Influence of Highlighting Words Beneath Icon on Performance of Visual Search in Tablet Computer

Li Wang[1](✉), Liezhong Ge[2], Ting Jiang[1], Hongyan Liu[2], Hongting Li[2], Xinkui Hu[2], and Hanling Zheng[2]

[1] National Key Laboratory of Human Factors Engineering, China Astronaut Research and Training Center, Beijing, China
wanglikunyu@126.com
[2] Zhejiang Sci-Tech University, Hangzhou, China

Abstract. This study compares the influence of different kinds of highlighting words beneath icons on visual search performance on the interface of tablets through response time and accurate rates of participants completing a search task. The results indicate highlighting words below icons could improve performance of searching a target icon; and when the icons are gray, under the condition of color words and flicker words is more effective for visual search. When the icons are colorful, under the condition of flicker words is more effective for visual search.

Keywords: Highlighting words · Icon color · Visual searching performance

1 Introduction

Visual information search is a basic demand of computer or other electronic products users as well as touch-screen tablets users. Among the information, the most common forms are two kinds, namely graphics and text [1]. For the user interface of tablets, icon has important function to transfer graphics and text information. In order to operating fast and searching the target icons, designers and researchers have done a lot of research on highlight of visual information.

In the field of ergonomics, about icon research mainly focuses on several aspects [2]:

1. Complexity: Users search simple icons faster than complex icons [3].
2. Specificity: Users are prefer to specific icons instead of abstract icons, although specific icons are not always better than abstract ones on response time and accurate rate of searching target [4, 5].
3. Familiarity: If users are familiar with icons, they could give a fast and accurate response whether the icons are specific or abstract [6].
4. Semantic distance correlation: Many researchers believe that the semantic distance and the icon has a close relationship, but due to lack of electronic database icons, objective measuring index for icons have not been proposed now [7].

© Springer International Publishing Switzerland 2015
R. Shumaker and S. Lackey (Eds.): VAMR 2015, LNCS 9179, pp. 81–87, 2015.
DOI: 10.1007/978-3-319-21067-4_10

5. Other factors: Knowledge about target, visual stimulus characteristics (such as size, color, spatial location), semantic features of icons (such as classification) etc. [2].

Studies have shown that highlighting can attract rapidly more attention to the targets especially for visual search, so as to improve the search performance [8]. Others study highlighting performance of different color under the condition of a single color or compound colors background. The results show that under a single color background like light blue or light green, search performance of red highlight is the best. But advantage of red highlight under natural color is not so obvious [9]. Some other scholars study preview effect on color highlight through preview search paradigm. They find that color high salience does not improve preview effect, but loss some preview effect [10]. Ge et al. (2000) compare performance of three highlight under the background of white and black, which are high, middle and low frequency. The results indicate that flicker can effectively improve the visual search performance, when the flicker frequency high (above 27 Hz) [11]. Besides color, underline as highlight can also effectively promote the performance of visual search, especially under condition of difficult task or white background [12]. If visual material is graphics, Hu et al. (2001) study that shading can the performance of visual search significantly [13].

However, these studies are mainly applied in the field of desktop computer, mobile phone or web browsing. In recent years, with the popularity of touchscreen products like tablets, how to improve icon search performance on the touchscreen has become the urgent problem to solve. The aim of this study is to study highlight of words below icons on the tablet interface. Examine whether highlights will improve search performance of icons, and thus to provide a reference for words design below icons.

2 Methodology

The independent variables of this experiment are icon colors and highlighting styles, which icon colors have two levels such as gray and colors and highlighting styles of words have four levels such as none, color, flicker and bold. The dependent variables are accurate rate and response time of completing searching a target icon. The response time is recorded between target icon appearing and response of participants. And control variables are icon content, appearing sequence of target icon, and icons position on the searched interface and experiment conditions.

For this experiment, two factors within-subject design are adopted. Eighteen persons participates the experiments. And they are divided into two groups randomly, which each group has 9 participants including 4 males and 5 females. One group conducts the trials with gray condition firstly, and then color condition. The sequence of the other group's trials is opposite. Under one icon color, four kinds of highlighting style of words are presented randomly.

2.1 Participants

Eighteen persons (10 females) participated in the experiment. They all complete written informed consent in accordance with institutional guidelines of Zhejiang Sci-Tech University. The age range is between 20–45 years old. The education backgrounds are bachelor degree or above. Their visions are normal or corrected to normal. There are no color blindness or weakness and right-handed.

2.2 Apparatus

The experiment is conducted on a Newman NewPad. The screen resolution is 1280*800 pixels and the size is 10.1 inches. And the operating system is Android 4.1. The program is written by JAVA language.

Thirty-six icons were arranged in a 6*6 matrix with each icon covering 256px *256px. The font below icons is Chinese Arial, size five. The spacing between adjacent icons is 20 dp. The spacing between adjacent characters (four Chinese characters) below one icon is 10 dp. The horizontal distance between subjects' eyes and the middle icon on the screen display is 30 cm. And the angle between the Newman NewPad and the horizontal plane is about 45 degrees.

The 36 icons are presented on the black ground like Fig. 1. And the Fig. 2 shows the four kinds of highlighting styles of words. For each trial, a target icon and 35 interference icons are presented to the participants. In order to remove the effect of position of and sequence icons, the position of the icons are arranged randomly, and target icons are posited uniformly on the four quadrants of screen.

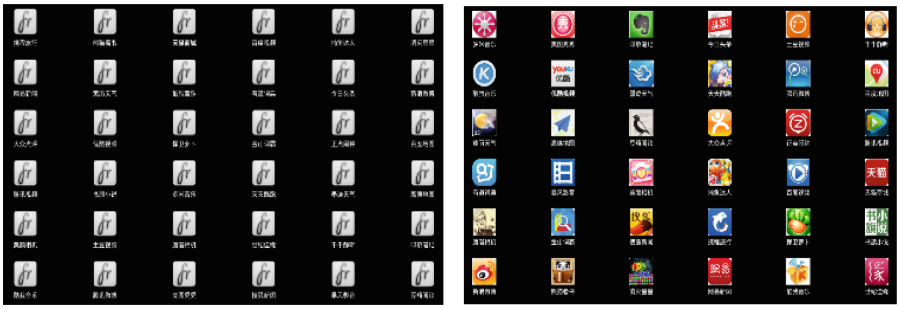

Fig. 1. Icon color (Left-color; Right-gray) (Color figure online)

Fig. 2. Highlighting styles of words (from left to right: none; color; flicker; bold) (Color figure online)

2.3 Tasks and Procedure

Before experiments, the participants should read the instruction and know the procedure and requirements of the experiments. Then sign the consent forms. After completing these, participants begin to conduct sets of exercises until the accurate rate is 85 %. If participants could not respond in 10000 ms, the result is counted as an error.

Then, formal experiments appear. For each trial, a target icon was firstly presented for 2000 ms, and then a search interface including the target icon and 35 distracter icons appeared. Subjects were asked to find the target icon as soon as possible and click it. The task must complete in 10000 ms. Otherwise skip into next task automatically and this task is recorded as an error. The whole formal experiments are controlled by JAVA programs.

3 Results and Analysis

3.1 Description

Table 1 showed the descriptive statistics of response time and accurate rate of completing searching a target icon.

For gray icons, the time of participants searching a target icon with color words and flicker words is less than the other two kinds highlighting styles of words. And the accurate rate of searching a target icon with color words and flicker words is higher than the other two kinds highlighting styles of words.

For color icons, the time of participants searching a target icon with flicker words is the least.

And the accurate rate of searching a target icon with color words is highest, which is 100 %.

3.2 Effects of Different Icon Color

The repeated measure ANOVA on icon color yield significant main effects on response time and accurate rate. For response time, the results indicate that the significant is less 0.01 ($F(3,51) = 70.42$, $P < 0.01$) between gray icons and color icons while participants search a target icon using the two kinds of icons. The average response time of participants' searching a target icon under condition of color icons is 2717.00 ms

Table 1. Descriptive statistics

	Gray		Color	
	Time (ms)	Accurate rate (%)	Time (ms)	Accurate rate (%)
None	5391.96 (751.29)	69.79 (14.74)	3073.98 (662.01)	91.32 (9.86)
Color	1954.87 (426.17)	99.65 (1.47)	2815.77 (374.50)	97.92 (4.29)
Flicker	1850.53 (207.34)	99.65 (1.47)	1841.06 (156.66)	100 (0.00)
Bold	5399.23 (770.02)	65.28 (13.76)	3137.19 (474.09)	92.01 (7.37)

Note: The number in parentheses is the standard deviation.

(416.81) while the average response time under condition of color icons is 3649.14 ms (538.70). For accurate rate, the results also indicate that the significant is less 0.01 ($F(3,51) = 68.71,\ P < 0.01$) between gray icons and color icons while participants search a target icon using the two kinds of icons. The average accurate rate of participants' searching a target icon under condition of color icons is 95.31 % (5.38) while the average accurate rate under condition of gray icons is 83.59 % (7.86).

3.3 Effects of Different Highlighting Style

The repeated measure ANOVA on highlighting styles of words yield significant main effects on response time and accurate rate. For response time, the results indicate that the significant is less 0.01 ($F(3,51) = 266.52,\ P < 0.01$) among the four kinds of styles while participants search a target icon. The average response time of participants' searching a target icon under condition of color words or flicker words is 2385.32 ms (400.33) or 1845.80 ms (182.00) while the average response time under condition of none of highlighting or bold words is 4232.97 ms (706.65) or 4268.21 ms (622.05). For accurate rate, the results also indicate that the significant is less 0.01 ($F(3,51) = 63.16,\ P < 0.01$) among the four kinds of styles while participants search a target icon. The average accurate rate of participants' searching a target icon under condition of color words or flicker words is 98.79 % (2.88) or 99.83 % (0.74) while the average response time under condition of none of highlighting or bold words is 80.56 % (12.30) or 78.65 % (10.57).

3.4 Interaction Effects of Icon Color and Highlighting Style

The results of the repeated measures model indicate that interaction effects of icon color and highlighting styles of words on response time is significant ($F(3,51) = 91.55,\ P < 0.01$). When the icons are gray, the response time of participants under the condition of color words and flicker words is less than those under the condition of none of highlighting and bold words. However, there isn't significant difference between flicker words and color words and between none of highlighting and bold words. When the icons are colorful, the response time of participants under the condition of flicker words is less than the other styles.

The results of the repeated measures model indicate that interaction effects of icon color and highlighting styles of words on accurate rate is also significant ($F(3,51) = 31.34,\ P < 0.01$). When the icons are gray, the accurate rate under the condition of color words and flicker words is higher than those under the condition of none of highlighting and bold words. However, there isn't significant difference between flicker words and color words and between none of highlighting and bold words. When the icons are colorful, the accurate rates under the condition of flicker words and color words are higher than none of highlighting and bold words.

After the formal experiment, participants were instructed to evaluate the satisfaction of the color and the highlighting type of words of each icon based on a 5-point scale (1: very unsatisfied; 5: very satisfied). The results shown in Table 2 indicate that

Table 2. Participants' satisfaction on different highlighting styles of words

Highlighting styles	None	Flicker	Color	Bold
Scores	1.50	4.72	4.33	2.33

participants are more likely to choose flicker words and color words. But 83.33 % of participants choose flicker words and only 16.67 % participants choose color words. None of participants select none of highlighting or bold words. In addition, participants suggest that the words can be presented in other font, or magnified font or rotated and so on.

4 Conclusion

1. Highlighting words below icons could improve performance of searching a target icon, which indicate that highlighting words is suitable for touch screen devices like tablets.
2. Not all highlighting styles could improve visual searching performance. The results Color words and flicker words below icons are more suitable.
3. When the icons are gray, under the condition of color words and flicker words is more effective for visual search. When the icons are colorful, under the condition of flicker words is more effective for visual search.

A good icon and highlighting style design concentrate on not only in appearance, but on user performance and experience [14, 15]. The results of the experiments are helpful to reveal the characteristic of the individual in searching target in theory and practice. In addition, a follow-up study will further explore while the words below icons does not change, whether highlighting styles of icons will influence on visual search performance.

References

1. Yang, H.: Research on Interface Design of Mobile Internet Application of Smart Phone. Wuhan University of Technology (2013)
2. Yu, N.Z., Ge L.: A literature review of icon ergonomics research. In: Proceedings of Conference on Psychology and Social Harmony (CPSH 2012). Wuhan University, Scientific Research Publishing, p. 4 (2012)
3. Byrne, M.D.: Using icons to find documents: Simplicity is critical. In: Proceedings of INTERCHI 1993, pp. 446–453 (1993)
4. Everett, S.P., Byrne, M.D.: Unintended effects: varying icon spacing changes users' visual search strategy. In: Conference on Human Factors in Computing Systems, pp. 24–29 (2004)
5. Sarah, I.: Graphics and semantics: the relationship between what is seen and what is meant in icon design. In: Harris, D. (ed.) EPCE 2009. LNCS, vol. 5639, pp. 197–205. Springer, Heidelberg (2009)

6. Isherwood, S.J., McDougall, S.J.P., Curry, M.B.: Icon identification in context: the changing role of icon characteristics with user experience. Hum. Factors **49**(3), 465–476 (2007)
7. McDougall, S., Reppa, I., Smith, G.: Playfoot, David: Beyond emoticons: combining affect and cognition in icon design. In: Harris, Don (ed.) EPCE 2009. LNCS, vol. 5639, pp. 71–80. Springer, Heidelberg (2009)
8. Nothdurft, H.-C.: Attention shifts to salient targets. Vis. Res. **42**(10), 1287–1306 (2002)
9. Li, H., Li, W., Wang, P.: Study on Color highlighting under color background. 应 Chinese J. Appl. Psychol. **01**, 62–69 (2011)
10. He, F., Liu, Ch.: The effect of color salient on preview search. In: Proceedings of 2010 International Conference on Psychology, Psychological Sciences and Computer Science (PPSCS 2010). International Science and Engineering Center, Hong Kong; Huazhong University of Science & Technology, China; Howard University, 4 (2010)
11. Ge, L., Kong, Y.: A study of blinking as a type of highlighting in white and black display background. Psychol. Sci. **01**, 28–30 (2000)
12. Hu, F., Ji, L., Ge, L.: An ergonomic study using texture as highlighting codes on graphical displays. Chin. J. Ergon. **02**, 10–12 (2001)
13. Ge, L., Xu, W., Zhong, J.: A study on underline highlighting in difference display backgrounds and difficulty levels. Chin. J. Ergon. **04**, 6–8 (2001)
14. Guo X.: Research on the Usability of Software User Interface Based On Icon Design. Nanjing University of Aeronautics and Astronautics (2012)
15. Teng, Z.H., Jin, S., Zhen, Y.: The visibility of icon in graphical user interface of mobile phones. Packag. Eng. **04**, 66–70 (2013)