

# 18 Use of color in warnings

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## Introduction

Warnings are risk communications used to inform people about hazards and to provide instructions so as to avoid or minimize undesirable consequences such as death, injury, or property damage. Warnings are used in a variety of contexts for numerous kinds of potential hazards. For example, a product warning might be used to inform about the electrocution hazard associated with using a carpet-cleaning machine, whereas a sign warning might be used to advise people to stay out of an electrical-transformer box. Color is usually advocated for use in warnings for the purposes of attracting attention and conveying a sense of hazard. This chapter is a review of the literature on color as it relates to warnings.

Because there has been extensive research on color in a variety of domains, this chapter limits its focus to warnings associated with products, equipment, and environments. Although a few studies will be mentioned that were done in the context of traffic research, for the most part this chapter does not attempt to cover transportation safety. Another related area that is not covered is color research pertaining to radar and computer displays. There has been substantial human factors research on this topic since World War II, and the issues are well covered by Christ (1975) and others (Cardosi and Hannon, 1999; Remington et al., 2000).

### Warnings as a method of hazard control

Warnings are one of the three main methods used to control hazards in products and environments.

The two other methods are designing out and guarding against hazards to prevent them from adversely influencing people and property. In these two methods, the hazards are eliminated, reduced, or positioned so people cannot be hurt or property damaged. Examples include removing a toxic chemical from a cleaning product to make it a nontoxic one, or putting a barrier (e.g., a locked door) between high-voltage equipment and people. But some hazards cannot be completely eliminated by design, and sometimes guarding is incomplete. One example is powered lawnmowers, which possess sharp spinning blades that can potentially cut something other than grass. The intended purpose of the product is desirable and beneficial, yet it possesses hazards. In modern lawnmowers, attempts have been made to design out or reduce hazards or to guard against them. A cowl cover over the spinning blades prevents most types of bodily contact. A "dead man's" switch stops the rotor from spinning when the operator's hands are released from the handle. Moreover, the placement of the handle in relation to the spinning blades and motor acts to position users away from the spinning blades (i.e., guarding by distance).

Designing out and guarding strategies are generally recognized as the best ways to control hazards in products and environments (Sanders and McCormick, 1993). Warnings are used when hazards have not been completely designed out or guarded against; in other words, they deal with residual hazards. Given their third place position in hazard control or as the strategy of "last resort," it becomes clear that warnings are



Figure 18.1 US CPSC-mandated power lawnmower warning.

important. Warnings that do not do their job in hazard control may result in people being harmed and property being damaged.

Warnings have multiple purposes. The most obvious purpose has already been mentioned: prevention of injury and property damage. Warnings serve to communicate hazard information to persons at risk. This purpose reflects the fundamental right that people be given informed consent when placed in risky conditions. While lawnmowers have many aspects of design and guarding to control hazards, the hazard of sharp blades coming into contact with operators and others remains. A warning for this residual hazard is necessary. Almost all adults know that lawnmowers with spinning blades can cause severe injury if used improperly. So why is a warning needed? Despite people knowing about the hazard, their body parts still get amputated by lawnmowers. Relevant information is not always in cognitive awareness. Warnings in this case serve as a reminder, or a cue, to bring forth the latent knowledge (in long-term memory) to awareness (into working memory) when and

where it is needed. Indeed, the US Consumer Product Safety Commission (CPSC) required a warning, shown in Figure 18.1, to be attached on all powered walk-behind lawnmowers.

What type of information is generally necessary to make an adequate warning? Empirical research (e.g., Wogalter et al., 1987), standards (e.g., American National Standards Institute (ANSI) Z535 series, 2012), and guidelines (e.g., FMC, 1985; Westinghouse, 1981) suggest that visual warnings should have certain basic components. These include (1) a signal word panel (described below), (2) a statement of the nature of the hazard, (3) the consequences if the hazard is not avoided, and (4) instructions on what to do or not do to avoid the hazard and consequences. The signal word panel is comprised of a signal word, usually DANGER, WARNING, or CAUTION along with a predominant color, usually red, orange, and yellow, together with an alert symbol (an upright triangle surrounding an exclamation point). Not every warning needs to include all of these message components (Wogalter et al., 1987). Some of the information can be combined

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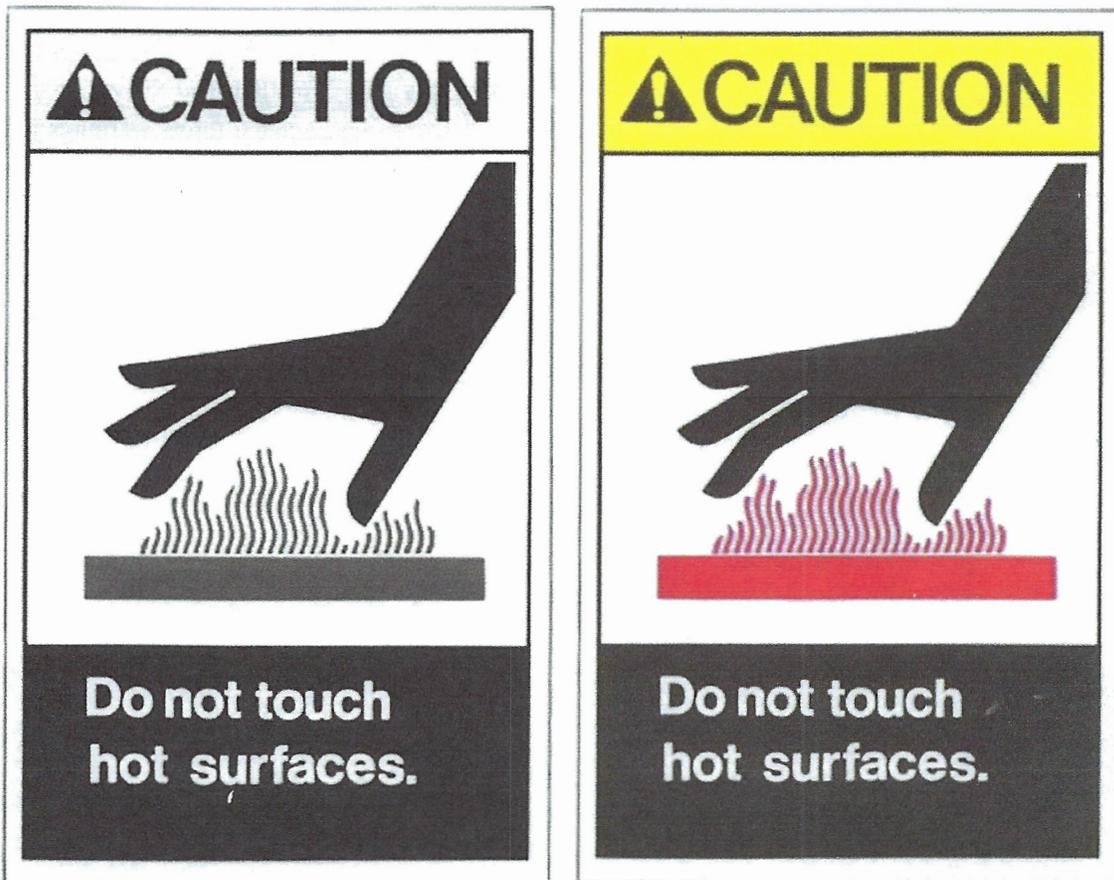


Figure 18.2 ANSI-style “hot surface” warning: (a) without and (b) with color.

or cued by other information in the warning (e.g., a slippery floor sign might not have to state explicitly the consequence of falling). Part of the message may be given by pictorial symbol(s). Generally, all components should be considered in warning designs unless there is reason to believe that virtually everyone knows the absent information.

According to the ANSI Z535 standard, color plays a prominent role in the design of warnings located on product labels and environmental safety signs. One part of the standard (ANSI Z535.1) has specific color specifications (based on Munsell HVC and CIE 1931 xyY illuminant C coordinates) and Pantone equivalents for safety labels, signs, and tags. Other parts of the standard concern product labels (ANSI Z535.4) and

environmental safety signs (ANSI Z535.2). An exemplar ANSI-style sign is shown on the right panel of Figure 18.2. Note the pervasive difference by adding color from the black and white (grayscale) in 18.2a to color in 18.2b.

The ANSI standard and other guidelines use a colored signal word panel that comprises a relatively large portion of the warning (around 20–30%), indicating that it holds considerable importance. Figure 18.3 illustrates the red, orange, and yellow signal word panels for DANGER, WARNING, and CAUTION. The lettering itself is white or black and the background is colored. DANGER is printed in white with a red background, whereas WARNING and CAUTION are printed in black with an orange or yellow background, respectively. The panel also



**Figure 18.3** Three ANSI color-signal word panels (red, orange, yellow).

includes the safety alert symbol (signal icon). Traditionally, the alert symbol has been black and white; however, in recent years, due to efforts to harmonize international standards such as ISO (International Organization for Standardization) with the ANSI standards, yellow is increasingly being used to fill the triangle surrounding the exclamation point.

The ANSI signal word panels are intended to have different meanings in terms of severity and probability of the hazard:

- The red DANGER panel is intended to indicate a hazardous situation that, if not avoided, will result in death or serious injury (immediate and grave danger).
- The orange WARNING panel is intended to indicate a hazardous situation that, if not avoided, could result in death or serious injury.
- The yellow CAUTION panel indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

There is no signal word/color combination that signifies a minor injury *will* result, if not avoided.

ISO also suggests that warnings convey three levels of hazard (ISO 3864, 2011).

The US Department of Homeland Security (DHS) initially, after being formed following the 9/11 attacks, had a color-coded threat system

similar to the ANSI Z535. Red was used to denote the highest level of threat followed by orange and yellow (Mayhorn, Wogalter, and Shaver, 2004). This system of color-coded threat warnings has since been discontinued. A similar system has been used by the US Environmental Protection Agency as the Air Quality Index that ranges from “Good” colored green to “Unhealthy” colored red to indicate health risks associated with breathing pollutants in the air. The US National Weather Service also has color-coded warnings to communicate severe weather. For example, “Severe Thunderstorm Warnings” are color-coded in orange.

For many years, the US Occupational Safety and Health Administration’s (OSHA) Hazard Communication (29 CFR 1910.1200) regulations for employee workplace safety had just two levels for DANGER (red) and CAUTION (yellow), but now accepts and adopts ANSI Z535’s three levels, adding WARNING (orange) (Cheatham, Shaver, and Wogalter, 2003).

Color is used to demark a variety of safety, health, and emergency equipment and procedures. Red is used for fire protection and emergency stops (William, 2001). Orange is used in traffic/highway signs and in marking dangerous parts of equipment such as areas that can cut, shock, or otherwise injure. Yellow is used for marking hazards on curbs, pedestrian walkways, and traffic-bumps/humps. Other colors are used in other hazard-related applications. Purple is used to indicate radiation. Blue is used in the railroad industry in warnings about not starting, using, or moving equipment while it is being repaired. Green is sometimes used to indicate first-aid equipment (William, 2001) and increasingly in exit signs.

While some parts of the standards, guidelines, and regulations have held up quite well in terms of empirical investigation, some have not. This chapter reviews the research findings that do (e.g., red connoting the highest hazard) and do not (e.g., orange connoting a higher level of

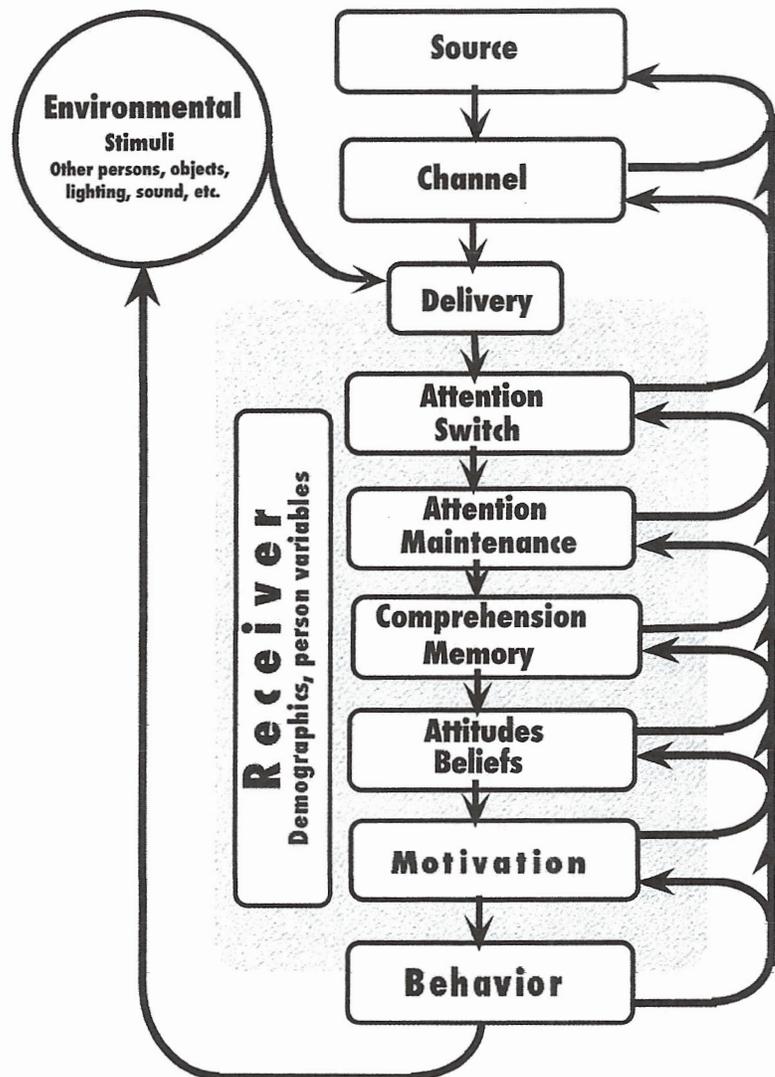


Figure 18.4 Communication-human information processing (C-HIP) model.

hazard than yellow) comport to standards, guidelines, and regulations.

### Communication-human information processing (C-HIP) model

A framework that has been successfully applied to warning processing is the communication-human information processing (C-HIP) model (see Wogalter, 2006). This model assists in understanding how users process warnings and in understanding how a warning might fail. As depicted in Figure 18.4, C-HIP has two main

sections, each with several component stages. The first section of the framework uses a basic communications framework to focus on a warning message being sent from one entity (i.e., the source) to another (i.e., the receiver) through some channel(s). The second section of the model focuses on the receiver and how people internally process information. This portion of the model interfaces with the first through effective delivery of the warning to targeted individuals. If not blocked or prevented in some way at one of the stages, processing will continue across

several stages: attention switch, attention maintenance, comprehension and memory, beliefs and attitudes, and motivation, and it possibly ends in compliance behavior with respect to the warning.

We will use the C-HIP model as an organizing framework to discuss the effects of color in warnings. In general, this chapter reviews two major ways color is influential in warning processing. Initially discussed is research concerning color as an aid to hazard comprehension. Later, research is described that shows that color aids in shifting attention to warnings.

### Hazard comprehension: meaning conveyed by color

This section concerns hazard connotations conveyed by color. According to the C-HIP model, users extract meaning at both the comprehension and beliefs stages. The question here is what do people get from seeing a particular color in terms of hazard? Numerous studies have examined the hazard association values of basic colors.

In one experiment, Griffith and Leonard (1997) had participants make ratings (using a set of bipolar semantic differential scales related to the factors of evaluation, potency, and activity). Using these measures, they found high to low color ratings ordered as: red, green, orange, black, white, blue, and yellow. Griffith and Leonard

(1997) did several follow-up experiments. The first experiment found high to low ratings of perceived risk to colors ordered as red, orange, black, yellow, green, blue, and white. The second experiment found a somewhat different ordering of risk: red, black, yellow, orange, green, and blue. In a third experiment, Griffith and Leonard (1997) found the high to low ratings to be ordered as red, yellow, black, orange, blue, and green.

Wogalter, Kalsher, Frederick, Magurno, and Brewster (1998) conducted several experiments with different groups of participants who rated individual colors on the amount of hazardousness conveyed (with a rating of 0 indicating low hazard and an 8 indicating high hazard). Table 18.1 shows the results from undergraduate students, a group of adult community volunteers, and a group of industrial manufacturing workers. Note the similarity of ratings between the groups. Red is rated the highest, followed by a group of three colors (yellow, orange, and black), followed by the remaining colors. Consistent with most studies, red is rated highest followed by yellow, orange, and black, although the ordering of this second-tier group of colors changes across different studies.

### Cross-cultural differences in hazard and color perception

Several studies have looked at cross-cultural perceptions of hazard conveyed by color. Dunlap,

Table 18.1 *Mean hazard-perception ratings for three groups of participants. Higher numbers indicate higher ratings of hazard*

	Undergraduates	Community volunteers	Industrial manufacturing workers
Red	3.2	3.1	3.5
Yellow	2.2	2.2	2.1
Orange	2.0	1.9	1.5
Black	2.0	1.5	1.8
Purple	1.1	0.4	0.8
Green	0.8	0.6	0.7
Blue	0.8	0.6	0.9
White	1.0	0.2	0.3

Table 18.2 Mean (M) hazard ratings and standard deviations (SD) for colors by English and Spanish language users

English	M	SD	Spanish	M	SD
Red	7.02	1.61	Red	6.65	1.77
Yellow	5.06	2.62	Orange	4.27	2.48
Black	4.96	2.70	Black	4.17	2.68
Orange	3.30	2.58	Yellow	4.12	2.39
Magenta	2.49	2.49	Green	3.17	2.50
Blue	2.35	2.30	Magenta	2.85	2.30
Brown	2.26	2.22	Blue	2.83	2.41
Green	2.23	2.10	Brown	2.62	2.37
White	2.02	2.66	Gray	2.60	2.35
Gray	1.91	1.79	White	2.35	2.22

Granda, and Kustas (1996) asked 1,169 participants across several different language groups (including English, German, Scandinavian, and Spanish) to rate the color words (not the actual colors) according to perceived hazard. The results showed a consistent pattern of the color names across language groups. The term *red* resulted in the highest hazard ratings followed by *orange*, *yellow*, *blue*, *green*, and *white*, respectively.

Borade, Bansod, and Gandhewar (2008) asked 50 industrial workers in India to rate the level of hazard communicated by seven colors. Results indicated that these Indian workers rated red as connoting the highest level of hazard followed by orange, yellow, black, blue, green, and white. In both studies, the term *red* resulted in the highest hazard ratings followed by *orange*, *yellow*, *blue*, *green*, and *white*, respectively.

Using English-speakers, Smith-Jackson and Wogalter (2000) evaluated 10 safety colors from the ANSI Z535.1 safety color standard. The colors were red, yellow, black, orange, magenta, blue, brown, green, white, and gray. Colors cut from the actual ANSI standard were rated on an 8-point scale of perceived hazard. The results are shown in Table 18.2. Also included in this table are the results from Wogalter, Frederick, Herrera and Magurno (1997), who used the same stimuli and procedure as Smith-Jackson and Wogalter

(2000) but examined the hazard perceptions of Spanish language users living in the USA who spoke little or no English. Both studies showed that red was rated the highest hazard color followed by a grouping of three colors of yellow, black, and orange, which in turn were followed by the remaining six colors.

Although it has been posited in the warning literature that red may have little or no hazard connotation in certain cultures and countries, data on this are either sparse or non-existent. Luximon, Chung, and Goonetilleke (2008) investigated how 88 Hong Kong Chinese rated the degree of hazard posed by different colors. Results suggested that while Chinese rated red as having the highest level of hazard, there was a difference in the interpretation of the colors orange and yellow between Asian and Western cultures. Even with this difference, the results across the existing studies investigating color and hazard perception cross-culturally have been relatively consistent, particularly for the color red. This is fortunate because many countries have adopted Western signage to accommodate international visitors. For example, the octagon-shaped, red stop sign has become universal; even the English word STOP is used in some non-English-speaking locales across the world.

Further support that red indicates an intrinsic heightened level of hazard comes from two experiments using native French-speakers by Pravossoudovitch, Cury, Young, and Elliot (2014). In one experiment, participants indicated whether red-, green-, or gray-colored words were danger-related (e.g., emergency, threat) or safety-related (e.g., shelter, refuge). The reaction time data indicated that participants were significantly faster at identifying danger-related words when they were presented in red. Interestingly, analysis of error data revealed that the most mistakes were made when danger words were presented in green color. In a second experiment, Pravossoudovitch et al. used symbols rather than words to assess whether red, green, or gray color affected people's categorization of danger- and safety-related concepts. Consistent with the results from their first experiment, participants were significantly faster at categorizing danger-related symbols colored red. Moreover, non-danger-related symbols were categorized as danger-related when they were presented in red. The findings indicate a strong a red–danger association across multiple tasks.

Collectively, these findings indicate that red is associated with the highest level of perceived risk, whereas the ratings of risk for the other colors are lower and vary from study to study. Although there are a few cross-cultural studies and the results thus far are fortunately reasonably consistent, there might be differences in yet untested cultural groups. Further assessment in this regard is important in making warnings better to reach more people inclusively (Mayhorn, Wogalter, Goldsworthy, and McDougald, 2013).

### Color with signal words

A large body of research has examined colors in conjunction with signal words. Most research has examined three main hazard-related signal words in conjunction with the colors specified in the previously mentioned standards and guidelines. Additionally, research has also explored

the connotation of other words such as DEADLY, URGENT, ATTENTION, and NOTICE. Likewise, a few studies have examined a larger set of colors than the three main colors.

One set of studies examined whether signal words with and without color differ on perceived hazard. In these studies, participants rated individual components of or entire warnings on scales such as perceived hazard, urgency, intended carefulness, cautiousness, and compliance intent. As will be seen in the descriptions of studies that follow, regardless of the specific dimensions, scale points, and anchors, the findings are relatively consistent.

Initial work conducted by Bresnahan and Bryk (1975) compared chromatic signal word panels and graphics with achromatic (i.e., black and white) versions of these stimuli on perceived hazard. DANGER and CAUTION were presented within colored signal word panels (red and yellow, respectively) and their results showed that colored panels connote a higher level of hazard than the words printed achromatically. These findings in turn were consistent with research conducted by Kline, Braun, Peterson, and Silver (1993), who studied four classes of products (i.e., general-purpose cleaners, bathroom cleaners, adhesives, and automotive merchandise) in combination with three main signal words (DANGER, WARNING, and CAUTION) that were presented in color or achromatically, creating a total of 24 separate stimuli. Results indicated that colored warning stimuli were rated higher in hazard connotation and were perceived as more readable than those presented in black and white.

As mentioned earlier, studies like Bresnahan and Bryk's (1975) compared colored signal word panels with non-colored ones and found that having color increased their rated hazard value. However, this early study did not examine whether the colors were appropriately matched to signal words as found in standards and guidelines.

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Most of the research involving color and signal words examined whether people's perceptions correlate with the rules espoused in standards and guidelines. Chapanis (1994) found that red, orange, yellow, and white were perceived as being associated with high to lower hazard, respectively. With respect to signal words and color, greatest consistency and heightened perceived hazard was found for DANGER with a red background. However, there was little agreement about what colors were best associated with WARNING and CAUTION, as the results showed that both were equally associated with yellow and orange.

Griffith and Leonard (1997) asked participants what color came to mind when a set of words were read to them and compared these results to the specifications given in standards and guidelines. Participants presented with the signal word DANGER produced the response "red" 77% of the time. The term CAUTION received the response yellow 48% of the time. However, WARNING produced orange 5% of the time and NOTICE (a non-hazard-related signal word) produced blue 8% of the time. Thus the DANGER-red association in standards and guidelines is strong but the other term-color pairings are not consistent with the specifications in standards and guidelines. In another experiment by Griffith and Leonard (1997), participants generated the greatest number of signal words for red than any other color. The greatest association to red was to the signal word DANGER and the greatest association to yellow was to the signal word CAUTION. For orange, the signal words WARNING and CAUTION were tied, with each being reported 43% of the time. Using a different procedure, Griffith and Leonard (1997) asked participants to give colors and signal words that were associated with eight hazard scenarios. He found that the colors red, yellow, and black were the most common words assigned to the hazard scenarios. Again, consistent with other research was the finding that red is associated with the highest level of perceived hazard and with the signal word DANGER. The mapping of

colors to other signal words such as WARNING and CAUTION as specified in standards and guidelines was less consistent.

### Color in warning graphics

Some studies have examined whether warnings with colored graphics are rated higher in hazard (and other related measures) than achromatic warnings. Bresnahan (1985) found that certain graphics and shapes (circle or circle-slash – i.e., prohibition or negation) in red produced higher hazard ratings than those that were in black. Williams, Kalsher, Maru, and Wogalter (2000) also found that colored symbols were rated more effective than black and white symbols. More recently, McDougald and Wogalter (2014) found that highlighting portions of safety pictorials at relevant places benefited comprehension performance relative to no or irrelevant highlighting.

### Colored containers and labels

Some investigators have examined whether color can be applied differently than simply as part of warnings to communicate the hazard level involved. The effect of color on bottle containers has been examined. Serig (2000) found that hazard ratings for red containers in various shapes were higher than white containers. The yellow container was rated at a hazard level that was intermediate between the other two.

Wogalter, Magurno, Dietrich, and Scott (1999) manipulated the background colors of labels on easy-open caps of pill bottles. There were six bottle label conditions. Four had labels attached to the cap differing only in color along with two different no-cap label control conditions. In one experiment, older adults (mean age = 75) rank ordered six differently labeled and colored containers for an actual over-the-counter (OTC) product on six dimensions (e.g., label noticeability, willingness to read). The results showed greater preference for containers with cap labels regardless of color. In a second experiment, information-acquisition performance was measured after older participants (mean age = 79 years) were exposed

to the labels briefly. The results showed that there was greater knowledge and preference for containers with the cap labels. Also, the yellow cap was preferred over the orange and white caps (orange and white were the predominate colors as the rest of the labeling). Color distinctiveness was also entertained as a reason for the benefit of yellow, but this explanation was not fully supported because ratings of the green cap (a distinctive color) were not higher than the other cap conditions.

**Multicolor warnings**

Most studies discussed thus far have examined ratings of individual hazard colors, but a few studies have examined combinations of more than one color. Although not all color combinations were studied by Wogalter et al. (1998), some fairly common color combinations shown in rectangular bars were tested (e.g., black and yellow). This study involved multiple manipulations that were not orthogonal, and thus the findings are complex. Several points can be taken from the pattern of means shown in Table 18.3 from Wogalter et al. (1998). First, if red is one of the combination of colors, then the bar is rated highly. Second, yellow and black are rated highly in connoted hazard, and the combination of orange and black tends to be lower. Third, black and white (achromatic) is rated lowest. Wogalter et al. (1998) also had participants rate a variety of combinations of colored signal words and shape configurations. Because of the numerous

experiments included in Wogalter et al. (1998), we cannot discuss all of the results in this chapter. Readers interested in manipulations of color and shape (and signal word) and in their combinations on hazard perception should consult this work. A portion of the findings is also described in Wogalter et al. (1995).

Another kind of graphics-related manipulation was done by Rashid and Wogalter (1997), who examined different kinds of rectangular borders around warning signs that were manipulated in terms of different colors (comprising one or two colors), varied thicknesses, and local shape/configuration (solid, inward pointing arrows, jagged, diagonal). The five highest rated borders were black and red stripes, black and yellow stripes, red sawtooth, red inward arrows, and black and yellow inward arrows. Table 18.4 shows the ratings of the five colors tested, collapsed across the border conditions. In this analysis, colors were ordered in perceived hazard (high to low ratings): red, yellow, green, blue, and black.

**Mismatch between signal word and color**

Edworthy and Austin (1996) discuss the need to map or match the connoted urgency of a warning to the appropriate level of hazard. Some of the reasons include the reduction of uncertainty about hazards, reduction of delays in acting on more urgent hazards, and avoidance of habituation over time. Another aspect of color-hazard mapping

Table 18.3 Mean hazard ratings for multicolor bars

	Undergraduates	Community volunteers	Industrial manufacturing workers
Black/yellow	2.3	2.2	2.3
Black/red/white	2.0	2.2	2.3
Red/white	1.9	2.2	2.4
Black/orange	2.0	1.9	1.5
Black/white/red	1.7	2.1	2.1
Black/white	1.2	1.6	1.2

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Table 18.4 likelihood perception

- Red
- Yellow
- Green
- Blue
- Black

Table 18.5 Signal word

- Deadly
- Poisonous
- Lethal
- Fatal
- Danger
- Harmful
- Hazardous
- Warning
- Caution
- Critical
- Beware
- Stop
- Careful
- Attention
- Notice
- Important
- Prevent
- Reminder
- Directions
- Needed
- Information
- Mean

research is noted by Pravossoudovitch et al. (2014) on what happens when there is a mismatch of color to signal words, such as danger-related words presented in green and non-danger symbols presented in red. Their findings indicate that participants' word and symbol categorizations are affected by color.

Table 18.4 *Mean ratings of attention attraction, likelihood of reading warning, and hazard perception for colors*

	Attention	Read	Hazard
Red	4.68	5.16	5.64
Yellow	3.95	4.25	4.19
Green	3.97	4.19	4.00
Blue	3.86	4.14	3.56
Black	2.97	3.68	3.81

The mismatch issue is further elucidated by Braun, Silver, and colleagues, who conducted several studies showing an interaction of color and signal word. For example, Braun, Sansing, Kennedy, and Silver (1994) used 21 signal words that were selected from a study by Wogalter and Silver (1990) and divided them into high-, moderate-, and low-hazard words. Each of the terms was printed in red, orange, green, and blue lettering on a white background. The control was printed in black, making a total of 105 word/color combinations. Participants were asked to rate the stimuli on a 9-point scale from 0 representing not at all hazardous to 8 representing extremely hazardous. The main results are illustrated in Table 18.5. It can be seen that the hazard conveyed by a signal word is affected by its color. WARNING in orange conveys about the

Table 18.5 *Mean hazard ratings for signal word and color combinations*

Signal word	Red	Orange	Green	Blue	Black
Deadly	7.47	6.77	5.43	5.27	6.30
Poisonous	7.03	6.47	5.17	5.27	5.63
Lethal	7.03	6.43	5.43	5.00	5.67
Fatal	6.93	6.50	5.47	5.53	5.97
Danger	6.90	6.43	4.67	4.43	5.00
Harmful	6.67	5.53	4.20	4.23	4.37
Hazardous	6.27	5.73	4.40	3.90	4.27
Warning	6.23	5.50	3.77	3.63	4.23
Caution	6.17	5.03	3.00	3.43	3.53
Critical	5.70	4.40	3.77	3.00	3.63
Beware	5.53	5.13	3.57	3.53	3.73
Stop	5.13	4.20	2.70	2.30	3.17
Careful	4.60	3.47	2.43	2.10	3.07
Attention	4.43	3.53	2.37	1.50	2.20
Notice	4.33	3.17	1.80	1.63	1.90
Important	4.23	3.93	2.50	1.63	2.27
Prevent	4.13	3.57	2.53	1.77	2.67
Reminder	3.70	2.63	1.67	1.50	1.70
Directions	3.07	1.97	0.80	0.97	1.17
Needed	2.97	2.40	1.67	1.23	1.40
Information	2.93	2.80	1.60	1.03	1.47
<i>Mean</i>	5.31	4.55	3.28	2.99	3.49

same level of hazard as FATAL in green. DEADLY in red, which was the highest, was much higher than DEADLY in green or blue. This study indicates that it is possible to adjust hazard value by simultaneously manipulating the signal word and the associated color.

Another study by deTurck, Goldhaber, and Richetto (1991) has shown an interaction of color and associated text, but, this time, using phrases and not signal words. They showed alcohol-warning statements that differed in the amount of “fear” they produced from low fear (e.g., “may be hazardous to your health”) to moderate fear (“may cause fetal alcohol syndrome in your baby”). They found that when the higher (in this case, moderate) fear statements were paired with the color red, they were rated as more hazardous. However, when red was paired with a low-fear phrase, it was rated lower. They suggest that colors and phrases can bolster hazard connotation if paired in a consistent message but may reduce it if paired inconsistently (e.g., green with higher-fear messages).

Warnings are likely to be more effective when correctly matched with the hazard than warnings that take a less concordant approach. The mixing of different cues conveying the extent of the hazard such as color and signal word could provide a more precise way to match a warning to a hazard. Additional research is needed to determine the utility of using multiple cues, which cues are more important, how many levels of hazards can be usefully given, and whether there is a breakdown leading to confusion when cues are discordant.

### Discussion about inconsistent findings

Red is consistently rated as having the highest hazard, with other colors rated lower and more variable than red in hazard connotation. Differences in the findings for colors other than red could be due to a host of reasons including methodological and procedural differences. Another potential candidate is the variability of

and differences in the stimuli used between studies. For example, as noted by Pravossoudovitch et al. (2014), specific chroma qualities of the color rendering and lighting could affect the results. For example, some studies used different kinds of color printing of signal words. Many of the aforementioned studies reviewed used ANSI signal word panels where there is a large amount of surface area in color. Even though the word itself (the lettering) is printed achromatically (black or white) in signal word panels according to the ANSI standard, the background is colored. However, in some studies only the word or text is printed in color (the lettering itself is colored) on a white background. Most of the time colored text produces very little surface area that is actually colored – it is not very salient except when the text is very large with bold stroke widths. Consider, too, yellow-colored text printed on a white background as compared to how the ANSI standard uses yellow with the signal word CAUTION, where a yellow background is combined with black lettering. The former would be more difficult to see and read than the latter, and would probably get a lower rating than most other colors that have higher contrast on a white background. Also of some difficulty in comparing studies is that while some studies report the color value specifications, others do not. For example, Smith-Jackson and Wogalter (2000) used the exact colors in the ANSI Z535.1 standard (actually cutting out the colors in the standard). There are many versions of red, and it is not uncommon for warnings on labels of consumer products to have lettering that looks more pinkish (and thus weaker) than a saturated red.

### Fluorescent colors

Research has also examined whether fluorescent or neon colors affect hazard connotation. Tomkinson and Stammers (2000) found an ordering of red, orange, yellow, and green in ratings of hazard, urgency, and attention-gettingness. They also found that fluorescent colors were rated

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higher than their traditional color counterparts, but only when they were evaluated side by side, not when they were independently assessed.

Recent work by Zielinska, Wogalter, and Mayhorn (2014) also explored fluorescent colors and a wider selection of traditional colors in terms of hazard connotation and importance. A total of 33 colors specified in ANSI Z535, ISO 3864–2011, the US Department of Transportation Federal Highway Administration (FHWA), and Pantone Neon, and 3 M fluorescent colors were used as stimuli. Eighty-nine participants were asked to rate each color presented in randomized order for perceived hazardousness and importance (1 = not at all to 10 = extremely). Hazardousness was defined to participants as “being risky or dangerous” and importance was defined as “of great significance or value.” Table 18.6 shows the means and standard deviations. Red was associated with the highest hazard and importance scores. However, there were differences between the reds as specified by different organizations. Consistent with previous research, orange, yellow, and black maintained their “second-tier” status with regard to perceived hazardousness and importance. Most interesting, however, was the finding that the fluorescent colors provided by 3 M closely approximated the perceived levels of hazardousness and importance connoted by red.

### Summary of color’s effect on hazard perceptions

From the research reviewed in this section, a number of conclusions can be offered. The addition of color increases perceived hazardousness compared to black and white. Red is clearly the highest connoting color. This connection of color to danger is considered very strong (Pravossoudovitch et al., 2014) and seems to be shared by many cultures. Orange and yellow follow next from red in hazard connotation. Some studies show concordance with standards and guidelines that denote orange as being higher in hazard than yellow, but

most studies show that there is little or no difference in connotation between these two colors or the signal words associated with them, WARNING and CAUTION. With the exception of black, the other colors have little or no hazard connotation. As we have seen, the ordering of the second-tier colors changes from study to study. Sometimes there are significant differences among them and sometimes not. These differences could be due to a whole host of reasons, including methodological reasons (such as the specific colors and rating scales used). The specific ordering reported in a given study could simply be due to sampling error.

The association between color and signal word is high with respect to the color red and the signal word DANGER. There is a strong association with red and hazard-related signal words as well as to the word STOP. Also, there appears to be a moderately high association between yellow and CAUTION. Some of the differences in yellow/CAUTION and orange/WARNING might be due to spillover from people’s exposure to other related domains such as traffic, exit, and fire signs. Additionally, the color black has a moderate association with the words FATAL, DEADLY, and POISON. Black is commonly used for some hazard-connoting symbols such as the skull and crossbones symbol to represent poison. The results of recent research on fluorescent colors suggest that these might provide an alternative to red to promote hazard comprehension. Inherently tied to the fluorescence of colors is its potential for attracting attention, which initiates the processing of warning information by the receiver (Wogalter, 2006).

### Color and attention switch

Thus far we have discussed research that has examined the hazard connotation of colors. However, a main and very important reason for using color in warnings is that it can help attract

Table 18.6 Mean hazard and importance ratings (standard deviations in parentheses) according to color and color systems (from Zielinska, Wogalter, and Mayhorn, 2014)

	Mean Hazard					Mean Importance				
	ANSI	ISO	FHWA	Neon	3 M	ANSI	ISO	FHWA	Neon	3 M
Red	7.5 (2.7)	7.0 (2.9)	7.3 (2.7)	–	–	8.3 (1.9)	7.7 (2.2)	7.8 (2.1)	–	–
Orange	6.1 (2.5)	5.7 (2.5)	6.0 (2.4)	–	7.9 (2.4)	6.0 (2.2)	5.5 (2.4)	6.1 (2.3)	–	7.6 (2.4)
Yellow	5.7 (2.3)	5.3 (2.3)	5.4 (2.3)	–	7.3 (2.3)	6.3 (2.2)	6.0 (2.5)	6.5 (2.2)	–	7.3 (2.4)
Green	2.5 (1.6)	2.5 (1.7)	2.5 (1.7)	3.8 (2.5)	–	5.8 (2.5)	5.9 (2.6)	5.8 (2.7)	4.8 (2.4)	–
Blue	2.4 (1.6)	2.4 (1.5)	2.7 (1.6)	2.5 (1.6)	–	4.8 (2.3)	5.0 (2.5)	4.7 (2.4)	4.3 (2.5)	–
Pink	–	–	4.0 (2.5)	–	–	–	–	4.0 (2.4)	–	–
Purple	2.7 (1.9)	–	3.2 (2.3)	3.1 (2.2)	–	3.5 (2.0)	–	3.5 (2.1)	3.5 (2.1)	–
Yellow-green	–	–	4.4 (2.5)	5.7 (2.4)	7.1 (2.3)	–	–	4.2 (2.4)	5.3 (2.3)	7.1 (2.6)
Brown	2.5 (2.1)	–	2.6 (2.1)	–	–	3.6 (2.4)	–	3.5 (2.4)	–	–
Gray	2.3 (2.0)	–	–	–	–	3.7 (2.5)	–	–	–	–
Black	3.9 (3.2)	4.2 (3.2)	–	–	–	5.8 (3.1)	5.8 (2.9)	–	–	–
White	2.1 (2.0)	2.3 (2.2)	–	–	–	5.1 (3.1)	4.9 (3.1)	–	–	–

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Attraction of attention is important because warnings are usually only a small part of the visual scene surrounding a user. When a new product is purchased and the box opened, is the warning going to draw attention at that time or at a later time (or never)? Color can add salience and generally the most salient items will be more likely to draw attention and receive glances that may in turn elicit further examination. There are certainly exceptions to this rule, such as when a person is seeking different kinds of information or is under time stress, etc. It can depend on the tasks that the person is doing. Moreover, other stimuli in the context could be more salient than the warning. However, as a general rule, a salient warning has a better chance of attracting attention than a non-salient warning. Color can be used to enhance the conspicuousness of the warning to help make it stand out more in its contextual environment. Of course, not just any color can be used for this purpose. We have discussed the hazard-connoting value of red, followed by a grouping of orange/yellow, in turn followed by the other colors. Thus we may desire to use red as the main color of a warning to connote a potentially serious hazard, but the color red should not be used if the rest of the product or environment is mostly red. For example, a red-colored warning intended to inform firefighters of the hazards associated with water pressure on a red fire truck will be unlikely to attract their attention. It would not stand out in this context. An orange or yellow warning with other aspects reflecting hazard (e.g., shape cues) should probably be used. Of course, if there is an opportunity to change the color of the environment so that it is not largely red, this would allow the use of red warning for a severe hazard.

Empirical research has examined whether colored warnings are more noticeable than achromatic warnings. Most research in this area has been done in a few specific ways. Some

researchers have measured reaction time, as participants tried to find a target as quickly as possible. Some of the ways that stimuli vary in these studies include having varied colorations including no color, and having color serving as a cue or a non-cue for target selection. Additional studies examined eye movements and whether color affects and attracts initial glances and saccadic movements. Later we briefly discuss legibility research as it relates to attention maintenance or its holding capability to allow encoding of the material.

### Reaction time research

Young (1991; see also Laughery, Young, Vaubel, and Brelsford, 1993) examined search times to find warnings embedded on a large set of simulated alcoholic beverage labels where the warnings were orthogonally manipulated on four salience variables (pictorial, color, signal icon, and border) to determine their effect on noticeability of warning information. The alcohol warnings were entirely printed in red or they were in black ink (like the rest of the labels). Participants viewed 96 simulated alcohol labels on a computer, half with a warning and half without. Response latencies were recorded as participants indicated whether or not a warning was present on the label. The results showed that warnings having color, a pictorial symbol, or an alert had significantly faster response times than warnings without them.

Similarly, Bzostek and Wogalter (1999) had participants try to find warnings on a simulated nasal decongestant label presented on a computer screen. Warnings were designated by the presence of different kinds of icons that were achromatic (black on white) or in color (blue or red on white). Some trials had no warnings. Response time measurements indicated that the presence of a colored icon (blue or red) shortened search times for a warning located in various locations on the label. In other results, participants preferred red symbols over blue or black ones.

## Eye-movement research

The attention-switch aspect of color has also been investigated in eye-movement research. Generally, multiple measures are recorded such as initial saccadic movement, eye fixations, total time on target (as in attention maintenance), and the number of fixations, while individuals look at, read, or search for certain information. Laughery and Young (1991) and Laughery, Young, Vaubel, and Brelsford (1993) employed eye tracking to reveal scan patterns of participants searching for warning messages on alcoholic beverage containers. Thirty-eight alcoholic beverage labels were constructed such that 24 contained a warning label. For each label examined, participants indicated whether or not it contained a warning. Manipulated warning features were color, presence of a safety alert symbol, a pictorial symbol, and a border. The results showed that color (or any of the individual components) did not significantly reduce times to find the target warnings, but combinations of more than one feature significantly decreased search times. Thus multiple cues, including color, build upon the warning's salience, benefiting search performance.

## Influence of fluorescent colors on attention switch

In recent years, fluorescent colors have been increasingly used in highway sign contexts. The fluorescent colors most frequently used in warnings are yellow-green, orange, and yellow. Although fluorescent colors have been used on highway signs, their application on product labels has not yet been prevalent. We see some promise in these colors in the hazard-connotation research mentioned earlier (e.g., Tomkinson and Stammers, 2000; Zielinska, Wogalter, and Mayhorn, 2014). That research notwithstanding, fluorescent colors primarily benefit warnings most for the purpose of attention switch – that is, to make a warning salient in an environment and to attract attention. Schieber, Willan, and Schlorholtz (2006) found that fluorescent color is beneficial for attracting

attention to unexpected targets. The results showed that fluorescent yellow-green was more likely to elicit initial fixations than non-fluorescent highway colors, and thus the effect of fluorescent colors is probably due to its increased noticeability (cf. Schieber, Larsen, Jurgensen, Werner, and Eich, 2001).

Burns and Pavelka (1995) investigated the relative advantage of fluorescent colors over standard colors for detection, color recognition, and conspicuity against a complex dark background in a field study. Fluorescent retroreflective materials were detected with higher frequency and recognized with greater accuracy at further distances than the corresponding standard highway colors. Fluorescent colors were found to be more conspicuous during daylight than the corresponding standard highway colors.

## Behavioral compliance

In the warnings area, behavioral compliance is considered “the gold standard” of effectiveness measures. Behavioral compliance research measures whether people actually carry out the safe behavior directed by a warning. Unfortunately, these kinds of studies are relatively rare in the research literature because they are difficult to conduct. It is time-consuming to construct a believable hazardous situation, and thus most studies on warning effectiveness use other methods as indications of effectiveness, such as those described in this chapter. However, a few studies have directly measured behavioral compliance in which warning color has been manipulated; these are described below.

Shaver and Braun (2000) conducted a behavioral compliance study in which a warning was placed on a door directing people to use an alternate door. The color of the signal word CAUTION was manipulated (red background, yellow background, or black background with white print). Scaffolding was erected in front of a building to simulate a construction area. The presence of a sign significantly increased the

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## Other warning

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proportion of people using the alternate exit. However, the traffic patterns did not vary as a function of other manipulated variables such as color. The authors noted that the placement and salience of the signs may have been inadequate as it appeared that many people did not notice the sign until it was too late.

Rodriguez (1991) measured behavioral compliance to a warning in which color and shape were manipulated. Results indicated that a red label elicited higher ratings of danger, with a green label next, and a black and white label the lowest. A red octagon was found to be significantly more effective than other combinations in terms of producing greater retention of label detail and also evoking higher ratings of perceived danger. There was no significant effect of color, but compliance was low across conditions, suggesting a floor effect.

Silver and Braun (1995) were able to find an effect of color on compliance to printed warnings. Sixty-five persons interacted with a pool-water test kit and a two-part adhesive. The warning on each product was red, green, or black. Behavioral compliance was assessed according to whether participants donned protective gloves as directed by the warning. They found that warnings printed in red resulted in a higher proportion of compliant behavior than warnings in green or black.

### Other warning and color topics

In this section we briefly cover topics that did not fit particularly well into the two main categories of hazard connotation and attention switch that have been focused on thus far.

#### Legibility studies and attention maintenance

Ellis, Dewar, and Milroy (1980) evaluated several versions of X-shaped railroad crossbuck designs. Comparisons were made between an older Canadian design and newer designs (having blades separated by 90° versus blades with 45°

angles) and either as a white sign with a red border or a yellow sign with a black border. There were no differences between the experimental conditions in terms of glance legibility and legibility distance (being able to read print from a distance), but other results showed that white signs with a red border produced faster reaction times and better comprehension than yellow signs with a black border. Additionally, legibility distance for fluorescent colors was longer (i.e., better) than for non-fluorescent colors (also see Schnell, Bentley, Hayes, and Rick, 2001).

#### Color in combination with other features enhances memory

Most studies looking at warning memory have manipulated several variables simultaneously to make the warning highly conspicuous. Frequently, color is one of the features. Young and Wogalter (1990) examined the effect of salience on memory of warnings in an owner's manual in an incidental exposure study where participants were not told in advance that memory of warnings was of interest as they perused an owner's manual for a gas-powered electric generator or a natural gas stove. They found that warnings that used conspicuous print (made conspicuous by yellow/orange highlighting and bigger/bolder lettering) were better remembered than print that was not conspicuous (i.e., having the same type print as the other text in the manuals). These findings are consistent with results reported by Angiolillo and Roberts (1991), who found that people rate technical manuals having color as being more likely to be read and that they preferred the use of color to highlight types of information. Similarly, Kelley, Gaides, and Reingen (1989) found that vivid warnings that included a symbol and a red border produced better memory than non-vivid warnings that lacked these characteristics. Meingast (2001) found that containers that had high-quality warnings that included color resulted in higher perceived salience and better memory of the

material. Because several variables are yoked together, it is difficult to determine whether color or other specific features or their combination caused the memory effects. From these studies, all that we can say is that warning conspicuity (in which color probably played a part) led to better memory. Additional research would be needed to disentangle the relative contribution of color and other aspects in individual manipulations.

### Computerized displays used in future warnings

Much of the present chapter has reviewed research where color has been manipulated in the context of traditional, static warnings such as labels attached to products or signs positioned at entrances of construction sites. As technological innovations continue to evolve, these static warning displays will be enhanced in the future through the use of dynamic displays (Wogalter and Mayhorn, 2005). Advanced warning systems will probably have properties that are different from and better than those in traditional static warnings. For example, recent advances in flat-panel displays and electronic paper could provide dynamic warnings in applications heretofore not considered. Electronic systems with sensors could be used to process information to enable dynamic warnings to be appropriately tailored to the situation and potentially to target users' characteristics.

There has been a growing realization that multimodal warnings are increasingly necessary to communicate safety information in complex warning systems such as advanced automotive collision-warning systems (Mayhorn, Wogalter, and Laughery, 2014). Color coding could be integrated into these multimodal warning systems. In one relevant example of a warning system for vehicles, Erlichman (1992) found that people's most preferred method of vehicle collision-warning systems used multimodal cues. The results indicated that, as a group, the combination

of color (compared to monochrome), audio tone, text, and voice message was the preferred method of signaling. Moreover, recent work from Baldwin and Lewis (2014) suggests that hazard mapping involving colors in driver vehicle interfaces is essential to communicating changes in situational criticality. This research applies directly to the adoption of color in dynamic displays in future warning systems. Consider systems that display changing circumstances detected by sensors such that warning content is adjusted as the conditions occur. For example, wind sensors on bridges could provide input into systems that display in-cabin information to drivers of heavy trucks about dangerous conditions before crossing a bridge with excessive crosswinds. The urgency of the situation could be cued through color coding. Another benefit to dynamic warnings is that they can be tailored to the characteristics of specific users or environmental conditions. One example is that display presentations in bright ambient lighting could be made brighter with enhanced contrast.

### Implications and conclusions

Collectively, the literature reviewed in this chapter furthers our understanding of how color can enhance (and in some cases, hinder) information processing of warnings. Several conclusions can be offered. First, the presence of color in combination with signal words and pictorial symbols affects hazard comprehension.

Second, certain colors – namely, red, orange, and yellow – are specified in standards and guidelines to communicate different levels of hazard. Black and white are usually present in hazard warnings in conjunction with the main colors, and in the printing of signal words in conjunction with the three main colors.

Third, some aspects of the standards and guidelines with respect to color are supported. For example, the color red consistently and strongly connotes hazard. Orange and yellow connote a

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hazard level that is less than red but higher than other colors. However, orange and yellow do not strongly differ in hazard connotation, as indicated by a variety of measures (including their ties to signal words). Thus, while standards and guidelines specify three distinct levels of hazard in their warning-systems approach, there seems to be just two that people understand. Given these findings, one could conclude that orange and yellow (and the corresponding signal words WARNING and CAUTION) could be used interchangeably with little or no differential effect. Given that the intention was to have three levels, how might this situation be rectified? One way is to use combinations of colors and alternative signal words. ANSI already has some other signal words that are intended to indicate important non-hazard information and that are paired with non-hazard colors such as green and blue. Including this level of hazard (i.e., none) could be used to make three levels of hazard with one of the levels being no hazard: (1) high (red), (2) higher than none and less than high (orange, yellow), and (3) none (green and blue). But, an argument can be made that there ought to be another, higher, level of hazard added to the set. One way to do this is to have an even higher level than the highest level of hazard that existing standards and guidelines currently offer. Presently, the highest level is red and DANGER. However, Drake, Conzola, and Wogalter (1998) found that people assign extremely dangerous descriptions/phrases including ANSI's definition of DANGER/red ("to indicate a hazard that will cause severe injury or death") more frequently to the alternative signal word DEADLY than they do to DANGER. In other words, ANSI's definition ascribed to DANGER, actually fits DEADLY better. Moreover, and as mentioned previously, Wogalter et al. (1998) explored a variety of configurations and colors of warnings, including alternatives to those of existing standards and guidelines. The red, black, and white combination was rated very highly in hazard connotation, just

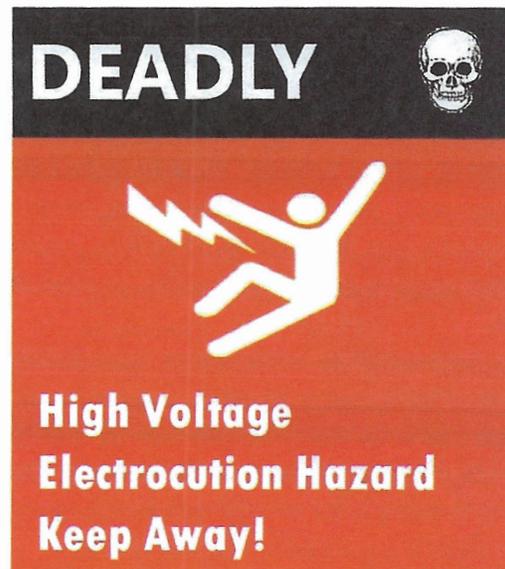


Figure 18.5 Alternative sign configuration similar to one evaluated in Wogalter *et al.* (1998).

below the combination of yellow and black. Using these and other results (e.g., Wogalter and Silver, 1995), some alternative designs such as those shown in Figure 18.5 could be used to expand the set of hazard-connoting warnings.

The warning configuration in Figure 18.5 has several advantages. It is the highest-connoting signal word according to research (e.g., Drake et al., 1998; Wogalter and Silver, 1995). It is novel, so it is more likely to be looked at and examined. It contains a great deal of red, as it is used as the background color of the message panel. It has a pictorial (skull) that has a higher hazard connotation than the alert symbol (Smith-Jackson and Wogalter, 2000). Companies would not want to use this on their products except when it is essential. Thus, when it is used, it would be more attractive of attention due to its relative novelty. Because it would not be used frequently, viewers would be less likely to habituate to it. Indeed, a similar configuration was rated significantly higher than the current and older ANSI DANGER configurations in ANSI Z535.2 (Wogalter et al., 1998).

Fourth, some fluorescent colors – namely, those from 3 M – were given ratings for hazard

connotation and importance – as high as the color red in several systems (e.g., ANSI Z535). Furthermore, these fluorescent colors may be particularly useful in their attention-switch capabilities in certain contexts. Because most tests on fluorescent colors' attention-getting performance have been in outside environments, future research ought to evaluate their utility on product labels.

As cone receptors in the retina immediately transduce light energy based on colored wavelengths, color is likely to offer an advantage over other warning features or components. The early processing at the level of receptors probably helps make it a good early warning system.

With respect to warning theory, color also benefits the comprehension and belief stages and, ultimately, compliance. Red connotes the highest level of hazard followed by orange and yellow, and sometimes black is part of this latter group. Colors are often tied to text (e.g., signal words) and symbols/graphics. Color in conjunction with text can support, increase, or reduce the hazard connoted by the word. Color highlighting also supports memory and comprehension for safety information encountered on warnings. Color appears to support several processing stages described in the C-HIP model (Wogalter, 2006) from initial attention switch through maintenance, comprehension, and memory, potentially leading to compliance behavior. Advances in technology continue to offer new approaches to use color in a dynamic way to describe current conditions.

The specific contribution of color coding as understood by ordinary people in actual situations is difficult to determine. The reasons are multi-fold. As mentioned earlier, context may play a part in communicating the level of the hazard in stronger ways than the color of the warnings. For example, it is questionable whether the color of a sign (red versus yellow) matters very much when it is located on a door with very large letters stating "DANGER 40,000 Volts, Keep Away."

Results from numerous studies reviewed in this chapter indicate that color can significantly affect hazard perception. Color can serve to support other cues in a label or sign, and probably should not largely conflict with them (e.g., by using a green or blue background for a severe warning). However, there is some indication that it might be possible to convey a gradient of connotation along a wider range of hazard by mixing different cues. Large mismatches among the cues may confuse people, however. Additional research on this topic would be beneficial. Related to this is the issue of redundant cues. Combining several features such as color, symbols, and wording can help support the understanding of a hazard. Color can also act as a cue to people who may not be able to read or understand the language text printed on a sign or label. Such people may realize that a sign or label is a warning by its coloration cues even when not knowing what the words mean. Moreover, a person who is color deficient or views a warning under poor lighting conditions could use alternate cues to extract meaning from the warning.

Why should such high-level care be taken in the development and presentation of warnings? The answer relates to a reason given at the outset of this chapter. Warnings are intended to do the work of hazard control. They are used when product designers, employers, or public communities cannot (or for other reasons do not) design out or guard against all of the hazards. When residual hazards remain, warnings are supposed to protect people from harm, but their success depends on many factors including whether the warning has attention-attraction aspects and features that aid understanding. If people do not notice the warning (because perhaps it is achromatic or is the same color as its contextual environment), or they do not understand the warning (no color is used or the color used has little or no hazard connotation), then there are likely to be problems with this hazard control method working. Warning development should not be a slipshod

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affair. Warnings should be constructed to be effective in hazard control, and color is an integral part of the toolbox the warning designer should consider using.

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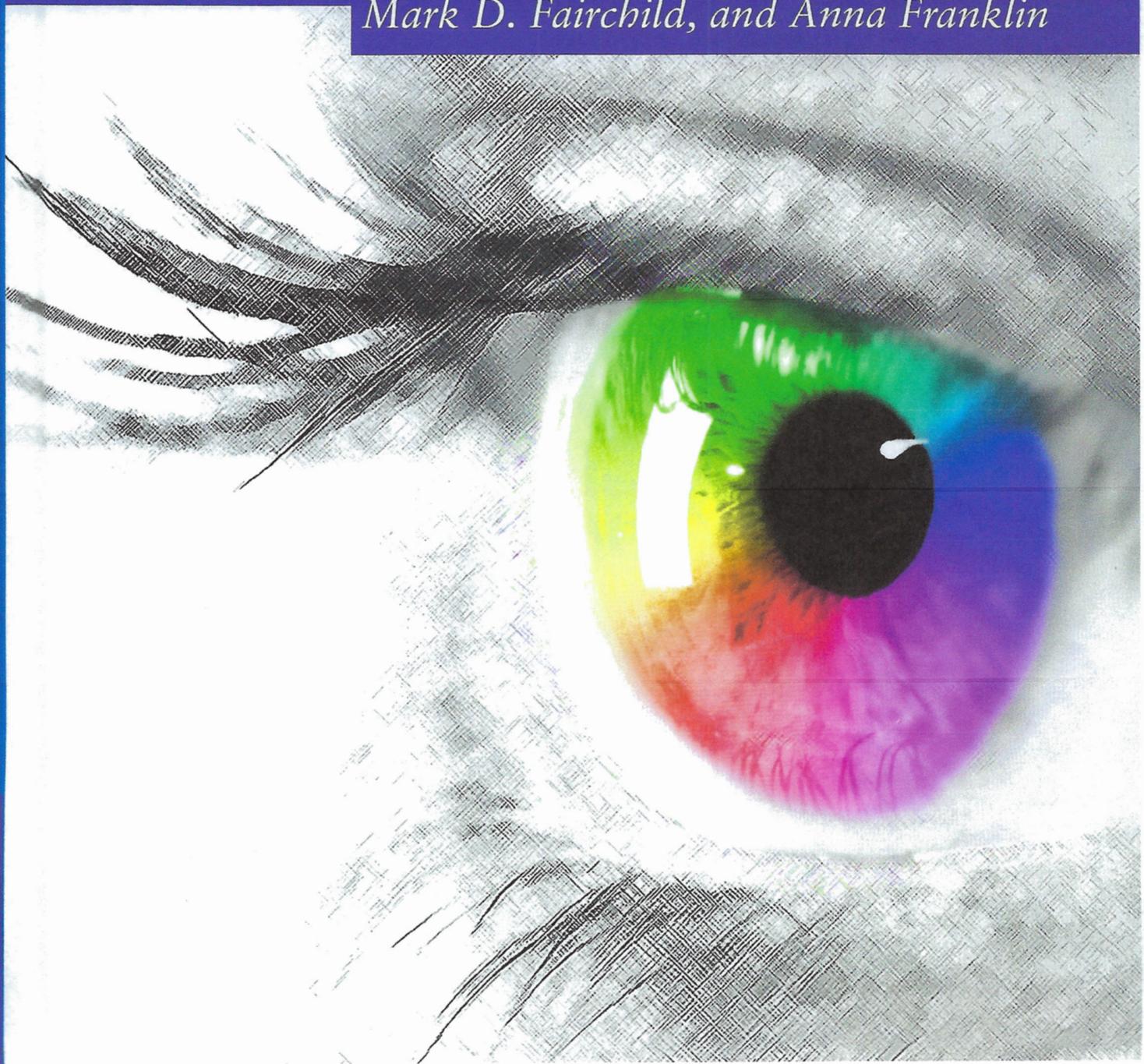
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# HANDBOOK OF COLOR PSYCHOLOGY

*Edited by Andrew J. Elliot,  
Mark D. Fairchild, and Anna Franklin*



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