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A three-stage model summarizes product warning and environmental sign research

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ABSTRACT

The past 25 years have experienced a substantial amount of research on safety communications, more specifically, warnings. This article focuses on the most important factors in designing effective warnings. The warning process is modeled in three stages. Effective warnings attract attention; elicit knowledge, and enable compliance behavior. Two main categories are design factors and non-design factors. Non-design factors include the effects of target audience and situational factors. For attention, important design factors are size, color/contrast, signal word, graphics, and format. The non-design factors for attention include context, location, and distraction. Design factors affecting the knowledge and compliance stages include explicit wording and pictorials to provide hazard, consequences and instructional content. Non-design factors for the knowledge stage include familiarity and perceived hazard. Non-design factors for the compliance stage include modeling the behavior of others and cost of compliance. The research literature offers practical design recommendations to aid application decisions.

1. Introduction

During the last 25 years there has been a substantial, and increasing, amount of research on safety and risk communications, warnings. The research has encompassed both theoretical issues as well as application concerns. There has been a number of reviews and collections of the warnings research literature. Two are collections of research articles from the *Proceedings of the Human Factors and Ergonomics Society* (Laughery et al., 1994; Wogalter et al., 2001). Lehto and Miller (1986) reviewed the early literature on warnings, and they have followed with several editions of an annotated bibliography. A book by Edworthy and Adams (1996) contained a general review of visual and auditory warnings. Other reviews published in the mid- and late-1990s include Laughery and Wogalter (1997), Parsons et al. (1999), Wogalter et al. (1999a) and Wogalter and Laughery (1996). More recent reviews are reported in Laughery (2006), Laughery and Wogalter (2006) and Wogalter and Laughery (2004, 2006). Also, a substantial handbook that reviews the warnings literature has been published (Wogalter, 2006).

This article presents an overview of the warning research literature. The intent is to focus on the most important factors in designing effective visual warnings, such as labels, signs, tags, and product manuals. For research and reviews of auditory warnings and warnings in other sensory modalities, see e.g., Edworthy and Hellier (2006), Haas and Edworthy (2006). Although this discussion is limited to warnings presented to the visual sense, there is some overlap of the higher order processing. In other words, after the sensation experience, there are common processing systems independent of the receiving modality. Some processes, particularly the later ones, in the knowledge and compliance stages, are applicable regardless of the sensory modality that initiated it.

2. Purpose of warnings

Warnings can be viewed as a communication tool for achieving environmental and product safety. The purpose of warnings may be addressed from several perspectives, as a provider of information, as an influence on behavior, and as a reminder.

2.1. Provide information

As a communication, a warning is intended to provide information for the audience to whom it is directed. According to research as well as US standards and guidelines (ANSI Z535, 2002; FMC, 1985; Westinghouse Electric Corporation, 1981), warnings should include information about the hazard, the potential consequences, and safe and unsafe behaviors. The information should allow informed decisions regarding compliance. One metric for success might be whether the warning information was received and understood.

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2.2. Influence behavior

Warnings are also used to influence behavior. A warning on a door that says "*DANGER, High Voltage, You could be Electrocuted, Keep Out!*" in 5-in. lettering accompanied by an electrical shock symbol will probably work in terms of people not opening the door. Although the wording for high voltage sign is certainly not the best that could be constructed, the sign would likely be more effective than the original or with no warning. Consider, however, another hypothetical warning that instructs users to wear protective equipment when working with some toxic substance. It turns out that despite being in the presence of this warning, people do not wear the appropriate equipment. In terms of being effective with regard to behavioral compliance, this warning in this context would be considered a failure. The warning did not achieve its behavioral purpose.

2.3. Reminder

The reminder function of warnings concerns the fact that a person may have some latent or dormant knowledge in their head about a hazard, but may not be aware of it at the proper time. Thus, the reminder purpose of warnings is to aid in cuing relevant information from memory into awareness at the time it is needed. Most people know conceptually that there are certain areas in which smoking is not permitted, so seeing a symbol comprised of a prohibition (circle slash) icon over a drawing of a lighted cigarette will remind most smokers not to smoke in the area. The sign serves as a cue to existing knowledge.

3. Warnings and the safety hierarchy

In the fields of safety, engineering, as well as in human factors and ergonomics, there is a basic set of strategies to prevent hazards from injuring people and damaging property, sometimes called the *hazard control hierarchy* (Sanders and McCormick, 1993). This hierarchy defines priorities for addressing product or environmental hazards: first is to design them out, second is to guard against them, and third is to warn.

The first and preferable approach to dealing with hazards is to eliminate them through an alternative design. Substituting a non-toxic component for a toxic component in a chemical product is an example. However, it is not always technologically and/or economically feasible to design out hazards.

Guarding, the second priority, can be viewed as a means of preventing contact between people and the hazard. Physical guards such as personal protective equipment, highway barricades, and fences around swimming pools are examples. Guarding may also be procedural, such as the physician's prescription needed for purchasing certain medications, or a combination of both physical and procedural, such as a "dead man's" switch that stops hazardous motion of equipment when a handle or switch is released by the operator, as in many walk-behind lawnmowers. However, like the alternative design issues, guarding is not always feasible or effective, which means another method is needed.

A third line of defense against hazards is to warn. As already noted, warnings are intended to provide information needed to use a product (or perform in an environment) safely. Warnings, like the other strategies can also be limited in terms of effectiveness. People may not see or hear a warning, they may not understand it, or they may not be sufficiently motivated to comply with it. But these concerns are not a basis or an excuse for not giving a warning when it is appropriate to do so. Rather, these limitations have two practical implications. One is that the warning needs to be designed in a manner that makes it more likely to be effective by employing design parameters described later in this article. The second point is that the warning should be regarded as one tool or approach for addressing product and environmental safety. It should not be considered a cure for poor design and guarding (Laughery and Wogalter, 1997).

4. Theoretical approaches

Theoretical efforts regarding warnings have generally been based on one or both of two classic theoretical perspectives: communications theory and human information processing theory. A typical communications model consists of four components:

- Source – origin of the warning message.
- Medium – how the message is presented.
- Message – content of the message.
- Receiver – target audience of the message.

The human information-processing (HIP) framework consists of stages (e.g., attention, memory, etc.) through which warning information flows within individuals receiving the information. In basic HIP models, information is processed from one stage to the next stage. If processing is successful, it continues to the next stage. If not successfully processed at a stage (some blockage), the flow may be disrupted and the warning may fail.

Wogalter et al. (1999a) combined the communications and information processing models into a unified theoretical framework, referred to as C-HIP. The C-HIP model is shown in Fig. 1. Similar models have been proposed by Lehto and Miller (1986) and Rogers et al. (2000).

The feedback loops on the right in Fig. 1 indicate that what occurs at one stage may influence other stages. For example, the warning may be noticed and examined (attention switch and holding stage), but not understood (the comprehension stage). As a result of not understanding, the person may read it again, thus moving the process back to an earlier stage. (Alternatively, the individual may instead move onto look at something else altogether.) Another example of a later stage influencing an earlier stage occurs when a person believes a product is safe and as a result, does not look for or examine a warning. This processing would

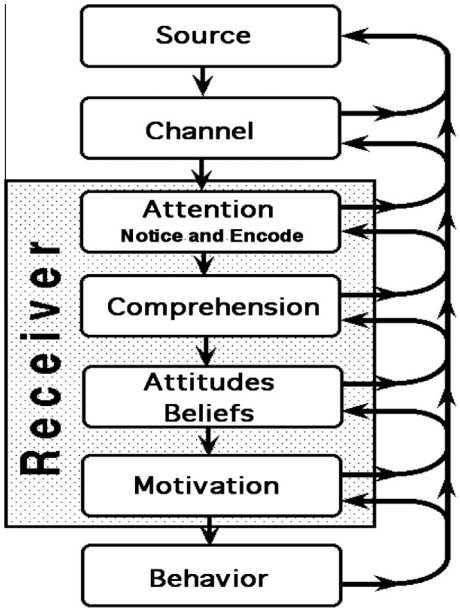

Fig. 1. C-HIP model.

involve a feedback loop in which the Beliefs/Attitude stage affects the Attention stage. The point is that processing a warning message may be more complex than a simple flow of information through a linear sequence of stages.

The C-HIP model and others like it have been used for organizing, guiding and reviewing warnings research. This review takes a somewhat simpler approach to discussing the research. Warning research is organized around a three-stage model that globally covers the main parts of C-HIP model's Receiver section. The three stages are: Attention, Knowledge and Compliance (see AKC model in Fig. 2). The three-stage AKC model differs from the C-HIP model by focusing only on the main stages of the Receiver portion of the C-HIP. To further translate between models, AKC's Attention stage includes noticing, attention getting, and attention switch. AKC's Knowledge includes comprehension, memory, beliefs, and some decision-making. Finally, AKC' Compliance stage includes compliance intent, motivation, some compliance decision-making, and behavior. These stages and research addressing factors influencing them are addressed in the following sections.

5. Context and background

As noted previously, the purposes of warnings can be viewed from different perspectives. Regardless of the perspective one considers or adopts, there are three things most people would agree warnings should achieve if they are to have a chance of being effective.

First, warnings must attract attention. People do not typically search for or seek out warnings; hence, warnings must be conspicuous. Second, the warnings must affect knowledge by promoting encoding, enhancing knowledge, and/or cuing existing knowledge to make the individual aware of the hazard, consequences and what to do to avoid the hazard.

Third, warnings should lead to appropriate decisions with respect to carrying out behavior. Leading into such decision making are the processes of the previous stages, most notably the knowledge stage. Information is needed for recipients to make informed decisions regarding behavior. Motivation may be necessary so that behavior is actually carried out. Such decisions can be viewed in terms of cost-benefit trade-offs. The costs may take the form of money, time, and/or effort (Wogalter et al., 1987, Wogalter et al., 1989). Benefits may include avoiding injuries, property damage, or negative health effects. Thus, a goal for warnings is to provide the information needed for compliance decisions to be made rationally and wisely. In the following sections we describe factors that affect attention, knowledge, and compliance.

Much of the empirical research on warnings has concerned design characteristics such size, color, presence and type of pictorials, as well as message content, as in information about hazards, consequences, and instructions. However, there are also non-design factors that influence warning effectiveness, such as target audience characteristics and situational circumstances. Sometimes non-design factors are more influential than design factors.

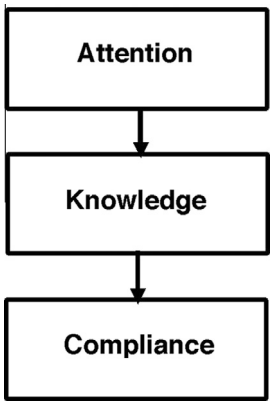

Fig. 2. 3-Stage attention, knowledge and compliance (AKC) model.

6. Attention

As noted, there are design and non-design factors that influence attention to warnings.

6.1. Design factors

A substantial amount of research has been reported that addresses the characteristics of warnings that affect whether the warning will be noticed and encoded. These characteristics are reviewed elsewhere (e.g., Laughery, 2006; Laughery and Wogalter, 2006; Wogalter and Vigilante, 2006). The factors that have shown significant effects are:

- *Location* – placed where it is likely to be encountered.
- *Size* – bigger is generally better.
- *Color* – hue differences for prominence.
- *Contrast* – brightness differences; black on white or vice versa for greater legibility.
- *Format* – "chunked" text and outline/bulleted lists attract attention better than large dense paragraphs of text.

Location or placement of a warning could be a design factor or a non-design factor depending on the circumstances. Location may be constrained by available space, but alternative designs can often be used to enlarge the space (e.g., Wogalter et al., 1999b; Wogalter and Vigilante, 2003; Wogalter and Young, 1994).

There are other constraints on the above design parameters due to environment. For example, orange is a good color but would not be a good design choice for a warning in a context in which most everything in the surrounding environment is orange. An excellent warning label or sign could be rendered ineffective if placed in a location which is not visible to users, e.g., such as below eyelevel or obstructed from view.

A different kind of design factor that is not in the above list is physical interactivity. Physical interactivity refers to a procedure in which people are required to interact with the warning before a product can be used. For example, Frantz and Rhoades (1993) reported that a warning that had to be physically removed before the product could be used was more likely to be noticed than a warning that did not require any overt physical manipulation. Wogalter et al. (1995) found that interactivity was one way to get familiar users to notice a warning.

6.2. Non-design factors: target audience and situational factors

Populations with various vision deficiencies should be considered in designing warning systems. For example, color blindness, and older adults with presbyiopia can affect detection of the colors and sizes of warnings.

Distraction can play a role in effectiveness. An individual may be distracted or be so involved with a task such that he or she does not notice the warning. Enhanced salience (i.e., employing the above design factors) could counteract distraction or failure to see the warning.

Other target audience factors, such as age and gender have been examined in numerous studies. The results are not robust, but there is a trend that women and older members of the target audience are more likely to notice warnings. However, these broad

demographics differences are not strong, especially compared to the factors discussed in this article. Others have reviewed age and gender effects (see e.g., Mayhorn and Podany, 2006; Rogers et al., 2000; Smith-Jackson, 2006; Vredenburgh and Helmick-Rich, 2006).

7. Knowledge

There are both design and non-design factors that influence warnings knowledge.

7.1. Design factors

Warnings should assist persons in comprehending hazards, consequences, and instructions. Design factors that facilitate warning effectiveness with respect to knowledge include:

- *Well-known terms* – meaningful high frequency terms.
- *Signal word* – Bold printed words that are intended to convey levels of hazard
- *Connotation* – Meaningful nonverbal elements such as color connote hazard.
- *Brevity* – Promotes comprehension because more people will read shorter text
- *Format* – potentially show some organized structure to the information via format, such as in bulleted, numerical or outline format.
- *Explicitness* – giving specific information rather than general information.
- *Symbols/Pictorials* – potentially a picture can be worth a lot (perhaps a thousand words) if it conveys meaning quickly.

7.1.1. Terminology, brevity and format

Textual warnings should be presented using well-known terms. Generally this means that the terms occur with relatively high frequency in a language so that they are likely familiar to the target audience. Warnings should be written to be as brief, as possible, since the shorter the material the more likely people will read it. Signal words can potentially convey the level of hazard involved. Of the conventional signal words, DANGER connotes higher hazard than WARNING or CAUTION. Color can provide meaningful connotative information. The colors red, orange, and yellow tend to connote the greatest levels of hazard as compared to other colors. Research indicates that red is perceived as connoting more hazard than orange or yellow, which usually are not found to differ between them but both are generally higher than other colors (e.g., Chapanis, 1994; Wogalter et al., 1998a). Format can help provide information by conveying an organized structure. Bulleted, lists and outline formats are preferred (Desaulniers, 1987; Wogalter and Shaver, 2001; Wogalter et al., 2002).

7.1.2. Explicitness

Explicitness in the context of warnings has been defined as information that is specific, detailed, clearly stated, and leaves nothing implied (Laughery and Wogalter, 2006). The explicitness of content information has emerged in research on warnings as an important factor for warning effectiveness in terms of knowledge (Laughery and Smith, 2006).

As already discussed, the content of warnings should include hazard, consequences and instructional information. Explicitness has been shown to be a factor in all three of these information categories. Consider this descriptive example. A 48-year-old person, named Isaac Stellar, uses a floor stain on his family's dining room hardwood floor to refinish parts of it. Assume that the container label has the following hazard, consequence and instruction information:

> Flammable
> Risk of Burn Injury
> Use with adequate ventilation.

One hour after applying the product, there is a fire that completely destroys the Stellar house in which Mr. Stellar is badly burned. Mr. Stellar does not smoke and after the incident states that he was not intending to light a match or a lighter or anything like that. He said he opened the two windows of the dining room mainly because of the smell. The fire marshal's investigation concludes that the fire was likely caused by vapors, which traveled along the surface of the floor to a water heater wherein the pilot light ignited it. Like many people, Mr. Stellars' impression of the term "Flammable" did not suggest much more than a common candle flame. Most people do not know the technical definition of "flammable" in contrast with the term "combustible." According to the US Hazardous Substance Act (US 16 CFR 1500) regulations and the National Fire Protection Association (ANSI/NFPA 321/30) standard, materials labeled as "combustible" are actually less of a fire hazard than "flammable," but many people in the general public erroneously believe the reverse (Main et al., 1993; Patton, 1995). Flammable liquids labeled Flammable are more hazardous if the flash point is below 100 °F. Flammable liquids labeled Combustible are those liquids that have a flash point at or above 100 °F.

Following this incident, Mr. Stellars admitted knowing beforehand (like most adults) that fires could cause burns and injuries, so the consequence statement in the warning was not very informative; it is not specific/explicit. Mr. Stellars states that he thought the open windows would effectively dissipate the vapor. Unfortunately, the windows were high above the floor and the weather service recorded minimal wind in the area that day. Mr. Stellars was also unaware that the vapors could travel long distances along a floor and in this case to where the gas-fired water heater was located. Also it did not occur to him that a gas water heater, which was some distance away in the basement, was something to be concerned about when doing a household task such as re-staining the hardwood floor. The label's non-explicit warning reveals little or nothing about the specific nature of the safety problem. Much of it is essentially useless in telling the user what the problem is and what to do or what not to do.

Consider the following warning as a possible alternative:

> Serious Fire, Burn, and Explosion Hazard
>
> Vapor is heavier than air – it can travel along the ground long distances to low spots and be ignited at a remote location. Do not allow matches, lighters, electrical switches, sparks or pilot lights within 50 ft. (15 m). More distance is better. If product is used indoors, make sure there is moving, ventilated air to the outside.

This is not the definitive final wording or a warning that would actually go on a product but it is a better warning than the earlier one. It is longer than the original, but much less vague. It describes the hazard in a way that is likely to be more meaningful to a lay consumer than the term "flammable" alone. The hazard is also more explicit in spelling out that vapors can collect and move to a distant location to an ignition source, and gives some specific examples of various ignition sources to consider. It also talks more about the kind of ventilation needed if used indoors. Undoubtedly more safety information is needed on an actual label of floor stain beyond the explicit warning given here. Consumer testing could further enhance it. The point is that a generally worded warning

provides little or no benefit if it fails to convey information that enables users to make informed decisions.

7.1.3. Pictorial symbols

Pictorials can play an important role in noticing warnings and conveying hazard information (e.g., see Wogalter et al., 2006; Young and Wogalter, 1990). The benefit to compliance partly is due to the noticing and knowledge stages. Pictorials can also benefit certain target audiences where illiteracy and language barriers exist. Further, pictorials may be used to communicate hazard, consequence and/or instructional information. A few examples follow in Figs. 3–5, which communicate hazard, consequence and instructional information respectively. Meaningful pictorials are effective in communicating the types of information that facilitate more informed decisions.

There may be conflicts between some of the design guidelines. For example, brevity is associated with greater likelihood of reading, but there may be exceptions (e.g., Laughery and Wogalter, 1997). For example, Silver et al. (1991) reported a positive correlation between message length and willingness to read a warning for pest control products. This is possibly because longer warnings were usually given on the more hazardous products and research has shown that people are more likely to read warnings on more hazardous products (e.g., Wogalter et al., 1991). Brevity may also conflict with the explicitness criterion, because specific descriptions sometimes require lengthier warnings. Sensible design decisions should consider the nature of the hazard, the target audience, and situational circumstances. The point is that the warning development process should involve both brevity and explicitness considerations to ultimately convey the nature of the hazard, the negative consequences that could result, and how to avoid the hazard.

Fig. 3. Pictorial symbol illustrating hazard.

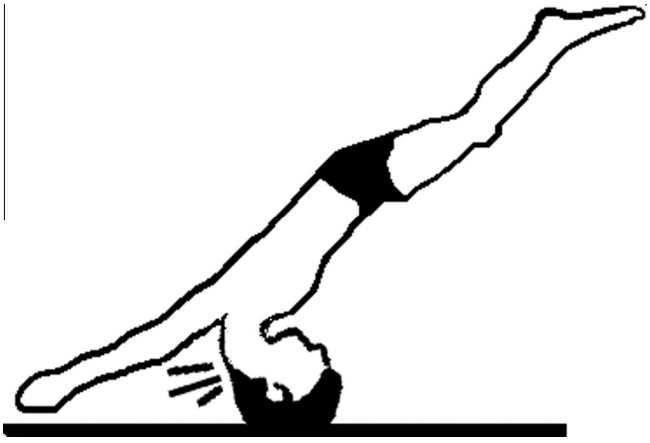

Fig. 4. Pictorial symbol illustrating consequences.

Fig. 5. Pictorial symbol illustrating instructions.

7.2. Non-design factors: target audience and situational factors

Target audience characteristics and the situation in which a warning is presented are factors that influence whether a warning will fulfill the knowledge purpose. The levels of perceived hazardousness and familiarity have been shown to be especially influential.

7.2.1. Perceived hazardousness

Perceived hazard has been defined as a composite variable that takes into account the likelihood of the hazard and the severity of the potential consequence. Research (e.g., Wogalter et al., 1991, 1993) indicates injury severity tends to be more influential in people's hazard perceptions than injury probability with respect to consumer products. Probably this is due to people's beliefs that the likelihood of injury for most consumer products is very small.

7.2.2. Familiarity

Familiarity is a belief that is largely derived from people's experience with a particular or similar product or environment. It is tied to knowledge although not perfectly. People may feel or believe they are familiar but still not know all of the necessary information about safety based on their personal experiences.

7.2.3. Knowledge stage affecting attention stage

People's a priori perceptions of the degree of hazard and familiarity associated with a product or environment are important determinants of whether a warning is attended. Numerous studies have found that the greater the level of perceived hazard (e.g., Otsubo, 1988; Wogalter et al., 1991) and familiarity (Godfrey et al., 1983; Godfrey and Laughery, 1984), the more likely people will look for and read warning information. However, Godfrey and Laughery (1984) reported that the more familiar women were with tampons, the less likely they were to notice warnings regarding toxic shock syndrome. As might be expected, hazard perceptions are highly correlated with familiarity, and greater familiarity reduces the likelihood of seeking or reading a warning on a same (or similar) product.

8. Compliance

Whether or not people using a hazardous product or performing some task in a hazardous environment decide to comply with a warning depends on both the design of the warning and the characteristics of the persons and situation involved. Research on warning compliance has typically employed one or both of two dependent measures: behavioral intentions and behavior (see e.g., Kalsher and Williams, 2006; Silver and Braun, 1999; Wogalter and Dingus, 1999 for reviews of this research).

As noted previously, warning compliance decisions can be viewed in the context of cost-benefit tradeoffs. People may not comply with a warning because the costs (in terms of time, effort, and/or money) are perceived to outweigh the benefits of compliance. Thus, beliefs and attitudes feed into decision making regarding whether or not to comply (see the C-HIP model, Fig. 1). Hence, in order to make informed compliance decisions, it is important that the warning be attended to and that it contain the information needed to enable informed decisions. As already discussed, the warning needs to be salient and provide the hazard, consequences, and appropriate behavioral information required to make an informed decision.

8.1. Design factors

Design factors important for compliance include those already discussed with respect to attention and knowledge stages. Two of them are given specific focus here: explicitness and pictorials.

8.1.1. Attention and knowledge factors

In previous sections, warning design factors affecting attention and knowledge were identified. Those factors are also important in determining compliance. If a warning is *not* attended and understood, it cannot have a direct effect on behavior. Thus, location, size, color/contrast, signal word, format and symbols/pictorials are not only important factors for attention and knowledge goals of warnings; they are also design parameters affecting compliance. Reviews of these factors on compliance can be found in Kalsher and Williams (2006), Rogers et al. (2000) and Silver and Braun (1999). Here we discuss two factors: explicitness and pictorial symbols. Both were discussed in the knowledge section, but they are important in compliance.

8.1.2. Explicitness

The explicitness of content information has emerged as an important contributing factor to compliance (Laughery and Smith, 2006). As discussed previously, explicit content can include hazard, consequences and instructional information. For example, in Section 7.1.2, two warnings were contrasted: a general one and an explicit on. In Mr. Stellar's situation, compliance would be benefitted if he had been given more specific information on the hazards involved in using the floor stain, what the consequences could be, and what he needed to do to avoid those consequences.

Another point of contrast between the two warning examples is that providing explicit information in all three categories (hazard, consequences, and instructions) can facilitate informed compliance decisions. From a motivational perspective, it is not surprising that more explicit information influences compliance. More specific instructions can lead to correct and proper safety behavior. In Mr. Stellar's case, compliance would be more likely if there were instructions telling users specifically what to do if there is non-moving (static) air. For example, the warning might have described an appropriate fan setup to help move vapors to the outside before they migrate to other dangerous areas such as a basement water heater. Also, more specific description of consequences (generally of higher severity) tend to promote greater compliance (Laughery and Smith, 2006; Wogalter et al., 1999c).

8.1.3. Pictorial symbols

Pictorials' benefits are often attributed only to the noticing and knowledge stages, but pictorials can also be beneficial in the compliance stage (e.g. Jaynes and Boles, 1990; Wogalter et al., 1997a). One direct benefit is that they can be used to communicate instructional information, as shown in Fig. 5. They function better in this role when the symbols are representational and direct as opposed to being abstract. They can also benefit compliance with certain target audiences where illiteracy and language barriers exist. They can also enable more informed cost-benefit trade-off decisions. Thus, it is not surprising that meaningful pictorials contribute to warning compliance.

8.2. Target audience and situational factors

Several target audience and situational variables have been shown to influence warning compliance. For a review of the research see Rogers et al. (2000) and Wogalter and Laughery (2006). Among the most important factors are familiarity, modeling, stress, and cost of compliance.

8.2.1. Familiarity

The familiarity effect was discussed in the knowledge stage of processing, and it has been shown to influence warning compliance. According to numerous studies (including Burnett et al., 1988; Goldhaber and deTurck, 1988; Lehto and Foley, 1991; Wogalter et al., 1995), people who are more familiar with a product are less likely to comply with warnings directed toward the product's hazards. However, the effects of familiarity are somewhat more complex in that some research indicates that compliance increases with greater familiarity. For example, Ortiz et al. (2000) reported that when applying pesticides, people who were familiar with the product were more likely to comply with a warning (wear protective equipment) than those who were less familiar. A possible explanation for these apparent inconsistencies is that familiarity is mediated by the perception of hazard. With lower levels of perceived hazard, compliance will be less likely. Thus, in cases in which familiarity is associated with increased appreciation of hazardousness, greater compliance will result. This explanation is also consistent with the notion that compliance is an outcome of a cost-benefit analysis.

8.2.2. Modeling

Warning compliance, like other modes of behavior, is influenced by social context and the behavior of others. People will tend to model the safe or unsafe behavior of others. Several studies have been reported that show a robust effect of modeling on warning compliance (deTurck et al., 1999; Edworthy and Dale, 2000; Wogalter et al., 1989).

The behavior of others is a form of instruction regarding appropriate and/or inappropriate behavior. If a vehicle passenger observes the owner/driver fasten the seat belt, the passenger is more likely to do the same. This explanation is also consistent with viewing compliance as a cost-benefit trade-off decision.

8.2.3. Stress

Time pressures (Wogalter et al., 1997b, 1998b) or the presence of other concurrent mental activities that result in multi-tasking (Wogalter and Usher, 1999), can interfere and reduce compliance rates. These effects start by limiting attention, whose effects cascade through to the knowledge and compliance stages. The compliance stage reflects a limitation on the ability to carry out multiple

tasks concurrently which compliance to a warning might get the short shrift.

8.2.4. Cost of Compliance

A substantial amount of research has explored the effects of cost of compliance on whether or not people will comply with warnings. Costs may take the form of money, time, effort, and/or convenience. The results of the research have been consistent and robust across a variety of settings (e.g., Rogers et al., 2000; Silver and Braun; 1999).

In general, the greater the cost of compliance, the lower the likelihood of compliance. Conversely, the lower the costs of compliance, the greater the likelihood of compliance. Likewise perceived cost of non-compliance is influential such as when severe consequences are described.

9. General discussion

In this article we have taken the position that in order to be effective, warnings must capture attention, influence knowledge, and affect compliance decisions. There are many factors that influence the success or failure of warnings with respect to these three stages. These factors were partitioned into two categories: design and non-design factors with the latter including influences of target audience and situation. Within this framework, the most influential factors on warning effectiveness were described.

In the attention stage, important design factors are location, size, color/contrast, and presence of a signal word, format, and symbols/pictorials. Also, target audience and situation factors such as perceived hazardousness and familiarity affect attention. These same factors serve as an important basis for the knowledge stage.

Research clearly indicates a direct relationship between perceived hazardous of a product or environment and likelihood that a warning will be noticed and encoded. By contrast, the greater the familiarity, the less likely the warning will be attended.

In the compliance stage, some of the same factors that influence attention and knowledge are also important, since if the warning goes unnoticed (or otherwise not processed) it cannot be directly effective in influencing compliance. Two design factors were discussed: explicitness and the use of pictorials. The research shows that the presence of more explicit hazard, consequences and instructional information in warnings increases the likelihood of compliance. Well-designed meaningful pictorials can also benefit compliance.

Familiarity with the product or environment relates to perceived hazardousness and compliance but the relationship is complex. Warning compliance tends to increase with higher levels of perceived hazard. However, if experience results in a lower hazard perception, compliance will be less likely. Modeling is a social phenomenon that appears to have consistent effects on compliance. People tend to do what others do. If one or more ‘‘models’’ comply, then others will usually follow their lead. One of the most robust factors to influence warning compliance is cost of compliance. The greater the cost in terms of time, effort, and/or money, the less likely people will comply with warnings.

This article summarizes the authors' impressions of some of the most substantial findings of the warnings research carried out and reported during the past quarter century. Good progress in advancing knowledge about the processes involved has been made. The research has laid the groundwork for defining principles of warning design that can assist the warning designer is developing effective warnings. Practical design recommendations can be derived from the body of literature to aid application decisions.

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