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Communication

Usability of the Stylus Pen in Mobile Electronic Documentation

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Abstract: Stylus pens are often used with mobile information devices. However, few studies have examined the stylus' simple movements because the technical expertise to support documentation with stylus pens has not been developed. This study examined the usability of stylus pens in authentic documentation tasks, including three main tasks (sentence, table, and paragraph making) with two types of styluses (touchsmart stylus and mobile stylus) and a traditional pen. The statistical results showed that participants preferred the traditional pen in all criteria. Because of inconvenient hand movements, the mobile stylus was the least preferred on every task. Mobility does not provide any advantage in using the stylus. In addition, the study also found inconvenient hand support using a stylus and different feedback between a stylus and a traditional pen.

Keywords: stylus; touch screen; usability; input device; documentation

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1. Introduction

This study explored the usability of a stylus pen, focusing on writing tasks in a mobile environment. This paper presents the usability of two different stylus pens, comparing their systems with traditional pen-based handwriting. We also discuss the advantages of stylus writing and suggest a theoretical model of stylus pen use.

With rapidly growing touch-sensitive technology, including computer environments and user interfaces, many handheld information devices such as smart phones and personal digital assistants (PDAs) are used [1] for reading and creating documents. Various applications and input devices with touch-sensitive screens are popular in tablet personal computers (PCs), desktops, and e-book reader devices. Thus, with a touch-sensitive screen, it is possible to process input signals using the keyboard or keypad and support physical writing tasks. In other words, digital writing tools have improved and perform the same tasks as analog tools [2].

However, text entry using touch-sensitive screens such as handheld devices is difficult, although people want accurate inputting devices for touch-sensitive screens [3]. Representatively, a pen is the most common tool used as an input device and pointing tool. Inputting signals using pen-shaped devices has been used in many computer systems with touch-sensitive screens, emphasizing the advantages of touch-sensitive screens. Several studies on PDA interfaces using stylus pens have been conducted [4–6]. However, little research has been conducted on the effects of using a stylus pen to write documents using a touch-sensitive screen [7].

In comparison with traditional handwriting [8], stylus writing is difficult because of the limitations of stylus pens and their support systems [9]. Some studies have examined the usability of a stylus with small devices to overcome limitations such as limited space [10,11]. In these experiments, they focused on basic tasks using a stylus such as steering and pointing, not documentation tasks. Because little research has focused on the usability of a stylus, we need to study the usability of stylus pens in documentation tasks.

2. Related Work

With handheld devices, users can write and read in any place. Some studies of efficient inputting devices for using handheld devices in reading and writing tasks have been conducted [12,13].

Among the functions of information devices, some studies provided visual effects for reading tasks [14]. Other research focused on legibility, efficiency, and the reaction of users [15,16]. These studies focused on the purposes of information devices such as e-books in reading content. Although people still prefer the format of books, information devices are replacing books because of their convenience and the expansion of e-book devices.

Writing tasks are as important as reading tasks. In writing tasks, we already know the importance of the writing function in education and society [17]. Related to our study, we found some differences between traditional pens and stylus pens in writing tasks. Traditional handwriting does not have limitations in pen and paper selection [18]. Each user can select a combination of different pens and papers to create a document. However, the combination set of pen and paper is not permanent. Thus, traditional handwriting requires ongoing costs to maintain this combination. In contrast, writing with a stylus pen only requires the initial costs. Furthermore, compared with paper, engineers and designers must design stylus pens within the limitations of hardware and software [19]. Due to mobility, one of the biggest issues with electronic devices, stylus writing prefers a stylus pen that is designed smaller than a traditional pen, which limits its usability [20]. Therefore, we must consider analyzing and improving the stylus pen's usability [21].

Some studies examined the usability of the stylus pen [22]. In a study of the stylus pen's performance, Ren and colleagues studied the components of stylus pens [23]. Based on an analysis of the stylus pen's components, they designed various types of stylus pens. Then, they studied the combinations of stylus pen components which were given the best ratings by users of various ages, ranging from 10 to 60. Their experiment included pointing tasks and drawing tasks. However, the study did not consider editing and creating a real document. In addition, the researchers did not consider the gap between the real environment of creating a document and using a stylus pen and touch-sensitive screen.

From a different angle, Takahashi and colleagues focused on the effect of the full length of the stylus pen using PDAs [24]. They performed experiments using adults who had better writing skills than younger users. In their study, they found the most suitable pen-length. However, their research did not consider creating a document. In other words, these two research studies focused on basic functions such as steering and pointing.

In studies on usability, one study focused on increasing the accuracy of character recognition. In the case of the stylus pen, because users create documents with touch-sensitive screens using electric ink, we found technical supports including software and hardware with the ability to minimize the stylus pen's errors and accurate work as traditional handwriting [25].

With technical support of touch-sensitive screens and software, computing systems can detect and recognize the forms of characters which are created by stylus. That is, beyond the level of simple character recognition, touch-sensitive technology has improved to the point that the screen can recognize multi-touch and mobility. The results of some studies have found the characteristics of movement and direction in using stylus pens [25,26].

By analyzing the stylus pen's movement, the stylus pen and touch-sensitive screen can overcome limitations. Compared with traditional handwriting, technology can provide support that enables the stylus pen to demonstrate its advantages in document modification and character recognition [27,28].

Some studies have focused on the feedback of stylus pen writing, which is similar to the feedback of traditional handwriting. Lee and colleagues devised a stylus pen which has tactile feedback if people use stylus pens on PDAs or touch-sensitive screens. In this study, users exhibited more efficient and active actions in writing tasks because of tactile feedback [29]. Basically, the study of the feedback effect is based on a touch engine of handheld devices for efficient feedback delivery [30,31].

As more studies are conducted using stylus pens in information devices with a feedback effect, we can evaluate stylus pen writing compared to traditional handwriting. Due to the advantages of the initial stylus pen, the stylus pen has become a powerful writing tool. As stylus pen writing gradually resembles traditional handwriting, the future direction of the stylus pen will improve to compare more favorably with traditional handwriting.

Therefore, this study explored the usability of a stylus pen, focusing on writing tasks. In order to do this, this study conducted the experiment using two different stylus pens and traditional pen-based handwriting.

3. Experiment

3.1. Method

3.1.1. Participants

Twenty-one subjects (10 male and 11 female) participated in the experiment. The average age of subjects was 23.3 (subject ages ranged between 19 and 27 years, SD = 2.37).

3.1.2. Design and Task

The independent variables were writing tools (traditional pen, touchsmart stylus, or mobile stylus) and gender (male or female) of participants. Table 1 shows the specifications of stylus pens and traditional pens. To evaluate the performance between stylus pen writing and traditional handwriting, we set three main tasks: writing a sentence (28–35 characters), drawing a table (six lines, four rows with 200–210 characters), and creating a paragraph (paragraph title and a table with 700–720 characters). Each task included three sub-tasks. Each sub-task within the main tasks was configured with different content. We measured the usability evaluation based on time consumption. Participants then filled out a subjective assessment questionnaire about their preference of stylus pens, which included four questions of readability (the stylus pen I used made my writing easy to read), level of comfort (the stylus pen I used was comfortable to use), ease of manipulation (the stylus pen I used was easy to manipulate), and attractiveness (the stylus pen I used was attractive to use), on a seven-point rating scale, ranging from 1 (worst) to 7 (best). Task completion time and seven-point subjective rating were recorded as the dependent variable. Moreover, we used 10-inch tablet computers for all tasks.

3.1.3. Procedure

The experiment was conducted in a room with a chair, desk, and overhead fluorescent lighting. Participants were free in their actions. The procedure was as follows:

1. Researcher reads a simple instruction set.
2. Researcher presents the first sentence through the computer monitor and participant writes the first sentence using a traditional pen.
3. After writing the first sentence, participant has a five-second interval.
4. Researcher presents the second sentence through the computer monitor and participant writes the second sentence using a traditional pen.
5. After writing the second sentence, participant has a five-second interval.
6. Researcher presents the third sentence through the computer monitor and participant writes the third sentence using a traditional pen.
7. After writing the third sentence, participant has a 10-second interval.
8. Repeat steps (from 2–7) for three tasks of drawing a table.
9. Repeat steps (from 2–7) for two tasks of writing a paragraph.
10. Participant fills out a questionnaire, including questions on the level of comfort, readability, ease of manipulation, and attractiveness.

11. In order to know the overall impressions on using a traditional pen, researcher conducts two-minute interview session.
12. Repeat steps (from 2–11) using touchsmart stylus pen.
13. Repeat steps (from 2–8, 10 and 11) using mobile stylus pen (Figure 1).

At the end, participants were encouraged to give comments and explain their feelings toward stylus pens and traditional pens. In the experiment, all tasks and orders of the used stylus pens were randomly designed. Moreover, because of the limitation of the used mobile stylus size, we did not present the two tasks of writing a paragraph with mobile stylus.

Table 1. The specifications of traditional and stylus pens. Center of mass is the distance from front side.

Specifications	Traditional pen	Touchsmart stylus	Mobile stylus
Company	Hi-tech	HP	Samsung
Full length (mm)	140	125	50
Diameter (mm)	10	10	7
Screen size (mm × mm)	260 × 164	260 × 164	73 × 44
Center of mass (mm)	74	65	25
Weight (g)	22.5	15.2	10.5
Shape	Circle type	Circle type	Circle type
Interface environment	-	-	Handheld device
Signal detection	-	Electrostatic detection	Pressure-sensitive detection

Figure 1. Mobile stylus used in the experiment.

3.2. Results

3.2.1. Consumed Time

The mean and standard deviation (SD) of the task completion time needed to write a sentence according to three types of writing tools were: traditional pen, 13.09 s (2.03); touchsmart stylus, 16.65 s (3.17); and mobile stylus, 17.97 s (3.98). A repeated-measures ANOVA was carried out with the two within-subject variables. The main effects of the writing tool and gender were significant ($F(1,19) = 35.89$, $p < 0.01$; $F(1,19) = 4.73$, $p < 0.05$). The interaction between writing tools and gender was significant ($F(1,19) = 5.63$, $p < 0.05$) (Figure 2).

In the task of drawing a table, the mean and standard deviation, according to the three types of writing tools, were: traditional pen, 104.99 s (8.91); touchsmart stylus, 117.47 s (8.97); and mobile stylus, 138.03 s (8.38). A repeated-measures ANOVA was carried out with the two within-subject variables. The main effects of the writing tools and gender were significant ($F(1,19) = 166.04, p < 0.01$; $F(1,19) = 8.47, p < 0.01$). However, no interaction was significant ($p > 0.05$) (Figure 3).

In the task of writing a paragraph, the mean and standard deviation, according to the two types of writing tools, were: traditional pen, 368.30 s (12.36); touchsmart stylus, 416.61 s (22.27). A repeated-measures ANOVA was carried out with the two within-subject variables. The main effects of the writing tool and gender were significant ($F(1,19) = 225.01, p < 0.01$; $F(1,19) = 6.04, p < 0.05$). However, the interaction between the writing tool and gender was not significant ($p > 0.05$) (Figure 4).

These results revealed that the participants wrote more efficiently when using a traditional pen. Males wrote more rapidly than females when the participants used the touchsmart stylus and mobile stylus. Especially in large documents (above 200 characters), males achieved better results than females using the touchsmart stylus and mobile stylus compared with a traditional pen. Moreover, mobility did not prove to be an advantage in using the stylus pen. On the contrary, mobility of the stylus pen had a negative influence on the documentation.

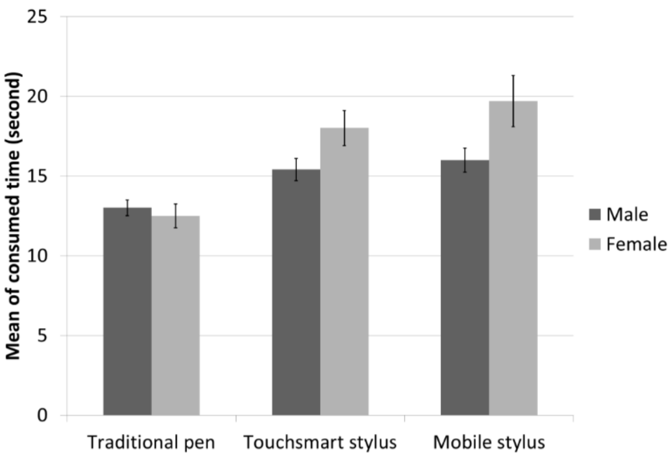

Figure 2. Mean of consumed time in first task (writing a sentence).

3.2.2. Subjective Assessments

We performed RM-ANOVA on each measure (readability, level of comfort, ease of manipulation, and attractiveness) using the seven-point subjective rating as the dependent variable. The writing tool was used as the independent variable.

- Readability: The main effect of the writing tool was significant ($F(1,19)=610.08, p < 0.01$). However, the main effects of the gender and interaction were not significant ($p > 0.05$).
- Level of comfort: The main effect of the writing tool was significant ($F(1,19) = 329.99, p < 0.01$). However, the main effects of the gender and interaction were not significant ($p > 0.05$).
- Ease of manipulation: The main effect of the writing tool was significant ($F(1,19) = 86.02, p < 0.01$). However, the main effects of the gender and interaction were not significant ($p > 0.05$).
- Attractiveness: The main effect of the writing tool was significant ($F(1,19) = 519.97, p < 0.01$). However, the main effects of the gender and interaction were not significant ($p > 0.05$).

These results showed that participants preferred the traditional pen in all subjective areas. Figure 5 shows the results of the seven-point scale questionnaires in each category.

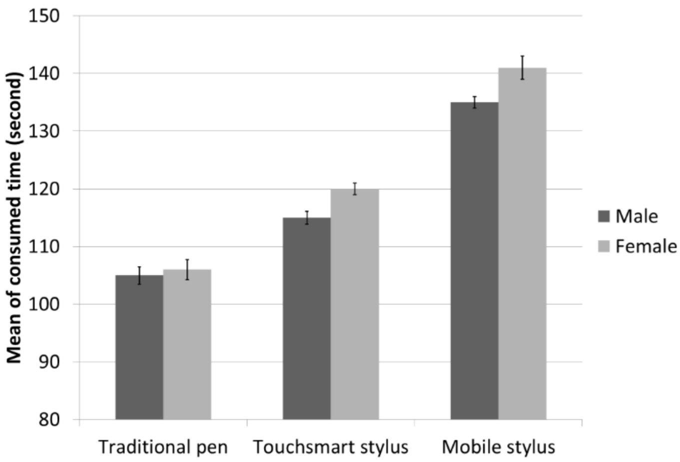

Figure 3. Mean of consumed time in second task (drawing a table).

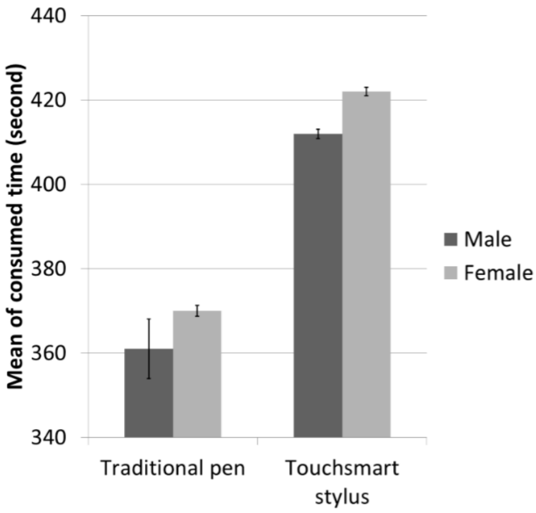

Figure 4. Mean of consumed time in third task (writing a paragraph).

4. Discussion

This experiment was conducted to measure the usability of a stylus when writing documentation (including touch-sensitive screens). Moreover, the results from the interviews showed that 90% of users actually preferred a traditional pen compared with the two stylus pens. Twenty percent of users ranked the touchsmart stylus higher than the traditional pen for readability.

In interviews, participants revealed that the feedback of the touch-sensitive screen was unrealistic compared with the feedback of traditional pen and paper. In the case of writing with a traditional pen, participants did not need to confirm their output every time. In contrast, because of the touch-sensitive screen's adaptation, participants wanted to confirm their output repeatedly. Additionally, males adapted more easily than females to using stylus pens. Males were faster than females in performing the assigned tasks.

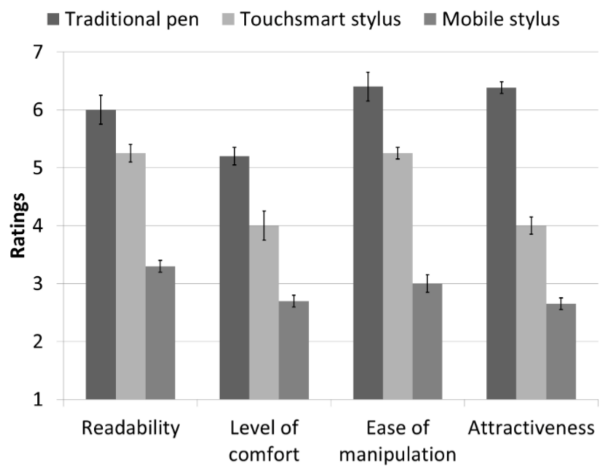

Figure 5. Average ratings (high values are good).

5. Conclusions

Along with the rapid growth of touch-sensitive screens and stylus technologies, improving usability of the stylus at a level equal to a traditional pen with paper is necessary [32]. Participants complained of discomfort in their hands. In addition, some participants complained that they could not see the document entirely. Therefore, they found it inconvenient to write a document. If we use a stylus pen in the mobile environment, we will suggest solutions such as multimodal feedback to improve the usability of the stylus as suggested in several previous studies [33–35]. In addition, some study participants answered that stylus pens made them tired due to absence of support under their writing hand. With mobile technologies, this will be an important consideration when participants use stylus pens. In this experiment, our touch-sensitive screens were the pressure-detected type.

Finally, we will extend our study by introducing suitable feedback solutions such as tactile or sound schemes for using stylus pens in various environments [36,37]. Also, further research is recommended to help participants so that they will not get tired using stylus pens. Moreover, although the concept of usability is mainly evaluated by the three components of effectiveness, efficiency, and satisfaction, this study did not consider the concept of effectiveness. Therefore, future studies should be conducted in measuring all components.

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Author Contributions

Eunil Park and Sang Jib Kwon contributed to the analyses and experiment and the majority of the manuscript writing. Angel P. del Pobil contributed to data interpretation and collection.

Conflicts of Interest

The authors declare no conflict of interest.

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