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THE EVALUATION OF THE TEXT DESIGN FOR THE DIGITAL SIGNAGE USING ELECTRONIC PAPER

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ABSTRACT

We examined the readability of Japanese text presented on a large electronic-paper display (font size: 48mm × 48mm), which is expected to be used as digital signage in public space. First, the appropriate line and character spacing was examined using the method of paired comparison. We changed the spacing between the lines or characters (100%, 75%, 50%, 25%, and 0% of the character size) and asked the participants to evaluate the readability of the text on the electronic paper. The results showed that the horizontally-written text on the electronic paper was the most readable when the line spacing was 50% or 75% of the character size and the character spacing was 25%. The vertically-written text was most readable with 50% or 75% line spacing and 0% or 25% character spacing. Secondly, we conducted an experiment in order to estimate the appropriate display duration. The participants were asked to read 240 characters, which were written horizontally or vertically on the electronic paper, at a comfortable speed. The results revealed that the participants read approximately 8 or 9 characters per second, in both the horizontally and vertically written text. Finally, we compared the readability of the text between the display media (paper, LCD, and electronic paper), and our preliminary results suggested no significant difference between them. We proposed a text design for digital signage using electronic paper on the basis of our empirical data.

Keywords: *Electronic paper, readability, text design, visual search*

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1. PURPOSE

Electronic paper is useful in advertisements and emergency signs, since it is rewritable and energy-saving. Recently, electronic paper replaced the cathode ray tube (CRT) and liquid crystal display (LCD) in some public spaces. Although the readability (easiness to read text) of the text on the electronic paper has been examined in previous studies (e.g., Okano et al., 2005), the studies were conducted using small displays such as e-books. In the present study, we examined the readability of Japanese text on a large electronic paper display (960 mm × 1536 mm), which is expected to be used as digital signage in the public space; we specifically examined the line and character spacing, which maximizes the readability of the text. After determining the best spacing, we measured the viewers' reading rate of sentences in order to examine the duration for which the advertisement should be displayed. The readability of the text largely depends on spacing, because texts can be hardly read when the characters are too crowded (Pelli et al., 2007). On the other hand, texts with high readability will provide us easiness, comfort, and satisfaction which are important elements of Kansei.

2. EXPERIMENTS (METHODS AND RESULTS)

The present study consisted of 5 experiments. In Experiment 1-3, we examined the appropriate line and character spacing in horizontally- and vertically-written text. In Experiment 4, we estimated the appropriate display duration of the text with the appropriate line and character spacing that was obtained in Experiment 1. Finally, in Experiment 5, we compared the readability of the text between 3 display media—electronic-paper, liquid crystal display (LCD), print paper—using a visual search task.

2.1. Experiment 1: The evaluation of line spacing in horizontal text

2.1.1. Participants

Twenty two participants—14 females and 8 males—aged between 18 and 50 years, participated in the experiment. Each participant had normal or corrected-to-normal vision.

2.1.2. Experimental settings

The experiments were conducted using a large electronic-paper display (E ink Corporation). The display size was 960mm × 1536mm (diagonally, 72 inches), and the distance between the display and the participant was set at 4m (Figure 1). The graphics adapter was used at a resolution of 240 × 384 pixels with the display pixel size at 4mm × 4mm. The smallest font (LIM Uni-Type, font size: 48mm × 48mm) was used for the electronic paper display, and the experiments were conducted in the laboratory with an illumination of 163.9~456.9lx.

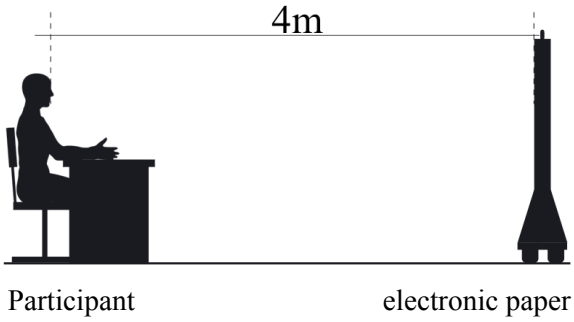

Figure 1: Experimental Settings

2.1.3. Tasks and Procedures

The readability of the texts with different line spacings was evaluated using the method of paired comparisons. First, a participant was made to sit on the chair, which was placed 4m away from the display. On the display, two sets of sentences with different line spacings were presented, one above the other (Figure 2). The participants were then asked to report the sentence he/she was able to read more easily, using a 5-point scale. We varied the line spacing at 5 levels (100%, 75%, 50%, 25%, and 0% of the character size; character spacing of 25% character size on the basis of the results of YOROISAWA, 1982). We displayed all the combinations of the 5 sentences (i.e., 20 combinations).

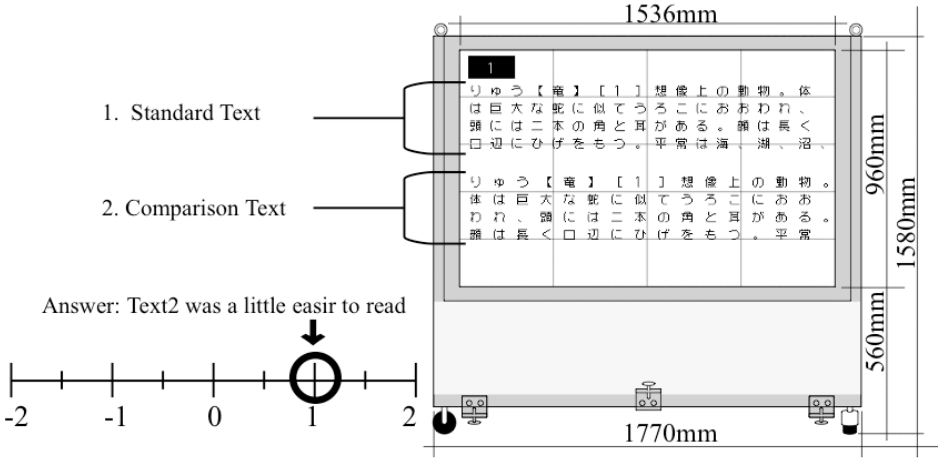

Figure 2: Evaluation method and electronic paper used in experiment

2.1.4. Results

We applied the participants' answers to a yardstick (Figure 3). The statistical analysis showed that the text was most readable when the line spacing was 50% of the character size, and 75% was the second best line spacing. There was no statistical difference between 50% and 75%, and the 50% and 75% line spacings were significantly better than the others. In addition, it was also clear that the participants found it extremely difficult to read the sentences with 0% spacing.

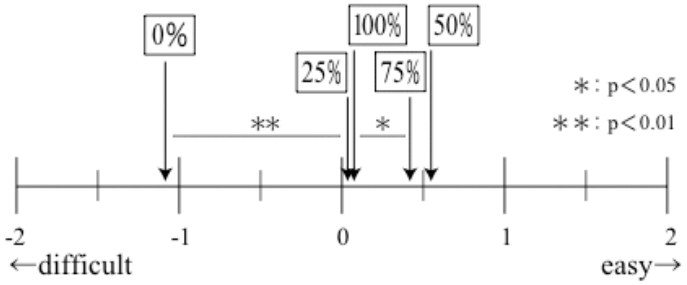

Figure 3: Result from Experiment 1 (line spacing)

2.2. Experiment 2: The evaluation of character spacing of horizontal sentences

2.2.1. Participants

As there were no significant differences in the readability between the 50% and 75% line spacings, we used both line spacings to determine the most readable character spacing. Twenty-two participants—11 females and 11 males—evaluated texts with 50% line spacing, while 19 participants—8 females and 11 males—evaluated texts with 75% line spacing. Each participant had normal or corrected-to-normal vision.

2.2.2. Experimental settings

The experimental settings were the same as those in Experiment 1.

2.2.3. Tasks and procedures

The tasks were the same as those in Experiment 1. We varied the character spacing at 5 levels (100%, 75%, 50%, 25%, and 0%)

2.2.4. Results

As shown in Figures 4 and 5, we applied the answers to a yardstick. In the case of both the 50% and 75% line spacings, the text was most readable when the character spacing was 25%. The 25% character spacing was significantly better than the other character spacings, regardless of the line spacing.

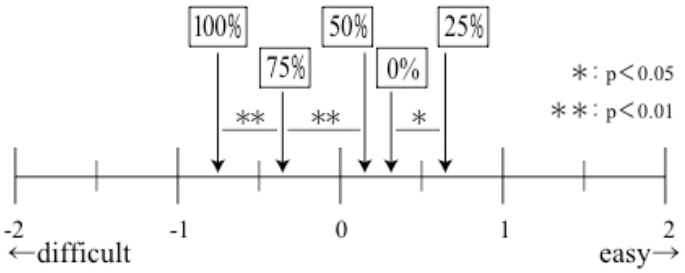

Figure 4: Result from Experiment 2-1 (character spacing, line spacing 50%)

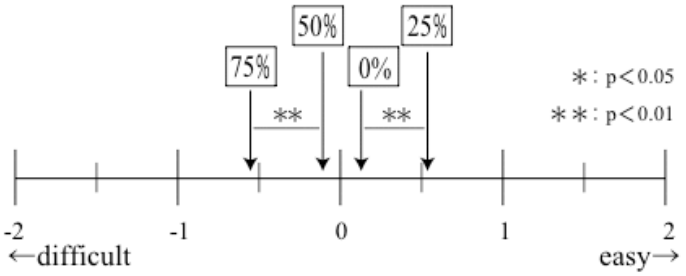

Figure 5: Result from Experiment 2-2 (character spacing, line spacing 75%)

2.3. Experiment 3: The evaluation of text design of columnar writing

2.3.1. Participants

Twenty-two individuals—14 females and 8 males—participated in the evaluation of line spacing (Experiment 3-1), while 20 individuals—11 females and 9 males—participated in the evaluation of character spacing (Experiment 3-2). Each participant had normal or corrected-to-normal vision.

2.3.2. Experimental settings

The experimental settings were the same as in Experiment 1 and 2.

2.3.3. Tasks and Procedures

We also examined the line and character spacings, which could maximize the readability of the sentences of columnar writing, and the tasks were the same as those in Experiment 1-2, expect for the use of columnar spacing.

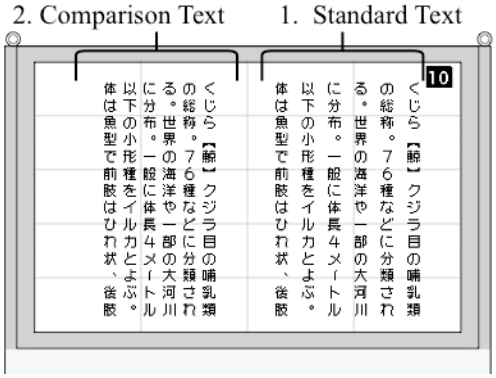

Figure 6: Columnar-writing text

2.3.4. Results

We applied the participants' answers to a yardstick. In the evaluation of line spacing, the statistical analysis revealed that the text was most readable when the line spacing was 50% of the character size, and 75% was the second-best line spacing (see Fig 7). There was no statistical difference between 50% and 75%, and the 50% and 75% line spacings were significantly better than the others.

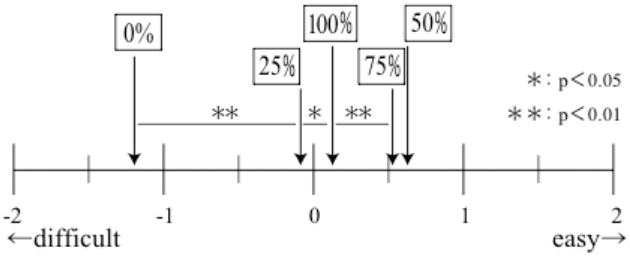

Figure 7: Result from Experiment 3-1 (line spacing)

In the evaluation of character spacing, as shown in Fig. 8, in the case of the 50% line spacing, the text was most readable when the character spacing was 25%, and 0% was the second-best character spacing. In the case of the 75% line spacing, the text was most readable when the character spacing was 0%, and 25% was the second best character spacing. In both the 50% and 75% line spacings, no statistical difference between 25% and 0% was observed, and the 25% and 0% line spacings were significantly better than the others. The values were the same as those in the case of the horizontal sentences. However, it becomes clear that the text with 0% spacing was also readable, and the legibility was statistically the same as that of the text with 25% spacing in the case of the columnar sentences.

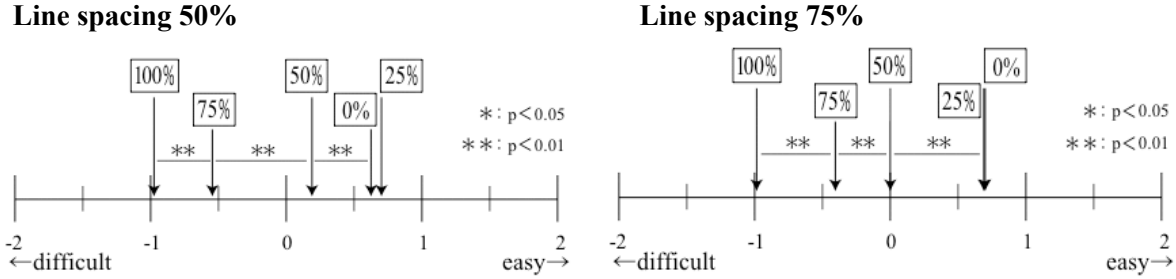

Figure 8: Result from Experiment 3-2 (character spacing, line spacing 50% (left), 75% (right))

2.4. Experiment 4: The evaluation of the reading rate of the sentences

We evaluated the reading rate of the texts with appropriate line and character spacing in order to determine the appropriate duration for the presentation of the advertisements.

2.4.1. Participants

Thirty-three participants—12 females and 21 males—were included in this study, from among who 19 participants (8 females and 11 males) were presented with horizontal text and fourteen participants (4 females and 10 males) were presented with columnar writing. Each participant had normal or corrected-to-normal vision.

2.4.2. Experimental settings

The experimental settings were the same as in Experiment 1

2.4.3. Tasks and Procedures

Based on the results of Experiment 1-2, we displayed the text of 240 characters with the most readable line and character spacing, i.e., 50% line spacing and 25% character spacing (Experiment 3-1 (Horizontal writing)). According to the results of Experiment 3-2 (Columnar writing), we displayed the text of sentences. The number of characters and the character and line spacings are as follows:

204 characters (75% line spacing and 25% character spacing),

256 characters (75% line spacing and 0% character spacing),

240 characters (50% line spacing and 25% character spacing),

and 300 characters (50% line spacing and 0% character spacing).

The participants were also asked to read the sentences silently at her/his comfortable speed, and the time required to read all the characters was recorded.

The participants asked to read sentences silently at her/his comfortable speed, and the time required to read all characters was recorded.

2.4.4. Results

As shown in Fig. 7, there is no significant difference in the reading time between the text formats. In the case of the horizontal text, the average reading rate was 8.4 characters/second, while in the case of the columnar text, the average reading rate was 9.0~9.7 characters/second.

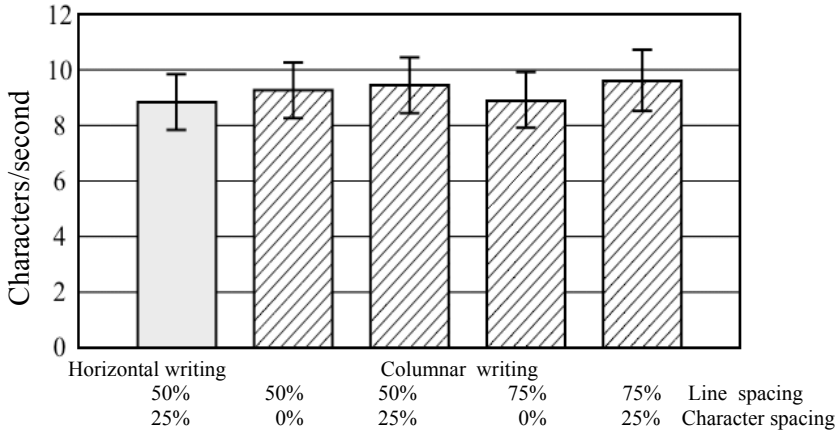

Figure 9: Experiment 3: The average number of characters read per second

2.5. Experiment 5: Comparison of display media

We also compared the performance of the visual search between three display media—electronic-paper, liquid crystal display (LCD), and paper print.

2.5.1. Participants

There were 68 participants—31 females and 37 males—in this experiment. From among these, 21 participants (12 females and 9males) were part of the electronic-paper condition, 20 participants (10 females and 10 males) were part of the LCD condition, and 27 participants (9 females and 18 males) were part of the paper print condition. Each participant had normal or corrected-to-normal vision.

2.5.2. Experimental settings

The same size of display media was used in the experiment.

A) Electronic-paper: the same display that was used in Experiment 1 was used here. The display size was 384 mm×768 mm. The graphics adapter was used at a resolution of 96×768 pixels.

B) LCD: MulitiSyncLCD4215 NEC, Japan. The display size was 523.0mm×930.3mm (diagonally, 42 inches). The graphics adapter was used at a resolution of 1366×768 pixels.

C) Paper print: Premium Glossy Photo Paper (170) EPSON, Japan. The paper size was 384×610mm. Tasks and procedures

2.5.3. Tasks and Procedures

First, the participants were asked to view a target character for 15 sec on the display. After that, the target disappeared, and the second display appeared immediately. In half the trials, the target was present, whereas it was absent in the other half. The number of characters on the display (target + distracters or distracters only) was 4, 8, 12, 20, or 28. The participants tried to detect the target as quickly and as accurately as possible. They reported the presence/absence of the target along with its location. The accuracy and the time required to find the target was recorded.

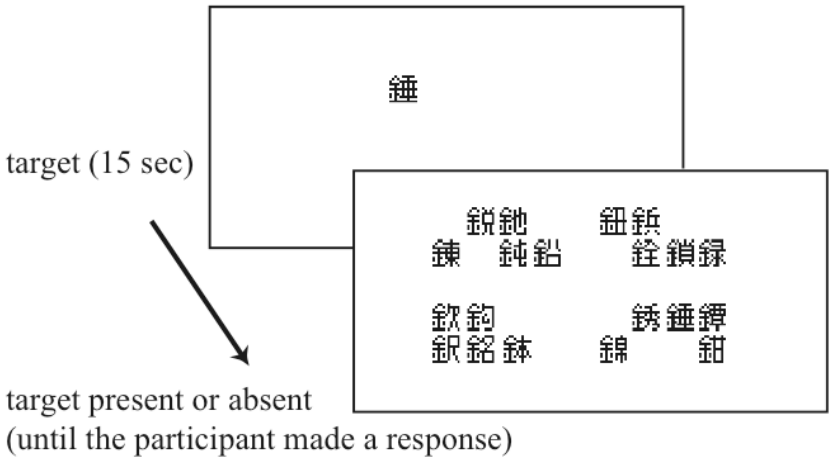

Figure 10: An example of one trial

2.5.4. Results

For the data analysis, we used search times in the target-absent trials since they can be considered as the time taken to read all the characters in the display. In order to compare the readability, the time taken to read all the characters in the display should be the most appropriate index. The analysis of variance (ANOVA) indicated that there are no significant differences in the search times between the three display media.

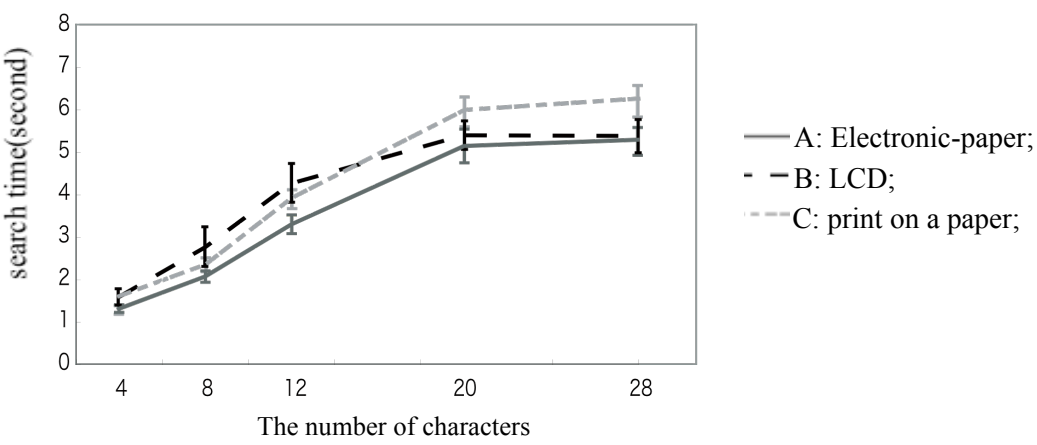

Figure 11: Results from Experiment 6: The average search time in the absence of a target character

3. DISCUSSION

Our results revealed that the text displayed on the electronic paper is the most readable when the line spacing was 50% or 75% of the character size and the character spacing was less than 25% of the character size, regardless of horizontal vs. columnar text. The most readable spacing in our study was almost the same as that reported by Yoroisawa in 1982, where he used the CRT display for the test. Further, with regard to the duration, our results revealed that the reading rate of the text on the electronic display was approximately 8–9 characters per second. Osaka (1998) had reported that the reading rate of Japanese characters on the paper was 7.7–11.5 characters per second, and our results were consistent with those of Osaka (1998). In the visual search task, our preliminary results showed that the participants could detect words on the Electronic paper display equally as fast as they could on the LCD and paper. In conclusion, the above results showed that texts on the electronic paper can be adjusted just like in other display media, and can be as readable as the texts presented on LCD and paper. Because the best line and character spacing may vary with other factors such as character size (Yoroisawa, 1982), character type (e.g., Latin characters), and illuminance, further studies should be conducted. Appropriate spacing and display speed we proposed here is now used in the electronic paper signage in subway stations in Sendai, Japan, and our follow-up survey showed that subway users are satisfied with the text design in the electronic paper signage [5].

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