Design Factors on Dynamic Text Display

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

Abstract— **Electronic information display systems are widely used in public places. The increase in use of light-emitting diodes (LED) display arouses our interest in the effective methods of displaying dynamics text. In order to overcome the limitations of screen size of the display units, numerous means of presenting moving materials on dynamic display have been invented. However, in the past, researchers only focused on the studies of dynamic text display on small screens such as cellular phones, pagers and desktop phones and some researches concern about the optimal dynamic text display in website design. So far, no studies have been found on LED display board for optimal display method. There are many factors that would affect the readability of electronic text. This paper reviews some related empirical studies concerning the various display methods of dynamic text presentation. The factors explored in this review are the text display type, character type, text display direction, and text/background color combination. The review would be helpful to researchers in formulating further research plans and methodology for determining the optimum dynamic text display methods on LED display boards.**

Index Terms—**Dynamic text display, light-emitting diodes, human performance**

I. Introduction

Electronic information display systems are widely used in public places such as cinemas, airports, transportation, shopping malls, fast food chain stores, etc. Most of these display systems employ cathode ray tubes, liquid crystal displays, gas plasma displays, or light-emitting diodes as the output device. The explosion of communication technology in past decades and the increase in use of light-emitting diodes (LED) display arouses our interest in optimizing effective methods of displaying dynamic text. However, in the past, some researchers mainly focused on the studies of dynamic text display on small screens of devices such as cellular phones, pagers and desktop phones [1], [2] and some researches were concerned about the optimal dynamic text display in website design [3]–[6]. A number of studies concerning dynamic message signs (DMSs) used in transportation have been found [7], [8] while there are no studies on optimal dynamic display using LED display for indoor usages. It maybe an interesting question of what the best display method is to deliver electronic text message for indoor LED displays. An LED display simply acts as a display output unit like a computer screen. The text display method, character type, text display direction, text color, etc. can be freely chosen by designers or operators. Thus the different combinations of the selected factors could affect the readability of electronic text. This paper reviews some related empirical studies concerning the various display methods of dynamic text presentation. The factors explored in this review are the text display type, character type, text display direction, and text/background color combination. This review provides a useful summary of important findings on these design factors to human factors researchers for further exploration of the best dynamic text presentation methods on LED displays.

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II. Display Type

A. Rapid Serial Visual Presentation

The rapid serial visual presentation (RSVP) method involves displaying successive words of some textual information at a fixed point on the screen, usually at a predetermined rate and in rapid succession. It was firstly introduced by Forster [9] in a study of the comprehension and processing of written language. The advantage of RSVP was related to the elimination of eye movements, leading to a possible reduction in cognitive load [10]. Bernard, Chaparro and Russell [11] investigated the effect of text presentation speed in reading English on small screens and found that the optimal rate was about 250 words per minute (wpm). Wang and Kan [12] performed a dual-task experiment that examined the influence of an RSVP display field on the comprehension performance in reading static and dynamic Chinese text on an LCD display. Their results indicated that the optimal speed for presenting text on an RSVP display was approximately 140 characters per minute (cpm). In a Chinese RSVP study conducted by Chen and Chien [13], the text was presented either one character, phrase-oriented or one sentence at a time on small screens. The results showed that when the presentation method was in the phrase-oriented format, reading comprehension with a lower speed of 171 wpm was significantly higher than that with speeds of 350 and 260 wpm. In another study conducted by Chen and Chien [15] on the effect of dynamic display on reading Chinese text on different small screens, it was found that RSVP appeared to be the most viable alternative on small screens, which led to the highest reading comprehension for Chinese readers. In a study investigating the effect of RSVP display design on Chinese reading performance in accomplishing dual tasks with small screens, Chen and Chien [15] found that participants performed best at speeds ranging from 171 to 350 cpm and performed worst at 430 cpm. The presentation mode factor

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(character-by-character, word-by-word, and one-line format) significantly influenced subjects' reading comprehension. Their results suggested that different text-flow orientations can be adopted when designing an RSVP display for reading Chinese text and further studies are required to determine the optimum speed of RSVP display for better reading of Chinese text and user acquaintance.

B. Leading

Leading display is one of the conventional Internet homepage design methods for presenting dynamic information on visual display terminals (VDTs). The leading display method presents the words by sequence and moves the string of words from right to left. With regard to the studies on Chinese leading display, Wang, Chen and Chen [5] examined the effect of leading display design of dynamic information on users' visual performance and visual fatigue. The results revealed that speed was a significant factor for subjects' searching performance. It was also found that subjects performed better searching in terms of error percentage under the condition of 250 than 300 cpm. However, in a VDT leading-display reading study conducted by Wang and Chen [4], subjects' reading comprehension did not show a significant difference under 250 or 300 cpm. In the static and leading display information dual tasks research of Wang, Fang and Chen [16], speeds of 250 and 300 cpm were shown to have no significant difference on subjects' searching performance on static display and information comprehension on leading display. Wang and Kan [12] performed a dual-task experiment that examined the effects of leading display design in reading static and dynamic information on LCD display. The results showed that subjects performed the best comprehension under 195 cpm and there was no performance difference under 250 and 300 cpm conditions. Other than presentation speed, the jump length of dynamic information characters is another important design factor in leading method. Jump length signifies the continuity of leading display characters movement. Under the same speed setting, the movement of leading display characters looks much smoother for a shorter jump length setting [4]. In an English leading-display study, subjects' reading accuracy was found higher for faster speed (260 wpm), and was higher as jump length increased [17].

C. Scrolling

In many researches on scrolling, the speeds of scrolling were always controllable by the operators or designers in which they moved through the document by operating a handle [6] or scroll arrow [18]. However, the fixed display speed method will be employed in our planned research. In the vertical scrolling, text usually moves in a line-by-line manner or scrolls continuously and automatically a raster at a time up from the bottom of the screen. In a study exploring the optimal methods of presenting dynamic text on different types of screen (laptop, palm-type pocket computer, communicator and mobile phone), Laarni [1] found that the efficiency of the vertical scrolling mode improved with an increase in display width from 3 to 27.5 cm. This implied that the wider the screen, the better the performance will be for vertical scrolling. It is also found that scrolling was the fastest method when people read from a laptop-, a PDA- and a communicator-type window. Chen and Chien [14] studied the effect of dynamic display and speed of display movement on reading Chinese text on a small screen and suggested that a vertical continuous scrolling display with a speed of 305 cpm should be used to present Chinese text information for the PDA and mobile phone screen types.

III. CHARACTER TYPE

Chinese typography is also a factor that affects visual performance at VDT workstations. Shieh, Chen and Chuang [19] examined the effect of Chinese typography on users' visual performance with static information. Their results showed that subjects' visual performance (correct percentage) in a quick characters identification task was better when the typography was a true type rather than the standard Kai type. However, Wang and Chen [4] found that Chinese typography had no significant effect on subjects' reading performance in a VDT leading-display study. In comparison with the characters identifications task, the effect of Chinese typography on comprehension performance in reading task was relatively lower. Therefore, both of the true and standard Kai types of Chinese typographies can be chosen in the leading display design. A research done by Chan and Lee [20] showed that traditional Chinese characters of Ming style enabled faster reading times and received higher preferences than Li style characters for static information on computer displays.

IV. TEXT DIRECTION

Languages such as Korean, Japanese and Chinese are written in various directions, which are often written horizontally from left to right and sometimes vertically from top to bottom. Thus the text display direction becomes one of the interesting factors investigated in past years. Chen and Chen [21] compared the scanning directions in Chinese reading of three groups of Chinese subjects: first-grade, fifth-grade, and college students. Their results showed that vertical reading was found to be faster than horizontal reading; however, the vertical superiority disappeared when subjects had several years of experience in horizontal reading at the fifth grade. They thus suggested that college students were equally efficient in both horizontal and vertical readings presumably due to the fact that they had sufficient experience with both types of reading under normal circumstances. They also found that subjects had better comprehension scores in horizontal than vertical reading when they were required to read fast. Hwang, Wang, and Her [22] investigated the effect of character spacing, control of the change mode of the display, scrolling speeds and text format (vertical or horizontal) of Chinese information display on VDTs and reported similar results as that of Chen and Chen [21]. It suggested that display format (vertical or horizontal) had no significant effect on performance of college students. Seo and Lee [23] studied the head-free reading of horizontally and vertically arranged text in Korean writing and their results showed that reading was 24% faster for horizontally arranged

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text, primarily due to the larger gaze amplitude in horizontal reading, with smaller numbers of saccades and fixations. Another study was conducted by Kajii and Osaka [24] who examined the recognition of briefly presented Japanese words. They found that the performance was better for horizontally displayed words than for vertically displayed words.

V. Text/Background Color Combination

Some researches reported that color contrast of text/background of dynamic display had significant effects on users' visual performance. Wang, Chen and Chen [5] reported that subjects' search error decreased when the text/background color contrast increased. In addition, Wang and Chen [4] studied the effects of text/background color combination for VDT leading display on user's reading performance and the results showed that color difference was also a significant factor in subjects' reading performance at a leading display. Subjects' reading performance for the color combinations with higher color difference (black-on-white, white-on-black, and blue-on-yellow) was significantly better than that with lower color difference (red-on-white, blue-on-white, and green-on-white). A recent study by Yang, Waters, Cabrera, Wang and Collyer [25] on enhancing messages displayed on dynamic message signs in driving simulation experiment showed that amber-colored messages resulted in the shortest response time and that subjects took longer time to respond to red-colored messages. A wide range of colors is available with the LED displays, and most colors being used in the LED displays are red, green, and amber. However, no study has been done on exploring the choice of effective colors or color combination for increasing the readability of messages delivered from LED displays.

On visual display terminals, luminance contrast between the text and background colors is an important factor in text/background color combination. Shieh and Lin [26] indicated that visual identification performance and subjective preference increased as the luminance contrast of text/background color combination became greater. Moreover, color can provide an additionally subjective benefit by making display work more pleasant. Thus, many text/background color combinations are used to attract users and to increase the attractiveness of a homepage. Besides, Shieh and Chen [27] reported that subjects' viewing distance was significantly affected by color combination.

VI. Summary

In summary, three common types of dynamic text display method used for dynamic text display were studied by researchers in recent decades: RSVP, leading, and scrolling. Specific design factors such as character types, text direction, and text/background color combinations were also studied for the optimal display and better reading performance. However, most researchers mainly focused on the studies of dynamic text display on small screens of cellular phones, pagers and desktop phones and some researches were concerned about the optimal dynamic text display in website design. So far, no studies were found on indoor LED display board for optimal display method. Thus, this review should be helpful in providing information for formulating further research plans and methodology and establishing the hypotheses for determining the optimum dynamic text display methods on LED display boards.

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