Effect of the Color Tablet Computer's Polarity and Character Size on Legibility

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Abstract. This study aimed to explore how different polarities and character sizes on tablet e-readers affect users' legibility and visual fatigue. Following the experimental method, 30 participants were required to search for the target words in pseudo-texts; meanwhile, the experimental data were connected to an exclusive database through the Internet. Thus, the participants' search times, accuracy rates, and visual fatigue levels could be analyzed. As indicated by the analytic result, all the four kinds of character size affected search time. Specifically, the 8-pt target words on a 10.1-inch screen had the slowest search speed. As character size increased to 12 pt, search speed became significantly faster. Besides, the interaction between polarity and character size had a significant effect on the accuracy rate of searched target words. This study showed that as a character size increased, polarity produced a higher accuracy rate, and that negative polarity had a more significant effect than positive polarity. Under positive polarity, 8 pt had the lowest accuracy rate, and 10 pt had the next lowest accuracy rate. However, after the character size was increased to 12 pt or above, the accuracy rate was not promoted. Moreover, a larger character size produced a higher accuracy rate. Therefore, 12 pt and 14 pt got the best performance. As for visual fatigue, a small character size was the main factor. The findings of this study can be used in the design of tablet e-readers.

Keywords: tablet computer, legibility, visual fatigue, character size.

1 Introduction

Mobile devices have been around in our daily lives. While on the move, users depend on portable mobile devices to access real-time information and read texts conveniently. By using mobile devices, users can not only surf the Internet but also read real-time messages, e-mail, and data files. Different text contents and character sizes presented on the screens may affect a user's working efficiency and satisfaction level

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[1]. Poorly-designed display layouts easily cause fatigue to the user and reduce his/her efficiency in reading texts and browsing pages [2]. On the contrary, well-designed reading devices contribute to the legibility of texts.

The polarity and character size of any tablet computer have a great influence on a user's search efficiency. With the color LCD employed as the display medium, this study investigated how different polarities and character sizes affected the search efficiency and visual fatigue of those users who read Chinese texts. As the experimental tool, the tablet computer was connected to an online database. Afterwards, the relevant trials were conducted and analyzed; also, the levels of subjective visual fatigue were measured. This study was intended to probe into the current status and limitations of the tablet computer used for reading Chinese texts. In addition, further analyses and discussions herein are expected to be referred to when tablet computers are designed and developed in the future.

There are two types of polar display on the screen: positive polarity and negative polarity. Positive polarity refers to black characters on white background while negative polarity refers to white characters on black background [3]. Wang and Chen suggested that polarity had no significant effect on visual performance or subjective preference [4]. Cushman discovered that words displayed under positive polarity tended to be read faster, but comprehension shower no difference at all [5]. Saito et al. and Nishiyama also argued that positive polarity was better than negative polarity [6, 7]. Contrarily, Mills and Weldon maintained that negative polarity is more suitable for computer screens, for users feel less sensitive to the flashing of the screen with negative polarity display than with positive polarity display [8]. Chan and Lee investigated reading on a 15-inch CRT computer screen, employing different fonts and character sizes [3]. They discovered that the 14-pt Ming-style font, double line height and positive polarity showed a higher reading rate and legibility than the 10-pt Li-style font, single line height and negative polarity. Shen et al. explored two different display media i.e., electronic paper made of cholesteric liquid crystal (Ch-LC) and electrophoretic electronic ink (E-ink), discovering that positive polarity produced a higher accuracy rate than negative polarity [9]. There are a lot of factors that influence positive polarity and negative polarity, and it is still not determined which kind of polarity is superior. Unlike previous e-readers which focused on black-and-white displays, this study employed a tablet computer as the experimental tool.

Various fonts and character sizes on the display significantly affect a user's reading performance. Boyarski et al. investigated textual readability on the desktop computer [10]. The researchers discovered that character size had a significant effect on the recognition rate and that different fonts affected reading performance. As for the effect of different character sizes on reading performance, Bernard et al. studied children aged from 9 to 11, comparing 12-pt with 14-pt characters [11]. It was determined that the 14-pt sans serif font was more appealing, readable, and recognizable. I. Darroch et al. made a similar study, focusing on mobile devices with a pocket-sized screen [1]. It was learned that the character sizes from 8 pt to 12 pt were more suitable for the user.

Huang et al. studied Chinese characters, employing a PDA as the experimental tool [12]. The researchers discovered that the 1.0-mm character whose resolution was

below 250 dpi was the most illigible. By contrast, the 3.0-mm character showed the highest reading speed. Chai et al. made another study to compare the recognition rates of different Chinese typefaces [13]. According to the above study, the Ming typeface performed better than Kai typeface and that the standard typeface performed better than the Li typeface. Huang et al. also compared the performances of different character sizes on PDA screens with different resolutions; besides, the researchers recommended the character size compatible with small screens [12]. However, some other studies suggested that a larger character size did not always produce a better reading performance [3, 8] . In some cases, a smaller character size performed better than a larger one in terms of reading speed. To exolre the relationships between polarity and character size, this study experimented with the character sizes from 8 pt to 14 pt presented under different polarities, with the legibility compared in various conditions. And the findings can be refered to by those engaged in designing Chinese-reading interfaces.

2 Methods

2.1 Experimental Design

With a tablet e-reader employed as the experimental tool, this study aimed to explore the effect of polarity and character size on visual performance. Following the experimental method, the 30 participants were required to locate the target words in pseudo-texts. Thus, the effects of the two variables on the search time, accuracy rate, and subjective fatigue level were determined. Formerly, the relevant experiments primarily counted the correct words found by the participants [9, 14-16]. Unlike those previous studies, this study established an online database to increase experimental accuracy. By utilizing WiFi technology embedded in the tablet computer, the participant was connected to the Internet, logged onto the exclusive website, and then started the trial. Recorded in the website automatically, the experimental results were analyzed as objective information.

With a tablet computer serving as the experimental tool, this study was intended to evaluate how legibility and visual fatigue are affected by two independent variables, i.e., polarity and character size. The new Ming typeface was used in Chinese pseudo-texts, which were presented under two different kinds of polarity, namely, positive polarity and negative polarity. Meanwhile, there were four different character sizes used: 8 pt, 10 pt, 12 pt, and 14 pt. Consequently, the independent variables consisted of two polarities and four character sizes. In other words, there were 8 (2×4) trials in total, with 30 participants undertaking the within-subjects trials. Also, in compliance with the principle of counterbalance, the order in which each participant operated the experimental interface varied with his/her experimental sequence. Through built-in WiFi technology in the tablet computer, the participant was connected to the exclusive website for legibility and visual fatigue. After entering his/her personal information in the website, the participant started to perform the 8 trials in the predetermined sequence. As soon as each of the trials was completed, its experimental results were automatically stored in the system.

During each trial, the participant had to read the meaningless pseudo-text appearing on the tablet computer. Once a target word in the pseudo-text was found, the participant had to be touch it with his/her finger, and then it turned red in color, which meant a successful search. When the participant misjudged the target word and touched it by mistake, the false one also turned red and was recorded in the system. But it was excluded from the evaluation of the accuracy rate.

2.2 Participants

30 participants (15 males and 15 females) were involved in the trials. They were all ninth-graders aged from 18 to 23 (M = 20.30, SD = 1.39). None of them was color-blind or suffered from other eye diseases. Their natural or corrected eyesight was above 0.8. The experimental sequence of each participant was randomly arranged through permutation and combination. Additionally, each participant was rewarded with NT$200 after all the trials came to an end.

2.3 Measurements of Legibility

Reading Speed and Accuracy. In previous studies, reading speed and accuracy rate were regarded as the chief indicators of reading performance. With pseudo-texts searched, how fast the target words were found by the participant was effectively measured [9, 14-16]. Besides, the measurement of accuracy revealed whether the participant recognized the text typeface clearly. In that way, the effect of character size on reading accuracy was determined [14]. The pseudo-texts used in this study are explained below.

1. The pseudo-texts consisted of randomly-selected traditional Chinese characters, all of which were selected from the first 198 frequently-used characters in the standard Chinese typeface list [13]. Each pseudo-text appeared to be a normal Chinese passage, but it was meaningless to read. This study was meant to evaluate word recognition in various experimental situations rather than passage comprehension. Any meaningful text would have interfered with the evaluation of word recognition [17].
2. Each pseudo-text contained 2500 traditional Chinese characters. Moreover, each of the target words was arranged in such a way that it appeared at an interval of 100 to 150 characters. For instance, if 六 (six in Chinese) was chosen as a target word, it appeared randomly in the pseudo-text, but never at the beginning or end. There were 25 target words in each pseudo-text. To eliminate any anticipatory behavior, the participant was not told the total number of the target words before a trial.
3. Throughout the trials, every participant was required to locate the target words as fast as possible. Furthermore, the search time and the number of the correct words were automatically recorded in the computer system. To prevent fatigue from disturbing the experimental operations, the participant had to rest for 5 minutes after each trial.

4. The tablet computer was employed as the experimental tool. By means of its built-in WiFi capability, the participant was connected to the website, with the personal information entered in the website. Each participant is required to complete the trials in the predetermined sequence, and the results are automatically recorded in the system. The pseudo-texts read by each participant are selected randomly, and the order in which they are read by the 30 participants differs from one to another. Since all the experimental procedures are recorded and executed on the website, the errors arising from artificial interpretation are reduced. In this way, the experimental results are more objective and accurate.

Measurements of Visual Fatigue. After the legibility test is conducted by the participant, his/her visual fatigue is measured mentally. Generally, the change in the scores from the subjective questionnaire are taken as the criteria of visual fatigue [9, 14-17]. As for measuring the subjective fatigue, the participant is required to answer a subjective measurement questionnaire [18]. There are six questions in the questionnaire as set forth below: 1) I have difficulties in seeing; 2) I have a strange feeling around the eyes; 3) My eyes feel tired; 4) I feel numb; 5) I have a headache; 6) I feel dizzy looking at the screen. Each question is given a score ranging from 1 to 10. While 1 stands for "not at all", 10 stands for "very much". Based on the responses to the 6 questions, the participant's fatigue level after the legibility test is identified.

2.4 Apparatus and Workplace Condition

As is explained below, the experimental tool is composed of software and hardware. (1) Software: Microsoft ASP.NET 2.0 is used to establish the legibility and visual fatigue website. After logging in, the participant can start to conduct the trials, with the experimental results automatically recorded on the website. (2) Hardware: the tablet PC, acer ICONIA W510, is employed. Its dimensions are 167.5 (W) x 258.5 (L) x 8.8 (H) mm, its screen size is 10.1", and its resolution is 1366 × 768 px.

The screen is put on a table which is 73 cm in height, with its center being 18 cm away from the table surface. The screen center is 36 cm away from the edge of the table. The distance between the participant's eyes and the screen is 50 cm. Besides, the participant's chin is upheld by a chin support. The screen inclines at an angle of 105 degrees [9, 14-16, 19]. The above parameters remain unchanged throughout the experiment. As for the chair, it can be adjusted to match the individual requirement for comfort. The ambient luminance is 700 lux and the light source is DL65[9].

2.5 Data Collection and Analysis

The information collected during this research includes the participant's personal information, the time spent in locating the target words, accuracy, and the subjective visual fatigue questionnaire. The ways these kinds of information are processed are explained below.

1. Search time and accuracy: immediately after each trial, the participant's search time and accuracy rate will be automatically recorded in the system. The search

time refers to the total time spent by the participant in finding the 25 target words during the legibility test. Accuracy means the total number of the correct target words divided by the total number of clicks (touches).

2. Subjective visual fatigue questionnaire: the scores for the six questions on the subjective questionnaire are added up to get the measurement of subjective visual fatigue. The original data is processed with Microsoft Excel and then analyzed with the statistical software SPSS to get the variable values. The adopted significant level is $\alpha < 0.05$.

3 Result

3.1 Search Time

With the tablet computer adopted as the experimental tool, this research is aimed to compare the effects of polarity and character size on the search time, accuracy, and subjective satisfaction.

As is shown in Table 1, polarity has no significant effect on search time. By contrast, character size has a significant effect on search time ($F_{(3, 87)} = 4.508$, $p< 0.01$). The mean search time of 8 pt is 288.367s, that of 10 pt is 280.317s, that of 12 pt is 251.000s, and that of 14 pt is 282.200s. After the LSD multiple range test is used to analyze the result, it is discovered that 12 pt takes a shorter time than 10 pt, 14 pt, and 8 pt (Table 2.).

3.2 Accuracy

As shown by the ANOVA of accuracy rate in Table 3., polarity has a significant effect on accuracy rate ($F_{(1, 29)} =4.213$, $p <0.05$). The accuracy rate resulting from positive polarity is 91.8%, which is significantly higher than that of negative polarity, or 88.5%. Moreover, character size has a significant effect on accuracy rate of searched target words ($F_{(3,87)} = 10.921$, $p< 0.001$). Through the LSD multiple range test (Table 4.), it is discovered that the mean accuracy rate of positive polarity and negative polarity is 91.8% and88.5% respectively. In other words, the accuracy rate resulting from positive polarity is higher than that resulting from negative polarity. As shown in Table 3., character size exerts a significant effect on the accuracy rate of the searched target words ($F_{(3,87)} = 0.069$, $p< 0.001$), while screen size makes no significant difference. Through the LSD multiple range test (Table 4.), it is discovered that the accuracy rate of 8 pt is 85.5% , that of 10 pt is 89.9%, that of 12 pt is 92.2%, and that of 14 pt is 93.1%. That is to say, 12 pt and 14 pt show the highest accuracy, 10 pt ranks third, and 8 pt has the poorest accuracy.

As is shown in Fig. 1., the interaction between polarity and character size has a significant effect on the accuracy rate of searched target words ($F_{(3, 87)} = 4.027$, $p< 0.01$). As polarity increases in this study, all the four character sizes showed a higher accuracy rate of searched target words, especially the character size presented in negative polarity. Under negative polarity, 8 pt has the lowest accuracy. However, after the character is enlarged, a higher accuracy rate is produced.

Table 1. ANOVA result of search time

Source	*df*	SS	MS	*F*
Within subjects	29	908532.671	31328.713	
Polarity (P)	1	6773.437	6773.437	.658
P × Subject within group	29	298303.438	10286.325	
Character size (C)	3	50033.279	16677.760	4.508**
C × Subject within group	87	321877.346	3699.740	
P × C	3	1555.246	518.415	.167
Subject within group	87	270468.379	3108.832	

Significant at * ≦0.05 ; **≦0.01; ***≦0.001 level.

Table 2. Mean values of search time under each level of the independent variables and LSD's multiple range tests on significant factors

Source	n	Search time (s)	Std. Error	LSD
Polarity				
Positive (P)	30	270.158	14.637	
Negative (N)	30	280.783	11.513	
Character size				
8 pt	30	288.367	12.119	8, 10, 14＞12
10 pt	30	280.317	11.369	
12 pt	30	251.000	11.907	
14 pt	30	282.200	17.006	

Table 3. ANOVA result of accuracy

Source	*df*	SS	MS	*F*
Within subjects	29	2.258	.078	
Polarity (P)	1	.067	.067	4.213*
P × Subject within group	29	.459	.016	
Character size (C)	3	.208	.069	10.921***
C × Subject within group	87	.553	.006	
P × C	3	.062	.021	4.027**
Subject within group	87	.447	.005	

Significant at * ≦0.05 ; **≦0.01; ***≦0.001 level.

Table 4. Mean values of accuracy under each level of the independent variables and LSD's multiple range tests on significant factors

Source	n	accuracy (%)	Std. Error	LSD
Polarity				P＞N
Positive (P)	30	91.8	.021	
Negative (N)	30	88.5	.019	
Character size				
8 pt	30	85.5	.027	14, 12＞10＞8
10 pt	30	89.9	.017	
12 pt	30	92.2	.017	
14 pt	30	93.1	.017	

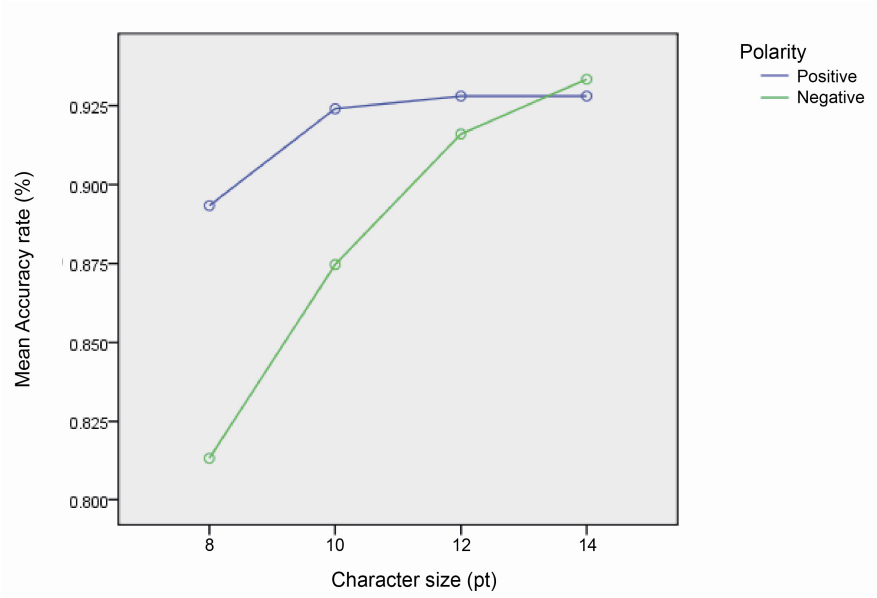

Fig. 1. Polarity × Character size interaction for accuracy rate

3.3 Subjective Visual Fatigue

As shown by ANOVA of subjective visual fatigue in Table 5., polarity has no significant effect on subjective visual fatigue. On the other hand, character size has a significant effect on subjective visual fatigue ($F_{(3,87)}$ = 56.891, p< 0.001). It is discovered that a smaller character size causes more subjective visual fatigue. Through the LSD multiple range test (Table 6.), it is discovered that the mean subjective visual fatigue score of 8 pt is 20.350 points, that of 10 pt is 18.475 points, that of 12 pt is 13.203 points, and that of 14 pt is 11.031 points. The above results indicate that, in terms of subjective visual fatigue, 8 pt gets the highest level, 10 pt ranks second, 12 pt ranks third, and 14 pt gets the lowest level.

Table 5. ANOVA result of subjective visual fatigue

Source	*df*	SS	MS	*F*
Within subjects	29	1170.334	40.356	
Polarity (P)	1	3.792	3.792	.269
P × Subject within group	29	408.385	14.082	
Character size (C)	3	3440.776	1146.925	56.891***
C × Subject within group	87	1753.936	20.160	
P × C	3	50.247	16.749	1.284
Subject within group	87	1134.646	13.042	

Table 6. Mean values of subjective visual fatigue under each level of the independent variables and LSD's multiple range tests on significant factors

Source	n	subjective visual fatigue	Std. Error	LSD
Polarity				
Positive (P)	30	15.639	.528	
Negative (N)	30	15.890	.419	
Character size				
8 pt	30	20.350	.715	8＞10＞12＞14
10 pt	30	18.475	.692	
12 pt	30	13.203	.505	
14 pt	30	11.031	.660	

4 Discussion

4.1 Search Time

The time spent in searching the target words and the accuracy rate are the critical indexes to legibility [9, 14-16]. It is discovered by this research that character size all have a significant on search time.

Character size also has an effect on the user's searching speed. The smallest character size, namely, 8 pt, takes the longest search time. When the character size is increased from 8 pt and 10 pt to 12 pt, its searching speed is improved. However, when the character size reaches 14 pt, it takes a longer time than 12 pt but a shorter time than 10 pt. The result agrees with the conclusion reached by other researchers, who compared the Chinese legibility on the 15" screen [3]. Besides, the conclusion of this research that the smaller character size causes slower reading speed agrees with the findings of other researchers [11, 20]. Generally speaking, the larger character size accelerates reading speed. Moreover, when it reaches the critical point, the maximum reading speed is achieved. Nevertheless, if the critical value is exceeded, reading speed will decline [16, 21]. However, there is some limit on searching speed, which does not increase endlessly as the screen size and the number of words in a line increase. A study was made to compare the reading performance shown by 25 cpl

(characters per line), 55 cpl, and 100 cpl [22]. It was discovered that 55 cpl performed best, 100 cpl ranked second, and 25 cpl performed worst.The Ch-LC display, E-ink display and conventional paper were used by other researchers to compare the effect of different character sizes on the search time spent in reading English texts [14]. It was discovered that the 3.3-mm font got the highest reading speed. But if the font exceeded 3.3 mm, the reading speed could not be enhanced any more. On the other hand, too small a font also caused reading difficulty, especially the 1.4-mm font.

4.2 Accuracy

Polarity and character sizes are the major factors influencing the accuracy rate of searched articles. This study shows that, in terms of searching with e-readers, the accuracy rate of positive polarity is clearly higher than that of negative polarity. Although the LCD colour display employed in this study is different from a CRT display or VDT electronic paper, positive polarity is significantly superior to negative polarity in terms of accuracy rate. The findings of this study are similar to those obtained by Bauer & Cavonius [23] and Shen et al. [9]. Bauer & Cavonius investigated the effects of polarity on reading performance, discovering that the accuracy rate of positive polarity was clearly higher than that of negative polarity. Shen et al. analyzed how different dispalys affected visual perfromance and fatigue by comaring liquid crystal displays (Ch-LC), electrophoretic electronic ink display (E-Ink), and paper. The above researchers discovered that the accuracy rate of negative polarity was significantly lower than that of positive polarity.

Besides, as a character size becomes bigger, the accuracy rate of Chinese text-reading is higher. However, it is discovered by this study that the character size above 12 pt does not enhance accuracy anymore. The above conclusion is similar to the findings of Lee et al. (2008) [14], who discovered that too small a character size led to reading difficulty and the declining accuracy of text recognition. On the contrary, as the character size became larger, accuracy was improved. Yet, when the character size exceeded a particular value, the accuracy rate of reading did not improve anymore.

The interaction between polarity and character size has a significant effect on the accuracy rate of searched target words. As shown by this study, as a character size increases, polarity produces a higher accuracy rate, and negative polarity has a more significant effect than positive polarity. Under positive polarity, 8 pt has the lowest accuracy, and 10 pt has the next lowest accuracy. However, after the character size is increased to 12 pt or above, the accuracy rate is not promoted. As a character size increases, negative polarity produces a significantly higher accuracy rate. Under negative polarity, 8 pt has the lowest accuracy. After the character size is increased from10 or12 pt to 14 pt, negative polarity shows a significantly higher accuracy rate of searched target words. As for 8 pt and 10 pt, positive polarity has a significantly higher accuracy rate than negative polarity. However, when the character size is increased to 12 or 14 pt, positive polarity and negative polarity show no significant difference in accuracy rate.

4.3 Subjective Visual Fatigue

As for the measurements of subjective visual fatigue, it is discovered by this research that character size is largely responsible for visual fatigue. It is discovered that, when searching the 8-pt words, the participant is most likely to feel tired. Besides, the 10-pt words rank second in terms of visual fatigue, 12-pt ranks third, while the 14-pt words are least likely to cause visual fatigue. Another study was made to compare different sizes of English typefaces which were read on the 17" screen [24]. It was discovered that the 12-pt font combined with any typeface got the highest level of readability. Moreover, the 10-pt font caused more difficulty in reading than the 12-pt font. The main reason was that the larger character size generated better readability. Still another study was made to compare the comprehension score for the 10-pt and 14-pt Chinese characters which were read on the 15" screen [3]. It was discovered that the 14-pt font performed better than the 10-pt font in terms of reading comfort, reading ease, reading fatigue and overall performance. Furthermore, the result was statistically significant.

References

1. Darroch, I., Goodman, J., Brewster, S., Gray, P.: The effect of age and font size on reading text on handheld computers. In: Costabile, M.F., Paternó, F. (eds.) INTERACT 2005. LNCS, vol. 3585, pp. 253–266. Springer, Heidelberg (2005)
2. Streveler, D.J., Wasserman, A.I.: Quantitative measures of the spatial properties of screen designs. pp. 81–89 (1984)
3. Chan, A., Lee, P.: Effect of display factors on Chinese reading times, comprehension scores and preferences. Behaviour & Information Technology 24(2), 81–91 (2005)
4. Wang, A.H., Chen, M.T.: Effects of polarity and luminance contrast on visual performance and VDT display quality. International Journal of Industrial Ergonomics 25(4), 415–421 (2000)
5. Cushman, W.H.: Reading from microfiche, a VDT, and the printed page: subjective fatigue and performance. Human Factors: The Journal of the Human Factors and Ergonomics Society 28(1), 63–73 (1986)
6. Saito, S., Taptagaporn, S., Salvendy, G.: Visual comfort in using different VDT screens. International Journal of Human-Computer Interaction 5(4), 313–323 (1993)
7. Nishiyama, K.: Ergonomic aspects of the health and safety of VDT work in Japan: A review. Ergonomics 33(6), 659–685 (1990)
8. Mills, C.B., Weldon, L.J.: Reading text from computer screens. ACM Computing Surveys (CSUR) 19(4), 329–357 (1987)
9. Shen, I., Shieh, K.K., Chao, C.Y.: Lighting, font style, and polarity on visual performance and visual fatigue with electronic paper displays. Displays 30(2), 53–58 (2009)
10. Boyarski, D., Neuwirth, C., Forlizzi, J.: A study of fonts designed for screen display. pp. 87-94 (1998)
11. Bernard, M.L., Chaparro, B.S., Mills, M.M.: Examining children's reading performance and preference for different computer-displayed text. Behaviour & Information Technology 21(2), 87–96 (2002)

12. Huang, D.L., Patrick Rau, P.L., Liu, Y.: Effects of font size, display resolution and task type on reading Chinese fonts from mobile devices. International Journal of Industrial Ergonomics 39(1), 81–89 (2009)
13. Cai, D., Chi, C.F., You, M.: The legibility threshold of Chinese characters in three-type styles. International Journal of Industrial Ergonomics 27(1), 9–17 (2001)
14. Lee, D.S., Shieh, K.K., Jeng, S.C.: Effect of character size and lighting on legibility of electronic papers. Displays 29(1), 10–17 (2008)
15. Lin, Y.T., Lin, P.H., Hwang, S.L.: Investigation of legibility and visual fatigue for simulated flexible electronic paper under various surface treatments and ambient illumination conditions. Applied Ergonomics 40(5), 922–928 (2009)
16. Lin, H., Wu, F.G., Cheng, Y.Y.: Legibility and visual fatigue affected by text direction, screen size and character size on color LCD e-reader. Displays (2012)
17. Boschman, M.C., Roufs, J.A.: Text quality metrics for visual display units:: II. An experimental survey. Displays 18(1), 45–64 (1997)
18. Heuer, H., Hollendiek, G., Kröger, H.: Die Ruhelage der Augen und ihr Einfluß auf Beobachtungsabstand und visuelle Ermüdung bei Bildschirmarbeit. Zeitschrift für Experimentelle und Angewandte Psychologie 36(4), 538–566 (1989)
19. Turville, K.L., Psihogios, J.P., Ulmer, T.R.: The effects of video display terminal height on the operator: a comparison of the 15 and 40 recommendations. Applied Ergonomics 29(4), 239–246 (1998)
20. Tullis, T.S., Boynton, J.L., Hersh, H.: Readability of fonts in the windows environment. pp. 127-128 (1995)
21. Legge, G.E., Pelli, D.G., Rubin, G.S.: Psychophysics of reading—I. Normal vision. Vision Research 25(2), 239–252 (1985)
22. Dyson, M.C., Haselgrove, M.: The influence of reading speed and line length on the effectiveness of reading from screen. International Journal of Human-Computer Studies 54(4), 585–612 (2001)
23. Bauer, D., Cavonius, C.: Improving the legibility of visual display units through contrast reversal. Ergonomic aspects of visual display terminals, pp. 137–142. Taylor and Francis, London (1980)
24. Bernard, M.L., Chaparro, B.S., Mills, M.M.: Comparing the effects of text size and format on the readibility of computer-displayed Times New Roman and Arial text. International Journal of Human-Computer Studies 59(6), 823–835 (2003)