The study of Suitable Conditions for Human Reading

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Abstract: *Depending on adjusting the setting of letters, the suitable reading conditions had been investigated. The detail of the settings of the words are respective word size, word type, and polarity. By analyzing the result of recognition, comfort rating, searching time, and density of the reading ability testing, we found that the letters with Arial font, positive polarity, and large size were the elements for comfortable reading. The effect of density on reading ability was also fitted in with the model of Steven's work of psychophysics theory. Depending on the results, the key effects of reading ability had been discovered.*

Keywords: human factor; reading ability; paper-like display.

Introduction

In recent years, the technology of flat panel display had been well developed. And liquid crystal display (LCD) becomes the most popular one in the TV and monitor markets. Following the improvement of image quality, how to make an image which meets the affinity for human eyes would be the main issue. In the past years, it became a hot topic gradually for the relationship between human factor and image quality. A LCD with high contrast ration, reflectance, high luminous etc., would be the most favorite to customers [1-4]. After the CRT was replaced by LCD, e-paper and e-book would be the future market to catch up for LCD. The main issue is how to make LCD become a paper like display. Analyzing the optical properties in lots kinds of documents provided the basic requirements of paper like display such as contrast ratio, reflectivity and whiteness. But the image quality of e-paper or e-book is still not good enough due to the lake of parameters of human factor in the display design. Therefore, the parameters of human reading must be investigated to promote the design of the display.

In this study, a series of experiments were done to investigate the effect of several factors on the reading ability. Then, took the result into an extended result, and compared it to the theory of psychophysics. Finally, the limitation for un-comfortable of human reading was found

Experimental Design

The experiments consist of three factors, word size, word type and polarity, were investigated. The word size of the sample of the document is setup from 6pts to 14pts. The three word types , Arial, Times New Roman, and PMingLiU, were choosen, respectively. The other factor is polarity, which positive polarity means a document with white words and black background, and the negative polarity is contrary. Therefore, there are thirty different combinations formed by these three factors.

The subjects were eight male and four female between 25 and 35 years old. All had 0.8 corrected visual acuity or better and normal color vision.

The experiments were proceeded in a quiet room with an ambient illumination of 700lux. Before starting the test, the subject is allowed to adjusted the seat so that they fell comfortable. The distance between eyes of subjects and

the test document is 60 cm, which is the common distance for reading newspaper or books.

The testing document was printed out by hp color LaserJet 3550N with white paper (purchased from UPM). There were five hundred and fifty one letters randomly arranged on the test document, each row had nineteen words and there were twenty-nine rows on the test document. Subjects were asked to read the test document and count how many “A” in the test document.

After the test, three results were recorded, i.e., searching time, searching acuity and comfort rating. The searching time means the time of the subject spend to finish the test. The searching acuity means the corrective ratio of the test. The comfort rating is rated by the subjects, with 1 representing ‘‘comfortable’’ and 10 representing ‘‘uncomfortable’’.

Result

The results consisted of four parts.

First, the effect of each factor would be shown, including word size, word font and polarity. The effect of word size on reading ability was shown in Fig. 1. And the three sub-diagrams were shown for the effect on recognition, comfort rating, and searching time. It revealed that the larger size provided the advantages of comfortable reading and shorter searching time. But when the letter became larger, the recognition would be going worse. This result may due to the easier reading for larger letters and that induces the reading mistake due to careless.

The effect of word font on reading ability was shown in Fig. 2. Similar to Fig. 1, the three sub-diagrams were shown for each response. Letter fonts included Arial (A), Times New Roman (T), and PMingLiU (P). From the result, the most suitable font for reading was Arial. And, Similar to the effect of word size, the more comfortable the letter font was, the lower recognition and the shorter searching time there would be. This effect was not as strong as the letter size.

The effect of polarity on reading ability was studied. The positive polarity was a document with black words and white background, and the negative polarity was apposite to positive polarity one. The positive polarity was comfortable to read. And the searching time was faster than the negative polarity case. In the part of recognition test, there's no significant difference between positive and negative polarity. Based on the above, the positive polarity reveals was suitable polarity for reading.

Second, the rate of effect of these three factors would be shown. As shown in Fig. 4(a). The effect of word size on comfort rating of different polarity was shown. It showed that, no matter what polarity was, the larger word size, the more comfortable was kept. That means that the word size is the most important factor to induce

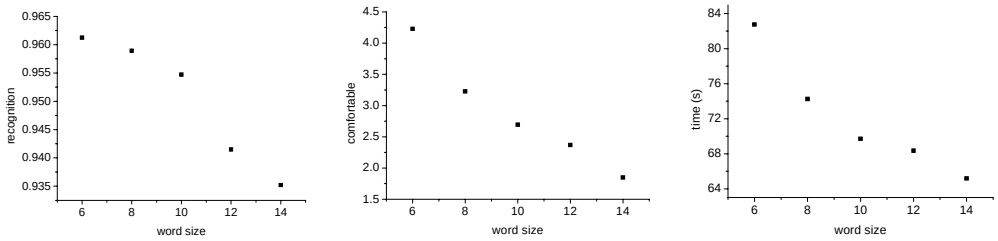

Figure 1. The effect of the word size on the reading ability (a) recognition, (b) comfort rating, (c) searching time

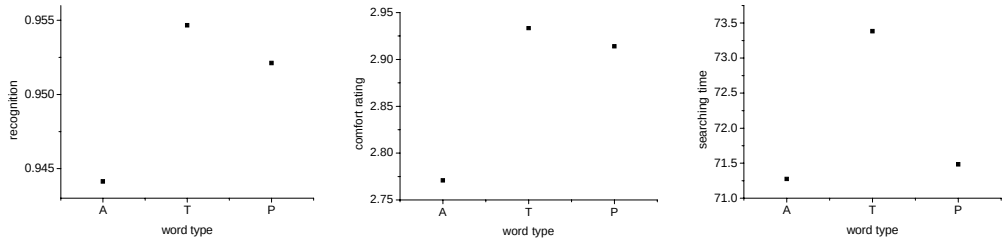

Figure 2. The effect of the word font on the reading ability (a) recognition, (b) comfort rating, (c) searching time

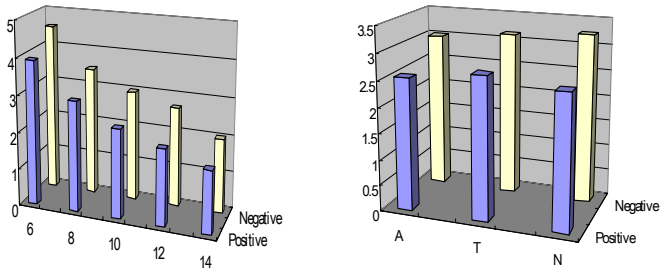

Figure 4. (a) the effect of word size on comfort rating of different polarity, (b) the effect of word font on comfort rating of different polarity.

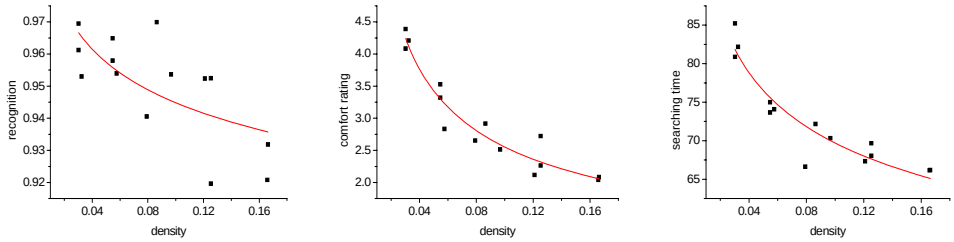

Figure 5. The effect of the density on the reading ability and its fitting curves (a) recognition, (b) comfort rating, (c) searching time

Figure. 6 The five groups divided from the total data **Figure. 7** limitation of density for comfortable reading

the eyes fatigue. Then, in order to compare the importance of the other factors, the other result was shown in Fig. 4(b). From this figure, it showed that the tendency is different for different polarity. It means that the power of the polarity is higher that word font, therefore, the tendency would be changed by different polarity.

Third, the result would be shown is the effect of the density on the reading ability. The definition of density is the ratio of the occupation ratio of black letters in test

document. While changing the letter sizes and/ or fonts, the density of letters would change significantly. In Fig. 5, the effect on recognition, comfort rating, and searching time and it fitting curves was shown, and it indicated that the letters with low density would be good to reed. The fitting curve was followed the model of Steven's work of psychophysics.

To find out the limitation condition in which human can read comfortably. We divided the 360 data into five groups, as shown in Fig. 6. It could be considered that the limitation of comfortable reading is the average of the forth group, and it is 3.487. It means that a document, which comfort rating is higher than 3.487, is not good to read. Following this, it could be extended that the document with density higher than 0.048 is not good to read, as shown in Fig. 7.

Discussion

The effect of the reading condition on reading ability had been investigated. It indicated that, under proper document setting, people can read comfortably with low fatigue. The setting consists of larger word size, Arial font, positive polarity and low density. And the limitation of the setting induced eyes fatigue wsa also reported.

By these results, the designer of e-paper or e-book can design a new product follow these conditions to offer a display which is suitable for human reading.

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