Increased Comprehension of Warning Pictorials with Color Highlighting

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Although symbols or pictorials are increasingly being used to communicate warning information, people's comprehension of them is not guaranteed and sometimes can be quite low. The current study sought to determine whether adding colored highlighting to the relevant components of a pictorial benefits comprehension of the warning. There were three highlighting conditions: more relevant parts were highlighted, less relevant parts were highlighted, or no highlighting. Each participant was shown pictorials in each of the three highlighting conditions and asked to write a short description about what each pictorial communicates. The results showed that participants were more likely to correctly understand the intended conceptual meaning of pictorials when the most relevant parts were highlighted in comparison to the other two conditions. Highlighting less relevant parts led to poorer comprehension than no highlighting at all. Appropriately color highlighting relevant parts of complex pictorial symbols could be a useful method of enhancing comprehension.

INTRODUCTION

Warning symbols or pictorials are increasingly being used to convey warning information to users of different languages, circumvent illiteracy, and provide effective hazard communications for world-wide trade (Wogalter, Silver, Leonard, & Zaikina, 2006). Symbols have a number of other purposes. They can facilitate the attraction of attention (Bzostek & Wogalter, 1998). Additionally, some symbols can be capable of conveying semantic concepts (Davies, Haines, Norris, & Wilson, 1998; Wogalter, Sojourner, & Brelsford, 1997). However, symbols for complex concepts are not always understood. Misunderstandings can be caused by several factors including artistry and conceptual abstractness. The American National Standard Institute's Criteria for Safety Symbols (ANSI Z535.3, 2007) is a U.S. standard with criteria for comprehension acceptability. To be acceptable in terms of comprehension, 85 percent of a sample of 50 people must comprehend the intended concept with no more than 5 percent of the people experiencing critical confusion (wrong, opposite answers) when the warning is displayed without text. Numerous studies have shown that many common symbols fail to attain ANSI criteria (Wogalter et al., 2006). Developing high quality symbols that yield high comprehension is challenging (e.g., Davies et al., 1998). Abstract and nonvisible concepts are very difficult to communicate by symbols alone.

Several studies in the human factors and ergonomics (HFE) literature have examined strategies to increase the comprehension of symbols (e.g., Gill, Barbera, & Precht, 1987; Rogers, Lamson, & Rousseau, 2000). These strategies include adding context and detail and increasing legibility. It is usually recommended that warnings, both pictorial and text-based, be as simple to understand as possible. This simplicity limits complexity and detail, which in turn limits potentially useful contextual information.

Context in the form of lesser relevant details in a pictorial may distract a viewer and reduce the likelihood that the viewer focuses on the most relevant information, thus potentially detracting from comprehension (Wogalter et al., 2006). However, the less relevant information could provide contextual information that could aid in comprehension.

The current research examines the use of color highlighting on selective parts of complex pictorials on comprehension. Previous research indicates that highlighting can focus attention on a specific stimulus (Wickens, Alexander, Ambinder,

& Martens, 2004). Highlighting could be used in warning pictorials to focus attention to key areas of a pictorial in order to enhance comprehension of those warnings. Wogalter and Rashid (1998) found that warnings with thick, colored borders were more likely to attract attention compared to similar signs with thin or no borders, which was determined by looking at the behavior of passers-by. Distinctive color can be used constructively to attract individuals' attention from other stimuli in the environment to a warning. Highlighting parts of pictorials may serve a similar purpose in directing individuals' attention to the relevant details (Bzostek & Wogalter, 1999). By assisting in the focus of the most relevant details, the highlighting could positively benefit pictorial comprehension. However, highlighting might impair pictorial comprehension if less relevant details are highlighted.

Figure 1 shows highlighting with the color white used in a "hold handrail and attend to children and avoid sides" pictorial commonly found at escalator entrances in the U.S.

Figure 1.
Example of a highlighted complex safety pictorial commonly used in the U.S. at escalator entrances.

Highlighting the most relevant parts of complex pictorials might facilitate comprehension performance over no highlighting. However, highlighting less relevant parts could impair comprehension particularly if individuals believe only the most relevant parts are highlighted.

METHOD

Participants

A total of 84 North Carolina State University undergraduate students majoring in a variety of subject areas participated to meet research requirements for an introductory psychology course: 35 were male and 49 were female (mean age = 18.7, *SD* = 1.2)

Materials and Procedure

Participants signed up for the experiment via a web link. The link navigated them to an online questionnaire. Participants were randomly assigned to one of three groups.

The questionnaires used in the experiment were comprised of ten pictorials, each with a different conceptual meaning. Three other pictorials served as foils / distracters. The distracters were always given to participants in the unhighlighted condition and were included in the set to reduce the likelihood of participants guessing the purpose of the experiment. As such, they were not included in the analysis. The three highlighting conditions were applied to the ten pictorials: relevant highlighting, less relevant highlighting, and no highlighting. Relevant highlighting included yellow highlighting that encircled the most pertinent portion(s) of the pictorial in order to determine its meaning. Less relevant highlighting included yellow highlighting that covered contextual or irrelevant portions of the pictorial.

The conceptual meanings (referents) of the ten manipulated pictorials were: (1) hold onto ladder with your hand while keeping both feet on it, (2) use safety clamps on a bar when lifting weights, (3) do not stand under a ladder while holding it, (4) keep wrists straight and lifted while typing, (5) keep medication out of reach of children, (6) check mirrors while driving, (7) hold onto something while standing in a bus, (8) look both ways before crossing a road, (9) do not overload electrical plugs, and (10) turn pan handles inward while on stove. Between the three questionnaires, all pictorials were represented by each condition. Because there were 10 pictorials presented in three conditions, there

was an unequal distribution of pictorials in each group: each participant saw either three or four pictorials of each condition. However, pictorials and conditions were counterbalanced with equal numbers of participants.

Participants were presented with each pictorial together with context, e.g., a short description as to where someone might see the pictorial. Participants were then instructed to type what they thought the pictorial meant in the space provided. Once they typed this information, they continued down the page to provide descriptions for subsequent pictorials. After completing the comprehension portion of the study, the participants completed a short demographic survey.

Responses were evaluated by two independent judges. They evaluated the correctness of the conceptual meaning of participants' responses with respect to each pictorial's conceptual meaning. Responses needed to reasonably match the intended meaning of the referent in order to be considered correct. Exact wording was not required. For example, the answer "Maintain three points of contact with the ladder at all times" was considered correct for the pictorial instructing viewers to hold onto ladder with your hand while keeping both feet on it. General responses such as "use ladder properly" were not considered correct responses.

RESULTS

For comprehension accuracy, the number of correct interpretations of the pictorials by each participant was calculated for each of the three conditions. Inter-rater reliability was calculated based on the percent of agreement between the two scorers and was 0.92, and Cohen's Kappa, a measure of nominal scale response agreement between two raters by taking into account chance agreement between raters (Hubert, 1978), was 0.84. Descriptive statistics for the frequency of correct responses (accuracy) and mean proportion correct responses are shown in Table 1. An ANOVA indicated a significant effect of the highlighting manipulation (relevant highlighting, less relevant highlighting, and no highlighting), $F(1.73, 142.17) = 68.29$, $MSE = .92$, $p < .001$, partial $\eta^2 = .45$.

Table 1
Mean and proportion of correct responses (and standard deviation in parentheses) as a function of highlighting condition. N=84.

	Accuracy Correct			
	Frequency		*Proportion*	
Highlighting Condition	*M*	*SD*	*M*	*SD*
Relevant	2.07	(1.10)	.61	(.30)
Less Relevant	.47	(.67)	.15	(.22)
No Highlighting	1.07	(.91)	.32	(.26)

Paired comparisons among means showed that comprehension was higher for relevant highlighting than less relevant or no highlighting. Also, comprehension was lower for less relevant highlighting than for no highlighting (ps < .02). Similarly, an ANOVA on the proportion correct scores produced a significant effect, $F(1.92, 159.63) = 66.78$, $MSE = .07$, $p < .001$, partial $\eta^2 = .45$, with comprehension scores higher for relevant highlighting than for no highlighting, which in turn was higher than less relevant highlighting (ps < .02).

DISCUSSION

The results show that relevant highlighting aided in participants' comprehension of the warning-related information conveyed in the pictorial. This benefit could be due to attracting and directing viewers' attention to relevant information within the pictorial, and thus helping them to ascertain its purpose.

Although simpler is usually better with regard to pictorials, sometimes multiple elements and greater complexity are needed. The pictorials used as stimuli in this study were more complex than most simple safety symbols. The pictorials were hand drawn graphics with multiple elements. Being composed of numerous elements, it allowed for some of them to be designated as less relevant

and more relevant. Safety symbols of lesser complexity may not benefit as much from highlighting.

The present results suggest that some complexity can be reduced by relevant highlighting. That is, some of the deleterious effects of greater complexity and detail might be mitigated by focusing attention on the relevant parts. The results support the idea that guidance of visual attention can be aided through highlighting. In this way pictorials can contain lesser relevant detail without necessarily hurting performance because of complexity. Highlighting prioritizes visual attentional focus to the most important parts of the pictorial, with less relevant details providing a support role.

However, there is a potential downside to highlighting. If the highlighting is not located on the most relevant parts, then highlighting could reduce comprehension, as shown in the present results. In fact, we found that highlighting irrelevant items was worse than no highlighting at all. Highlighting draws visual attention to particular areas with people assuming the object(s) highlighted are relevant because someone apparently and purposely highlighted it. This is confusing and clearly could hurt comprehension of the pictorial's meaning. When less relevant parts are highlighted, people may assume the highlighted areas are more relevant than they are. Miscomprehension could result as a potential outcome. Thus based on the present experiment's results we can say that if highlighting is used, it should only highlight the most relevant portions of the pictorials.

One limitation of the present study is that only young adults (undergraduate students) were used. Future studies ought to examine whether the effects of highlighting are similar for a wider range of age groups. Previous research suggests that older adults do worse at comprehending safety pictorials and other research suggests that they are also at a greater risk of as they perform more poorly than younger adults in symbol comprehension tests (Hancock, Rogers, Fisk, 2001; Sojourner and Wogalter, 1998; Zwaga, & Boersema, 1983).

Additional research is needed on what kinds of pictorials benefit the most from relevant highlighting. The technique of highlighting can be included in the symbol designer's "tool box" as a potential way to increase pictorial comprehension.

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