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Effectiveness of Colors used on Safety and Health Signs for Communicating Severity of Injury

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Abstract. Signs are used extensively in workplaces and on products to identify hazards and provide instructions for appropriate behavior. A fundamental element of these signs is the signal-word panel located at the top of the sign. The colors and words in this panel are intended to convey information about the hazard identified. One type of hazard information concerns the severity of injury/illness associated with the hazard. The standard of the American National Standards Institute (ANSI) for facility signs uses three severity categories: 1) death or serious injury, 2) minor or moderate injury, and 3) property damage. The standard specifies which signal-word panel format, including color, to use based in part on the severity category. The purpose of this study was to determine if college students associate color with severity. The sample population consisted of 59 students tested in nine small groups. Twelve signs were shown to them in random order. Five of the signs had a color for the background of the signal-word panel. The colors were red, orange, yellow, blue, and gray. The signal word was a nonsense word and the text panel contained repetitions of the letter x in sentence format. Subject rated their impressions of the colors using two ordered rating scales for severity. Results indicated that color had a highly significant effect on severity ratings. Median ratings were generally consistent with the ANSI standard, except for orange. Red rated highest on both scales. Blue and gray rated lowest. Yellow and orange were in between red and blue. According to the ANSI standard, orange should indicate the same severity as red. These results indicated that orange was associated with less severity than red. Apparently, the ANSI standard's use of orange to identify a hazard associated with death or a serious injury is questionable.

INTRODUCTION

Whenever possible, workplace hazards should be eliminated through engineering and/or administrative controls. When such controls are not feasible, employees need a way of knowing what the hazard is and the extent to which the hazard exists. Training and safety signs are primary tools for conveying this information to employees.

The American National Standards Institute (ANSI) has a voluntary consensus standard for environmental and facility safety signs (ANSI 1998a). It is intended to standardize visual hazard communications in workplaces. The standard describes a consistent visual layout intended to achieve a

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national uniform system that will increase recognition and avoidance of hazards. A nationally recognized, standard format should also help minimize the propagation of unique safety sign designs.

The steps connecting a warning sign and human behavior were recently modeled by Wogalter, DeJoy, and Laughery (1999). According to the model, when someone encounters a safety sign for the first time, they must notice the sign, pay attention to it, understand the intended message, believe the message, be motivated to perform safely, and finally behave according to the instructions on the sign. Research to examine this connection between signs and behavior is quite difficult due to the stepwise connection listed above. This project addresses particular features that are thought to affect the step of understanding the intended message.

The standard for facility signs (ANSI 1998a) uses three severity categories: 1) death or serious injury, 2) minor or moderate injury, and 3) property damage. The standard specifies the background color of the signal-word panel based, in part, on the severity category. Red or orange is specified for a hazard associated with death or serious injury. Yellow is for a hazard associated with moderate or minor injury, and property damage. Blue is for a sign conveying safety policy information. Gray is not included in the ANSI standard. For a more complete analysis of the scheme for determining the signal-word panel, see the Jensen (2001) paper in last year's ISOES Conference Proceedings.

This study was undertaken to determine if college students intuitively understand the intended meaning of certain features of workplace safety signs. The feature reported in this paper is the color used in the signal-word panel. The experiment examined the effect of color on ratings of injury severity.

METHODS

Subjects and Materials

In all, 59 undergraduates from Montana Tech of The University of Montana participated in this study. The students each received ten dollars for their participation. Of the students, 52.5 percent were male (31), and 47.5 percent were female (28). Students were selected by sending out a campus wide email to all professors. This email contained information about the experiment and asked the professor that if they planned to cancel a class within the next two weeks, they might be interested in having their students participate in this study. Five professors responded to the email, offering seven classes for participation. The students were told by their professors that they were to come to class like normal, but a graduate student would be conducting an experiment. Students were also informed that they would receive ten dollars for their participation.

Twelve workplace safety signs were constructed. Five of the signs had a color for the background of the signal-word panel. The colors were red, orange, yellow, blue, and gray. Each signal-word panel contained the nonsense word RESVRE as shown in Figure 1. This nonsense word was used in a very significant prior study by Wogalter et al. (1998). Signs were developed on computer using Maxisoft software and then printed on 8.5 by 11 inch photograph quality paper. Colors were compared with standard safety colors using sheets obtained from GretagMacbeth, a supplier of specialty color papers, to assure the sign colors conformed to the ANSI standard for safety colors (ANSI 1998b). The message panels of all signs consisted of black lettering on a white background to comply with the ANSI standard. X's were used in the message panel to make the sign look more like a sign one would encounter in a workplace setting while not containing a word message that might detract from the focus of the study.

Procedures

Subjects were briefed on the experiment and they signed an informed consent before continuing. They were then provided with an answer booklet and the experiment commenced. Students first read a paragraph restating the instructions and answered three questions about age, gender, and if they had been trained in how to interpret workplace safety signs. Signs were then shown in a predetermined random order at 45-second intervals. Students viewed a sign and then rated it on three scales presented on a page. This procedure was repeated for all five colored signs. Then each sign was displayed again and subjects rated it on three other rating scales on a page. Thus, each sign was rated on six scales. Ratings from the two severity scales are reported in this paper. The severity scales were on different pages of the answer booklet.

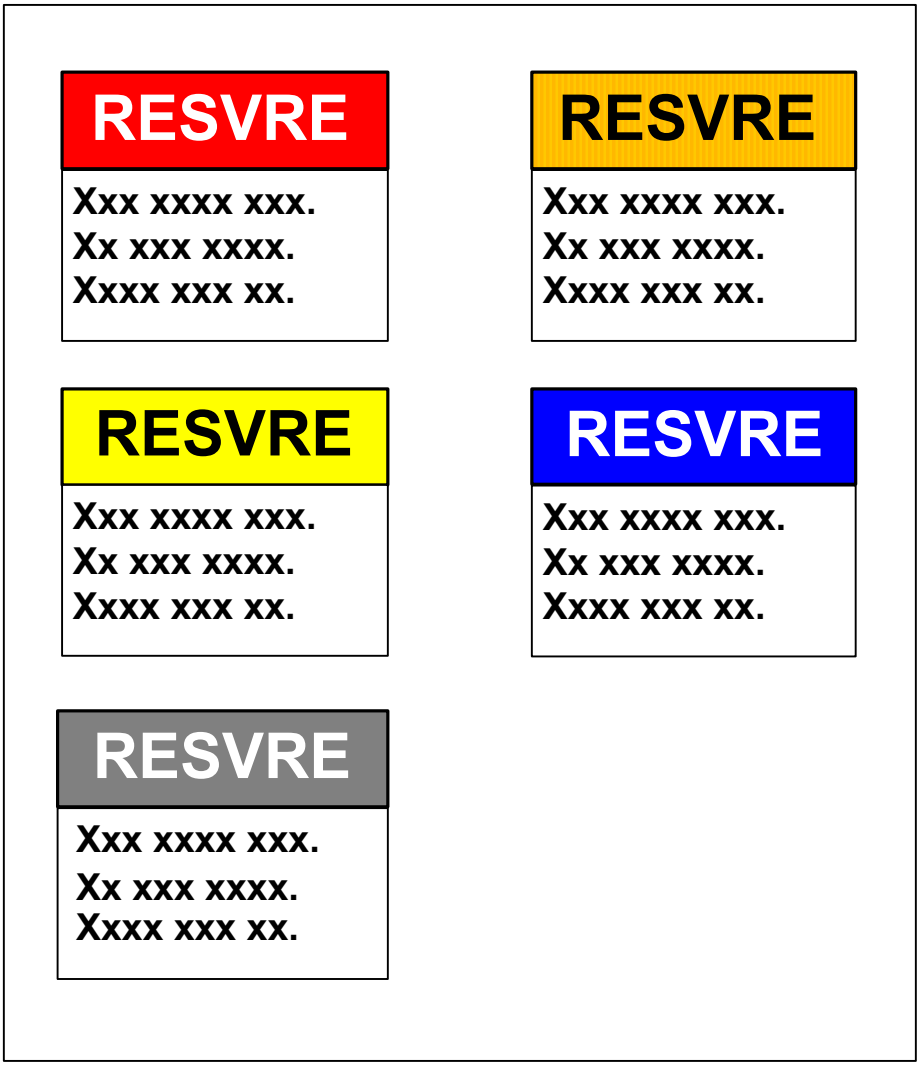

Figure 1: Colored signs used in this study. (Left column; red, yellow, and gray; Right column: orange and blue)

Rating Scales

One severity scale was constructed from the ANSI severity categories used to determine color: 1) death or serious injury, 2) moderate or minor injury, and 3) property damage. The rating scale used for this consisted of the following question and ordered categorical responses -- "This style of sign seems appropriate for a hazard that will cause:

- Property damage
- Minor injury
- Moderate injury
- Serious injury
- Death"

The second severity scale was adapted from a prior study (Silver and Wogalter, 1989). It consisted of the following question and ordered categorical response choices -- "This style of sign seems appropriate for a hazard that will cause:

- Not severe
- Slightly severe injury
- Severe injury
- Very severe injury
- Extremely severe injury"

Analysis

Responses were assigned numerical values for data analysis. A zero was used for the least severe category, with other category values increasing by one as severity increased. Minitab (Minitab Inc., 1998) was used to assess and analyze all data. Statistics performed on the data included the Friedman Test and basic descriptive statistics. Another statistical package called SigmaStat (Jandel Scientific 1995) was used to perform the Student-Neuman-Keuls Tests to determine significance of differences among treatments.

RESULTS

Results of the Friedman Test indicated a highly significant effect of color on each severity rating scale. For the first scale (ANSI severity), the Friedman Test Statistic was 134 with a P-value of 0.00. For the second scale, the Friedman Test Statistic was 161 with a P-value of 0.00. The Student-Neuman-Keuls test found that all colors were significantly different from all other colors except blue and gray on the first (ANSI) severity scale.

Tables 1 and 2 show the median (always a whole number) and the estimated median provided in the Minitab output for each color. Table 1 is for the first (ANSI) rating scale. Table 2 is for the second rating scale.

Table 1: Median ratings for first severity scale by color

Color	Median	Estimated Median
Red	3	3.0
Orange	2	1.4
Yellow	2	2.0
Blue	1	0.4
Gray	0	0.2

Table 2: Median ratings for second severity scale by color

Color	Median	Estimated Median
Red	3	3.0
Orange	1	1.0
Yellow	2	1.8
Blue	0	0.2
Gray	0	0.6

DISCUSSION AND CONCLUSIONS

Results of the first severity rating scale (Table 1) indicate that red was associated with a serious injury. Yellow was associated with moderate injury. Orange ratings were in the moderate to minor injury range. Blue was associated with property damage or minor injury. Gray was clearly rated in the lowest severity category. Regrettably, there was no category for absence of harm, so one cannot tell if gray was actually associated with property damage or with an even less severe level such as absence of harm. The rating for orange was clearly inconsistent with the ANSI standard. According to the ANSI standard, orange should convey the same severity message as red. These findings show orange rated significantly lower than red. Furthermore, orange even rated lower than yellow -- a finding also inconsistent with the ANSI standard.

Results of the second severity rating scale (Table 2) indicate that red was associated with a very severe injury. Yellow was associated with a severe injury. Orange was associated with a slightly severe injury. Blue and gray ratings were between not severe and slightly severe injury. The order of ratings for color was consistent with the ANSI standard except for orange. According to ANSI, orange should rate as high as red and higher than yellow. These findings indicate that orange rates significantly lower that red, and lower than yellow. Thus, orange is clearly out of order.

Both rating scales indicated that orange differed from red in the minds of this sample of college students. This is inconsistent with the ANSI standard. However, because color was isolated as a sign feature, the findings do not extend to the combination of color and signal word. In other words, the word DANGER on a red background may or may not convey the same information about severity as the word WARNING on an orange background. This is just one of the many research issues that should be addressed in future studies.

It would be useful to compare findings from these college students with a sample of working adults. A prior study comparing sign ratings by college students with those of people from the community and industry found far more similarities than differences (Wogalter et al., 1998). However, there are still concerns, particularly in the legal community, about how representative college students are of the employed workforce. Therefore, a comparative study is recommended.

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