

Comparison of Handwriting Performance of Paper / Tablet / e-Paper in Various Conditions including Standing Position

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ABSTRACT

Evaluations were performed in writing speed and subjective impression of handwriting task on paper, tablet, and e-paper. The tasks were performed at the three conditions: (1) writing on a desk, (2) writing without desk, (3) writing in a standing position. Our results indicated advantages of e-paper especially in the standing position.

1.INTRODUCTION

Not only liquid crystal type tablet terminals but also electrophoretic type e-paper terminals are expected to be popular in various scenes. These terminals are also expected to be applied to textbooks and notebooks that can be hand-written like paper. In this research, we performed handwriting tests on electronic media. We tried to clarify the superiority/inferiority of the electronic media in terms of working efficiency and comfort compared with paper. Subjects were ordered to perform their tasks on three media: paper, liquid crystal tablet, and electrophoretic e-paper. Their tasks were (1) writing work on a desk (sitting position), (2) writing work without a desk (sitting position), and (3) writing work in standing position. We examined writing speed and subjective evaluations of these tasks in each medium.

2.EXPERIMENTAL METHOD

The tasks given to the subjects were to make handwriting copy of Japanese texts sheet (Fig. 2) pasted on a whiteboard. Subjects (12 university students) performed handwriting on the three media: paper [A3 size notebook: 86 g], LCD tablet [Apple iPad Pro: 677 g], and e-paper [Sony DPT-RP1: 349 g]. The three media are shown in Fig.1. The conditions for handwriting tasks were (1) writing task on a desk, (2) writing task without desk but sitting position, (3) writing task in a standing position. We prepared 9 different texts for totally 9 handwriting tasks (for 3 media x 3 condition), so that each subject could be given different text every time.

Typical working scenes are shown in Fig.2. Figure 3 shows dimensions in each working condition. The distance from a subject to the whiteboard was 1m in sitting conditions (1) and (2) (Fig. 3). On the other hand, the distance from a subject to the whiteboard was not fixed in the standing condition (3), because subjects were not ordered standing position in the room. (Fig.3). All the subjects performed handwriting task in the order of condition (1) → (2) → (3). We gave training tasks to all the subjects, before starting their tasks, for the purpose of practicing handwriting on each medium. The order of

usage of the three media was changed depending on the subjects for compensation of supposed effect of getting accustomed to the simple tasks. We asked the subjects to answer subjective evaluation questions just after each writing task every time. Table 1 shows details of experimental conditions.

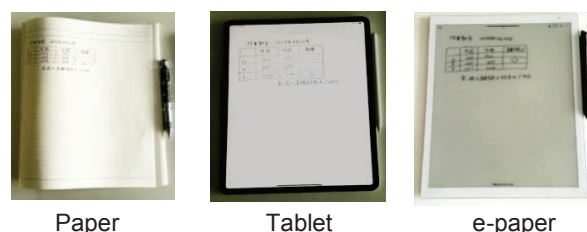
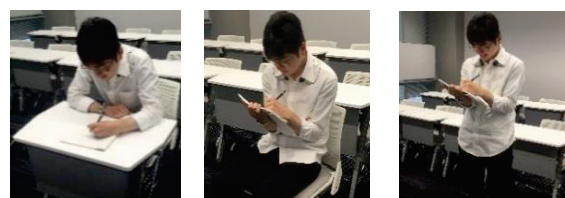


Fig.1 The three media for handwriting tasks

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	午前	午後	戸締り
A	101	102	○
B	202	203	
C	305	306	

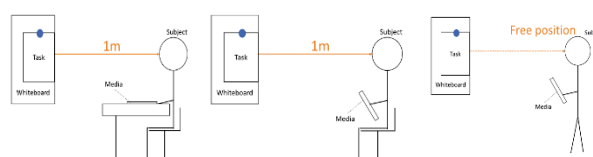
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Fig.2 Typical texts for handwriting tasks



(1) On a desktop (2) Without a desk (3) Standing position

Fig.3 Positions for handwriting tasks



(1) On a desktop (2) Without a desk (3) Standing position

Fig.4 Dimensions in each handwriting task

Table 1 Experimental conditions

Conditions	Details
Medium	<ul style="list-style-type: none"> • Paper (A3 size Notebook) • LCD Tablet (Apple iPad pro, 12.9[in]) • e-Paper (SONY DPT-RP1, 13.3[in])
Illuminance	1400 [lx] on desktop
Subjects	university students (12 subjects)

Table 2 Evaluation results

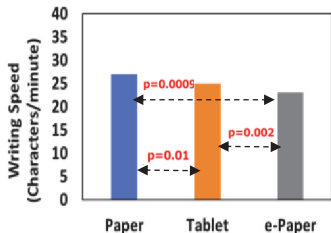
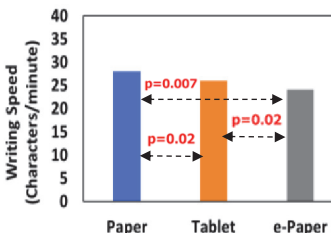
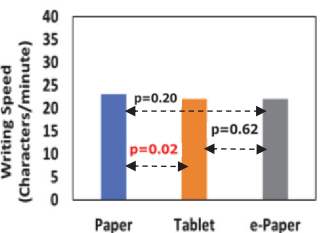
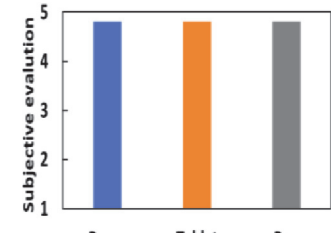
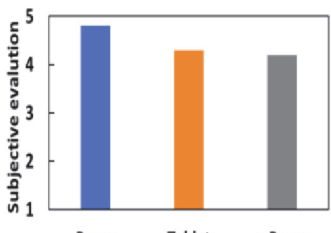
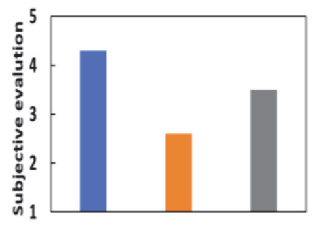
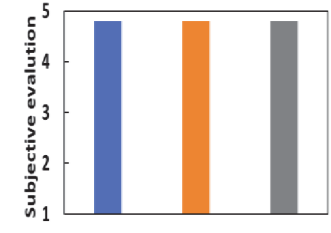
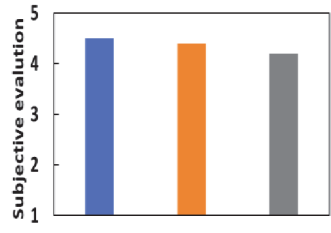
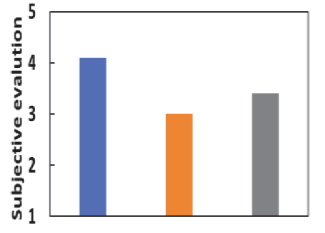
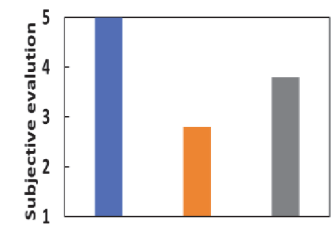
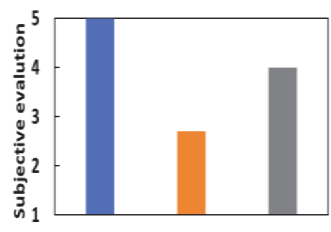
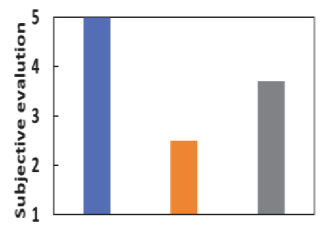
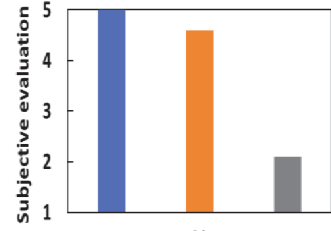
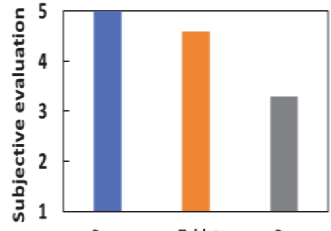
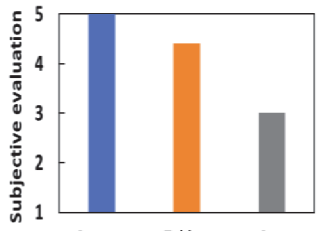
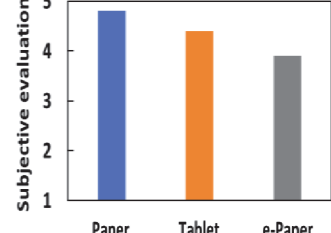
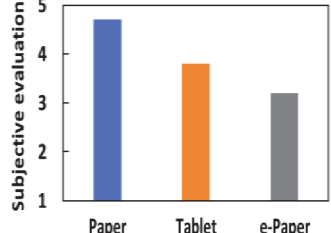
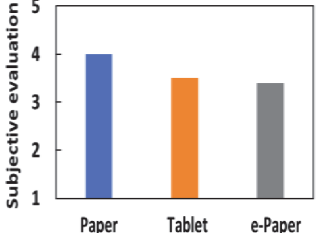
	(1) on a desk	(2) without desk	(3) in standing position
Writing speed	 <p>Writing Speed (Characters/minute)</p> <p>Paper Tablet e-Paper</p> <p>$p=0.0005$ $p=0.01$ $p=0.002$</p>	 <p>Writing Speed (Characters/minute)</p> <p>Paper Tablet e-Paper</p> <p>$p=0.007$ $p=0.02$ $p=0.02$</p>	 <p>Writing Speed (Characters/minute)</p> <p>Paper Tablet e-Paper</p> <p>$p=0.20$ $p=0.02$ $p=0.62$</p>
Impression of media lightness	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>
Easiness of holding media	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>
Less eye fatigue	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>
Impression of response of pens for handwriting	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>
Strength of stress feeling	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>	 <p>Subjective evaluation</p> <p>Paper Tablet e-Paper</p>

Table 3 Time consumption [sec]
: (1) handwriting on a desk

	Paper	Tablet	e-paper
Max	135	143	155
Average	112	120	129
Min	83	91	100

Table 4 Time consumption [sec]
: (2)handwriting without a desk

	Paper	Tablet	e-paper
Max	130	141	150
Average	108	117	125
Min	82	95	97

Table 5 Time consumption [sec]
: (3)handwriting in standing position

	Paper	Tablet	e-paper
Max	163	169	168
Average	133	136	136
Min	100	102	102

3.RESULTS

Table 2 shows the mean values of the writing speed (number of characters written per minute). The measured writing speeds were in the order of [paper > tablet> e-paper] in all the three working conditions. In the handwriting task(3) in standing position, the difference of writing speeds between the media was very small. Significant differences between the average writing speeds of each medium are shown in Table 2.

There were statistically significant difference of averaged writing speeds between paper and tablet in all the tasks (significance $p < 0.05$). In task(3) in the standing position, there was no significant difference between paper and e-paper, and between electronic paper and tablet. Tables 3 to 5 show time consumption of each task, as a reference.

The results of subjective evaluation are also shown in Table 2. The orders of impression of medium lightness and also easiness of holding medium were [paper > e-paper> tablet] with remarkable difference in the standing hand writing task(3). The evaluated order of less eye fatigue was [paper> e-paper> tablet] in all the three working conditions. It is noteworthy that the light emitting tablet terminal was most fatiguing.

4. SUMMARY

1) The writing speeds were [paper> tablet> e-paper] in all the working conditions, but the difference in the standing condition was quite small.

2) In the standing hand-writing condition, the tablet was evaluated to be the heaviest and most difficult medium to hold.

3) Tablet showed remarkably strongest eye fatigue under all the conditions.

4) Our results indicated advantages of e-paper especially in standing position.

REFERENCES

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