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Comprehension and redesign of recently introduced water-sport prohibitive symbols in South Korea

Yohana Siswandari [1], Woojoo Kim [1], Shuping Xiong*

Ergonomics and Applied Biomechanics Laboratory, Department of Human and Systems Engineering, School of Design and Human Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan, 689-798, South Korea

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ABSTRACT

The goal of this study is to evaluate the comprehensibility of recently introduced water-sport prohibitive symbols by the Ministry of Knowledge Economy (MKE, now the Ministry of Trade, Industry and Energy) of South Korea, and to redesign the poorly comprehended symbols based on participants' feedback and three universal ergonomic principles. Evaluation of comprehensibility and cognitive features of fourteen water-sport prohibitive symbols were conducted with forty Korean participants. Only two out of fourteen symbols have comprehension rates higher than the level recommended by ISO standard. Four poorly comprehended symbols are redesigned based on ergonomic design principles and participants' feedback. A follow-up experiment with another group of twenty Korean participants was conducted to verify the effectiveness of the redesign process and results showed redesigned symbols have better adherence to ergonomic design principles and enhanced comprehensibility than the original ones. The findings may serve as a useful input for researchers and designers in creating easily comprehended symbols to promote safety.

Relevance to industry: Warning symbols have long been used as an interface to communicate critical situation-specific information to prospective users in industrial undertakings so that the risk of accidents and injuries can be reduced. The findings of this study provide useful information for designers in developing easily comprehended symbols to promote safety.

1. Introduction

Warning symbols have been extensively used as an interface to communicate critical situation-specific information to their prospective users. Warning symbols with positive messages which provide information of encouraged behavior or permitted practice are called permissive symbols (Shieh and Huang, 2003). In general, a permissive symbol includes a green circle on a white square and the action within the green circle is permitted. On the other hand, prohibitive symbols refer to warning symbols with negative messages conveying information about conditions that should be prevented or avoided (Glover et al., 1996; Shieh and Huang, 2003). A prohibitive symbol usually includes a pictorial within an overlaid red circle slash. The style of red circle and slash was recommended by ISO 3864 (1984) and ANSI Z535.2 (1991), and it has been used worldwide to express negation of a specific item or activity. However, when designing prohibitive symbols designers have to be very careful not to let a distinctive feature of the pictorial obscured by the red slash (Dewar, 1976; Murray et al., 1998). Usually, these kind of symbols are found in public places and one of the most obvious examples of prohibitive symbols are traffic symbols. However, these symbols also have been widely used in other public places, such as hospitals, train or subway stations, working stations and factories, etc.

Beaches are one of the public places at which prohibitive symbols are displayed. Previous studies have stated that beaches have implemented a wide range of actions directed towards reducing the potential effects of dangers on beachgoers (Franklin et al., 2010; Hatfield et al., 2012; Matthews et al., 2014). By the end of 2011, the Ministry of Knowledge Economy (MKE, now the Ministry of Trade, Industry and Energy) of South Korea (http://www.mke.go.kr) had introduced fourteen water-sport prohibitive symbols. The importance of prohibitive symbols being able to communicate their intended warning messages has been widely acknowledged. A theoretical framework by Wogalter et al. (1999) named C-HIP

* Corresponding author.
E-mail address: maverickhkust@unist.ac.kr (S. Xiong).
[1] Both authors contributed equally to this work.

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(Communications-Human Information Processing) model showed the stages involved as information flows from a source to a receiver who then processes the warning information to subsequently produce behavior. This model suggested that while warning information might not lead to behavioral compliance, it still can effectively influence precursor processing stages. As suggested by the C-HIP model, if a bottleneck exists at the comprehension stage, the receiver (prospective user) might not notice the warning message implied by the symbol (Wogalter et al., 1999).

Considering that these prohibitive symbols are intended to alert people to potentially dangerous situations, there was an obvious need for detailed investigation of the comprehensibility of the symbols. However, until this study was conducted, there was no indication or published statement from the Korean government that these symbols have been assessed. Moreover, after a thorough literature review, no other studies were found to have reviewed or assessed this specific set of water-sport safety symbols. Therefore, the goals of this study were to (a) evaluate the comprehensibility of the recently introduced water-sport prohibitive symbols by MKE in South Korea among their major prospective users (Koreans), and (b) redesign the poorly comprehended prohibitive symbols using participants' feedback and three ergonomic design principles: physical and conceptual compatibility, familiarity, and standardization. The first principle, physical and conceptual compatibility, is described as the correspondence between the symbol and the message it represents. Whereas familiarity is described as the frequency of the symbol encounters. The third principle, standardization, is defined as consistency, homogenous representation of forms/colors/symbols/directions and so forth, in all symbols for presenting a similar message (Ben-Bassat and Shinar, 2006).

Two sequential experiments were conducted to achieve the aforementioned objectives. The first experiment was aimed to assess the comprehensibility of the recently introduced water-sport prohibitive symbols by MKE among Koreans. Informative feedback collected from participants and ergonomic design principles were utilized in the redesign process of the poorly comprehended symbols. A follow-up experiment was conducted with another group of participants to verify the effectiveness of the redesign process for the poorly comprehended symbols identified in the first experiment.

2. Experiment 1: comprehension test and subjective feedback

2.1. Participants

Forty Korean college students consisting of twenty young males and twenty young females voluntarily participated in this experiment (Table 1). The inclusion criteria were that they should have normal or corrected-to-normal vision, have no symptoms of color blindness, and have no previous experience of learning the meanings of the water-sport symbols tested here.

2.2. Materials and procedure

All fourteen recently introduced water-sport prohibitive symbols were selected for this study (Fig. 1). Even though in reality, the warning messages could be also conveyed with Korean text, only the pictorial symbols were shown in this experiment, because pictorial symbols can quickly communicate concepts and may be better remembered than text (Lehto, 1992; Rogers et al., 2000; Lesch, 2003; Hancock et al., 2004). Pictorial symbols are also useful in conveying safety information to members of diverse educational levels (Kim et al., 2006) and cultures (Rogers et al., 2000). All symbols were fitted into 7 cm × 7 cm squares without borders. These symbols were presented at the center of a computer screen, at a viewing distance of 60 cm (subtending 6.67°) from the screen (Ng and Chan, 2007; Liu and Ho, 2012). To comply with the angle requirement, an adjustable chair was used for the participants.

The Ishihara color blindness test was conducted to screen out participants suffering from color blindness prior to the experiment. Each qualified participant was tested individually in two sequential sessions: (1) a guessing test of the water-sport prohibitive symbols, and (2) a symbol cognitive features evaluation and feedback session for design improvements. At the end of the test, a questionnaire was administered for capturing each participant's general characteristics (gender, age, etc). The whole experiment lasted for approximately 1.5 h and was conducted in Korean to obtain reliable experimental data from Korean participants.

2.2.1. Session I: guessing test of recently introduced water-sport prohibitive symbols

Whether or not a prohibitive symbol could convey the intended meaning was measured using a guessability score. The guessability score (GS) refers to the accuracy level of guessing the meaning of a symbol (Ng and Chan, 2007; Ou and Liu, 2012). In this session, three simple safety prohibitive symbols were given as practice prior to the testing of fourteen randomly presented water-sport prohibitive symbols. The investigated symbols were displayed on the computer screen and for each symbol, the participant was asked to guess its actual meaning in an open-ended test (Wolff and Wogalter, 1998). The decision to let participants say the meaning of the symbols in their own words (open-ended test) instead of choosing among multiple choices (multiple-choice test) was made because the open-ended test is less likely to produce constrained and distorted participant reports (Neisser, 1987) and it more closely mirrors the cognitive processes and thus yields better ecological validity (Dewar, 1994; Wolff and Wogalter, 1998; Ou and Liu, 2012). Each participant was given a chance to look at the symbol for 10 s first, and then asked to give answers verbally within 15 s. Exact responses from the participants were recorded, and the participants' comprehension of the symbol was evaluated by two independent judges afterwards. After participants finished giving their answers for one symbol, the next symbol was displayed on the screen, and the same procedure was repeated until all fourteen symbols had been evaluated. The whole session was recorded by a video camera and also the built-in voice and computer screen recording software, oCam version 13.0. At the end of session I, a 2 min break was given prior to the beginning of session II.

Table 1
General characteristics of experimental participants.

Participants' information	Experiment 1 (comprehension test and subjective feedback)	Experiment 2 (evaluation of redesigned symbols and comparison with the original ones)
Total number of participants	40	20
Age in years (mean ± standard deviation)	19.6 ± 1.3	20.3 ± 1.6
Gender proportion	1: 1 (20M, 20F)	1: 1 (10M, 10F)