0
5	しりょういんさつ	しりょういわさつ	1
10	ろんぶんよむ	ろわぶわよむ	2
12	れんしゅうなし	れわしゅうなし	1
23	あるみほいる	あるみほいる	0
18	せんたくものほす	せわたくものほす	1
19	ろくがよやく	くがよやく	1
17	すけじゅーる	すけじゅーる	0
14	いんたらくしょん	いんたらくしょん	0
13	あさってしめきり	あさってしめきり	0
22	やさいじゅーす	やさいじゅーゆ	1
8	あしたはやすみ	あしたはやすみ	0
3	れぽーとしめきり	れぽーとしめきり	0

Table G.7: Result of participant G.

ID	Presented phrase	Transcribed phrase	Number of errors
14	いんたらくしょん	いぬたらくしょん	1
22	やさいじゅーす	やさいぢゅーす	1
24	ごめんなさい	ごめんなさい	0
6	すいどうだい	すいどうだい	0
19	ろくがよやく	ろくがよやく	0
12	れんしゅうなし	れんしゅうなし	0
7	ごごきゅうこう	ごごきゅうこう	0
17	すけじゅーる	すけじゅねる	1
15	かいぎりまいんだ	かいぎりまいんだ	0
5	しりょういんさつ	しりょういんさつ	0
11	どようのみかい	どようのみかい	0
4	かいぎしりょう	かぎしりょう	1
13	あさってしめきり	あさってちめきり	1
20	ぺっとぼとる	ぺっとぼとる	0
10	ろんぶんよむ	ろんぶんよむ	0
23	あるみほいる	あるみほいる	0
18	せんたくものほす	せんたくものほす	0
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
8	あしたはやすみ	あしたはやすみ	0
21	かんとりーまあむ	かんとりーまたむ	1
9	びでおへんきゃく	びでおへんきゃく	0
3	れぽーとしめきり	れぽーとちめきり	1
2	あしたかいぎ	あしたかいぎ	0
16	さぼてんにみず	さぼてんをみず	1

Table G.8: Result of participant H.

ID	Presented phrase	Transcribed phrase	Number of errors
7	ごごきゅうこう	ごごきゅうこう	0
24	ごめんなさい	ごめんなさい	0
8	あしたはやすみ	あしたはやすみ	0
14	いんたらくしょん	んたらくしょん	1
5	しりょういんさつ	しりょういんさつ	0
16	さぼてんにみず	さぼてみず	2
18	せんたくものほす	せんたくものほす	0
22	やさいじゅーす	やすゅーす	3
4	かいぎしりょう	かいぎしろょう	1
10	ろんぶんよむ	ろんぶんよむ	0
21	かんとりーまあむ	かんとりーまあむ	0
15	かいぎりまいんだ	ないぎりまいんだ	1
3	れぽーとしめきり	れほーとしめきり	1
17	すけじゅーる	すけじーる	1
19	ろくがよやく	ろくがよやく	0
2	あしたかいぎ	あしたかいぎ	0
11	どようのみかい	どようのみかい	0
9	びでおへんきゃく	びでおへんきゃく	0
6	すいどうだい	すいどうだい	0
12	れんしゅうなし	れんしゅうなし	0
20	ぺっとぼとる	ぺっとぼとる	0
23	あるみほいる	たるみほいる	1
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
13	あさってしめきり	あさってしめきり	0

Table G.9: Result of participant I.

ID	Presented phrase	Transcribed phrase	Number of errors
12	れんしゅうなし	れんしゅうなや	1
2	あしたかいぎ	あしたないぎ	1
10	ろんぶんよむ	ろんぶんよむ	0
19	ろくがよやく	ろぬあよやう	3
13	あさってしめきり	あさってしめきり	0
3	れぽーとしめきり	れぽんそしめきり	2
11	どようのみかい	どよつのみない	2
21	かんとりーまあむ	なんとりーまあむ	1
24	ごめんなさい	ごめんなさい	0
14	いんたらくしょん	いんたらくしょん	0
6	すいどうだい	すいどだい	1
8	あしたはやすみ	あしたはやすみ	0
16	さぼてんにみず	さぼてんにみず	0
20	ぺっとぼとる	ぺっとぼとる	0
4	かいぎしりょう	かいぎしりょう	0
9	びでおへんきゃく	びでおへんいゃく	1
22	やさいじゅーす	やさぢゅーゆ	3
18	せんたくものほす	せんたくわのほす	1
7	ごごきゅうこう	ごごきゅつのう	2
5	しりょういんさつ	しりょいんあつ	2
15	かいぎりまいんだ	かいきりめちんだ	3
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
23	あるみほいる	たるみほいる	1
17	すけじゅーる	すけぢゅーる	1

Table G.10: Result of participant J.

ID	Presented phrase	Transcribed phrase	Number of errors
10	ろんぶんよむ	ろんぶんよむ	0
12	れんしゅうなし	れんしゅうわし	1
3	れぽーとしめきり	れぽーとしめきり	0
5	しりょういんさつ	しりょういんさつ	0
18	せんたくものほす	せんたくものほす	0
15	かいぎりまいんだ	かいぎりまいんだ	0
17	すけじゅーる	すけじゅーる	0
19	ろくがよやく	ろくがよやく	0
1	ぎゅうにゅうかう	ぎゅうにぬうかう	1
14	いんたらくしょん	いんたらくしょん	0
6	すいどうだい	すいどうだい	0
20	ぺっとぼとる	ぺっとぼぼとる	1
4	かいぎしりょう	かいぎしりょう	0
2	あしたかいぎ	あしたかいぎ	0
23	あるみほいる	あるみほいる	0
13	あさってしめきり	あさってしめきり	0
16	さぼてんにみず	さぼてんにみず	0
11	どようのみかい	どようのみくい	1
24	ごめんなさい	ごめんなさい	0
22	やさいじゅーす	やさいじゅーす	0
7	ごごきゅうこう	ごごきゅうこう	0
9	びでおへんきゃく	びでおへんきゃく	0
21	かんとりーまあむ	かんとりーまあむ	0
8	あしたはやすみ	あしたはやすみ	0

Table G.11: Result of participant K.

ID	Presented phrase	Transcribed phrase	Number of errors
16	さぼてんにみず	さぼててんにみず	1
6	すいどうだい	すいどうだい	0
11	どようのみかい	どようのみかい	0
20	ぺっとぼとる	ぺっとぼとる	0
8	あしたはやすみ	あしたはやすみ	0
13	あさってしめきり	あさってしめきり	0
24	ごめんなさい	さこめんなさい	2
4	かいぎしりょう	かいぎしりょう	0
3	れぽーとしめきり	れぽーとしめきり	0
12	れんしゅうなし	れんしゅうなし	0
9	びでおへんきゃく	びでおへんきゃく	0
5	しりょういんさつ	しりょういんさつ	0
7	ごごきゅうこう	ごごきゅうこう	0
17	すけじゅーる	すけじゅーる	0
18	せんたくものほす	せぬたくものぁほす	2
19	ろくがよやく	ろくがよゃよやく	2
10	ろんぶんよむ	ろんぶんよむ	0
22	やさいじゅーす	やさいじゅーす	0
21	かんとりーまあむ	かんとりーまあむ	0
2	あしたかいぎ	あしたかいぎ	0
15	かいぎりまいんだ	かいぎりまいんだ	0
1	ぎゅうにゅうかう	ぎゅうにゅかう	1
14	いんたらくしょん	いんたらくしょん	0
23	あるみほいる	あるみほいる	0

Table G.12: Result of participant L.

ID	Presented phrase	Transcribed phrase	Number of errors
7	ごごきゅうこう	ごごなゅうこう	1
21	かんとりーまあむ	かんとらーまあま	2
15	かいぎりまいんだ	かいにりまいんだ	1
24	ごめんなさい	ごめんなさい	0
3	れぽーとしめきり	らぽーとしむきり	2
12	れんしゅうなし	れんそゅうなし	1
22	やさいじゅーす	やさいじゅんす	1
23	あるみほいる	あるみほいる	0
4	かいぎしりょう	かいぎしりょう	0
17	すけじゅーる	すけじゆーる	1
16	さぼてんにみず	たぼてんにみず	1
6	すいどうだい	すちどうだい	1
11	どようのみかい	どようのみかい	0
5	しりょういんさつ	しりょういんさつ	0
9	びでおへんきゃく	びでおへんきやく	1
10	ろんぶんよむ	ろんぶんよむ	0
8	あしたはやすみ	あしたはやすみ	0
14	いんたらくしょん	いんたらくしよん	1
13	あさってしめきり	たさってしめきり	1
20	ぺっとぼとる	ぺっとぼとる	0
2	あしたかいぎ	あしたかいぎ	0
1	ぎゅうにゅうかう	ぎゅうにゅうかう	0
18	せんたくものほす	せんたくものほす	0
19	ろくがよやく	ろくがよはく	1