



Color associations among designers and non-designers for common warning and operation concepts

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ABSTRACT

This study examined color-concept associations among designers and non-designers with commonly used warning and operation concepts. This study required 199 designers and 175 non-designers to indicate their choice among nine colors to associate with each of the 38 concepts in a color-concept table. The results showed that the designers and non-designers had the same color associations and similar strengths of stereotypes for 17 concepts. The strongest color-concept stereotypes for both groups were red-danger, red-fire, and red-hot. However, the designers and non-designers had different color associations for the concepts of escape (green, red), increase (green, red), potential hazard (red, orange), fatal (black, red), and normal (white, green), while the strengths of the 16 remaining associations for both groups were not at equivalent levels. These findings provide ergonomists and design practitioners with a better understanding of population stereotypes for color coding, and consequently to effectively use colors in their user-centered designs.

1. Introduction

Color has profound effects on the cognition and emotions of people, and its communication value carries different associations and meanings (Hill and Barton, 2005; Prado-León et al., 2006). In many aspects of the communication process, color is a vital and commonly used dimension for coding visual information. For example, color coding plays an important role in road speed and traffic speed control (Campagne, 2005). Color coding is even used in aircraft transmission radar displays to depict altitude information of high traffic density avenues (Tam et al., 2003). The proper color coding of medical gas cylinders and drug syringe labels acts as a safety measure to minimize or reduce the risk of medical errors (Haslam et al., 2006; Taylor and Davison, 2009). The use of appropriate color coding can help determine the intended conceptual meaning of warning signs and labels (Braun and Silver, 1995; Chapanis, 1994; McDougald and Wogalter, 2014). Wogalter et al. (2015) explained that color affects the perception of hazard information and its significance in the warning context of memorizing and comprehending safety information. Additionally, color coding is highly recommended in the human engineering design of visual alarms, visual warning indicators, and software graphic user interfaces in marine systems in compliance with human performance, workload, and safety and health requirements (ASTM F1166–07, 2013).

The appropriate assignment of colors compatible with the stereotypes for a population will help reduce the risk of misinterpreting

information and thereby improve safety because of the effective recognition of the operating conditions of machines, facilities and equipment in many industrial processes and other situations (Chan and Courtney, 2001). Color combinations with consistently high preference among users can be adopted as the default color scheme for interface design (Huang, 2010), and color combinations with different polarities should be considered for developing legible content on the interface (Humar et al., 2014). The color associations of entertainment graphics and movie genres for delivering emotionally stimulating content (Lee, 2005), population stereotypes for color association with software operations such as open, new, save, save as, undo, and close (Yu and Wu, 2009), and the relationship between color associations and pharmaceutical packaging (Chang and Lee, 2012) have been reported. Color associations with linguistic concepts, including letters, numbers and days of the week have been explored (Rouw et al., 2014). Pravossoudovitch et al. (2014) also tested the possibility of an implicit red-danger association with native French speakers and found a strong effect.

Several studies on population stereotypes have been conducted to determine which colors generally represent the concepts for a particular cultural population and specific context. Chan and Courtney (2001) studied population stereotypes for color associations with Hong Kong Chinese and found some associations that agreed with other populations (Yunnan Chinese and US people) and others associations that disagreed. Chan et al. (2003) examined color-concept associations for

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three Asian populations, namely, Hong Kong Chinese, Korean and Thai, and found that the three populations did not share all the common color-concept associations, demonstrating cross-cultural differences in color associations. A total of 20 out of the 38 test concepts had the same color associations for these groups. For instance, all groups selected red for “danger” and yellow for “standby”. However, discrepancies on preferred color mappings were found in the 13 remaining concepts. For example, Hong Kong Chinese and Korean samples selected black to represent “off”, whereas the Thai group selected red. With regard to the concept “reset”, Hong Kong Chinese group selected yellow whereas the Thais and Koreans selected red. Borade et al. (2008) examined hazard perception associations for safety system words (warning, caution, danger, attention, think, beware, go, notice, and safe) with colors (red, orange, yellow, blue, white, black, and green) among Indian industrial workers. Population stereotypes for color associations within specific occupational groups, namely, white collar workers, steel workers and managerial staff in Hebei Province, in mainland China were examined (Or and Wang, 2014; Wang and Or, 2015), and differences in color associations were found for different occupations.

Some studies have examined the factors that may affect the association of color-concept. Prado-León et al. (2006) investigated color associations in the Mexican university population and found that associations that differed significantly with gender, for example, the association of the color green with life, was significantly stronger for women than for men. Ko (2011) investigated color and product-function associations using shampoo in a real-world product scenario in Taiwan. Statistically significant associations for colors and shampoo functions were found as follows: red for hot oil treatment, yellow for bright and shiny hair, green for herbal extracts, blue for deep cleaning, purple for soothing, black for antiseptic, and white for anti-dandruff. The findings also suggested that the associations might be gender-specific. Lee and Hwang (2015) examined the effect of personal experiences on the interpretation of the meaning of colors used in the displays and controls on electric control panels (ECPs) in Korea, and found that interpretation varied according to personal experiences of using ECPs. All these research show that color association attributes can be markedly affected by the background and characteristics of the population and individuals involved.

Discrepancies between the perceptions of designer and non-designer regarding various design elements, such as product form, image-words and aesthetic attributes of web sites, have been reported in previous studies (Hsu et al., 2000; Karapanos and Martens, 2007; Koutsabasis and Istikopoulou, 2013). Therefore, the color-concept associations found for designers cannot be assumed to be applied to non-designers in user-oriented designs. Hsu et al. (2000) investigated the perceptions of designers and users regarding the product form of telephone design. Designers preferred a product form with an elegant style, whereas users preferred modern and sleek designs. Additionally, designers preferred product forms that were dependent on creativity, maturity and delicacy; the delicacy of design images played a more predominant role in affecting user preference. Karapanos and Martens (2007) examined the discrepancies between the perceptions of designers and users regarding their motivation in using TouchToPrint. Users considered the emotional aspects of the product whereas designers tended to value product efficiency and effectiveness as important and often failed to foresee user views and preferences on the product. Koutsabasis and Istikopoulou (2013) studied perceived web site aesthetics of users and designers. Designers considered the aesthetic attributes of unity, overall impression and meaningfulness to be very important. However, users were more concerned about the aesthetic attributes of artistic, harmony/order, analogy/symmetry, unity, overall impression, energetic, clear, pleasant, intriguing, enjoyable, beautiful, attractive/appealing, with imagination and originality. Zhang and Zhu (2009) conducted a pilot study on the perception of users and designers on mobile phone color and found that they have different perceptions for some colors and agreed in their perceptions of attributes and meanings of other colors.

Apart from the preliminary study of Zhang and Zhu regarding user and designer color perceptions of a particular product, no research regarding the differences between the associations of users and designers on color for general concepts, such as common warnings and operations.

To create successful human factors and ergonomics design, designers must consider end-user stereotypes throughout the design process. Qian et al. (2011) indicated that the internal representations of users and designers about designs are not equivalent and differences between the two groups should be recognized. The differences in the views of designers and users in relation to a user-centered design solution may have been operating at an unconscious level. Knowing thy users is, therefore, one of the basic tenets of user-centered design. Moreover, understanding the thinking of designers and the differences between the design representations of designers and users would increase the effectiveness of the design process greatly and assist towards better user-centered design and innovation (Mieczakowski et al., 2013). Examining the discrepancies between designers and users (non-designers) towards various color-concept associations is necessary to enhance the human factors and ergonomics design with respect to coloration cues. This study aims to examine the color associations for common warnings and operations concepts among designers and non-designers. Nine basic colors in common use and 38 general concepts in the areas of warnings, signs and equipment status, and action required were tested. The findings will result in the identification of the similarities and differences between designers and non-designers in associating colors with general concepts. Research regarding associations of colors with concepts and conditions will provide ergonomists, designers and other interested parties with knowledge on the implicit and unconscious meaning of color codes and better understanding of population stereotypes on various color-concept associations. The findings of this study will act as a useful reference for design practitioners to optimize color coding in the design to avoid selecting colors based on their own personal associations or preferences in user-centered design. This study will enable practitioners to use appropriate colors for information visualization and design decision-making, as well as to enrich the value of ergonomic user-centered design results.

2. Method

The experiment was conducted using a questionnaire-based study to examine the stereotypes for the color-concept associations of designers and non-designers.

2.1. Participants

Two groups of Chinese participants, namely, designers and non-designers, who would like to participate in the study of color-concept association study were examined using the Ishihara Pseudo Isochromatic Test (Richmond Products, 1983), in which six of the participants with color vision deficiency were screened out from the study. After color vision deficiency screening, for the designer group, there were 199 design graduates which have been professionally trained to create a number of design and artistic projects and has two to four years of design experience for clients in the industry (89 males and 110 females; with mean age of 21.6 years). The non-designer group, without any artistic design experience and relevant profession training, consisted of 175 undergraduates and postgraduates from the disciplines of engineering, science, business and humanities (118 males and 57 females with mean age of 23.4 years).

2.2. Stimuli

The stimuli for color-concept associations for designers and non-designers in this study were adapted from Chan et al. (2003) to facilitate the comparison of the results with previous studies regarding color

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