TOOLKIT

BY STUART O. PARSONS, JOSEPH L. SEMINARA, & MICHAEL S. WOGALTER

A SUMMARY OF WARNINGS RESEARCH

Add this handy resource to your toolkit for designing and evaluating product warnings.

OVER THE PAST DECADE AND a half, a tremendous volume of research has accumulated in the area of warnings and risk perception. We have learned a great deal about the factors that influence safety-related information processing and behavior. Guidelines for warning design no longer need to be based on expert opinion; they can now be supported by the results of empirical research.

This article reviews and summarizes data from more than 150 laboratory and field studies published mainly in the last 15 years and mostly in the Proceedings of the Human Factors and Ergonomics Society Annual Meeting (HFES). A broad overview of research findings is presented in 24 alphabetized sections. Although we do not explicitly give design recommendations, these studies contain implicit design guidelines. The summaries reflect our current knowledge on the factors that influence warning effectiveness.

We believe this review will be useful to human factors designers and consultants who produce and evaluate warnings. Additionally, it can serve as a handy reference guide that could be useful to government regulators, industry managers, consumer product organizations, industrial hygienists, marketers, researchers, expert witnesses, and attorneys who need guidance on warnings. As is common in many kinds of active research activities, the results of studies on any given topic will not concur with other study results. Despite this, we try to give general conclusions in our summaries. Further research will bring more detail and clarity to the field.

The major findings are given below in alphabetical order.

Age

As people age, certain physical and cognitive changes occur that can affect how older individuals perceive and process warning information. Designers of warnings need to consider these factors for the elderly population. Short-term memory capacity decreases as age increases, so warnings should be kept as brief and direct as possible. Bruyas et al. (1997) found that older people have difficulty establishing links between symbols and focus on elements of the display more than do younger ones. The legibility of printed warnings becomes especially important for older individuals whose visual acuity has decreased. Wogalter et al. (in press) found that older people preferred medicine containers with label designs that had larger print. Results also showed that large-print labels led to better knowledge acquisition compared with conventional labels. Regarding younger groups, it was found that warning signs were less effective with high school students than with middle school students (Goldhaber & deTurck, 1989).

Auditory Warnings

Auditory warnings offer advantages over visual warnings in certain situations because of their omnidirectional nature and their ability to attract attention. Auditory warnings can take several forms, including simple or complex tones, auditory icons (sometimes called *earcons*), and voice warnings. Nonverbal auditory warnings can be made more urgent by changing the

physical characteristics of the sound (Edworthy et al., 1991, 1995; Haas & Casali, 1993, 1995). Auditory warnings can influence perceptions of urgency and can vary as a function of parameters, such as pulse rate (Zobel, 1998). They are more easily understood when there is a recognizable association of the signal to a relevant aspect of the situation (e.g., a car-skid sound when braking is indicated; Belz et al., 1998). If there is no easily recognizable association, then the auditory warning must be learned or trained. This is less true for voice warnings than for nonverbal auditory warnings because the former can make use of existing language knowledge (Barzegar & Wogalter, 1998). The presence of a voice warning produced a strong and reliable increase in compliance compared with conditions without a voice warning (Wogalter et al., 1991b). However, a long, complex message may be better presented visually than auditorily if it can be displayed within a person's field of view (Barlow & Wogalter, 1993). The attention-grabbing ability of auditory warnings can lead to annoyance, particularly if there is a high incidence of false alarms (Bliss et al., 1995).

Believability

Warnings that explicitly describe the consequences of noncompliance are perceived as more believable than ones that only list hazards (Beltramini, 1988; Conzola & Wogalter, 1998). In addition, a relevant, respected source attributed to warning information has been shown to influence its believability and hazard ratings. For example, a warning from the U.S. Food and Drug Administration or the American Medical Association carries more weight than a warning from a general source, an irrelevant source, or no source (Resnick, 1998; Wogalter et al., 1997d).

Border

Warnings with wide, colorful, jagged borders are perceived as more effective. Adams and Edworthy (1995) found a linear relationship between border width and perceived urgency. A raised border that provided tactile cues to tool users increased perceived noticeability, comprehension, and recall (Kalsher & Wogalter, 1997). Signs with thick red and thick yellow/black diagonal striped borders around rectangular-shaped signs are more likely to evoke visual examination than signs with thin or no borders (Wogalter & Rashid, 1998). Whereas some research shows that geometric shapes such as a triangle with one corner pointing downward increases perceived hazard (Riley et al., 1982), other research shows no effect on incidental exposure memory and compliance (Barlow & Wogalter, 1993; Jaynes & Boles, 1990).

Brevity

In general, a shorter, concisely worded (to the point) warning is better than a longer, less direct, verbose one. However, message brevity must be balanced by the need to provide necessary, specific information without decreasing the likelihood that the warning will be read and believed. Perceived risk declines as a function of the number of less critical warning messages incorporated into a product warning (Chen & Gibson 1997). Research also shows that people prefer explicit warnings of moderate to longer length compared with briefer, less specific warnings (Kanouse & Hayes-Roth, 1980; Laughery & Stanush, 1989; Mazis et al., 1978).

Color

Adding color to a warning can increase its ability to attract attention, provided that the warning color is distinguishable from the surrounding background colors. Kline et al. (1993) found that colored warning labels were perceived as more readable and evocative of greater hazard than achromatic labels. In addition, Braun and Silver (1995b) found that the largest color effects occurred with reduced print legibility. In general, red connotes the greatest hazard level. Orange and yellow usually connote less hazard, and there is frequently no significant difference shown between them. Other than black, the remaining colors show little or no effects on perceived hazard. These perceptions hold for many populations and even for children as young as 8 years old and native Spanish language users (Adams & Edworthy, 1995; Chapanis, 1994; Edworthy & Warren, 1997; Wogalter et al., 1997b, 1998b). Research has shown that warnings printed in red (compared with other colors) produce faster detection time (Young, 1991), greater injury likelihood estimates (Braun et al., 1994), and higher compliance (Braun et al., 1994; Rodriguez, 1991).

Compliance

Compliance studies measure actual precautionary behavior (e.g., wearing personal protective equipment or carrying out specific safety-related procedures). One measure of the effectiveness of a warning is the amount of safety behavior that occurs when a warning is present compared with when it is absent. In general, these studies are given greater respect than ones using other kinds of outcome measures. Ideally, all warnings would be developed and tested in real-world environments using behavioral compliance measures. Unfortunately, it is not always possible to measure compliance when evaluating warnings because the costs and risks associated with compliance studies preclude their use in most situations. Therefore, much of the existing warnings research is based on measures of the prerequisite information-processing stages before compliance occurs (e.g., attention, noticing, reading, comprehension, beliefs, etc.). If measuring compliance is not possible, the best strategy for conducting warnings research is to use a number of measures that will, it is hoped, show the same or similar effects.

In a study of warehouse workers by Gomer (1968), warnings failed to cause a significant reduction in unsafe behavior, but these workers had not yet been trained. Conversely, numerous studies have shown that the presence of a warning can change behavior. In a meta-analysis of 15 experiments involving the presence versus the absence of warning labels on consumer products, Cox et al. (1997) concluded that warnings generally increase safe behavior, and that this increase is found for both nonstudent and student participants. Several warning design factors have been shown to positively influence compliance, including use of pictorial symbols (Jaynes & Boles, 1990) or a person's name (Wogalter et al., 1993a), proximal location (Frantz, 1994; Wogalter et al., 1995a), less cluttered environments (Wogalter et al., 1991b, 1993b), social influence (Wogalter et al., 1987b, 1988, 1989), warning redundancy (Wogalter et al., 1995a), time pressure (Wogalter et al., 1998c), and behavior modeling presented through a video display (Racicot & Wogalter, 1992), and the provision of necessary protective equipment (Dingus, 1991a, 1991b; Hunn & Dingus 1992; Wogalter et al., 1987b, 1988, 1989). Some personal factors have also been shown to influence compliance behavior, including individuals who report being more careful (Wogalter et al., 1991a) or less familiar or experienced with a product (Wogalter et al., 1995a) and those who engage in more kinds of high-risk behaviors (Purswell et al., 1986). Upon first exposure to a warning, progressively fewer people see it, read it, and comply with it (DeJoy, 1989). The addition of mandated warning information on products did not increase the number of people who read product labels (Pollack-Nelson, 1995).

In a study of driving speed, participants who received true warnings drove slower than did participants who received no warning. Participants who received false warnings initially drove at the same speed as those who received true warnings but increased their speeds following repeated false alarms (Nohre et al., 1998).

Two recent studies have investigated the effectiveness of warnings in the field. In three separate analyses involving vehicle handling, safety belt usage, and young children in bunk beds, and using national accident statistics, preliminary evidence failed to show that accident or injury rates decreased with the introduction of new warning labels (Arndt et al., 1998). In a series of field studies involving many service stations and attendants, it was demonstrated that the presence of good warning information on automotive tires and rims can prevent tire-rim mismatches and can probably prevent future accidents (Laughery et al., 1998). Warning compliance research should include a variety of appropriate population samples when possible (Cox et al., 1997; Wogalter et al., 1987b).

Consequence Information

There is at least a small risk of injury in most activities. The perceived risk must reach some threshold before people will expend effort to comply with warnings. The negative effects of noncompliance must be relatively high. Compliance appears to depend on whether people believe that they might be injured (Friedmann, 1988; Godfrey et al., 1985; Slovic et al., 1980). The ordering of statements may affect hazard perception (Braun et al., 1995). Consequence information is one of the four statements that warnings should include unless they are already well-known (Wogalter et al., 1987b). Giving information about injury and consequence informs people why it is important to comply and can also provide the impetus or motivation for individuals to comply with the warning's instruction (Leonard & Matthews, 1986; Wogalter & Laughery, 1996).

Conspicuity

Getting noticed and attended to are the first requirements of an effective warning, the prerequisites for further processing of its content. People who are not looking for a warning are less likely to notice and use that information even if they encounter it (deTurck & Goldhaber, 1988; Friedmann, 1988; Strawbridge 1986). Therefore it is essential for a warning to be as salient as possible so that it can capture the attention of those whose attention might be focused on some other task. In general, warnings are more likely to be noticed and read if they are relevant to users. For example, alcoholic beverage warning labels were more likely to be noticed by heavy drinkers, young men, and women of childbearing age (Kaskutas & Greenfield, 1991). The conspicuity or salience of a visual warning can be enhanced using such features as larger and bolder print, greater brightness and color contrast, highlighting, and the addition of special effects such as flashing lights. Research has shown that conspicuous warnings lead to greater likelihood of reading (Strawbridge, 1986), comprehension (Young & Wogalter, 1990), recall (Barlow & Wogalter, 1993; Griffith & Leonard, 1995), and compliance (Glover & Wogalter, 1997; Hopkins & Parseghian, 1997).

Consumer Buying Intentions

Product manufacturers often assume that the presence of warnings has a negative influence on consumers' purchasing intentions. However, most human factors research (e.g., Laughery & Stanush, 1989; D. Leonard, et al., 1989; Vaubel, 1990) does not support this view. Schwartz et al. (1983) found that people make use of hazard information in selecting among different brands. Furthermore, Ursic (1984) found that the presence of a product warning may have a positive impact on the perceived effectiveness and safety of a brand.

Culture/Ethnicity

As populations around the world increasingly interact, it is becoming more important that safety information is

communicated successfully to people of different languages and cultures. Warnings (especially those found in public environments, such as airports and train stations) should use language-independent pictorial symbols whenever possible. Spanish speakers did not always understand English signal words; however, a set of Spanish hazard words could be used to convey different hazard levels. Spanish-only speakers evaluated a set of colors and symbols (except an unhappy face with the tongue sticking out) similar to English-only speakers (Wogalter et al., 1997b). Because warning components that are useful in one culture may not transfer to other cultures, cross-cultural testing is advised (Trommelen & Akerboom, 1997; Wogalter et al., 1997b). A study by Resnick et al. (1997) found that U.S. populations hold manufacturers to a higher standard of safety than do Latin Americans or Asians.

Design

Beyond the semantic content of the wording, warning effectiveness also depends on its format and graphic layout. Presenting warning text as bullets in outline form is preferred to continuous, paragraph-style text. Warnings in outline layout were judged as more appealing, easier to process, and more effective than were warnings in other layouts (Desaulniers, 1987). Pictorial symbols and color can help make warnings more noticeable (Laughery & Young, 1991) and understandable (Wogalter et al., 1997a; Young & Wogalter, 1990). Shape (e.g., triangles, diamonds, and octagons) has also been found to have some effect (albeit small) on hazard perception and compliance (Cochran et al., 1981; Collins, 1983; Riley et al., 1982; Rodriguez, 1991). Combining multiple redundant features and modalities can be useful to enhance and more precisely code the degree of hazard and also facilitate message transfer in cases where one or more features or modalities are missed (Belz et al., 1998; Wogalter et al., 1991a).

Alternative label designs might also be useful. For example, Kalsher et al. (1994) found that tags and fold-out labels on small pharmaceutical containers were preferred over conventional labels. The addition of pictorial symbols to these expanded surface area labels was preferred over their absence. The design shape of a product container has also been shown to signal the degree of hazard associated with a product (Wogalter et al., 1997c). Frantz et al. (1993) found that less than half of engineering and law students could correctly identify the more effective of two label designs. Other research indicates that laypersons may not recognize that a warning is poor until they see a good one (Laughery et al., 1998; Wogalter et al., 1998a). Westinghouse (1981), FMC (1985), and ANSI Z535 (1998) give specific advice on how to format warnings. These guidelines are not necessarily all based on research results.

Explicitness

The specificity or detail with which the hazard, injury consequences, and instructions are described influences warning effectiveness. More explicit warnings have been associated with greater levels of perceived hazard, perceived injury severity, hazard knowledge, intentions to act cautiously, perceived concern by the manufacturer, and use of protective equipment (Dingus et al., 1993; Laughery et al., 1991, 1993; Laughery & Stanush, 1989). No clear relationship has been found between explicitness and purchase preference (Laughery & Stanush, 1989; Vaubel, 1990; Vaubel & Brelsford, 1991). Explicit consequences help motivate behavior (Wogalter & Laughery, 1996). Generally, more threatening warnings are perceived as more effective, but warnings of extremely high threat might not be posted as readily (Harris & Wiklund, 1989).

Familiarity

Familiarity reflects an individual's beliefs, knowledge, and experience in a specific domain. In general, familiarity varies inversely with warning detection (Goldhaber & deTurck, 1988a, 1988b), perceived hazard or risk (Godfrey et al., 1983; Karnes et al., 1986; Wogalter et al., 1991a), and compliance likelihood (Goldhaber & deTurck, 1988a, 1988b). People are more likely to notice a warning the first time they use a product than if they were to switch to a similar product (Godfrey & Laughery, 1984). Messages in familiar environments, on familiar products, and during familiar activities are likely to be filtered out (Otsubo, 1988; Purswell et al., 1986). However, injury experience may mediate these effects. Wogalter et al. (1993c) found that people who had been previously injured reported acting more cautiously than did those without such experience.

Gender

Most research has failed to find (or report) gender differences on warning related measures. The studies that do report significant gender differences suggest that females are more likely to look for, read, comply with, and find importance in warning information and perceive more danger and examine more information when making decisions involving risky products (Barlow & Hammond, 1995; Godfrey et al., 1983; Goldhaber & deTurck, 1989; LaRue & Cohen, 1987; Vredenburgh & Cohen, 1993). Gender factors are generally not relevant to warnings unless the message is more relevant to one gender than to the other (e.g., feminine hygiene products for women; Young et al., 1989).

Hazardousness

To the lay public, perceived risk, hazard, and danger are essentially the same thing (Young et al., 1990). Although many risk experts conceptualize risk as a probability of loss (or injury likelihood), most people

cannot easily conceptualize differences in small injury likelihoods. They instead rely on judgments of injury severity as their main consideration with regard to consumer product accidents and in their determination of precautionary intentions and actions (Wogalter et al., 1987a, 1991a; Wogalter & Barlow, 1990; Young, 1998; Young et al., 1990, 1992a), such as looking for a warning and complying with it (Godfrey et al., 1983). Vaubel and Young (1992), however, suggest that risk is multidimensional in nature. The greater a product's perceived hazard, the stronger the belief that warnings are necessary, the closer to the product one expects to find a warning, and the less warnings detract from the product's appearance (Wogalter et al., 1986, 1991a).

Precautionary behavior, according to Laux and Brelsford (1989), involves how much risk there is in using the product, the user's ability to prevent accidents, and the entity responsible for safety. Warnings can increase perceived hazard (Moore, 1990; Wogalter et al., 1994). In addition, as perceived hazard increases, the likelihood of noticing, reading, recalling, and complying increases (Desaulniers, 1989; Donner & Brelsford, 1988; Friedmann, 1988; Leonard & Matthews, 1986; Otsubo, 1988; Wogalter et al., 1986, 1991a, 1991b).

Many consumers tend to lack basic knowledge of physical concepts and hazards associated with electricity, dangerous vapors, and automobiles (Leonard et al., 1997; Leonard & Karnes, 1998; Patten, 1995). When people are forced to estimate injury probabilities, they are reasonably accurate, but there are systematic biases. People tend to overestimate injury likelihoods for consumer products with low accident frequencies and underestimate the risk of products with medium to high accident frequencies (Wogalter et al., 1993c). Warnings can be effective in correcting risk estimates (Bohannon & Young, 1993).

Interactive Warnings

Interactive warnings are positioned on products so that they physically interfere with task completion and require some type of manipulation for product use. This interruption can assist in drawing attention to the associated warning. Tests using such warnings resulted in higher noticeability, recall, and compliance (Dingus et al., 1993; Duffy et al., 1993; Gill et al., 1987).

Placement

Proper placement is one of the most important factors determining whether a warning will be effective. The type and effects of placement depend on the nature of the task being performed and the environment in which it is being performed. Warnings are generally more effective when they are presented near (in time and space) the hazard (Wogalter et al., 1991a). Placing safety posters in an area where people can view them daily is one way of effectively communicating safety-related information (Laner & Sell, 1960; Kalsher et al., 1991). The amount of visual clutter in the vicinity of a warning significantly increases search time (Laughery et al., 1993) and decreases compliance (Wogalter et al., 1993b). On-product warnings on most consumer products must compete with other information for attention. One possible way to enhance warning conspicuity is to increase the surface area of the labels using fold-outs and extended tags so that the warning material has more room to be expanded. Another is to include other features to make it stand out (larger, color, etc.). Enhanced-area labels increased product knowledge and compliance behavior (Wogalter & Young, 1994; Wogalter et al., in press).

The relative positioning of warnings with respect to other label components and warnings is a complex issue. For example, should warnings be placed before or following product instructions, or should they be embedded in the middle? Wogalter et al. (1985a; 1987b) found greater compliance when warnings were placed before rather than after a set of task instructions. Frantz et al. (1993) reported higher compliance rates when warnings were embedded within a set of task instructions. Wogalter et al. (1992b, 1993b) found that a warning embedded in instructions produced greater compliance (the wearing of protective gear) compared with a similar warning posted as a sign nearby. However, Strawbridge (1986) found that embedding critical warning information tended to reduce compliance compared with starting off with critical information.

One way of determining which kinds of information should be placed first on a product label or in the manual is by prioritizing the information based on importance, injury severity, and injury likelihood (Vigilante & Wogalter, 1997a, 1997b, 1998).

Print

The type and size of print used in warnings has been shown to influence the perceived hazard/urgency ratings and the likelihood that they will be read (Adams & Edworthy, 1995; Braun et al., 1992; Braun & Silver, 1995b; Silver & Braun, 1993). In general, larger, bold type in a simple, sans-serif font (such as Helvetica) is preferred for larger environmental signs. For labels with smaller print, serif fonts (such as Times) are acceptable. Bold type is preferred mainly because of its legibility; however, the characters' stroke width must not be so wide or so compressed that features of individual letters are obscured (Young et al., 1992b).

Recall

A warning's ability to facilitate recall is important because the information might not always be available when hazards are encountered. Ursic (1984) reported that the use of a pictogram, a stronger signal word, and capital letters in a safety warning had little effect on

recall of safety information. Gill et al. (1987) and Strawbridge (1986) found that participants frequently failed to recall a warning or warning information. However, other researchers have identified factors that aid in the recall of safety information, including repetition (Wogalter & Brelsford, 1994), relevance (Gardner-Bonneau et al., 1989), pictorials (Young & Wogalter 1988, 1990), and the presence of injury statistics (Conzola & Wogalter, 1998).

Responsibility

When a warning is absent or poorly designed and a nonapparent (hidden) product hazard produces severe injury, participant jurors allocate relatively more responsibility to the manufacturer and relatively less to the consumer compared with a situation in which a warning is present and the hazard is open and obvious (Laughery et al., 1997; Wogalter et al., 1998a). The testimony of a human factors expert can influence responsibility allocations when a poor warning is used for a nonobvious hazard and an injury occurs as a result (Wogalter et al., 1998a).

Signal Words

Signal words are one of the most important aspects of warning design (Young et al., 1995). A number of studies have examined the understandability and hazard perceptions associated with signal words. The four most common signal words (and those recommended for use by the American National Standards Institute) are "DANGER," "WARNING," "CAUTION," and "NOTICE." With few exceptions (e.g., Leonard & Matthews, 1986), signal word research has consistently shown that "DANGER" connotes the greatest degree of hazard and "NOTICE" the least (Wogalter & Silver, 1990). The distinction between the intermediate terms "WARNING" and "CAUTION" is less clear (Braun & Silver, 1995b; Chapanis, 1994; Drake et al., 1996; Leonard et al., 1988; Silver et al. 1993; Silver & Wogalter, 1989; Wogalter et al., 1994, 1995b). This ordering has been found to be consistent across college students, children as young as 8 years old, older adults, and nonnative English speakers (Edworthy & Warren, 1997; Silver, 1993; Silver & Wogalter, 1991; Wogalter & Silver 1995). In studies that have included the words "DEADLY" or "POISON," these terms are rated as connoting greater hazard than "DANGER" (Drake et al., 1996; Leonard et al., 1988; Silver & Wogalter, 1989).

The presence of a signal word together with a warning increased connoted product hazard (Wogalter et al., 1994). Highlighting of signal words in instructions had little effect, but the warnings themselves shortened task completion times and reduced error rates (Zlotnik, 1982).

Symbols/Icons/Pictorials

Nonverbal graphics can benefit international audiences that might not understand the language in a warning. Graphics might also aid low literates and children. Even if literate adults can read a warning's verbal portion, the presence of a symbol can help attract attention to the warning by endowing it with "visual interest" (Wogalter & Leonard, in press). In composing warning signs, local residents and students preferred using symbols more than all verbal components except for signal words (Young et al., 1995).

The function of pictorials that is considered most important is comprehension facilitation (Dewar, 1994). Existing standards and guidelines specify that symbols must attain high levels of comprehension in the population to be considered acceptable (Collins, 1983; Collins & Lerner, 1982). The current ISO 7001 Standard (1979), published by the International Organization for Standardization, established a criterion for symbols at 67% correct in a comprehension test. The ANSI Z535 standard requires 85% correct and no more than 5% critical confusion (opposite answer) errors in a comprehension test (Brugger, 1994; Zwaga, 1989). Jentsch (1996) found that conveying aviation safety information by pictorial means appeared to be largely effective across four language groups. However, several studies in the United States, Canada, and Europe have shown that many pictorial symbols currently being used or considered for use in various applications have comprehension rates lower than the aforementioned standards' criteria (Caird et al., 1997; Lerner and Collins, 1980; Mayer & Laux, 1989; Ringseis & Caird, 1995; Silver & Perlotto, 1997; Trommelen & Akerboom, 1997). Moreover, pictorials frequently provide only a portion of the information needed to understand the hazard; in other words, they sometimes do not convey information that can be conveyed more readily and completely by language (Laux et al., 1989; Sojourner & Wogalter, 1997, 1998).

Another important criterion is that symbols be legible. Gestalt principles of perception (specifying, for example, simple, bold, continuous figures; FMC, 1985; Sanders & McCormick, 1993) should be applied together with the process of generating ideas for initial prototypes and in refining them using test participants (Magurno et al., 1994). Open-ended testing of symbol comprehension is preferred over multiple-choice testing because of the potential for bias when less plausible distractors are included (Wolff & Wogalter, 1993). Testing in context produces higher comprehension scores (Silver, 1995; Wolff & Wogalter, 1993). Comprehension can be good if the pictorial concept is simple, visible, and specific; conversely, abstract concepts (and abstract picture renditions) are less likely to be understood or to influence perceived hazard (Alves-Foss et al., 1995; Wolff & Wogalter 1993; Young, 1997).

Understandability can be enhanced through familiarity (Vukelich & Whitaker, 1993) and by following a single short study period with the presentation of the referent name (Wogalter, 1997d). A circle combined with a single slash from its upper left to bottom right quadrants is increasingly being used to indicate negation or prohibition, but care must be taken so that the underlying pictorial is not obscured (Dewar, 1976; Glover et al., 1996; Murray et al., 1998; Sloan & Eshelman, 1981). Both the skull and crossbones symbol and the prohibition/negation symbol are associated with enhanced perceived hazard (Bresnahan, 1985; Kalsher et al., 1995; Wogalter, 1995b; Wogalter, 1997b). The safety alert symbol (sometimes called the *signal icon*) is an exclamation point inside a triangle that functions to signal the presence of a warning (Young, 1991), but it does not appear to substantially increase the level of perceived hazard (Wogalter et al., 1994, Young, 1997).

The presence of pictorials enhances memory (Young & Wogalter, 1988). Some research shows enhanced compliance behavior with pictorial symbols (Jaynes & Boles, 1990), whereas other studies do not (Friedmann, 1988; Wogalter et al., 1992b; 1993b). This is probably because the symbols did not add substantial value over the accompanying printed language message.

Although one purpose of symbols is to communicate across languages and cultures and to low-literate individuals (Jentsch, 1996; Wogalter et al., 1997b), the attainment of this goal cannot be realized without testing varied populations (Silver et al., 1998). Older individuals have lower legibility and comprehension levels of symbol recognition than younger or middle-aged persons (Morrell et al., 1990; Ringseis & Caird, 1995; Sojourner & Wogalter, 1998). Icons may be useful in assisting medication adherence by facilitating its scheduling (Morrow et al., 1996).

Wording

The verbiage of a warning should include four main elements: a signal word, a description of the hazard or hazards, a list of possible consequences, and instructions for avoiding the hazard (Wogalter et al., 1987b). The signal word should attract attention to the warning and immediately indicate the level of hazard present (ANSI 1991, 1998). The hazard description should be specific and complete but must also balance a need for brevity; otherwise it might not be read.

The list of consequences should be explicit and should relate to the hazard description (Laughery et al., 1993). The instructions for avoiding the hazard should describe specific actions to be taken (or not taken) by the warning recipient. For some environmental sign warnings, Wogalter et al. (1985b) found that hazard and instruction statements were consistently rated as important elements, whereas the consequence statement and signal word were less consistently rated as important. The need for a consequence statement depended on the particular hazard.

Inclusion of redundant information reduced perceived effectiveness. Signs containing a hazard and instructions (e.g., "GASOLINE—NO SMOKING") were rated as easier to understand, more informative, and more likely to be complied with than signs containing only the hazard or the instructions (Polzella et al., 1992). It is easier to convey a message that concurs with existing knowledge than it is to train people to learn information they do not already know (Kalsher et al., 1992; Leonard et al., 1991, 1995; Resnick, 1997). In the use of some consumer products, direct instructions can be as effective as a warning in eliciting the desired behavior (McCarthy et al., 1987).

Other Warning Compendia

Three other published compilations of the warning literature complement this article: Miller et al. (1993), Laughery et al. (1994), and Edworthy and Adams (1996).

Directions for Future Warnings Research

More studies measuring actual behavioral compliance and real-world warning effectiveness are sorely needed. Some situations disallow behavioral measurement because researchers cannot expose participants to actual danger. Therefore, research confirming the utility of alternative measures (e.g., subjective judgments) to predict compliance behavior is also required.

Developments in technology for immersive virtual reality could allow participants to be placed in apparently risky environments in which warnings could be varied and behavioral effects studied (Glover & Wogalter, 1997). Field studies that examine people's free-standing looking behavior (Wogalter & Rashid, 1998) could be used to determine the relative effectiveness of various warning features to attract and maintain attention. The extent to which state (alcohol, drugs, fatigue, and stress) and trait (personality and demographics) factors influence warning effectiveness should be studied in more depth. For example, is there a "risk taker" personality, as some presume? If so, to what extent does it predict warning compliance across different situations (Purswell et al., 1986)?

As the population ages and becomes more diverse, research needs to include a broader range of participants, including children, older adults, and nonnative peoples. There is also a need to study the effects of warnings using long-range longitudinal studies instead of the typical single-shot, cross-sectional studies. Finally, additional research is needed on ways to produce and assess the quality of text messages.

Conclusions

This extensive list of empirical studies substantiates

the position that people's reaction to warnings and labels is much better understood today than it was 15 years ago. Previously, guidelines were based on expert opinion by necessity because there was little specific research on warning characteristics. That is not the case today. Unfortunately, most studies exclusively use college students because they are available at low cost, but the trend in recent years has been to test more representative groups of individuals and to perform the tests in real-world settings when possible.

Another notable aspect is that study results conflict, most likely because of different populations, procedures, and criteria. These factors potentially limit the generalizability of the findings; yet, these are the best data available. Fortunately, our knowledge continues to grow. As important as the topic of warnings is for commerce, consumers, government, civil litigation, and the public welfare, it is surprising that very little research is funded by government or industry. We believe that sources such as industry, government, foundations, law firms, and consumer groups need to provide more support for fundamental work in this area.

Bibliography

Most references are from the Human Factors and Ergonomics Society Annual Meeting Proceedings. Others are indicated by their source publications. Because of space constraints, all publications with more than two authors are listed with the name of the first author and "et al."

Adams, A. S., & Edworthy, J. (1995). Quantifying and predicting the effects of basic text display variables on the perceived urgency of warning labels: Tradeoffs involving font size, border weight, and color. *Ergonomics, 38,* 2221–2237.

Alves-Foss, J. D. et al. (1995). The effects of pictograph explicitness on hazard perceptions, p. 934.

ANSI (1991, 1998). *Accredited standard on safety colors, signs, symbols, labels, and tags, Z535.1 5.* Washington, DC: National Electrical Manufacturers Association.

Arndt, S. R. et al. (1998). Warning labels and accident data, pp. 550–553.

Ayers, T. J et. al. (1989). What is a warning and when will it work? pp. 426–430.

Barlow, C. B., & Hammond, A. J. (1995). Decision making processes in risky and non-risky consumer product selection, pp. 356–360.

Barlow, T., & Wogalter, M. S. (1993). Alcoholic beverage warnings in magazine and television advertisements. *Journal of Consumer Research, 20,* 147–156.

Barzegar, R. S., & Wogalter, M. S. (1998). Intended carefulness for voiced warning signal words, pp. 1068–1072.

Beltramini, R. F. (1988). Perceived believability of warning label information presented in cigarette advertising. *Journal of Advertising, 17,* 26–32.

Belz, S. M. et al. (1998). Auditory icons as impending collision system warning signals in commercial motor vehicles, pp. 1127–1131.

Bliss, J. P. et al. (1995). Human probability match behavior in response to alarms of varying reliability. *Ergonomics, 38,* 2300–2312.

Bohannon, N. K., & Young, S. L. (1993). Effect of warnings in advertising on adolescents' perceptions of risk for alcohol consumption, pp. 974–978.

Braun, C. C., & Silver, N. C. (1995a). Interaction of signal word and color on warning labels: Differences in perceived hazard and behavioral compliance. *Ergonomics, 38,* 2207–2220.

Braun, C. C., & Silver, N. C. (1995b). Interaction of warning label features: Determining the contributions of three warning characteristics. pp. 984–988.

Braun, C. C. et al. (1992). Likelihood of reading warnings: The effect of fonts and font sizes, pp. 926–930.

Braun, C. C. et al. (1994). Differences in behavioral compliance as a function of warning color, pp. 379–383.

Braun, C. C. et al. (1995). Adding consequence information to product instructions: Changes in hazard perceptions. pp. 346–350.

Bresnahan, T. (1985). The hazard association value of safety signs. *Professional Safety, 30*(7), 26–31.

Brugger, C. (1994). Public information symbols: A comparison of ISO testing procedures. In *Proceedings of Public Graphics* (pp. 26.1–26.10). Utrecht, Netherlands: University of Utrecht, Psychonomics Department.

Bruyas, M. P. et al. (1997). Pictorial information on variable message signs: Road safety conditions. In *Proceedings of the 13th Triennial Congress of the International Ergonomics Association* (Vol. 3, pp. 308–311). Helsinki, Finland: Finnish Institute of Occupational Health.

Caird, J. K. et al. (1997). The comprehensibility of airline safety card pictorials, pp. 801–805.

Chapanis, A. (1994). Hazards associated with three signal words and four colours on warning signs. *Ergonomics, 37,* 265–275.

Chen, J. Y. C., & Gibson, R. D. (1997). Perceived risk dilution with multiple warnings, pp. 831–835.

Cochran, D. J. et al. (1981). An investigation of shapes for warning labels, pp. 395–399.

Collins, B. L. (1983). Evaluation of mine-safety symbols, pp. 947–949.

Collins, B. L., & Lerner, N. D. (1982). Assessment of fire-safety symbols. *Human Factors, 24,* 75–84.

Conzola, V. C., & Klein, K. W. (1998). Need for cognition: An individual differences approach to understanding warning effectiveness, pp. 811–815.

Conzola, V. C., & Wogalter, M. S. (1998). Consumer product warnings: Effects of injury statistics on recall and subjective evaluations, pp. 559–563.

Cox, E. P., III et al. (1997). Do product warnings increase safe behavior? *Journal of Public Policy & Marketing, 16*(2), 195–204.

DeJoy, D. M.(1989). Consumer product warnings: Review and analysis of effectiveness research, pp. 936–940.

Desaulniers, D. R. (1987). Layout, organization and the effectiveness of consumer product warnings, pp. 56–60.

Desaulniers, D. R. (1989). Consumer products hazards: What will we think of next? In *Proceedings of INTERFACE 89* (pp. 115–120). Santa Monica, CA: Human Factors and Ergonomics Society.

deTurck, M. A., & Goldhaber, G. M. (1988). Consumers' information-processing objectives and effects of product warnings, pp. 445–449.

Dewar, R. E. (1976). The slash obscures the symbol on prohibitive traffic signs. *Human Factors, 18,* 253–258.

Dewar, R. E. (1994). Design and evaluation of graphic symbols. In *Proceedings of Public Graphics* (pp. 24.1–24.18). Utrecht, Netherlands: University of Utrecht, Department of Psychonomics.

Dingus, T. A. et al. (1991a). A most critical warning variable: Two demonstrations of the powerful effects of cost on warning compliance, pp. 1034–1038.

Dingus, T. A. et al. (1991b). Two reasons for providing protective equipment as part of hazardous consumer product packaging, pp. 1039–1042.

Dingus, T. A. et al. (1993). Warning variables affecting personal protective equipment use. *Safety Science, 16,* 655–673.

Donner, K. A., & Brelsford, J. W. (1988). Cuing hazard information for consumer products, pp. 532–535.

Drake, K. L. et al. (1996). Signal words: Do definitions correspond to connoted hazard? p. 1281.
Duffy, R. R. et al. (1993). The effectiveness of an interactive warning in a realistic product-use situation, pp. 935–939.
Edworthy, J., & Adams, A. (1996). *Warning design: A research prospective*. London: Taylor & Francis.
Edworthy, J., & Warren, C. A. (1997). The impact of warning color and signal word on children's interpretation of hazard level. In *Proceedings of the 13th Triennial Congress of the International Ergonomics Association* (Vol. 3, pp. 312–314). Helsinki, Finland: Finnish Institute of Occupational Health.
Edworthy, J. et al. (1991). Improving auditory warning design: Relationships between warning sound parameters and perceived urgency. *Human Factors, 33,* 205–231.
Edworthy, J. et al. (1995). The semantic associations of acoustic parameters commonly used in the design of auditory information and warning signals. *Ergonomics, 38,* 2341–2361.
FMC. (1985). *Product safety sign and label system*. Santa Clara, CA: FMC Corporation.
Frantz, J. P. (1994). Effect of location and procedural explicitness on user processing of and compliance with product warnings. *Human Factors, 36,* 532–546.
Frantz, J. P., & Rhoades, T. P. (1993). A task analytic approach to the temporal placement of product warnings. *Human Factors, 35,* 719–730.
Frantz, J. P. et al. (1993). The ability of two lay groups to judge product warning effectiveness, pp. 989–993.
Friedmann, K. (1988). The effect of adding symbols to written warning labels on user behavior and recall. *Human Factors, 30,* 507–515.
Gardner-Bonneau, D. J. et al. (1989). Cigarette warnings: Recall of content as a function of gender, message context, smoking habits, and time, pp. 928–930.
Gill, R. T. et al. (1987). A comparative evaluation of warning label designs, pp. 476–478.
Glover, B. L., & Wogalter, M. S. (1997). Using a computer simulated world to study behavioral compliance with warnings: Effect of salience and gender, pp. 1283–1287.
Glover, B. L. et al. (1996). Pictorial negations: Preferences for different circle-slash variations, pp. 910–914.
Godfrey, S. S., & Laughery, K. R. (1984). The biasing effects of product familiarity on consumers' awareness of hazard, pp. 483–486.
Godfrey, S. S. et al. (1983). Warning messages: Will the consumer bother to look? pp. 950–954.
Godfrey, S. S. et al. (1985). Warnings: Do they make a difference? pp. 669–673.
Godfrey, S. S. et al. (1991). The new alcohol warning labels: How noticeable are they? pp. 446–450.
Goldhaber, G. M., & deTurck, M. A. (1988a). Effectiveness of warning signs: Gender and familiarity effects. *Journal of Products Liability, 11,* 271–284.
Goldhaber, G. M., & deTurck, M. A. (1988b). Effects of consumer's familiarity with a product on attention and compliance with warnings. *Journal of Products Liability, 11,* 29–37.
Goldhaber, G. M., & deTurck, M. A. (1989). A developmental analysis of warning signs: The case of familiarity and gender, pp. 1019–1023.
Gomer, F. E. (1986). Evaluating the effectiveness of warnings under prevailing working conditions, pp. 712–715.
Griffith, L. J., & Leonard, S. D. (1995). Effectiveness of warning labels as a function of visual impressions, p. 931.
Haas, E. C., & Casali, J. G. (1993). The perceived urgency and detection time of multi-tone and frequency-modulated warning signals, pp. 544–548.
Haas, E. C., & Casali, J. G. (1995). Perceived urgency of and response time to multi-tone and frequency-modulated warning signals in broadband noise. *Ergonomics, 38,* 2313–2326.
Harris, J. E., & Wiklund, M. E. (1989). Consumer acceptance of threatening warnings in the residential environment, pp. 989–993.
Hopkins, J., & Parseghian, W. A. (1997). A driving simulator evaluation of active warning signs, pp. 921–925.
Hunn, B. P., & Dingus, T. A. (1992). Interactivity, information, and compliance cost in a consumer product warning scenario. *Accident Analysis & Prevention, 24,* 497–505.
ISO 7001. (1979). *Public information symbols index, survey and compilation of the single sheets*. Geneva, Switzerland: International Organisation for Standardization.
Jaynes, L. S., & Boles, D. B. (1990). The effect of symbols on warning compliance, pp. 984–987.
Jentsch, F. (1996). Understanding of aviation safety pictograms among respondents from Europe and the U.S., pp. 820–824.
Kalsher, M. J., & Wogalter, M. S. (1997). The effects of a raised label border on warning effectiveness measures, pp. 811–815.
Kalsher, M. J. et al. (1991). Posted warning placard: Effects on college students knowledge of alcohol facts and hazards, pp. 456–460.
Kalsher, M. J. et al. (1992). Connected quantity of food-label modifier terms, pp. 528–532.
Kalsher, M. J. et al. (1994). Enhancing the perceived readability of pharmaceutical container labels and warnings: The use of alternative designs and pictorials, pp. 384–388.
Kalsher, M. J. et al. (1995). Hazard level perception of current and proposed warning sign and label panels, pp. 351–355.
Kanouse, D. E., & Hayes-Roth, B. (1980). Cognitive considerations in the design of product warnings. In L. A. Morris et al. (Eds.), *Product labeling and health risks* (Banbury Report 6, pp. 147–163). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
Karnes, E. W. et al (1986). Effects of benign experiences on the perception of risk, pp. 121–125.
Kaskutas, L., & Greenfield, T. (1991). Knowledge of warning labels on alcoholic beverage containers, pp. 441–445.
Kline, P. B. et al. (1993). The impact of color on warning research, pp. 940–944.
Laner, S., & Sells, R. G. (1960). An experiment on the effects of specially designed safety posters. *Occupational Psychology, 34,* 153–169.
LaRue, C., & Cohen H. H. (1987). Factors affecting consumers' perceptions of product warnings: An examination of the differences between male and female consumers, pp. 610–614.
Laughery, K. R., Sr., & Stanush, J. A. (1989). Effects of warning explicitness on product perceptions, pp. 431–435.
Laughery, K. R., Sr., & Young, S. L. (1991). An eye scan analysis of accessing product warning information, pp. 585–589.
Laughery, K. R., Sr. et al. (1991). Effects of explicitness in conveying severity information in product warnings, pp. 481–485.
Laughery, K. R., Sr. et al. (1993). Explicitness of consequence information in warnings. *Safety Science, 16,* 597–613.
Laughery, K. R., Sr. et al. (1994). *Human factors perspectives on warnings*. Santa Monica, CA: Human Factors and Ergonomics Society.
Laughery, K. R., Sr. et al. (1997). Allocation of responsibility for product safety: Warning and severity of injury effects, pp. 543–547.
Laughery, K. R., Sr. et al. (1998). Tire rim mismatch explosions: The role of on-product warnings, pp. 1088–1092.
Laux, L., & Brelsford, J. W. (1989). Locus of control, risk perception, and precautionary behavior. In *Proceedings of INTERFACE 89* (pp. 121–124). Santa Monica, CA: Human Factors and Ergonomics Society.
Laux, L. et al. (1989). Usefulness of symbols and pictorials to communicate hazard information. In *Proceedings of INTERFACE 89* (pp. 79–83). Santa Monica, CA: Human Factors and Ergonomics Society.
Leonard, D. C. et al. (1989). Pest-control products: Reading warnings and purchasing intentions, pp. 436–440.
Leonard, S. D., & Karnes, E. W. (1996). A case study of using human factors analysis on warnings, pp. 525–529.
Leonard, S. D., & Karnes, E. W. (1998). Perception of risk in automobiles: Is it accurate? pp. 1083–1087.

Leonard, S. D., & Matthews, D. (1986). How does the population interpret warning signals? pp. 116–120.
Leonard, S. D. et al. (1988). Scale values for warning symbols and words. In F. Aghazadeh (Ed.), *Trends in ergonomics/human factors V* (pp. 669–674). Amsterdam: Elsevier.
Leonard, S. D. et al. (1991). Adequacy of responses to warning terms, pp. 1024–1028.
Leonard, S. D. et al. (1995). Hazards may result from failure conceptual agreement, p. 931.
Leonard, S. D. et al. (1997). Electrical hazards in the home: What do people know? pp. 840–843.
Lerner, N. D., & Collins, B. L. (1980). Evaluation of symbols for fire safety, pp. 484–487.
Magurno, A. et al. (1994). Iterative test and development of pharmaceutical pictorials. In *Proceedings of the 12th Triennial Congress of the International Ergonomics Association* (Vol. 4, pp. 360–362). Mississauga, Canada: Human Factors Association of Canada.
Mayer, D. L., & Laux, L. F. (1989). Recognizability and effectiveness of warning symbols and pictorials, pp. 984–988.
Mazis, M. et al. (1978). Patient attitudes about two forms of printed oral contraceptive information. *Medical Care, 16,* 1045–1054.
McCarthy, G. E. et al. (1987). Measured impact of a mandated warning on user behavior, pp. 479–483.
Miller, J. M. et al. (1993b). *Instructions & warnings – The annotated bibliography: Vol. III.* Ann Arbor, MI: Fuller Technical Publications.
Moore, J. L. (1990). The effect of hazard and system information on estimated risk, pp. 508–512.
Morrell, R. W. et al. (1990). Effects of labeling techniques on memory and comprehension of prescription information in young and old adults. *Journal of Gerontology, 45,* 166–172.
Morrow, D. G. et al. (1996). Using icons to convey medication schedule information. *Applied Ergonomics, 27,* 267–275.
Murray, L. A. et al. (1998). Prohibitive pictorials: Evaluations of different circle-slash negation symbols. *International Journal of Industrial Ergonomics, 22,* 473–482.
Nohre, L. et al. (1998). The effects of warning false alarms on driving speed, p. 1627.
Otsubo, S. M. (1988). A behavioral study of warning labels for consumer products: Perceived dangers and use of pictographs, pp. 536–540.
Patten, R. L. (1995). Inadequate warnings on hardware store solvents: The general public does not understand the behavior of flammable vapors, p. 934.
Pollack-Nelson, C. (1995). Analysis of methylene chloride product labeling. *Ergonomics, 38,* 2176–2187.
Polzella, D. J. et al. (1992). Perceived effectiveness of danger signs: A multivariate analysis, pp. 931–934.
Purswell, J. L. et al. (1986). A prediction model for consumer behavior regarding product safety, pp. 1202–1205.
Resnick, M. L. (1997). An evaluation of nutrition label quantifier terms: Consumer perceptions vs. FDA definitions, pp. 395.
Resnick, M. L. (1998). The effects of four label design parameters on perceived reliability, efficacy and intent to purchase of over-the-counter medication, pp. 546–549.
Resnick, M. L. et al. (1997). Cultural differences in the perception of responsibility for child safety, pp. 836–839.
Racicot, B. M., & Wogalter, M. S. (1992). Warning compliance: Effects of a video warning sign and modeling on behavior, pp. 608–610.
Riley, M. W. et al. (1982). An investigation of preferred shapes for warning labels. *Human Factors, 24,* 737–742.
Ringseis, E. L., & Caird, J. K. (1995). The comprehensibility and legibility of twenty pharmaceutical warning pictograms, pp. 974–978.
Rodriguez, M. A. (1991). What makes a warning label salient? pp. 1029–1033.
Sanders, M. S., & McCormick, E. J. (1993). *Human factors in engineering and design* (7th ed.). New York: McGraw-Hill.
Schwartz, D. R. et al. (1983). The impact of product hazard information on consumer buying decisions: A policy capturing approach, pp. 955–957.
Silver, N. C., & Braun, C. C. (1993). Perceived readability of warning labels with varied font sizes and styles. *Safety Science, 16,* 615–625.
Silver, N. C., & Perlotto, C. N. (1997). Comprehension of aviation safety pictograms: Gender and prior safety card reading influences, pp. 806–810.
Silver, N. C., & Wogalter, M. S. (1989). Broadening the range of signal words, pp. 555–559.
Silver, N. C., & Wogalter, M. S. (1991). Strength and understanding of signal words by elementary and middle school students, pp. 590–594.
Silver, N. C. et al. (1993). Connoted strength of signal words by elderly and non-native English speakers, pp. 516–520.
Silver, N. C. et al. (1995). Comprehension and perceived quality of warning pictorials, pp. 1057–1061.
Silver, N. C. et al. (1998). Comprehensibility of pharmaceutical pictorials among people with mental retardation, pp. 656–660.
Sloan, G., & Eshelman, P. (1981). The development and evaluation of pictographic symbols, pp. 198–202.
Slovic, P. et al. (1980). Facts and fears: Understanding perceived risk. In R. C. Schwing & W. A. Albers (Eds.), *Societal risk assessment : How safe is safe enough?* (pp. 181–216). New York: Plenum Press.
Sojourner, R. J., & Wogalter, M. S. (1997). The influence of pictorials on evaluations of prescription medication instructions. *Drug Information Journal, 31,* 963–972.
Sojourner, R. J., & Wogalter, M. S. (1998). The influence of pictorials on the comprehension and recall of pharmaceutical safety and warning information. *International Journal of Cognitive Ergonomics, 2,* 93–106.
Strawbridge, J. A. (1986). The influence of position, highlighting, and embedding on warning effectiveness, pp. 716–720.
Trommelen, M., & Akerboom, S. (1997). Symbols for child care products. In *Proceedings of the 13th Triennial Congress of the International Ergonomics Association* (Vol. 3, 350–352). Helsinki, Finland: Finnish Institute of Occupational Health.
Ursic, M. (1984). The impact of safety warnings on perception and memory. *Human Factors, 26,* 677–682.
Vaubel, K. P. (1990). Effects of warning explicitness on consumer product purchase intentions, pp. 513–517.
Vaubel, K. P., & Brelsford, J. W. (1991). Product evaluations and injury assessments as related to preferences for explicitness in warnings, pp. 1048–1052.
Vaubel, K. P., & Young, S. L. (1992). Components of perceived risk for consumer products, pp. 494-498.
Vigilante, W. J., & Wogalter, M. S. (1997a). On the prioritization of safety warnings in product manuals. *International Journal of Industrial Ergonomics, 20,* 277-285.
Vigilante, W. J., & Wogalter, M. S. (1997b). The preferred order of over-the-counter (OTC) pharmaceutical label components. *Drug Informational Journal, 31,* 973–988.
Vigilante, W. J., & Wogalter, M. S. (1998). Product manual safety warnings: The effects of ordering, pp. 593–597.
Vredenburgh, A. G., & Cohen, H. H. (1993). Compliance with warnings in high-risk recreational activities: Skiing and scuba, pp. 945–949.
Vukelich, M., & Whitaker, L. A. (1993). The effects of context on the comprehension of graphic symbols, pp. 511–515.
Westinghouse (1981). *Product safety label handbook.* Trafford, PA: Westinghouse Printing Division.
Wogalter, M. S., & Barlow, T. (1990). Injury severity and likelihood in warnings, pp. 580–583.
Wogalter, M. S., & Brelsford, J. W. (1994). Incidental exposure to rotating warnings on alcoholic beverage labels, pp. 374–378.
Wogalter, M. S., & Laughery, K. R. (1996). WARNING! Sign and label effectiveness. *Current Directions in Psychology, 5,* 33-37.

Wogalter, M. S., & Leonard, S. D. (in press). Factors that influence warning salience/attention-gettingness. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication.* London: Taylor & Francis.

Wogalter, M. S., & Rashid, R. (1998). A border surrounding a warning sign affects looking behavior: A field observational study, p. 1628.

Wogalter, M. S., & Silver, N. C. (1990). Arousal strength of signal words. *Forensic Reports, 3,* 407–420.

Wogalter, M. S., & Silver, N. C. (1995). Warning signal words: Connoted strength and understandability by children, elders, and non-native English speakers. *Ergonomics, 38,* 2188–2206.

Wogalter, M. S., & Young, S. L. (1994). Enhancing warning compliance through alternative product label designs. *Applied Ergonomics, 25,* 53–57.

Wogalter, M. S. et al. (1985a). Behavioral effectiveness of warnings, p. 679–683.

Wogalter, M. S. et al. (1985b). Perceived effectiveness of environmental warnings, 664–668.

Wogalter, M. S. et al. (1986). Perceptions of consumer products: Hazardousness and warning expectations, pp. 1197–1201.

Wogalter, M. S. et al. (1987a). Consumer products: How are the hazards perceived? pp. 615–619.

Wogalter, M. S. et al. (1987b). Effectiveness of warnings. *Human Factors, 29,* 599–612.

Wogalter, M. S. et al. (1988). Warning compliance: Behavioral effects of cost and consensus, pp. 901–904.

Wogalter, M. S. et al. (1989). Effects of cost and social influence on warning compliance. *Human Factors, 31,* 133-140.

Wogalter, M. S. et al. (1991a). Consumer product warnings: The role of hazard perception. *Journal of Safety Research, 22,* 71-82.

Wogalter, M. S. et al. (1991b). Evaluating the behavioral effectiveness of a multimodal voice warning sign in a visually cluttered environment, pp. 718–722.

Wogalter, M. S. et al. (1992b). The influence of location and pictorials on behavioral compliance to warnings, pp. 1029–1033.

Wogalter, M. S. et al. (1993a). Behavioral compliance to personalized warning signs and the role of perceived relevance, pp. 950–954.

Wogalter, M. S. et al. (1993b). Behavioral compliance with warnings: Effects of voice, context, and location. *Safety Science, 16,* 637-654.

Wogalter, M. S. et al. (1993c). Risk perception of common consumer products: Judgments of accident frequency and precautionary intent. *Journal of Safety Research, 24,* 97-106.

Wogalter, M. S. et al. (1994). Influence of warning label signal words on perceived hazard level. *Human Factors, 36,* 547–556.

Wogalter, M. S. et al. (1995a). Compliance to owner's manual warnings: Influence of familiarity and the placement of a supplemental directive. *Ergonomics, 38,* 1081-1091.

Wogalter, M. S. et al. (1995b). Hazard associations of warning header components, pp. 979–983.

Wogalter, M. S. et al. (1997a). Comprehension and retention of safety pictorials. *Ergonomics, 40,* 531–542.

Wogalter, M. S. et al. (1997b). Connoted hazard of Spanish and English warning signal words, colors, and symbols by native Spanish language users. In *Proceedings of the 13th Triennial Congress of the International Ergonomics Association* (Vol. 3, pp. 353–355). Helsinki, Finland: Finnish Institute of Occupational Health.

Wogalter, M. S. et al. (1997c). Effect of container shape on hazard perceptions, pp. 390–394.

Wogalter, M. S. et al. (1997d). Effect of source attribution on judgments of warning credibility and compliance likelihood. In B. Das & W. Karwowski (Eds.), *Advances in occupational ergonomics and safety: Vol. II* (pp. 451-454). Louisville, KY: IOS Press.

Wogalter, M. S. et al. (1998a). Effects of warning quality and expert testimony on allocation of responsibility for consumer product accidents, pp. 665-669.

Wogalter, M. S. et al. (1998b). Hazard level perceptions of warning components and configurations. *International Journal of Cognitive Ergonomics, 2,* 123–143.

Wogalter, M. S. et al. (1998c). The influence of time stress and location on behavioral compliance. *Safety Science, 29,* 143–158.

Wogalter, M. S. et al. (in press). Enhancing information acquisition for over-the-counter medications by making better use of container surface space. *Experimental Aging Research.*

Wolff, J. S., & Wogalter, M. S. (1993). Test and development of pharmaceutical pictorials. In *Proceedings of INTERFACE 93* (pp. 187–192). Santa Monica, CA: Human Factors and Ergonomics Society.

Young, S. L. (1991). Increasing the noticeability of warnings: Effects of pictorial, color, signal icon and border, pp. 580–584.

Young, S. L. (1997). The role of pictorials in environmental safety signs, pp. 797–800.

Young, S. L. (1998). Relative importance of different verbal components in conveying hazard-level information in warnings, pp. 1063-1067.

Young, S. L., & Wogalter, M. S. (1988). Memory of instruction manual warnings: Effect of pictorial icons and conspicuous print, pp. 905–909.

Young, S. L., & Wogalter, M. S. (1990). Comprehension and memory of instruction manual warnings: Conspicuous print and pictorial icons. *Human Factors, 32,* 637–649.

Young, S. L. et al. (1989). Gender differences in consumer product hazard perceptions. In *Proceedings of INTERFACE 89* (pp. 73–78). Santa Monica, CA: Human Factors and Ergonomics Society.

Young, S. L. et al. (1990). Judgments of hazard, risk, and danger: Do they differ? pp. 503–507.

Young, S. L. et al. (1992a). Relative contribution of likelihood and severity of injury to risk perception, pp. 1014–1018.

Young, S. L. et al. (1992b). Effects of two type density characteristics on the legibility of print, pp. 504–508.

Young, S. L. et al. (1995). Relative order and space allocation of message components in hazard warning signs, pp. 969–973.

Zlotnik, M. A. (1982). The effects of warning message highlighting on novel assembly task performance, pp. 93–97.

Zobel, G. P. (1998). Warning tone selection for a reverse parking aid system, pp. 1242-1246.

Zwaga, H. J. G. (1989). Comprehensibility estimates of public information symbols: Their validity and use, pp. 979–983.

Stuart O. Parsons is president of Parsons & Associates and is involved in forensic and power systems human factors. He may be reached at 19740 Escuela Dr., Saratoga, CA 95070, sop@pacbell.net. Joseph Seminara is a consultant in the area of nuclear power plant human factors in control room design and is currently affiliated with Parsons & Associates. Michael S. Wogalter is an associate professor of psychology at North Carolina State University, conducting research in the area of warnings and risk communication. *The authors wish to thank Vincent C. Conzola, John Shafer, and an anonymous reviewer for their comments on an earlier version of this manuscript. Copies of HFES Annual Meeting papers cited here may be obtained from HFES (310/394-1811, hfes@compuserve.com). The cost is $10 per article.*