# Connoted Hazard and Perceived Conspicuity of Warning Configurations

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## Abstract

The effects of various elements comprising warning signs and labels on connoted hazard and perceived conspicuity were examined. The warning elements that were orthogonally manipulated included signal word, color, print/background color reversal, panel size, font size, and letter case. The component manipulations combined to produce 98 different warning configurations. The results confirmed some aspects of published standards in terms of color usage within the signal word panel. For example, in accordance with ANSI guidelines, signal words printed in white on a red background conveyed a higher level of hazard than any other ANSI signal word and background color style. Several significant interactions were found, supporting the notion that warning components need to be evaluated in combination with other components. Implications for the design of warnings are discussed.

## INTRODUCTION

Over the past several years, there has been an increasing interest in warning design. Research has indicated that factors of size, shape, color, and signal word can affect the level of hazard conveyed as well as the conspicuity of the warning (Adams & Edworthy, 1995; Wogalter, Kalsher, Frederick, & Brewster, 1998; Wogalter & Laughery, 1996). Research of this kind is important in that it facilitates the efforts to improve the effectiveness of warnings, e.g., increasing the likelihood of safety-related behaviors. However, as noted by Wogalter et al. (1998), a systematic examination of the relative effectiveness of particular warning components and combinations of components continues to be an area in need of examination.

The American National Standards Institute (ANSI) publishes standards and guidelines for the design of warnings. ANSI Z535.2 (1998) and Z535.4 (1998) provide guidelines for signal word and background color combinations for environmental signs and consumer products, respectively. Both ANSI documents recommend that text for the signal word panel appear in white on a red background, black on an orange background, and black on a yellow background to represent higher to lower levels of hazard, respectively.

Research supports some of the ANSI specifications. Numerous studies indicate that red conveys the highest degree of hazard (Adams & Edworthy, 1995; Braun & Silver, 1995; Wogalter et al., 1998). In relation to the remaining colors recommended by ANSI, i.e., orange and yellow, Wogalter et al. (1998) found that yellow conveyed more hazard than orange. Others have found that orange conveyed greater hazard than yellow or showed no difference (Braun & Silver, 1995; Chapanis, 1994).

Many of the aforementioned studies also examined the effect of signal word on hazard level conveyance. ANSI recommends the use of the signal words *DANGER, WARNING,* and, *CAUTION* to convey decreasing levels of hazard. Braun, Sansing, Kennedy, and Silver (1994) examined the interaction between signal word and color and found that there was a tradeoff between the two components. For example, the effect of a word associated with a higher level of hazard may be diminished by coupling it with a color associated with a lower hazard level. In terms of the effect of signal words recommended by ANSI, the signal word "Danger" has been found to convey the highest level of hazard (Chapanis, 1994; Wogalter et al., 1998). However, ANSI's defined difference between "Warning" and "Caution" is much less clear in that numerous studies have found no difference between the words, and for those that have found statistically significant differences, the difference was not large in practical terms (Wogalter & Silver, 1995; Wogalter et al., 1998).

The objective of the present study is to systematically examine the effects of various warning components and their combinations on connoted hazard and perceived conspicuity. The warning elements examined in the present study are signal word, font size, letter case, panel size, and signal word/background color combinations. The purpose is to examine their individual effects and possibly interactive effects on participants' judgments.

## METHOD

### *Participants*

Sixty North Carolina State University undergraduate students (36 females and 24 males) participated. The students received research credit in their introductory psychology course.

### *Materials*

Two sets of stimuli were employed in the study. Each set consisted of 48 warning signs. One set contained the signal word "DANGER" in the panel while the second set included the nonsense signal word "RESVRE" in the panel. The latter word was used to avoid having a real signal word influence the ratings of the other manipulated features. Also, it allows one to test whether signal word effects connoted hazard and/or perceived conspicuity. In lieu of text, the main body of each warning consisted of a series of X's, so that words themselves do not influence the ratings. The following within-subjects variables were manipulated to create the signs: (a) ANSI signal word and background color styles; (b) color; (c) panel width; (d) font size; and (e) letter case. Table 1 describes these within-subjects variables and their levels.

### *Procedure*

For both sets of warnings, every combination of the aforementioned elements was used. All stimuli were presented on 8.5 in x 11 in (20.3 cm x 27.9 cm) paper. Each warning was labeled with a numeric code such that the participant's evaluations could be tracked. Response sheets with numbered blanks corresponding to the warnung number were provided to participants.

Participants were randomly assigned to one of four between-subjects conditions with 15 participants in each group. Depending on the condition, participants either rated the warnings based on connoted hazard or perceived conspicuity, and the warnings either contained the signal word "Danger" or the nonsense word "Resvre."

The order of the warnings was randomized for each participant. Participants rated each warning on a 9-point scale. Verbal anchors were assigned to odd numbers as follows: 1 = no hazard, 3 = low hazard, 5 = moderate hazard, 7 = high hazard, and 9 = extreme hazard. The following were the anchors assigned to the odd numbers for the conspicuity ratings: 1 = extremely unlikely to capture attention, 3 = low likelihood of capturing attention, 5 = moderate likelihood of capturing attention, 7 = high likelihood of capturing attention, and 9 = extremely likely to capture attention.

## RESULTS

Results were analyzed using a 2 (signal word) x 2 (question type) x 2 (ANSI print/background color style) x 3 (color) x 2 (panel) x 2 (font) x 2 (case) mixed model ANOVA. Signal word and question type served as the between-subject factors while the latter five were within-subjects variables. The dependent variable was the perceived hazard or conspicuity rating for each warning, depending on the question type. An alpha level of .0003 was used based on the Bonferroni adjustment of the conventional significance level of .05 to control for the experimentwise error rate. Significant effects were examined by Tukey's Honestly Significant Difference (HSD) test.

Table 1
*Description of Within-Subjects Variables*

| Independent Variable | Levels | Description |
|---|---|---|
| *Color* | Red | Red panel or red signal word |
| | Orange | Orange panel or orange signal word |
| | Yellow | Yellow panel or yellow signal word |
| *ANSI Style* | Correct | White text on red panel background |
| | | Black text on orange panel background |
| | | Black text on yellow panel background |
| | Reverse | Red text on white panel background |
| | | Orange text on black panel background |
| | | Yellow text on black panel background |
| *Panel Width* | Small | 1-inch (2.54cm) panel containing signal word |
| | Large | 1.5-inch (3.81cm) panel containing signal word |
| *Font Size* | Small | Signal word printed in 48 point font |
| | Large | Signal word printed in 60 point font |
| *Letter Case* | All capital | DANGER |
| | Mixed | Danger |

The main effects of signal word and question type were not significant, $F(1, 56) = 0.07$, $MSe = 33.48$, *ns* and $F(1, 56) = 2.70$, $MSe = 33.48$, *ns*, respectively. Also, no significant main effects for color or panel width were found, $F(2, 112) = .61$, $MSe = 8.88$, *ns*, and $F(1, 56) = 13.47$, $MSe = 2.32$, *ns*, respectively. The analysis revealed a main effect of font size, $F(1, 56) = 82.99$, $MSe = 4.70$, $p < .0003$, with participants rating warnings with signal words printed with the larger print size significantly higher ($M = 5.45$, $SD = 1.75$) than the smaller print size ($M = 4.96$, $SD = 1.73$). A significant main effect of letter case was found, $F(1, 56) = 102.94$, $MSe = 2.05$, $p < .0003$. Signal words printed in all capital letters were rated significantly higher ($M = 5.48$, $SD = 1.78$) than those printed in mixed case ($M = 4.93$, $SD = 1.69$). A significant main effect for ANSI print/background color style was also found, $F(1, 56) = 116.63$, $MSe = 4.70$, $p < .0003$. Warnings configured with the correct ANSI print/background color style ($M = 5.64$, $SD = 1.74$) were rated significantly higher than those with the reverse ANSI print/background color style ($M = 4.77$, $SD = 1.66$).

The analysis also revealed several significant interactions, with ANSI print/background color style variable being involved in all of them. Albeit there was no main effect for color found, there was a significant ANSI print/background color style x color interaction, $F(2, 112) = 21.77$, $MSe = 3.98$, $p < .0003$. Warnings configured with the correct ANSI print/background color style and the color red were rated significantly higher than all other ANSI print/background color style x color combinations (see Table 2). There was no significant difference between the correct ANSI-orange and correct ANSI-yellow configurations. The reverse ANSI-red was rated the lowest among these conditions.

ANSI print/background color style x font size showed a significant interaction, $F(1, 56) = 25.51$, $MSe = 1.16$, $p < .0003$, with warnings configured with the correct ANSI print/background color style and larger font rated significantly higher than all other ANSI-font combinations, as shown in Table 3. The mean rating for warnings configured with the reverse ANSI print/background color style and signal words printed in the small font was significantly lower than the remaining ANSI print/background color x font configurations.

A significant ANSI print/background color style x signal word x font size interaction was found, $F(1, 56) = 23.80$, $MSe = 1.16$, $p < .0003$, with "Danger" printed in the larger font size and correct ANSI print/background color style being rated significantly higher than all other combinations of these warning elements (see Table 4). Post hoc tests showed that the font x ANSI print/background color style interaction varied with the level of signal word. In terms of the correct ANSI print/background color style configurations, the small "Resvre" print received significantly higher ratings than the small "Danger" whereas the large "Danger" was rated significantly higher than the large "Resvre." The opposite pattern occurred when configured with the inverse ANSI print/background color style, the small "Danger" received higher ratings than the small "Resvre" whereas the mean rating for the large "Danger" was slightly lower than that of "Resvre" in large print, but these differences were not significant.

A significant ANSI print/background color style x color x case interaction was also revealed, $F(2, 112) = 8.86$, $MSe = 0.92$, $p < .0003$. Analyses showed that the ANSI x color interaction differed depending on the letter case. The mean rating for each ANSI x color configuration was higher for signal words printed in all capital letters than those printed in mixed case (see Table 5).

Table 2
*Mean Ratings for ANSI Style x Color*

| | *Color* | | |
|---|---|---|---|
| | Red | Orange | Yellow |
| Correct ANSI style | 6.02 | 5.44 | 5.45 |
| Reverse ANSI style | 4.49 | 5.05 | 4.77 |

Table 3
*Mean Ratings for ANSI Style x Font Size*

| | *Font Size* | |
|---|---|---|
| | Small | Large |
| Correct ANSI style | 5.50 | 5.75 |
| Reverse ANSI style | 4.43 | 5.11 |

Table 4
*Mean Rating for ANSI Style x Signal Word x Font*

| | Danger | | Resvre | |
|---|---|---|---|---|
| | *Small* | *Large* | *Small* | *Large* |
| Correct ANSI | 5.36 | 5.93 | 5.64 | 5.63 |
| Reverse ANSI | 4.53 | 5.11 | 4.32 | 5.11 |

An ANSI print/background color style x signal word x panel width interaction was found, $F(1, 56) = 16$, $MSe = 1.23$, $p < .0003$. Comparisons among the means revealed that signs configured with "Resvre," the correct ANSI print/background color style, and smaller panels were rated significantly higher than the same configuration with the signal word "Danger" (see Table 6). However, signs configured with "Danger," the

Table 5
*Mean Ratings for ANSI Style x Color x Case*

| | Red | | Orange | | Yellow | |
|---|---|---|---|---|---|---|
| | *Capital* | *Mix* | *Capital* | *Mix* | *Capital* | *Mix* |
| Correct ANSI | 6.15 | 5.89 | 5.83 | 5.05 | 5.76 | 5.17 |
| Reverse ANSI | 4.78 | 4.18 | 5.25 | 4.85 | 5.08 | 4.46 |

correct ANSI print/background color style, and large panels received significantly higher ratings than the corresponding nonsense signal word combination.

Also, a significant ANSI print/background color style x signal word x case interaction x panel width was found, $F(1, 56) = 17.39$, $MSe = .98$, $p < .0003$. Analyses showed that the ANSI print/background color x signal word x panel size interaction varied with the level of letter case. As Figure 1 illustrates, warnings configured with the correct ANSI print/background color style, large panels, and "Resvre" were rated higher than the same combination with small panels when the signal words were printed in all capital letters, but significantly lower when the signal words were printed in mixed case.

Table 6
*Mean Ratings for ANSI x Signal Word x Panel*

| | Danger | | Resvre | |
|---|---|---|---|---|
| | *Small* | *Large* | *Small* | *Large* |
| Correct ANSI | 5.35 | 5.94 | 5.71 | 5.56 |
| Reverse ANSI | 4.70 | 4.93 | 4.64 | 4.79 |

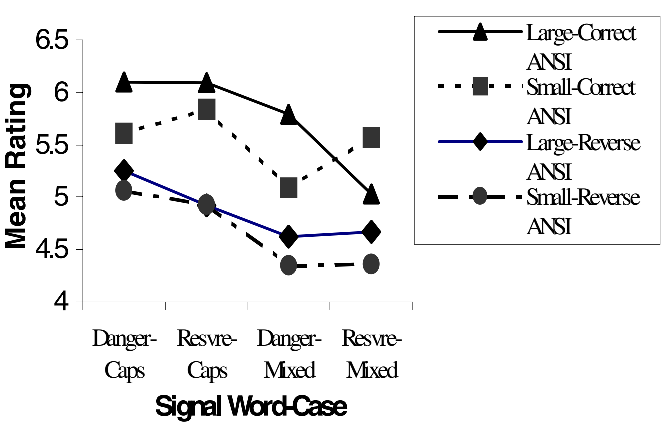


Figure 1. ANSI x signal word x panel size x case interaction

DISCUSSION

The present study examined the effects of systematically varied warning elements on connoted hazard and conspicuity. Many of the results confirmed the results of earlier research studies and published standards. Some of the different findings with respect to earlier research may be due to warning elements such as color frequently being examined in isolation rather than in the context of other components.

The ANSI print/background color style produced one of the most prevalent effects in the study. Not only was there a main effect of ANSI print/background color style, but all significant interactions involved this variable. Warnings configured with the correct ANSI print/background color style were rated significantly higher than those with the reverse ANSI print/background color style, confirming ANSI guidelines. However, the results failed to support other research on color (Braun & Silver, 1995; Wogalter et al., 1998). This "failure" should not be interpreted as an indication that color is not important, but that color must be examined in the context of other warning components rather than in isolation. The interaction between ANSI print/background color style and color supports this view. In accordance with existing research (Braun & Silver, 1995; Wogalter et al., 1998), ratings for the color red were higher than all other colors, but only when the warnings were configured with the correct ANSI print/background color style. On the other hand, ratings for signs consisting of the color red were significantly lower than other colors when configured with the reverse ANSI print/background color style.

The findings concerning ANSI print/background color style and color are important for two reasons. First, they confirm ANSI guidelines in terms of foreground and background color usage. Second, the findings indicate that including the color red in a warning does not alone connote greater hazard. It appears that the amount of red, or relevant ANSI color, in the panel is important. There is more color when it appears in the background than when it is printed in the foreground as the signal word. This reasoning also applies to findings regarding font size, panel width, and letter case. It appears that the quantity of color and/or warning components in the panel influences hazard perceptions. For example, the large font and/or signal words printed in all capital letters occupied a greater amount of panel space and were rated as connoting significantly greater hazard. In addition, the interactions involving panel width indicated that perceived hazard increased as the panel size increased, particularly when combined with signal words printed in all capital letters and large font. Larger panels occupy a greater proportion of the warning sign or label and, combined with a large font and all upper case letters may increase conspicuity, hence, perceived hazard.

Participants did not appear to differentiate between hazard and conspicuity when rating the signs as no main effects of this variable was found, and it did not interact with any other variable. Effects for question type may be absent because the level of hazard conveyed by a sign and its conspicuity are somehow related, or the variables selected for this study may have both hazard and salience qualities. In other words, signs that connote more hazard may be perceived as being more conspicuous, and vice versa. An alternative explanation is that participants may have unintentionally based their ratings on perceived hazard after being instructed to examine the signs, which made the signs "conspicuous." Thus, all of the warning stimuli are conspicuous in the rating task, so the dimension that differentiated them was hazard connotation.

Findings of this study confirm the importance of examining the effects of warning elements in the context of the entire warning sign, not in isolation. The evaluations of some warning elements vary depending on the level(s) of other elements present. These results indicate that warning designers should consider increasing the amount of color in the panel and/or space occupied by the signal word to convey greater degrees of hazard. It should be noted, however, that real messages were not included in the message panel, only a series of X's. Under certain circumstances, there may be a tradeoff between signal word panel size and message panel size. For instance, there may be cases in which a more detailed description of the hazard in the message panel is necessary to convey the hazard associated with the product of environment. This study did not investigate this, so further research will need to be conducted on this variable. There is still a need for the systematic examination of warning elements and their combinations. Knowledge about how the components in combination influence each other will allow more informed decisions on tradeoffs among the components. Other variables such as a different set of signal words, different color combinations, and print styles such as italics versus regular print need to be tested in order to gain a better understanding of the effectiveness of various warning configurations, hence, facilitate the design of better warnings.

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