# Using Different Gestural-Input Methods for Personal and Public Touchscreen Devices

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***Abstract*— User interfaces for personal communication devices or public devices are a flourishing research area. This article begins with a brief history of the current user interfaces of personal communication devices and public devices. Key factors in introducing different types of interfaces for different types of devices are presented, including their experiment methodology. Important factors to consider are identified and elaborated, such as focus of attention, text-related symbols versus simple linear symbols, novice versus expert performance, stressful versus stressless process, and the speed-accuracy trade-off.**

***Keywords- User interface; personal device; public device; text-related symbol; simple linear symbol***

## I. INTRODUCTION

Today, most input systems for user interfaces of personal or public devices ask users to input commands using a mouse or a keyboard with lots of toolbar buttons or menu items, or long addresses for selection. This clumsy type of user interface is inconvenient for small-screen devices such as PDAs, as it has no room to accommodate so many menu items and toolbars. Also, it is very time-consuming to type long addresses.

As such, user interfaces of different devices have changed in the past 50 years. To this day, many handy mobile devices use touchscreens. Computers and public kiosks are also starting to introduce touchscreen interfaces. Due to this, traditional input systems such as keyboards and mouse devices are being replaced with touch-based input systems. Ironically, this touch-based input system mimics the interaction of users with pen and paper, to which most persons are used from an early age. This system enables the users to interact with devices in efficient and natural ways [1]. Furthermore, even computer-unskilled persons can use their fingers efficiently with such devices. This makes touch-based interfaces suitable for a wide range of users and situations for which limited traditional manners of interaction could pose serious problems.

For this developed interface, a user-centered design approach is suggested. Although many devices are starting to use touch-based interfaces, there are no suitable interfaces for different purposes. For small-screen devices such as mobile touch phones and PDAs, which depend fully on pen- or finger-based user interfaces, traditional menu-selection or button-clicking interfaces or interfaces that require typing of long website addresses are inconvenient and useless with respect to fast and natural inputting. Even public kiosks in libraries or museums that use touch-based interfaces are encountering the same problems.

To avoid this problem, two types of gestural-input methods are suggested for devices with different purposes. Gesture based interfaces provide a new way for us to interact with devices, but also require us to make new decisions about which gestures we decide are usable and appropriate [2]. These decisions are based on the social and public settings where these devices are used on a daily basis.

## II. BACKGROUND

Several methods are currently commonly used on mobile devices with touch-based input systems. Two of these methods are gestural-input systems. They use alphabet-related text inputs and simple linear symbol inputs, respectively. In the alphabet-related text input method, a user inputs the first letter of a website name or program. For example, a user can input ‘g’ to connect to the Google website or ‘w’ to open a Microsoft Word program. A user can also go to the next page of the website by merely drawing a line from the left to the right. This is an advanced input model that saves time by making it unnecessary to type the full website addresses or to click many icons to open a program. This convenient input system is featured in some handy programs such as Sensiva. This program was originally designed for mouse movement.

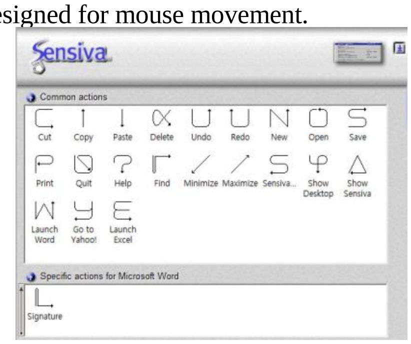


Figure 1. Sensiva

While the alphabet-related text input system is popular with some users, a more advanced input model is focused on in this paper, the simple linear symbol input method, which

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is famous for small devices such as touch mobile phones (e.g., iPhone, Galaxy S). In the simple linear symbol input system, a user simply draws a single line in different ways to control the input.

These two sets of symbol inputs have their own strengths and weaknesses. For the alphabet-related text input user, if the user understands the logic behind the relationship between the initials and the symbols, s/he will find it very easy to infer other symbols that have not yet been studied. In some cases, however, it is more time-consuming and difficult to draw complicated symbols than simple linear symbols. On the other hand, even if it takes a shorter time to draw simple linear symbols, such input system would be more difficult for a user who could not infer any without adequate practice.

There have been similar researches for gestural-input systems, but they didn't concentrate to touchscreen devices or user's purpose. Gestural input is an interesting starting point when investigating the social factors of multimodal interface acceptance [3].

## III. RELATED RESEARCH

### A. Sketch-based User Interface

The sketch-based user interface was designed to improve clumsy and inconvenient user interfaces. In this interface, a user inputs composite graphic objects using the sketch-based user interface. With the sketches of a few constituent primitive shapes of the user-intended graphic object, the candidate graphic objects in the shape database are guessed and displayed in a ranked list according to their partial structural similarity to what the user has drawn. The user can then choose the right shape from the list and replace the sketch strokes with the exact graphic object with proper parameters, such as position, size, and angle. This user interface is natural for graphic inputs and is especially suitable for schematic designs [4].

### B. Calligraphic Interface

CaliEdit is an application that is under development as a year-long undergraduate project at IST. It combines calligraphic interfaces with a traditional text editor. It allows users to manipulate text by directly drawing over it symbols that represent the most common editing tasks. It recognizes several common symbols that users draw on paper to represent their desired changes to the text, and effects those changes. The task analysis phase, with the help of questionnaires, identifies the most common symbols for the most common test correction tasks. The editor itself uses the CALI shape and gesture recognizer, ported to PalmOS, to help recognize those symbols [5].

### C. Unipad

Unipad is a stylus-based text entry technique. It combines single-stroke text inputs with language-based acceleration techniques, including word completion, suffix completion, and frequent word prompting. In a study with 10 participants, entry rates averaged 11.6 wpm with 0.9% errors after two hours of practice. In follow-on sessions to establish the expert potential, four users entered "The quick brown fox" phrase repeatedly for four blocks of 15 minutes each. Average rates on the last block ranged from 17.1 to 35.1 wpm, and peak rates reached 48 wpm [6].

### D. Touchscreens for Public Kiosks

To cater to a wide range of experiences with general public systems, it is important that little or no user experience is assumed for inputting in the system. Touchscreens provide a way of presenting keys or touch areas that can be changed for individual outputs [7].

Several years ago, the British public was less familiar with the concept of touchscreens and was less confident in using them than keyboards. Today, British users are more familiar with touchscreens. In the mentioned PD Web study (Maguire, 1997), 38 users were asked to rate how easy they found the use of touchscreens [8]. The answers follow.

TABLE 1 EASE OF USE OF TOUCHSCREENS

| **Ease of Use of Buttons and Commands** | | | | |
|---|---|---|---|---|
| Very easy | Easy | Medium | Difficult | Very difficult |
| 23 | 11 | 2 | 2 | 2 |

As the results show, the large majority found touchscreens either 'easy' or 'very easy' to use. Touchscreens are therefore a flexible solution to inputting via kiosks.

## IV. CUSTOMIZED SYMBOLS

In this experiment, symbols were created using Sensiva. The first set of symbols was for Test 1, and consisted of initials of programs or websites. Sensiva only works with one continuous line, so first letters of programs and websites were chosen and designed for to be drawn in one line. The second set of symbols was for Test 2, and consisted of simple linear symbols that could be drawn very easily and quickly. Those input symbols had their own outputs. Test 1 and Test 2 had their own method of symbols. Some of the symbols existed in the program, but most of the symbols were newly created for the tests.

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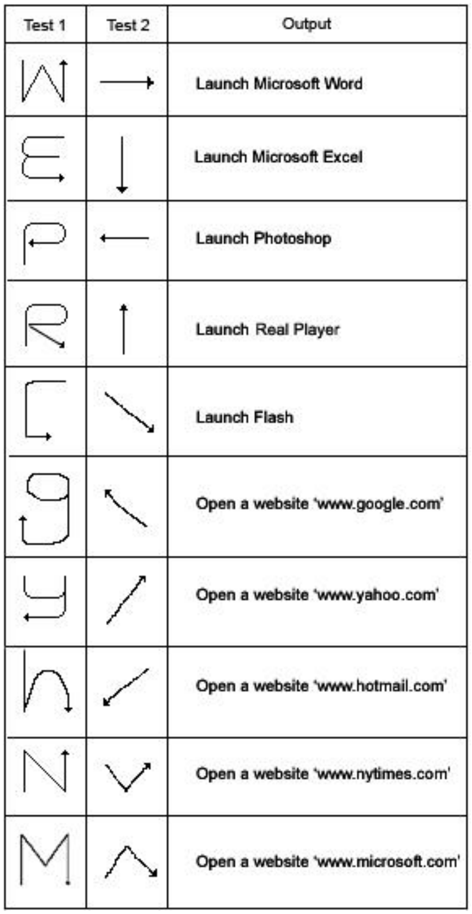


Figure 2. Symbols for the Tests

Ten different outputs were selected through the research for the tests. The ten sites that users most commonly used from their own systems (in English) were chosen. For each output, all the Test 1 symbols related to their initial letters were customized. For the Test 2 symbols, the simplest linear symbols were chosen for comparison. For Test 1, the participants easily guessed the other symbols after they understood the simple logic behind the meaning of the symbols. This is because all the symbols were related to their programs and sites' first letters. The Test 2 symbols, however, had no relationship to the outputs.

## V. MEASUREMENT OF EFFICIENCY

To decide which set of symbols was suitable to different devices, a comparative study of the two methods was performed. This study consisted of an in-depth comparison of the two input methods to choose the most suitable interface for different purposes. There were 100 participants in the experiments, 10 for each age group. 52 percent of them were clerks who are familiar with computers. 25 percent were students. The last 33 percent of participants were housewives and self-employed. Among them 43 percent answered they own their touch screen devices such as laptops or mobile phones and 25 percent answered they are familiar with touch pad or screens and rests have rare experiences to the touch screen devices.

### A. *Choice of Platform*

For the smooth use of the two sketch-based interfaces, a touchpad that was actually working was needed for the input system. A laptop computer with a built-in touchpad was used (Apple Macbook). To make the inputs actually work, the program Sensiva (Symbol Commander Software) was used, as it could customize the symbols for the experiments. To measure the time of use of the symbols, a digital camera took moving pictures of the process.

### B. *Stress Measurement*

The study focused on the amount of stress that occurred when the users were using the two sets of symbols. According to a study by researchers from the New York Presbyterian Hospital/Weill Cornell Medical Center, work-related stress causes only a temporary rise in blood pressure [9]. Thus, to measure the amount of stress, the instant change in blood pressure during the experiment was regarded as the amount of stress from the process. An OMRON automatic digital sphygmomanometer was used for the measurement. First, the normal heartbeat of each participant was measured before the test. During the test, the second set of blood pressure changes was compared with the first set.

### C. *Time Measurement*

The study also focused on the amount of time that was spent in using the symbols. From the recorded video, the time consumed while using the symbols was measured. This process had two steps. One was the analogy on the brain process time, and the other was the time that was spent for drawing the symbols. To distinguish between these two steps, the total time was divided into the recognition time and the drawing time.

#### 1) *Recognition Time*

This is time in which the participants first read the given questions and started to think of what the correct symbols for them were. The participants needed a certain amount of time to think before they started to draw the symbols. This time can vary according to each person's ability to memorize or recall symbols.

#### 2) *Drawing Time*

After the participants realized the correct symbols, they needed time to draw them on the touchpad. This time can vary according to each participant's ability to handle the touchpad.

#### 3) *Accuracy*

To measure the accuracy of both sets of symbols, the correct answers were counted among the 10 given test subjects for both sets of symbols during the whole study period. If the participants drew similar symbols but the output did not work, it was considered a wrong answer. Only cases when the output worked correctly were counted as right answers.

#### 4) *Period of Study*

To survey the changes in the test results, the participants were made to undergo three tests in four weeks. The first test

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(Trial a) was given to each group of participants who memorized for 10 minutes the alphabet-related text input symbols. The second test (Trial b) was given after three days of studying the symbols for at least 10 minutes each day. The third test (Trial c) was given a week after the first test, and the participants were asked to study the symbols everyday for at least 10 minutes a day. Simple linear input symbols (Test 2) were tested in exactly the same way as was the first set.

After one month, with no obligation to study the symbols, participants tested one more time how much they remember the symbols.

## VI. RESULTS

Test 1 (alphabet-related text input symbols) and Test 2 (simple linear input symbols) showed typical results for each section (i.e., stress, speed, accuracy, and study efficiency). These results showed which method is efficient for different devices. Average 1 means the average of Test 1, and Average 2 means the average of Test 2.

### A. Heartbeat Changes

The beats per minute (bpm) in each test changed with time, especially in Test 2 (simple linear symbols), in which the average bpm decreased at a high speed. Test 1 also had a low diminution rate throughout the test. Finally, for Trial c (one week of study), Test 2 had a much lower bpm rate than Test 1.

For both sets of symbols, the users' heartbeat rates were close to their normal bpm (before the tests). In Trial a (the 10-minute study), Test 2's bpm had a +9.38 score against the normal bpm, slightly higher than Test 1's +8.30 score. This means that right after the 10-minute study, the users experienced much stress in the tests for both sets of symbols. The simple linear symbols that required more memorization time and effort were slightly more stressful.

After three days and seven days, however, the bpm scores dropped gradually. The Test 2 scores were obviously much lower in Trial 2 and Trial 3. This means the participants found it more comfortable to use the simple linear symbols after much practice and memorization.

On the other hand, when the participants used the alphabetical symbols, their bpm did not change. This is because the initial symbols are easy to guess, so users have no problem using them.

TABLE 2 CHANGES IN THE BPM IN TEST 1, TEST 2

| Bpm | Normal | Trial a | Trial b | Trial c |
|---|---|---|---|---|
| Average 1 (Test 1) | 79.18 | 87.48 | 87.3 | 86.16 |
| Average 2 (Test 2) | 76.66 | 86.04 | 83.9 | 80.88 |

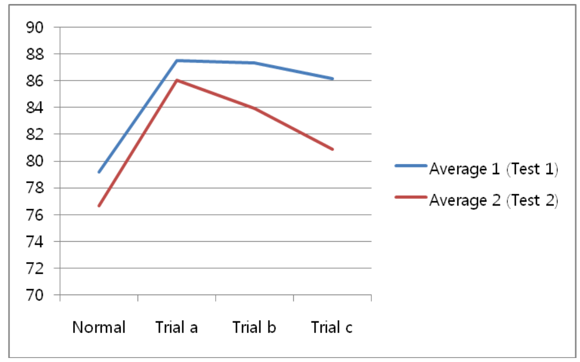


Figure 4. Comparison of the bpm Changes in Tests 1 and 2

The results of Tests 1 and 2 showed that once the participants became used to the symbols, they became less stressed than in the first trial (the 10-minute study). Also, the users were more comfortable with the simple linear symbols than the alphabetical symbols if they already knew the symbols well and have become used to them.

### B. Bpm Variation

The decline of the bpm to the normal bpm also showed a noticeable decline in bpm variations. Test 1 had a flat average decline, but Test 2 had a noticeably steep falling line. Due to this, in Trial c, Test 2 had less bpm variations than Test 1. The former results also showed that in Test 2, when the participants were using the simple linear symbols, they were less stressed than in Test 1. They became more stressed when they analogized the symbols than when they just drew simple symbols unconsciously after studying them.

TABLE 3 VARIATIONS IN THE BPM

| Variation (%) | Trial a | Trial b | Trial c |
|---|---|---|---|
| Average 1 | 10.64 | 10.40 | 8.94 |
| Average 2 | 12.55 | 9.70 | 5.67 |

### C. Recognition Time

While the participants were solving the given questions, the time they consumed was divided into two. The first period, defined as the "recognition time," was when the participants read the problem and memorized the symbols. The results of the two tests showed that the recognition time gradually decreased due to the time of study.

TABLE 4 AMOUNT OF RECOGNITION TIME

| Recognition (sec) | Trial a | Trial b | Trial c |
|---|---|---|---|
| Average 1 | 2.25 | 2.13 | 1.98 |
| Average 2 | 3.72 | 3.29 | 2.39 |

#### 1) Drawing Time

The second period was the time when the symbols were drawn. The results also showed that the more the participants studied the symbols, the more became familiar with them. The participants were gradually able to draw the symbols more easily and quickly. The Test 2 symbols, which were

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less complicated, took up a shorter time than the Test 1 symbols.

TABLE 5 AMOUNT OF TIME FOR DRAWING

| Drawing (sec) | Trial a | Trial b | Trial c |
|---|---|---|---|
| Average 1 | 2.28 | 2.13 | 2.01 |
| Average 2 | 1.56 | 1.36 | 1.25 |

*2) The Total Time*

To sum up, the recognition time and the drawing time were added to come up with the total time. It was found that the total time had the same aspect as the recognition time and the drawing time. The length of both time periods gradually decreased in the two tests. This means that the participants adjusted to both methods when they were studying for days, and that this helped reduce their study time.

One thing that is exceptional is that the total time in Test 2 caught up with the total time in Test 1 after one week of study (Trial c). In Trial a, Test 2 took a longer time than Test 1; but in Trial c, Test 2 took less time than Test 1. This means that once the participants became used to the simple linear symbols, they learned them faster than the alphabetical symbols.

TABLE 6 THE TOTAL TIME TAKEN FOR THE TESTS

| Total Time (sec) | Trial a | Trial b | Trial c |
|---|---|---|---|
| Average 1 | 4.528 | 4.262 | 3.984 |
| Average 2 | 5.288 | 4.654 | 3.513 |

## D. Correct Answer Changes

The participants' answers to the 10 questions in each test improved with time. They got more correct answers when they studied the symbols for a week than for 10 minutes. In Test 1, the average number of correct answers (CA) was much higher than in Test 2 in the first trial (Trial a).

After a week of study, however, Test 2 saw a marked 90% increase in CA, which almost caught up with Test 1. This implies that if the participants studied the simple linear symbols much longer, they would have gotten more correct answers than they did with the alphabet-related symbols.

TABLE 7 CHANGES IN NUMBERS OF CORRECT ANSWERS

| Correct Answers (%) | Trial a | Trial b | Trial c |
|---|---|---|---|
| Average 1 | 88.20 | 91.40 | 93.20 |
| Average 2 | 60.60 | 76.60 | 90.60 |

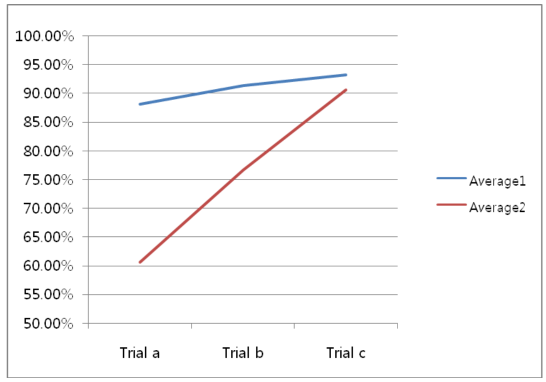


Figure 6. Changes in Numbers of Correct Answers

## E. Experts vs. Novices

The participants' 43 percents owns their personal touch screen devices like laptops and mobile devices and they answered they are very familiar to those devices. And rests are barely use touch screens devices or have little experiences. Due to this fact, we divided participants to two groups. 43 percents who have many experiences to experts, and the others to novices. Interestingly the results show experts was noticeably superior for every experiments at the first trial but soon novices get to the similar point after one week. This shows that novices who were not familiar to the touch devices can be experts within few weeks after sufficient experiences.

TABLE 8 BPM COMPARISON OF EXPERTS AND NOVICS

| BPM | Trial a | Trial b | Trial c |
|---|---|---|---|
| Experts | 85.4 | 84.2 | 83.7 |
| Novices | 87.4 | 85.1 | 84.5 |

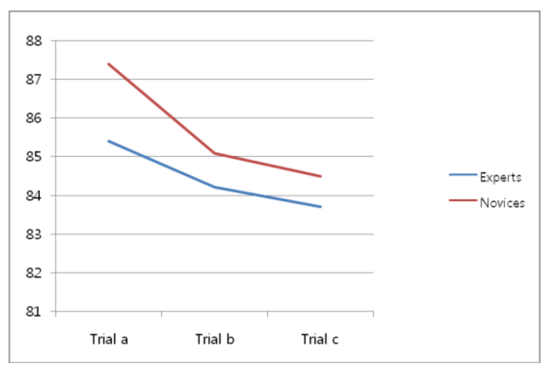


Figure 7. Bpm Comparison of Experts and Novices

TABLE 9 TIME COMPARISON OF EXPERTS AND NOVICES

| Total Time (sec) | Trial a | Trial b | Trial c |
|---|---|---|---|
| Experts | 4.125 | 4.024 | 3.872 |
| Novices | 5.52 | 4.484 | 3.925 |

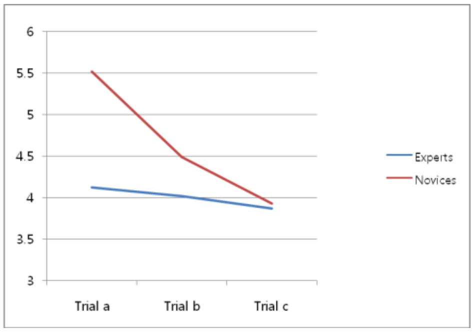


Figure 8. Time Comparison of Experts and Novices

TABLE 10 CORRECT ANSWER COMPARISON OF EXPERTS AND NOVICES

| Correct Answer (%) | Trial a | Trial b | Trial c |
|---|---|---|---|
| **Experts** | 85.00 | 88.50 | 92.70 |
| **Novices** | 72.00 | 74.60 | 89.30 |

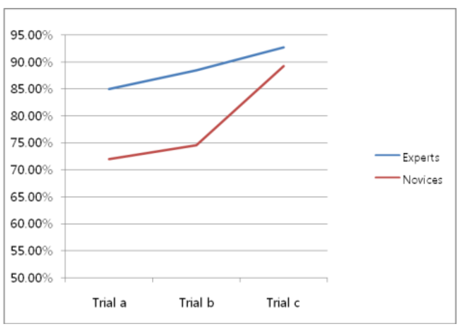


Figure 9. Correct Answer Comparison of Experts and Novices

## F. *Final Test*

After the three experiments, participants have one month break from the study. Then we give the last test. The result show that even the simple linear symbols became superior at the third trial, it comes to the start again without continuous study of symbols. Without steady use of those symbols most participants barely remember the use of linear symbols. The result show the averages of after one month correct answer become almost the same level to the first trial. On the other hand, experts group has significant result that they recognize linear symbols better then the novices. Through this, we can suggest that experienced touchscreen devices users can memorize both symbols more easily and remember longer.

TABLE 11 CHANGES IN NUMBERS OF CORRECT ANSWERS AFTER ONE MONTH

| Correct Answers (%) | Trial a | One month |
|---|---|---|
| **Average 1** | 88.20 | 87.60 |
| **Average 2** | 60.60 | 65.78 |

TABLE 12 NUMBERS OF CORRECT ANSWERS FOR EXPERTS AND NOVICES AFTER ONE MONTH

| Correct Answers (%) | Experts | Novices |
|---|---|---|
| **Average 1** | 92.38 | 84.20 |
| **Average 2** | 79.27 | 68.32 |

## VII. DICUSSION

The results showed the changes in the stress by heartbeat, speed, and accuracy with the time of study. These three elements all improved in time. Test 2 (simple linear symbols) especially saw a marked improvement in all the three tests. The stresses and the total time consumed remarkably decreased. The accuracy also increased step by step. The alphabetical symbols seemed more efficient in the first trial (after a 10-minute study) because the participants were able to guess the symbols without memorizing them. The more they learn the Test 2 symbols, however, the more efficient they became with such symbols than with the alphabetical symbols. Through their repeated study of the symbols, they were able to memorize the Test 2 symbols, after which the said symbols became easier to use. The experts who are familiar to the touchscreen devices get more correct answers, take shorter time and get less stress at first. However, novices get nearly equivalent scores after one week of study. At the last experiment, novices remembered both symbols less than experts.

## VIII. DICUSSION

Two methods of improving gestural-input symbol interfaces for different devices were presented in this paper. As the results showed, the two types of symbols have their own strengths and weaknesses. The alphabet-related symbols, which are initials of programs or site names, are easy to learn and guess in the case of new users who are not familiar with them. In Trial 1, even though the participants studied the symbols for only 10 minutes, they got a high rate of accuracy. After continuously studying the simple linear symbols, however, the participants became faster and more efficient with them. They became less stressed after they became used to the simple symbols. Participants who are experts to the touch screen devices get much higher scores for accuracy and need shorter time and little stress. Also, they remember symbols longer than novices.

Due to this, different gestural input methods for different devices are presented. We provide a new way to interact with touch screen devices upon the users' usability and appropriation.

For personal and small devices such as mobile phones, PDAs, and PMPs (Portable Media Players), simple linear symbols can be more practical and efficient. Users are always carrying these devices and spend much time using them. These are very intimate devices. This means that users can spare sufficient time to study the symbols these devices use. Once they become used to the simple symbols, they become very efficient with them.

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On the other hand, for public devices such as information kiosks in transportation stations or museum guide devices, alphabet-related symbols will be more efficient. Those devices have to be easy to use for both novices and experts. Once the users know the initial logic, they can easily and readily use any device.

At present, it is assumed that all users have certain abilities to study the symbols. In future works, this work may be extended by dividing users into specific ages and sexes for a usability test, to see how their abilities will change. A re-customization of the symbols is also planned for their optimum usability.

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