Computers in Human Behavior 63 (2016) 218–228

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Full length article

A study on the relationships between different presentation modes of graphical icons and users' attention

Hsuan Lin [a,*], Yu-Chen Hsieh [b], Fong-Gong Wu [c]

[a] Department of Product Design, Tainan University of Technology, Tainan, Taiwan
[b] Department of Industrial Design, National Yunlin University of Science and Technology, Yunlin, Taiwan
[c] Department of Industrial Design, National Cheng Kung University, Tainan, Taiwan

ARTICLE INFO

Article history:
Received 7 September 2015
Received in revised form
16 April 2016
Accepted 5 May 2016

Keywords:
Icon composition
Background
Polarity
Icon border
Fixation
Eye-tracking

ABSTRACT

With the vigorous development of applications (App), graphical user interfaces (GUI) have been widely found in computers and handheld devices. This study aimed to explore the relationships between different presentation modes of graphical icons and users' attention. An eye tracker was employed to measure each participant's experimental data; in addition, subjective evaluation of attention was conducted. Thus, the optimum presentation mode attracting the most attention might be determined. The experiment was designed to investigate two variables: icon composition and background. Through permutation and combination, six presentation modes were obtained as follows: line + positive background (M1), plane + positive background (M2), line + negative background (M3), plane + negative background (M4), line + no background (M5), and plane + no background (M6). Thirty-six participants were requested to view thirty stimuli, or the contour drawings of graphical icons, presented simultaneously in six modes mentioned above. The participants' fixation duration, fixation frequency, and subjective evaluation of attention were analyzed through two-way ANOVA. The analytical results showed that in terms of the three performance indicators above, M4 performed the best among the six presentation modes. Moreover, regarding icon composition, planes performed better than lines in terms of the three performance indicators. As for background, negative background performed the best in terms of the three performance indicators, positive background ranked second, and no background performed the worst. The findings can serve as a reference when icons are researched or designed in the future.

1. Introduction

With the rise of cellphones and tablets, the market of mobile applications (App) has been increasingly booming, so graphical icons have been commonly found in smart mobile devices. While working with the help of computers, tablets, or smartphones, users simply click on-screen graphical user interfaces (GUI), or visual icons, which allow them to operate computers or execute the program instructions (Näsänen & Ojanpää, 2003). With graphical icons presented in a relaxing way, users can locate their desired functions or objects more easily and quickly (Huang, 2008; Lindberg & Näsänen, 2003). That working mode enables users to manipulate the main menus, control buttons, and charts in a highly visual way; therefore, the software is used with much more ease (Memon, Banerjee, & Nagarajan, 2003). Also, users can intuitively input instructions to be executed and interact with devices (Wu, Lin, & You, 2011). Graphical icons are more suitable for a smaller display space, such as the small screens on handheld devices. It's because graphical icons can convey more information or show the minimum instructions in the limited space (Fleetwood & Byrne, 2002). Being more diversified as well as convenient, applications in cellphones, tablets, and computers are increasing constantly, with the number of corresponding icons also increasing. Under such a situation, designers tend to make icons more and more complex so that icons may provide large amounts of information in a limited space and enhance users' attention (Lindberg & Näsänen, 2003). Well-designed graphical icons can achieve such positive effects as drawing users' attention, shortening search time, reducing operational errors, and relieving users' burden. Therefore, for interface designers, icon presentation design of a GUI has remained an important consideration.

* Corresponding author.
E-mail addresses: te0038@mail.tut.edu.tw (H. Lin), chester@yuntech.edu.tw (Y.-C. Hsieh), fonggong@mail.ncku.edu.tw (F.-G. Wu).

http://dx.doi.org/10.1016/j.chb.2016.05.008
0747-5632/

In the past, research on graphical icons focused on their sizes, distances, background (Huang, 2008; Legge, Pelli, Rubin, & Schleske, 1985; Legge, Rubin, & Luebker, 1987) as well as contrast (Näsänen, Ojanpää, & Kojo, 2001). As for icon-searching, much emphasis was put on how subjective evaluation of usability is affected by brightness, contrast, sharpness (Näsänen & Ojanpää, 2003), position, number, color, and shape (Huang & Lai, 2008).

1.1. Visual attention

Attention refers to a continuous eye movement. An eye tracker can be employed to record the visual space, fixation duration, fixation frequency (number of fixations), and fixation points, in addition to helping a viewer make a choice or preference judgment (Ware, 2010). When the viewed images increase from one to two, the viewer's sight line will be pointed to the preferred direction. As a product is displayed at a physical store, its appearance design is intended to attract consumers' attention. For that purpose, the foremost step is to attract consumers' visual attention (Schiffman & Kanuk, 2000), which in turn leads to purchase and consumption. Likewise, as a product is displayed at an online store, the webpage layout may catch a user's attention and lead the user to search for relevant information. Such being the case, to convey the message properly is the primary focus (Landa, 2010). Nowadays, the online network is packed with innumerable sorts of information and countless goods. When a particular product displayed on a website captures people's attention, it means that the product is appealing (Baxter, 1995). Usually, webpage design depends on a larger picture or title to draw attention, thus inducing consumers to browse. The layout design can guide the readers' visual line and induce their reading focus to enhance their understanding of the content (Landa, 2010). In recent years, with the market of mobile applications (App) thriving, a new business model with business opportunities has come into existence. Icon design is highly beneficial to the marketing of applications. It is because icon presentation often holds a consumer's attention and in turn triggers the interaction between the consumer and an application. People's attention tends to be drawn to the image elements (Pettersson, 1993). Images play an important role in the reading activity, for they can grab the reader's attention and broaden the related text (Holmqvist & Wartenberg, 2005). Visual attention is aimed at a specific area of a visual display (Rayner, 1998). Information presented in images can captivate more visual fixation. Different kinds of images will cause viewers to have different kinds of visual fixation, intelligence, and visual learning (Pettersson, 1993). Aiming at e-commerce websites, Lee and Benbasat (2003) conducted research on attention and product memory. Their findings showed that high-definition images got more attention than low-definition ones; meanwhile, dynamic interfaces got more attention than static ones. Moreover, a high-definition image combined with a dynamic interface could capture more of a user's attention than just a single feature. Similarly, a webpage using big images enhanced the user's memory better than one using small images.

1.2. Eye tracking

When a scene or an object is being viewed, a person's eye movement can be divided into two categories, i.e., fixation and saccade, based on different viewing states. Fixation means the length of time when the sight point of an eyeball is relatively static, but not absolutely static, in a particular time span. By contrast, saccade means that the sight point quickly moves from one point in space to another (Buscher, Cutrell, & Morris, 2009; Rayner, 1998; Sereno & Rayner, 2003). Theoretically, the eyes are fixed during fixation while in reality there exist tremor, drift, and micro saccades (Ciuffreda & Tannen, 1995). Acquisition of information occurs only during fixation (Lindberg & Näsänen, 2003). Eyes are attracted to the most informative areas of a scene because they are physically distinctive and informative (Rayner, 1998). Pettersson concluded that there are five main points concerning the visual track and attention-attracting as follows. 1) People's attention is attracted solely by image elements. 2) The form of eye movement or fixation depends on what people expect to see or in what way they are told to see. 3) The information presented in the image can draw more eye fixation. 4) Different kinds of images result in different forms of fixation duration, intelligence, and visual learning. 5) There is a positive correlationship between fixation duration, intelligence, and visual learning (Pettersson, 1993).

An eye tracker can be employed to measure the track and fixation points of an eye movement so that the cognitive process of viewing may be explored (Hills & Lewis, 2011). The acquisition of visual information is produced by fixation. Before the eyeball moves on to the next word, a lot of procedures need to be completed within a single occurrence of fixation (Sereno & Rayner, 2003). To be exact, three visual procedures take place: sampling of the visual field, analysis of foveal part of the visual field, and planning of the next eye movement (Viviani, 1989). The process of fixation can reveal what the human's visual sense feels about a certain image, but the process of saccade cannot because of some physiological limitations of the eyeball, such as the visual masking effect (Rayner, 1998; Roefs et al., 2008). In order to know how the eyeball is controlled when a scene or an object is viewed, the following two aspects can be investigated: the fixation point and fixation duration (Deubel & Schneider, 1996). The human's visual system was simulated by Le Meur, Le Callet, and Barba (2007) based on spatial distance and temporal length separately. Concerning the display of images, the former adopted uniform icons to show the spatial distribution of the visual sense in the process of viewing, and the latter adopted central display to show the fixed focuses. In sum, as a stimulus is viewed by the eyeball, the fixation point, fixation duration, and fixation frequency are the critical indexes used to measure attention (Buscher et al., 2009; Deubel & Schneider, 1996; Pieters, Rosbergen, & Wedel, 1999; Underwood, 1998).

1.3. Related work

An eye tracker can be used to record fixation duration and fixation frequency in the process of word-reading so that the track of the eyeball movement may be realized. By employing the eye tracker combined with the LCD or CRT display, Näsänen, Karlsson, & Ojanpää (2001) investigated how different font sizes and contrasts affect display quality and search speed. It was discovered that on both the two displays, search time decreases as the font size increases. In other words, as the letter size increases, fixation duration and fixation frequency needed by a single search lessens. Moreover, under the condition of high contrast, there is no significant difference between the two displays in search time. However, in the case of low contrast, the search time spent on the CRT display is considerably longer than that spent on the LED display. Besides, in the case of low contrast and small font size, visual word-searching is done in a more sensitive way, which is beneficial to the evaluation of display quality. Furthermore, Goonetilleke, Lau, and Shihe (2002) suggested that despite the complexity of Chinese characters, there is no significant difference in visual search time. Based on eye movement, Li, Liu, and Rayner (2011) observed the location on which readers would fix their eyes when reading a Chinese sentence that contained a two-word or four-word phrase. It was found that readers' eyes landed at the center of a Chinese word when only a single fixation was made on the word, and that