

Influence of Highlighting Validity on Dynamic Text Comprehension Performance

Joey C.Y. So and Alan H.S. Chan

Abstract—The advanced display technology offers a variety selection of color and highlighting methods which have improved the presentation of textual information. However, it leads to the questions of what is the best way to highlight the information and which information should be highlighted in order to maximize the comprehensibility of the messages. This study investigated the effect of the highlighting and its validity on comprehension performance on LED display for Chinese reading. Four levels of validity (0%, 33%, 67% and 100%) and a control condition with no highlighting were tested. Each subject was required to perform the five experimental conditions in which different passages were read and comprehended. The results showed that the condition with 100% validity of highlighting was found to have better comprehension performance than other validity levels and conditions with no highlighting. The comprehension score of the condition with no highlighting effect was comparatively lower than those highlighting conditions with distracters, though not significant.

Index Terms—Highlighting, Validity of Highlighting Dynamic text display, Human performance

I. INTRODUCTION

Today, dynamic display systems are widely used in information communications medium. Most of these display systems employ cathode ray tubes, liquid crystal displays, gas plasma displays, or light-emitting diodes (LED) as the output device. Many of these displays are easily found in different parts of our life such as banks, stock markets, transportation, schools, etc. The use of these systems provides an extra mean of delivering messages or ads to customers or people during their travels to work in our fast-paced society. Highlighting in presenting load of information is thus often used to attract attention or emphasize something important on the display. The advanced display technology offers a variety selection of color and highlighting methods which have improved the presentation of textual information. However, it leads to a question of what is the best way to highlight the information for maximizing the comprehensibility of the messages. Highlighting methods include color coding, bold, italics,

underline, font size enlargement, font type, blinking, etc. Ridder [1] investigated how highlighting (words in blue and underlined) of hyperlinks affects incidental vocabulary learning, text comprehension and the reading process. They suggested that when reading a text with highlighted hyperlinks, readers are significantly more willing to consult the gloss for vocabulary learning. In the studies on text comprehension in multimedia environments of Chun and Plass [2], [3], it was indicated that when words are made salient, they are remembered better. Pouraghabagher and Bish [4] evaluated the information highlighting methods on computer screens using blinking, reverse video, color (red) and bold characters. Their results showed that blinking attracted the most attention of the eyes in the presence of one of the other three highlighted information; while color (red) highlighting received the least preference of eyes. Braun *et al.* [5] examined the effects of font type, font weight, point size contrast between signal word and the main body of the warning. Their results revealed that bold type was more likely to be read than Roman type and a 2-point size difference between the signal word and the main body of the warning would produce a greater likelihood of reading the warning over a 4-point one. Another study by Wu and Yuan [6] investigated the effect of highlighting on searching and reading performance and they found that highlighting can significantly improve table searching and that the best highlighting method was using color.

However, here comes the problem of when a display consists of both highlighted and non-highlighted information, search time would vary depending both on the time it takes to find the target under the highlighted and non-highlighted options. Some researchers found that although highlighting could decrease the searching time for a highlighted target, it increases the time for searching a target when it is not highlighted. In a searching task, the probability of indicating the location of a target or distractor was termed “validity”. For example, in Gomberg’s study [7], when the validity of the highlighting was 50%, the results showed that subjects were slower to find a target in a highlighted display that included blinking and reverse video than to find a target without any highlighting. It is verified by a later study done by Tan and Fisher [8], where the validity rate was increased to 100%, and the search time to identify the target was indeed faster. Although previous research has been performed in order to better understand task factors like highlighting, highlighting validity, dynamic text display with on computer screens on searching or comprehension performance, there are no studies to investigate the effects of highlighting validity on comprehension performance on LED display,

Manuscript received December 6, 2008. The work described in this paper was supported by a grant from City University of Hong Kong, Hong Kong, China [Project No. 7001367].

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typically for Chinese reading. In the current study, the validity of highlighting was studied and university students were recruited for testing. It is expected that highlighting will help the readers to better comprehend the passages and allow the readers to obtain better scores. It is also expected that the higher the validity highlighting, the better the comprehension score.

II. METHODOLOGY

A. Design

The aim of this experiment was to evaluate the effect of the highlighting and its validity on comprehension performance on LED display for Chinese reading. The validity of highlighting is defined as the correctness of highlighted information which would be asked in a comprehension task, for example, 0% validity means none of the highlighted information provided in the passage is asked in the comprehension test; 33% validity means 1 out of 3 highlighted words is the keyword we needed whereas the other two highlighted words were the 'distractors', and so on. Four levels of validity (0%, 33%, 66% and 100%) were tested. A condition with no highlighting was also tested. It acted as a control for later comparison. Each subject was required to perform the tests under the 5 experimental conditions in which different passages were read and comprehended. There were three passages to be tested in each condition. In total, they would have to read 15 passages. These passages with different validity of highlighting were presented in a random sequence for reducing the order effect of the factors. The subjects were informed that the validity of highlighting of individual passages might vary with 0%, 33%, 67% and 100% of the correct information being highlighted. In the comprehension task, multiple choice test was used in assessing their reading performance. Three multiple choice questions were asked for each passage. One point was given for a correct answer and the comprehension score of each condition ranged from 0 to 9.

B. Subjects

Thirty male and eight female undergraduates of City University of Hong Kong participated in this experiment. The mean age of the subjects was 25.7 (range = 20 to 35). All of them had normal or corrected-to-normal vision (Optical Co., Inc. Model 2000P Orthorator) and normal color vision (Ishihara Pseudo Isochromatic Plates).

C. Materials

15 unrelated passages were used for testing. The passages were on topics of health, medical care, hygiene, environment, leisure, transportation. All passages had no technical terms or names of unusual words. They were similar to those appeared in public transport, school, hospital, etc. The mean passage length, including punctuation marks, was 87 characters with a range from 78 to 96 characters.

D. Apparatus

A computer (Pentium VI – 2.8 GHz) with a 582mm X 326 mm (include housing) dual colors LED display was used for stimulus presentation. The panel size was 512 mm X 256 mm. The LED display dot dimension was 128 dots X 64 dots and its dot diameter was 3.75 mm with 4mm dot separation. It could display up to 4 rows of 8 traditional Chinese Characters of 64mm X 64mm large per line. A one-line leading display method moving text from right to left at a display rate of 240 characters per minute was selected to present all passages in this experiment. All characters were displayed in green except for some of the keywords/non-keywords that were highlighted in red.

E. Workplace conditions

The display was mounted at a height of 200 cm, subjects were requested to stand at a viewing distance of 300 cm from the screen center. The characters size displayed on the display subtended angles of 1° 13' arc at the subjects' eyes. The ambient illumination was about 300 lx. No glare or reflection appeared on the display screen.

F. Procedure

Before the experiment began, the subjects were informed of the aim of the tests and the display variables to be studied. An example of the procedure was demonstrated to familiarize subjects with the experimental setup. Subjects were asked to read the passages presented on the LED display and try their best to understand the messages. A set of question sheets with three questions on a page was given to each subject at the beginning of the test, however, they were not allowed to preview the questions before each presentation of condition. After reading the first passage on the display, they were instructed to attempt the three multiple-choice questions on the first sheet of the question set. After one minute, the next reading appeared on the display. The procedure was repeated until all the fifteen passages were read. The randomized validity of highlighting of the 15 passages was expected to make sure that the subjects had comprehended the passages instead of just memorizing the highlighting words and to avoid subjects from guessing the answers. In order to avoid mental or visual fatigue, a 5-minute break was given after reading the first 7 passages.

III. ANALYSIS

The comprehension score was analyzed with the multiple marginal regression models which used the generalized estimating equations (GEE) method to examine the effects of validity of highlight (0%, 33%, 67% and 100%). This regression technique was used because it adjusts for dependency of several measurements within one individual and is capable of dealing with missing data [9]. Bonferroni test was used for post hoc analysis to ascertain the differences between three or more related groups. All statistical analyses were computed using SPSS 15.0.

IV. RESULTS

The dependent measure collected in this experiment was the comprehension scores, the proportion of correctness denoted the reading performance of each highlighting conditions. The method for calculating proportion of correctness for each condition = (the number of questions – number of wrong answers) / the total number of questions. Altogether 1,710 (38 subjects x 5 conditions x 3 passages x 3 questions) data sets were collected. The comprehension scores of individual subjects ranged from 0 to 9 were converted to 0 to 100 %. The results of GEE analysis on comprehension score (%) showed that validity of highlighting was a significant factor ($p < 0.001$). Post hoc *Bonferroni* test showed that subjects performed the conditions with higher comprehension scores with 100% validity than that of 67%, 33% and 0% validity ($p < 0.001$) (Fig. 1). The graph of the comprehension performance of highlighting conditions is shown in Fig. 2. The results of *Bonferroni* test also showed that comprehension score in the condition with highlighting was higher than that of without highlighting ($p < 0.05$).

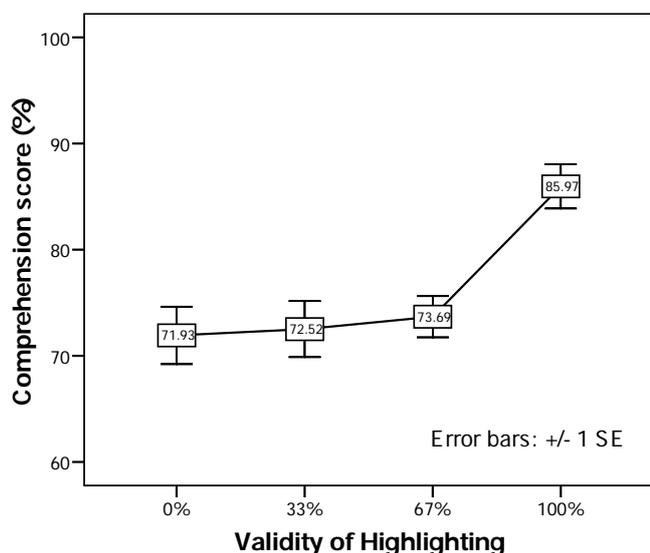


Fig.1 The graph of the comprehension performance of different validity of highlighting conditions

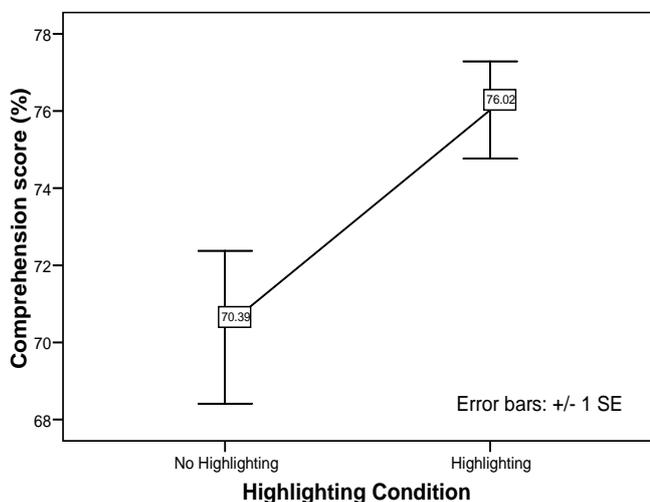


Fig.2 The graph of the comprehension performance of highlighting conditions

V. DISCUSSION

As shown in Fig. 1, the condition with 100% validity of highlighting was found to have better comprehension performance than other validity levels. This finding is consistent with the hypothesis that increase in validity rate would result in better comprehension performance. The high comprehension score obtained in 100% validity condition could be explained by the fact that the use of highlighting could provide a cue to the readers to spend more time on processing the important words and less time processing the unimportant words. This enabled them to have enough time to process the each word moving at a fixed display rate. As a result, it would be easier for the subjects to pick the correct answers, in the multiple-choice comprehension test after each reading. However, these results do not hold when there are some distractors (highlighted words not being asked) appeared in the conditions. The comprehension scores obtained in the condition with 67%, 33% and 0% validity were shown to be significantly lower than that of 100% validity. This is believed that the highlighting may lead the subjects to concentrate their processing on only those words and hence reduce their processing of the other words, which may also contain helpful information [10]. In other words, the subjects in the distractor conditions might have missed some information which led to poor performance in the comprehension test. Some researches have also been reported that although highlighting was found to decrease the time it takes to find a highlighted target, it increases the time it takes to find the target without highlighted [7] [8]. It is believed that highlighting could hinder comprehension if distractors are also highlighted in the same passage. On average, the comprehension score in the condition with no highlighting was comparatively lower than those in the highlighting condition with distractors, though not significant. This finding is consistent with the hypothesis that highlighting will help the reader to comprehend the passages and obtain better scores than no highlighting. However, our result is different from that of the Moravcsik and Healy [10], where subjects were requested to read out the passages as loudly and quickly as possible with some of the words being highlighted while still reading for comprehension. Their results indicated that highlighting important words to the readers could lead to less active processing of the passage, which resulted in poorer comprehension; whilst our results obtained in this experiment suggested that highlighting (even with some distractors) may somehow be good to the readers. It would be desirable to further investigate the comprehension performance under the highlighting conditions with distractors and without distractors and to study how distractors affect the performance.

VI. CONCLUSION

The effects of validity of highlighting on LED display for Chinese reading was investigated in this study. The results showed that the condition with 100% validity of highlighting was found to have better comprehension performance than other validity levels and conditions with no highlighting. The comprehension score of the condition with no highlighting

effect was comparatively lower than those highlighting conditions with distracters, though not significant. It is hoped that these results will assist in the formulation of recommendations for better design in regard of information presentation on display.

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