• 5 •

COMMUNICATION-HUMAN INFORMATION PROCESSING (C-HIP) MODEL

Michael S. Wogalter
North Carolina State University

ABSTRACT

This chapter provides an overview of the communication-human informaton processing (C-HIP) model. C-HIP is a framework that describes warning processing and organizes the warning research literature into a coherent structure. As part of the discussion, an overview of the influential factors at each stage of the model is presented. Other separate chapters in this Handbook give more details for each of the stages. Lastly, another practical aspect of the C-HIP model is described whereby it can be used as an investigative tool to determine why a warning failed.

INTRODUCTION

Research in warnings has grown considerably over the last 2 to 3 decades (e.g., see Laughery, Wogalter, & Young, 1994; Miller & Lehto, 2001; Wogalter, Young, & Laughery, 2001). During this time period, researchers have investigated a wide variety of variables. A framework was needed to organize and structure the research literature and to place some coherence onto the field while promoting needed research to fill gaps in our knowledge.

This chapter describes the Communications-Human Information Processing (C-HIP) model (Wogalter, DeJoy, & Laughery, 1999a). C-HIP is a framework that is useful for organizing and structuring the findings in warnings research. In describing C-HIP and its component stages, the chapter reviews some of influential research factors found at each stage. After going through the stages of the model, another benefit of the C-HIP model is described. A useful application of C-HIP is that it can serve as an investigative tool in helping determine the reason(s) why a warning failed to be effective.

The C-HIP model has several main parts. A representation of the model can be seen in Fig. 5.1. The first part of the framework uses some of the basic stages of a simple communication model (e.g., see McGuire, 1980). Here the model focuses on a warning message being sent from one entity to another, or in other words, sent by a source (sender) through some channel(s) to a receiver. In the second part of the model, the focus is on the receiver and how an individual processes that information. When the warning is delivered to the receiver, processing continues using a relatively simple information processing model that incorporates several substages: attention switch, attention maintenance, comprehension and memory, beliefs and attitudes, motivation, and ending in behavior. Similar information processing models have been discussed by others (Lehto & Miller, 1986; Rogers, Lamson, & Rousseau, 2000). See Lehto (chap. 6, this volume) and Cameron and DeJoy (chap. 22, this volume) for reviews of other warning process models.

One of the main benefits of the C-HIP model is that it serves as a framework for organizing findings in the warning research literature. Over the years, research has grown to an extent that it requires a lengthy book to cover what has been conducted in the latter parts of the last century (see Wogalter, DeJoy, & Laughery, 1999b). This chapter gives an overview of research findings relevant to each stage of C-HIP, but it is incomplete in discussing all the applicable research. However, there are chapters in this Handbook that describe each stage in detail. The stages and authors are: source (Cox & Wogalter, chap. 8), channel (Cohen, Cohen, Mendat, & Wogalter, chap. 9), attention switch and maintenence

Handbook of Warnings, Edited by Michael S. Wogalter, © 2006, Lawrence Erlbaum Associates (Mahwah, NJ).

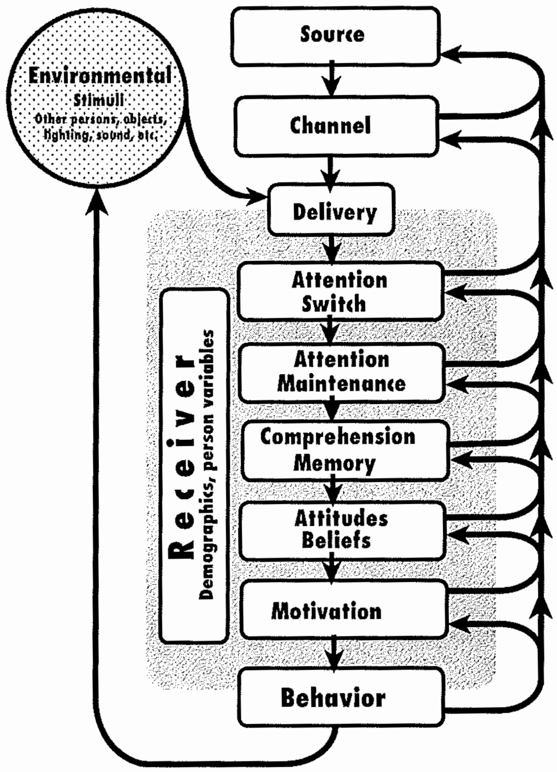

FIGURE 5.1. Communication-Human Information Processing (C-HIP) Model.

(Wogalter & Vigilante, chap. 18), comprehension and memory (Hancock, Bowles, Rogers, & Fisk, chap. 19), beliefs, attitudes, and motivation, (Riley, chap. 21), and behaviorial compliance (Kalsher & Williams, chap. 23). Several other chapters in this Handbook are relevant to the C-HIP model, most notably the chapters on individual differences (Smith-Jackson, chap. 24) and extrinsic factors (Vredenburgh & Helmick-Rich, chap. 28).

For readers who are familar with Wogalter et al.'s (1999a) C-HIP model, the current incarnation is somewhat different (see also Wogalter & Laughery, 2005a, 2005b). The current model is more explicit in four main ways. The first is that the stage of attention is now split into two separate stages—attention switch and attention mantenance. These two stages are affected by different variables. In addition, there is now the stage of delivery (see also Williamson, chap. 56, this volume). Delivery refers to interface (or point of reception) of the warnings arriving to the receiver through one or more channels. The third difference in the current model is a greater emphasis on the influence of other environmental stimuli. These are aspects other than a subject warning that may affect how the warning may be processed. They are extrinsic to the warning and include other people, other warnings, and other displays in the environment, as well environmental conditions such as illumination and background noise (see Vredenburgh & Helmick-Rich, chap. 28, this volume). The fourth major difference from the Wogalter et al. (1999a) C-HIP model is greater emphasis on the receiver's personal characteristics (e.g., demographics) and task involvment (see chap. 24 and chap. 27 on individual differences and culture by Smith-Jackson, this volume; Wogalter & Usher, 1999). These updates have been incorportated in the following description and discussion of C-HIP.

The C-HIP model is both a stage model and a process model. The C-HIP model is useful in describing a general sequencing of stages and the effects warning information might have as it is processed. If information is successfully processed at a given stage, the information flows through to the next stage. If processing at a stage is unsuccessful, it can produce a bottleneck, blocking the flow of information from getting to the next stage. If a person does not notice or attend to a warning, then processing of the warning goes no further. However, even if a warning is noticed and attended to, the individual may not understand it, and thus no additonal processing occurs beyond that point. Even if the message is understood, it still might not be believed; and so on through the stages. If all of the stages are successful, the warning process ends in safety behavior (compliance) attributable to the warning information. Although the processing of the warning may not make it all of the way to the behaviorial compliance stage, it can still be effective at earlier stages. For example, a warning might enhance understanding and beliefs but not change behavior.

Although the model tends to emphasize a linear sequence from source to behavior, there are feedback loops from later stages in the process that can affect earlier stages of processing as illustrated on the right side of Fig. 5.1. For example, when a warning stimulus becomes habituated from repeated exposures over time, less attention is given to it on subsequent occasions. Here, memory affects an earlier stage, attention. Another example of feedback effects is that individuals may not believe that some product, task, or environment is hazardous and, as a result, not think about looking for a warning. It is an instance where beliefs and attitudes, a later stage, affects the earlier stages of attention.

An overview of the factors affecting each stage of the C-HIP model are described in the following sections. As mentioned earlier, more detail for each of the stages can be found in the chapters in this Handbook. The next three sections cover the part of the model concerning communication from the source through some channel(s) to the receiver.

SOURCE

The source is the initial transmitter of the warning information. The source can be a person or an organization (e.g., company, government). One critical role of the source is to determine if there are hazards that need warnings. Such a determination needs some form of hazard analysis (see Young, Shaver, Grelser, & Hall, chap. 32, this volume; and also Frantz, Rhoades, & Lehto, 1999). Once a hazard is identified, the source must determine if there are better methods of controling it than warnings, such as eliminating the hazard or guarding against it using engineering and design (see, e.g., Laughery & Wogalter, 1997). There are several general guidelines on when to employ a warning:

1. There is a hazard that cannot be designed out or guarded.
2. The hazard, consequences, and appropriate safe modes of behavior are not known to persons at risk.
3. The hazards are not open and obvious; that is, the appearance of the product or environment does not clearly expose the hazards.
4. A reminder is needed to promote awareness of the hazard at the proper time.

There are other considerations such as the specific characteristics of the product and enviroment involved, the likelihood/frequency of an undesirable event, and the potential injury severity.

If the need for a warning exists, then the source needs to determine how the hazard(s) should be warned, for example, what channel(s) to use and the warning's intrinsic characteristics. In addition, the perceived characteristics of the source can influence people's beliefs, credibility, and relevance (Cox, 1999; Wogalter, Kalsher, & Rashid, 1999). Information from a reliable, expert source is generally given greater credibility. More about the source is given in chapter 8 by Cox and Wogalter (this volume).

CHANNEL

The channel is the medium and modality in which information is transmitted from the source to one or more receivers. Warnings can be presented on product labels, on posters/placards, in brochures, as part of audio-video presentations, given orally, and so forth. Most commonly, warnings use the visual (text and symbols) and auditory (alarms and voice) modalities as opposed to the other senses. There are exceptions, for example, an odor added to petroleum-based gases to enable leak detection by the olfactory sense, and rumble strips used to alert drivers to changes in roadway conditions that makes use of the tactile and kinesthetic senses (see Cohen, Cohen, Mendat, & Wogalter, chap. 9 this volume).

Media and Modality

There are two dimensions of the channel. The first concerns the media in which the information is embedded. The second dimension is the sensory modality used to capture the information by the receiver. Research comparing the effectiveness of language-based warnings presented visually (text) versus auditorily (speech) is conflicting (Cohen et al., chap. 9, this volume). However, the results generally show that presentation in either modality is better than no presentation whatsoever. Also warnings presented in more than one modality are generally more effective than those presented in a single modality. Thus, a video-based warning is better if the words are shown on the screen while the same information is given orally. Multimodal warnings provide redundancy. If an individual is not watching the screen, one can still hear it (Barlow & Wogalter, 1993; Wogalter & Young, 1991). If the individual is blind or deaf, the information is available in the other modality. In addition, if an individual sees and hears warning information in multiple ways, there is a greater likelihood that the message will be delivered to receivers at risk.

Longer, more complex messages may be better presented visually because reading language is generally faster and allows easier review and re-review of the material. However, shorter, less complex messages have a greater impact when presented auditorily than presented visually. Also, the auditory signal is generally better for switching attention (a stage described later). An implication from this is that a short auditory warning pointing to more detailed information accessible elsewhere would be beneficial for capturing attention as well as enabling the processing of longer and more complex information.

Warning System

As the above discussion suggests, the idea that a warning is only a sign or a portion of a label is too narrow a view of how warning information may be transmitted (Laughery & Wogalter, 1997). Warning systems for a particular product or environment may consist of a number of components. For example, a warning system for a prescription allergy medication may consist of several components: a printed statement on the box, on the bottle, and on an insert. Television and advertisements for prescription drugs in the United States also may contain warnings. The manufacturer's Web site and other Web sites may have warnings (Hicks, Wogalter, & Vigilante, 2005; Vigilante & Wogalter, 2005). The physician who prescribed the drug and the pharmacist that fills the prescription are other potential sources of warnings. Organizations, including government agencies and consumer and trade groups, could provide additional materials.

The components of a warning system may not be identical in terms of content or purpose. For example, some components may be intended to capture attention and direct the person to another component containing more information, or may be intended for different target audiences. The multiple components of the warning system can provide the advantages (e.g., redundancy) of multiple media and modalities described earlier.

Direct and Indirect Communications

The distinction between direct and indirect effects of warnings concerns the routes by which information gets to the target person. A direct effect occurs as a result of the person being directly exposed to the warning. Warnings can also be delivered indirectly. One example is learning about a hazard in a conversation with a family member. The employer or physician who reads warnings and then verbally communicates the information to employees or patients are also examples. Adults who have responsibility for the safety of children are another important category. Thus, a warning put out by a manufacturer may be useful even if an individual is not directly exposed to that warning. With respect to C-HIP, the material sent from the source (usually the manufacturer) to the receiver through some channnels provides the direct communication of warnings to the receiver. Indirect effects involve the delivery (discussed in the next section) of that warning information by others, which according to the current C-HIP model derives from the environmental component shown in Fig. 5.1.

Delivery

Although the source may try to disseminate warnings in one or more channels, the warnings might not reach some of the targets at risk. Delivery refers to interface (or point of reception) of the warnings arriving to the receiver. It is a separate stage in the current C-HIP model, in part presented in this way to emphasize its importance. A warning that a person sees or hears is a warning that has been delivered. A safety video that is produced but is not distributed or is distributed haphazardly such that the information never reaches the individual would be a delivery failure. It may be necessary to distribute warning information in multiple ways to reach receivers at risk. As previously stated, warnings disseminated by the source may have indirect effects, for example, the warning information from a disseminated safety video may be conveyed by someone who viewed it. The point is that if warnings given by a source do not reach the targets at risk either directly or indirectly, then the warning will have no or limited effects on the receiver.

Environment

Besides the subject warning, other stimuli are almost always concurrently present. These stimuli may be other warnings and a wide assortment of nonwarning stimuli. These stimuli compete with the warning for the person's attention (described further in the following). With respect to a given warning, these other stimuli may be described as *noise* that could potentially interfere with warning processing. Several examples can illustrate. A cellular phone ringing just when an individual begins to examine a warning may cause distraction and lead to the warning not being fully read. Another more salient warning could attract a person's focus instead. Other persons in the local environment not complying with a "respirator required" warning might suggest that its use is not really needed. Other environmental effects can include low illumination or other degraded visual conditions (e.g., fog, smoke).

Clearly the environment can have an effect on warning processing, but the individual may act on the environment and change it. Indeed, a close examination of the current C-HIP model reveals it can serve as a general cognitive processing model, showing continuous processing over time. It is not simply a warning-specific model.

RECEIVER

The receiver is the person(s) or target audience to whom the warning is directed. For a warning to effectively communicate information and influence behavior, the warning must first be delivered. Then attention must be switched to it and maintained long enough for the receiver to extract the necessary information. Next, the warning must be understood and must concur with the receiver's existing beliefs and attitudes. Finally, the warning must motivate the receiver to perform the directed behavior. The next several sections are organized around these stages of information processing.

Attention Switch

An effective warning must initially attract attention, and to do so, it needs to be sufficiently salient (conspicuous or prominent). Warnings typically have to compete with other stimuli in the environment for attention. Several design factors influence how well warnings may compete for attention (see Wogalter & Leonard, 1999; Wogalter & Vigilante, chap. 18, this volume).

Larger is generally better. Increasing the overall size of the warning, its print size, and contrast generally facilitate warning conspicuousness. Context also plays an important role. It is not just the absolute size of the warning, but also its size relative to other displayed information. A bold warning on a product label in which other items are in larger print is an example.

For some products, the available surface area is limited, for example, small product containers such as pharmaceuticals. Including all of the hazards on the primary on-product (container) label could reduce the salience of the most critical information (e.g., by decreasing print size). Solutions include expanding the surface area that might include the addition of tags or peel-off labels (Barlow & Wogalter, 1991; Wogalter & Young, 1994).

Color is an important attribute that can facilitate attention attraction (Bzostek & Wogalter, 1999; Laughery, Young, Vaubel, & Brelsford, 1993). Although there are some problems with using color as the only method of conspicuity, such as color blindness, it is frequently used as one of several features used to attract attention to warnings. The ANSI (2002) Z535 warning standard uses color as one of several components of the signal word panel to attract attention. Context again can play a role with respect to color as a salient feature. A yellow warning in a largely yellow environment will have less relative salience than the same warning in an environment without much yellow. The color should be distinctive in the environment in which it is placed.

Symbols can also be useful for capturing attention. One example is the alert symbol (triangle enclosing an exclamation point) used in the signal word panel in ANSI (2002) Z535 (Bzostek & Wogalter, 1999; Laughery et al., 1993). Symbols added to the message panel are usually intended for comprehension (discussed later) but also benefit the attention switch stage.

Warnings located near the hazard, both temporally and physically, generally increase the likelihood of attention switch (Frantz & Rhoades, 1993; Wogalter, Barlow, & Murphy, 1995). There are exceptions where the warning is presented too close in location and time such that the individual sees or hears it too late to avoid the hazard. A warning on a gas-powered, electrical generator about carbon monoxide hazards is more likely to be effective than one located in a separate, displaced owner's manual. Generally, placement directly on the product or its primary container is preferred (Wogalter, Breisford, Desaulniers, & Laughery, 1991; Wogalter et al., 1995).

Repeated, long-term exposure to a warning may result in a loss of its ability to evoke an attention switch at later times (Thorley, Hellier, & Edworthy, 2001). Habituation can occur even with well-designed warnings, but better designed warnings with salient features can slow the habituation process. Where feasible, changing the warning's appearance may be useful in reinvigorating attention switch previously lost because of habituation.

Tasks the individual may be performing and other stimuli in the environment may absorb attention and may compete with the warning for attention capture (Wogalter & Usher, 1999). Thus, the warning should have characteristics to make it highly salient in context.

Attention Maintenance

Individuals may notice the presence of a warning but not stop to examine it. A warning that is noticed but fails to maintain attention long enough for its content to be encoded is of little direct value. Attention must be maintained on the message for some length of time to extract meaning from the material. During this process, the information is encoded or assimilated with existing knowledge in memory.

With brief text or symbols, the warning message may be grasped very quickly, sometimes as fast as a glance. For longer, more complex warnings, attention must be held for a longer duration to acquire the information. In order to maintain attention in these cases, the warning needs to have qualities that generate interest so that the person is willing to maintain attention to it instead of something else. The effort necessary to acquire the information should be reduced as much as possible. Some of the same design features that facilitate the switch of attention also help to maintain attention. For example, large print not only attracts attention, but it also tends to increase legibility, which makes the print easier to read.

Frequently, the warnings printed on product labels and in some accessory materials (e.g., inserts or product manual) is so small that older adults with age-related vision problems are unable to read them without a magnifying glass (Wogalter, DeJoy, & Laughery, 1999b). Furthermore, those who may be able to read the words may not read them because of the effort involved or the belief that the print would be larger if it was important. Environmental conditions such as fog, smoke, and veiling glare can also negatively affect legibility and ease of identifying words and symbols (e.g., Collins & Lerner, 1982).

Print legibility can be affected by numerous factors including: choice of font, stroke width, letter compression and distance between letters, resolution, and justification (see Frascara, chap. 29, this volume). Although there is not much research to support a clear preference for particular fonts, the general recommendation is to use relatively plain, familiar alphanumerics. It is sometimes suggested that a serif font like Times Roman be used for smaller sized text and san serif font like Helvetica for large text sizes. The ANSI (2002) Z535.2 and Z535.4 standards provide a chart with print sizes for expected reading distances in good and degraded conditions.

Legibility is benefitted by high contrast between objects (e.g., text lettering) and their background. Black on white or the reverse has the highest contrast, but legibility can be adequate with other combinations such as black print on yellow and white print on red.

People will more likely maintain attention if a warning is readable with respect to formatting and layout. People perfer warnings that are in a list outline format as opposed to continous prose text (Desaulniers, 1987). Visual warnings formatted with plenty of white space and containing organized information groupings are more likely to hold attention than a single chunk of dense text (Wogalter & Vigilante, chap. 18, this volume; 2003). If a warning contains large amounts of text, individuals may decide too much effort is required to read it and direct their attention to something else. Formatting can also show the organization of the material, making it easier to search for and assimilate into memory (Hartley, 1994).

Comprehension

Comprehension concerns understanding the meaning of something, in this case, the intended message of the warning. Comprehension may derive from several components: subjective understanding such as its hazard connotation, more direct understanding of its language and symbols, and an individual's background knowledge.

Signal Words. Aspects of a warning can convey a level of subjective hazard to the recipient. The ANSI (2002) Z535 standard recommends three signal words to denote decreasing levels of hazard: DANGER, WARNING, or CAUTION (see also FMC Corporation, 1985; Peckham, chap. 33, this volume; Westinghouse Electric Corporation, 1981). According to ANSI Z535, the DANGER panel should be used when serious injury or death *will* occur if the directive is not followed. A WARNING panel is used when serious injury or death *may* occur. The CAUTION panel is used when less severe personal injuries or property damage may occur. Although CAUTION and WARNING have different specific definitions according to the standard, research shows that people do not readily distinguish between the two. Although the term DEADLY has been shown in several research studies to connote hazard significantly greater than DANGER, it has not been adopted in ANSI Z535 (e.g., Hellier & Edworthy, chap. 30, this volume; Wogalter, Kalsher, Frederick, Magurno, & Brewster, 1998; Wogalter & Silver, 1990, 1995).

According the ANSI Z535, the signal word panels for DANGER, WARNING, AND CAUTION are assigned specific colors: red, orange, and yellow, respectively. This assignment provides a form of redundancy. Like the words WARNING and CAUTION, most people do not distinguish between the colors orange and yellow (Chapanis, 1994; Wogalter, Kalsher, Frederick, Magurno, & Brewster 1998). The signal word panels also contain the alert symbol (triangle/exclamation point), which usually suggests that it is a warning (Wogalter, Kalsher et al., 1998; Wogalter, Jarrard, & Simpson, 1994).

Message Content

The content of the warning message should include information about the hazard, instructions on how to avoid the hazard, and the potential consequences if the hazard is not avoided (Wogalter, Godfrey, Fontenelle, Desaulniers, Rothstein, & Laughery, 1987). There are exceptions when the hazard is (a) general knowledge, (b) known from previous experience, or (c) "open and obvious," that is, apparent to everyone (except small children).

Hazard Information. The warning should tell what the safety problem is. Depending on the hazard, the informaton could be simply identifying the hazard or might require including more information such as telling more about the nature of the hazard and what the mechanisms are that produce the hazard.

Instructions. Warnings should instruct people about what to do or not do. Like the other statements, the instructions should be specific, telling exactly what should be done or avoided. A classic nonexplicit warning statement is "Use with adequate ventilation." Unfortunately, this common statement in warnings is inadequte to apprise people of what they should do. Does this statement mean open a window, two windows, use a fan, or something more technical in terms of volume of air flow per unit time? Without more information, users are left making inferences that may be partly or wholly incorrect (Laughery & Paige-Smith, chap. 31, this volume; Laughery, Vaubel, Young, Brelsford, & Rowe, 1993).

Consequences. Consequences information concerns what could result. Sometimes, it is not necessary to state the consequences. For example, a sign indicating "Slippery Floor" probably does not need to include a consequence statement "You Could Fall," as people can correctly infer that from "Slippery Floor" (Wogalter et al., 1987). However, one should be cautious in omitting consequence information, because people may not make the correct inference.

A common shortcoming of warnings is that consequences information is not explicit, that is, it is lacking important specific details (Laughery & Paige-Smith, chap. 31, this volume; Laughery, Vaubel, Young, Brelsford, Rowe, 1993). The statement "May be hazardous to your health" in the context of a toxic vapor hazard is insufficient by itself as consequence information because it does not tell whether it results in minor throat irritation and coughing or something more severe (e.g., permanent lung damage). As discussed in the following, awareness of severe consequences can also be a factor in motivating compliance behavior.

Symbols. Safety symbols may be used to communicate the information in lieu of or in conjunction with text (e.g., Dewar, 1999; Wolff & Wogalter, 1998; Young & Wogalter, 1990; Zwaga & Easterby, 1984). They can contribute to understanding when people who are illiterate or nonreaders of the primary language are part of the target audience.

Comprehension is a primary criterion for symbols (Dewar, 1999). Symbols that directly represent concepts are preferred if they can be developed (Wogalter, Silver, & Leonard, & Zaikina, chap. 12, this volume). In other cases, the meaning has to be learned such as with absract or arbitrary symbols representing the concepts of biohazard and radiation (Lesch, 2003; Wogalter, Sojourner, & Brelsford, 1997).

What is an acceptable level of comprehension for safety symbols? In general, symbols should be designed to have the highest level of comprehension attainable. The ANSI (2002) Z535 standard suggests a goal of at least 85% comprehension by a sample of 50 individuals representative from the target audience for a symbol to be used without accompanying text. If 85% cannot be achieved, the symbol may still have utilitiy (e.g., for attention capture) as long as is not badly misinterpreted. According to the ANSI (2002) Z535 standard, an acceptable symbol must also produce less than 5% critical confusions (opposite meaning or a meaning that would produce unsafe behavior). The International Organization for Standardization (ISO; 2001) has similar comprehension critera (see Deppa, chap. 37, this volume; Peckham, chap. 35, this volume).

Repeated exposure to an unchanging warning over time not only results in it being less effective in switching attention, but also for maintaining attention. Even a well-designed warning will eventually become habituated if repeatedly encountered. Fortunately, habituation implies that the person has learned some amount of information from the warning. Unfortunately, only part may be known. Some ways to slow down the habituation include using salient features and varying the warning's appearance (and content, if feasible and appropriate) every so often.

Although individuals may have knowledge about a hazard, they may not be aware of it at the time they are at risk. People have vast stores of knowldege based on an accumulation of experience in their lives. Despite this amazing storage space of memories, only a small portion of it is conscious at a given time. As people are doing tasks in daily life and at work, their minds are not always activating risk information. Thus, although persons may have some or even an extensive store of risk knowledge within them, this information and related knowledge may not be activated unless there is an external cue to avoid a hazard. Consider the electrical hazard tag on hair dryers. Because of its presence, people are more likely to be reminded to keep away from water than if the tag were not secured to the electrical cord. Of course, seeing this tag every day results in habituation where it is infrequently noticed. But its presence is better than its absence, as it may serve as a reminder to some other person. So despite habituation, the presence of a warning is more likely to cue relevant hazard information than if it were absent. Some symbols can cue a large amount of knowledge, much more than the literal interpretation. Without a reminder, known risk knowldge is less likely to come to awareness.

In summary, information in long-term memory can be cued by the presence of a warning, and the warning can bring forth related, previously dormant knowledge into conscious awareness. Reminders may be appropriate in situations where the hazard is infrequently encountered and forgetting may be an issue, and when there are foreseeable distractions or high task-load involvement that could pull attention away from normative hazard considerations.

Level of Knowledge. The levels of knowledge and understanding of the warning recipients should be taken into consideration. Three cognitive characteristics of receivers are important: language skill, reading ability, and technical knowledge.

It is not unusual for warnings requiring high-level reading skills to be given to people with lower reading abilities. In general, reading levels on warnings should be as low as feasible. For the general population, the reading level should be approximately a grade 4 to 6 skill level (expected ability of 10- to 12-year-old readers).

In addition to low-level reading skills, there are large numbers of functionally illiterate persons even in technologically advanced countries. For example, in the United States there are an estimated 16 million functionally illiterate adults. If so, successful warning communication may require more than simply keeping reading levels to a minimum. The use of symbols, speech warnings, and special training programs may be beneficial adjuncts. Moreover, these potential methods may also benefit literate persons. Different subgroups in the population may speak and read languages different from the majority in a geographic area. Because of increasing international trade and travel and the need to cross language barriers, this problem might require the use of multiple languages and graphics and transmission through multiple channels.

Despite these considerations, reading levels should be consistent with the reading abilities of the receivers. A warning to trained health care professionals should use standard verbiage expected by that population. These technical experts have a more complete understanding of domain-specific hazards and can perform their jobs better with area-appropriate technical data. A toxicologist working in an industrial facility might need the chemical content of a toxic material, the maximum safe level of a substance in the atmosphere in parts per million (ppm), and the biological reaction to exposure to a substances in order to issue warnings to other people who are without such levels of knowledge. Such technical information about hazards are necessary for communicating risks to trained personnel.

However, many end-users of chemicals do not have the relevant technical competence, and so technical chemical data is not likely to be successful if used as a warning. It is not usually necessary to give highly technical warning information to a general target audience of end-users. Indeed, it may be counterproductive in the sense that encountering such information may result in the receiver not attending to the remainder of the message. Instead, the information that these end-users need is to be informed that the substance is toxic, its potential for injury or illness, and how to use it safely (i.e., hazard, consequences, and instructions as described earlier). When there are multiple groups of people with different or limiting characteristics, different components (its intrinsic features and modality/media) of the warning system can be used to communicate to the different groups.

Beliefs and Attitudes

Beliefs and attitudes refer to an individual's knowledge that is accepted as true, although some of it may actually be untrue. For example, people's experiences with a situation or product can result in beliefs that a hazard is safer than it is. This quickly changes after involvment in a serious accident. According to the C-HIP model, a warning will be successfully processed at this stage if the message concurs with the receiver's current beliefs and attitudes. However, if the warning information does not concur, then beliefs and attitudes need to be altered before behavioral compliance is likely to occur. Certain circumstances may require that the message be made more persuasive to override existing incorrect beliefs. Several relevant and interrelated factors at the beliefs and attitudes stage are discussed in the following including hazard perception, familiarity, prior experience, and relevance (see DeJoy, 1999; Riley, chap. 21, this volume).

Hazard perceptions that people hold influence processing at the beliefs and attitudes stage. The greater the perceived hazard, the more responsive people will be to warnings, (e.g., looking for them and reading them). The converse is also true. People are less likely to look for or read a warning for products that they do not believe are hazardous. Perceived hazard is also closely tied to beliefs about injury severity, but it is interesting to note that injury likelihood is much less important in perceptions of risk or hazard for consumer products (Wogalter, Brelsford et al., 1991; Wogalter, Brems, & Martin, 1993). The more severe the potential injury, the more hazardous the product is perceived to be (Wogalter, Young, Brelsford, & Barlow, 1999). A warning might need to perform the task of changing people's beliefs that a hazard is more dangerous than they anticipated.

Familiarity beliefs are formed from past similar experiences stored in memory. It is the belief that most everything that needs to be known about a product or situation is already known. A person believing that they are adequately familar with a product might assume that a different, but similar, product operates in the same way and has the same hazards (which may not be true), reducing the likelihood that he or she will look for or read a warning (Godfrey & Laughery, 1984; Goldhaber & deTurck, 1988; Wogalter, Brelsford et al., 1991). Relatively speaking, hazard perception is more important than familiarity with respect to warnings. This is probably due to two main reasons. First, people more familiar with a situation or product may have more knowledge about the hazards and how to avoid them. Second, greater use also tends to increase exposure to warnings, which increases the opportunity to be influenced by them.

Related to familiarity is prior experience. Prior experience can be influential in other ways. Having experienced some form of injury or having personal knowledge of someone else being injured enhances the degree of danger (Wogalter, Brems, & Martin, 1993). Similarly, the lack of such experiences may lead to underestimating dangers or not thinking about them at all. Warnings that give vivid explicit consequences may convince people to change their beliefs.

Relevance is the belief that something is applicable to the person. If the individual does not believe the warning is relevant, then the warning may fail to fufill its intended mission. The individual may instead attribute the warning as being directed to others and not to him- or herself. One way to counter this is to personalize the warning so that it gets directed to relevant users and conveys facts that indicate that it is relevant (Wogalter, Racicot, Kalsher, & Simpson, 1994)

A point related to beliefs and attitudes and more specifically, to familiarity, concerns the problem of experts overestimating what people know, which, in turn, may affect what kinds of warnings are produced (Laughery, 1993). Experts in a domain can be so facile with their knowledge about a topic that they fail to realize that nonexperts do not have similar knowledge. What is obvious to them may not be as equally obvious to end-users. Without user input into the design of warnings, there may be a tendency to produce warnings that fail to meet the needs of end-users.

Motivation

Motivation energizies the individual to carry out an activity. Some of the main factors that can influence motivation are cost of compliance, severity of injury, social influence, and stress.

Compliance generally requires that people take some action and usually there are costs associated with doing so. The costs of complying may include time and effort to carry out the behavior (Wogalter, Godfrey et al., 1987; Wogalter, Allison, & McKenna, 1989). When people perceive the costs of compliance to be too high, they are less likely to perform the safety behavior. This problem is commonly encountered in warnings with instructions directing behaviors that are inconvenient, difficult, or occasionally impossible to carry out. One way to reduce cost is to make the directed behavior easier to perform. For example, if hand protection is required when using a product, the availability of gloves should be as simple, easy, and convenient as possible (Dingus, Hathaway, & Hunn, 1991).

The costs of noncompliance can also exert a powerful influence on compliance motivation. With respect to warnings, the main cost for noncompliance is some form of injury consequences. Hazard perception and people's reported willingness to comply with warnings is closely tied with beliefs about injury severity (e.g., Wogalter, Brelsford et al., 1991). Although people consider injury severity in their hazard judgments, they do not readily consider the likelihood or probability of injury (e.g., Wogalter, Brems et al., 1993; Wogalter, Young et al., 1999).

Another motivator is social influence (Wogalter, Allison, & McKenna, 1989; Edworthy & Dale, 2000. When people see others comply with a warning, they are more likely to comply themselves. Likewise, seeing others not complying, lessens compliance likelihood. Other factors affecting motivation are time stress (Wogalter, Magurno, Rashid, & Klein, 1998) and mental workload (Wogalter & Usher, 1999). Under high stress and workload, competing activities disperse resources away from processing warning information.

Behavior

The last stage of the sequential process is for individuals to carry out the warning-directed safe behavior. Behavior is one of the most important measures of warning effectiveness (Kalsher & Williams, chap. 23, this volume; Silver & Braun, 1999). Warnings do not always change behavior because of processing failures at earlier stages. Most research in this area focuses on the factors that affect compliance likelihood including those that enhance safety behavior and those that do not.

Some researchers used *intentions to comply* as the method of measurement because it is usually quite diffcult to conduct behavioral tests. The reasons include: (a) researchers cannot expose participants to real risks because of ethical and safety concerns; (b) events that could lead to injury are relatively rare; (c) the construction scenario must appear to have a believable risk, yet at the same time must be safe; and (d) running such research is costly in terms of time and effort. Nevertheless, compliance is an important criterion for determining effectiveness influences and to determine which factors work better than others. Compliance can also be measured indirectly. For example, determining whether protective gloves have been worn can be determined by whether they appear to be used or stretched in appearance (Wogalter & Dingus, 1999).

Receiver Variables

The receiver's characteristics and task workload can affect warning effectiveness (Young, Laughery, Wogalter, & Lovvoll, 1999). Indeed, evidence supporting this has already been discussed. Person variables (Rogers et al., 2000) such as the individuals' existing knowledge, beliefs, and language skill were noted in earlier sections as affecting whether and how a warning is processed. Mayhorn and Podany (chap. 26, this volume) describe research findings showing age-related declines in sensory and cognitive processing, that affect warning processing, particularly in attention switch and memory/comprehension stages. Not much systematic warning research has been conducted with respect to children, but Kalsher and Wogalter (in press) gives an overview of that research. In some studies, gender differences have been noted (e.g., see Laughery & Brelsford, 1991; Smith-Jackson, chap. 24, this volume) with women being somewhat more likely to look for and read warnings (e.g, Godfrey, Allender, Laughery, & Smith, 1983; LaRue & Cohen, 1987; Young, Martin, & Wogalter, 1989). Two other individual differences variables have been noted in the literature: self-efficacy (Lust, Celuch, & Showers, 1993) and locus of control (Donner, 1991; Laux & Brelsford, 1989). It is not completely clear whether the relative scarcity of research on personality variables and warning-related measures is due to the correlations being relatively small or that they have not attracted researchers as a topic of study. For more information on these topics, see chapters by

Smith-Jackson (chap. 24, this volume) and by Vredenburgh and Helmick-Rich (chap. 28, this volume).

Last, warning processing occurs in the context of other potential processing given other stimuli in the environment and the individual's ongoing and ever changing task behavior. Whether and how a warning is processed can depend on mental workload (Wogalter & Usher, 1999), time stress (Wogalter, Magurno et al., 1998), and processing strategy (deTurck & Goldhaber, 1988). An individual thinking about other information, under time pressure, and who is not in an information-seeking mode is less likely to fully process a warning compared to when not under those constraints. When such task loading can be anticipated (e.g., in emergency situations), the warning system may have to be highly salient to have a chance of attracting attention.

SUMMARY AND BENEFIT OF C-HIP

The C-HIP model divides the processing of warning information into separate stages that must be successfully completed for compliance behavior to occur. A bottleneck at any given stage can hinder processing at subsequent stages. Feedback from later stages can affect processing at earlier stages. The model is valuable in describing some of the processes and organizing a large amount of research.

The C-HIP model can also be a valuable tool in systematizing the assessment process to help determine why a warning is not effective. It can aid in pinpointing where the bottlenecks in processing may be occurring and suggest solutions to allow processing to continue to subsequent stages. Warning effectiveness testing can be performed using methods similar to those used in research. Evaluations of the processing can be directed to any of the stages described in the C-HIP model: source, channel, environment, delivery, attention, comprehension, attitudes and beliefs, motivation, behavior, and receiver variables. Some of the simple ways to do this are briefly described in the following:

- Evaluating the source attempts to determine whether the manufacturer has documented the hazards and has issued warnings. One important question to address here is whether there is anything missing from the current warning that should be there? Hazard analysis is needed to answer this question (see chapter by Young, Shaver, Grieser, & Hall, chap. 32, this volume).
- Evaluating the channel mainly addresses questions relating to how warnings are sent to end-users. What media and modalities are being used and are those adequate? Similarly, assessment regarding delivery asks whether end-users receive the warnings. If not, other channels of distribution of warning materials may need to be considered.
- Assessing attention switch asks the question of whether end-users see or hear the warnings. The answer could involve placing a warning on a product and having people carry out a relevant task and asking them later whether they saw the warning. Eye movement and response time paradigms can be used to measure what people tend to look at and how quickly.
- Assessing comprehension, uses several well-established methodologies involving memory tests, open-ended response tests, structured interviews, etc. These assessments can be valuable in determining what information was or was not understood, and suggesting revisions to warning text or symbols.
- Assessing beliefs and attitudes uses a questionnaire to determine people's pre-existing beliefs on the topics of perceived hazard and familiarity with the product, task, or environment. For example, if people's perceived hazard is too low, then this could indicate greater persuasiveness is needed.
- Assessing motivation uses measures of behavioral intentions. Low intentions to comply may indicate that consequence information should be enhanced (e.g., by being more explicit) or that cost of compliance should be reduced.
- Assessing behavioral compliance entails systematic observation that can be used in both lab and field settings. As mentioned earlier, measurement of behavioral compliance is generally more difficult than any of the other methods. It may also involve ethical issues such as participants' exposure to risk. However, in situations where the negative consequences are substantial, the effort and resources needed are usually warranted. Sometimes behavioral intentions are measured as a proxy for overt behavioral compliance—but, some caution should be heeded, as mentioned earlier.

By using these investigative methods (and others) in a systematic manner, the specific causes of a warning's failure could be determined. Limited resources could be directed at fixing the truly troublesome aspects that are limiting the warning's effectiveness rather than wasting resources by trying to fix the wrong aspects.

In summary, the C-HIP model describes the processing of warnings in a series of stages that could block processing of warnings. Although it has linear components from source to compliance behavior, there are feedback loops that account for later processing stages affecting earlier stages. The C-HIP model also serves as useful framework in organizing the growing body of research in the area. Last, the model can be used as an investigative tool to determine why a warning is inadequately carrying out its function.

References

ANSI (2002). *Accredited Standards Committee on Safety Signs and Colors—Z535.1-5.* Arlington, VA: National Electrical Manufacturers Association.

Barlow, T., & Wogalter, M. S. (1991). Increasing the surface area on small product containers to facilitate communication of label information and warnings. In *Proceedings of Interface 91* (pp. 88–93). Santa Monica, CA: Human Factors Society.

Barlow, T., & Wogalter, M. S. (1993). Alcoholic beverage warnings in magazine and television advertisements. *Journal of Consumer Research, 20*, 147-155.

Bzostek, J. A., & Wogalter, M. S. (1999). Measuring visual search time for a product warning label as a function of icon, color, column, and vertical placement. *Proceedings of the Human Factors and Ergonomics Society, 43*, 888-892.

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

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

Cox, E. P. III (1999). Source. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 85-97). London: Taylor & Francis.

DeJoy, D. M. (1999). Beliefs and attitudes. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 183-219). London: Taylor & Francis.

deTurck, M. A., & Goldhaber, G. M. (1988). Consumers' information processing objects and effects of product warning. *Proceedings of the Human Factors Society, 32*, 445-449.

Desaulniers, D. R. (1987). Layout, organization, and the effectiveness of consumer product warnings. *Proceedings of the Human Factors Society, 31*, 56-60.

Dewar, R., (1999). Design and evaluation of graphic symbols. In H. J. G. Zwaga, T. Boersema, & H. C. M. Hoonhout (Eds.), *Visual information for everyday use: Design and research perspectives* (pp. 285-303). London: Taylor & Francis.

Dingus, T. A., Hathaway, J. A., & Hunn, B. P. (1991). A most critical warning variable: Two demonstrations of the powerful effects of cost on warning compliance. *Proceedings of the Human Factors Society, 35*, 1034-1038.

Donner (1991). Prediction of safety behaviors from Locus of Control statements. In *Proceedings of Interface '91* (pp. 94-98). Santa Monica, CA: Human Factors Society.

Edworthy, J., & Dale, S. (2000). Extending knowledge of the effects of social influence in warning compliance. In *Proceedings of the XIVth Triennial Congress of the International Ergonomics Association and 44th Annual Meeting of the Human Factors and Ergonomics Society*, (vol. 4; pp. 107-110). Santa Monica, CA: Human Factors and Ergonomics Society.

FMC Corporation (1985). *Product safety sign and label system*. Santa Clara, CA: Author.

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., Rhoades, T. P., & Lehto, M. R. (1999). Practical considerations regarding the design and evaluation of product warnings. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 291-311). London: Taylor & Francis.

Godfrey, S. S., Allender, L., Laughery, K. R., & Smith, V. L. (1983). Warning messages: Will the consumer bother to look? *Proceedings of the Human Factors Society, 27*, 950-954.

Godfrey, S. S., & Laughery, K. R. (1984). The biasing effect of familiarity on consumer's awareness of hazard. *Proceedings of the Human Factors Society, 28*, 483-486.

Goldhaber, G. M., & deTurck, M. A. (1988). Effects of consumer's familiarity with a product on attention and compliance with warnings. *Journal of Products Liability, 11*, 29-37.

Hartley, J. (1994). *Designing instructional text* (3rd ed.). London and East Brunswick, NJ: Kagan Page and Nichols.

Hicks, K. E., Wogalter, M. S., & Vigilante, W. J., Jr. (2005). Placement of benefits and risks in prescription drug manufacturers' web sites and information source expectations. *Drug Information Journal, 39*, 267-278.

International Organization for Standardization (ISO).(2001). *Graphical symbols—Test methods for judged comprehensibility and for comprehension, ISO 9186*. Geneva, Switzerland: Author.

Kalsher, M. J., & Wogalter, M. S. (in press). Hazard control methods and warnings for caregivers and children. In R. Leuder & V. Rice (Eds.), *Ergonomics for children*. Boca Raton, FL: CRC Press.

Kalsher, M. J., Wogalter, M. S., & Racicot, B. M. (1996). Pharmaceutical container labels and warnings: Preference and perceived readability of alternative designs and pictorials. *International Journal of Industrial Ergonomics, 18*, 83-90.

LaRue, C., & Cohen, H. (1987). Factors influencing consumer's perceptions of warning: An examination of the differences between male and female consumers. *Proceedings of the Human Factors Society, 31*, 610-614.

Laughery, K. R. (1993, July). Everybody knows: Or do they? *Ergonomics in Design*, 8-13.

Laughery, K. R., & Brelsford, J. W. (1991). Receiver characteristics in safety communications. *Proceedings of the Human Factors Society, 35*, 1068-1072.

Laughery, K. R., Vaubel, K. P., Young, S. L., Brelsford, J. W., & Rowe, A. L. (1993). Explicitness of consequence information in warning. *Safety Science, 16*, 597-613.

Laughery, K. R., & Wogalter, M. S. (1997). Risk perception and warnings. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (2nd ed.) New York: Wiley-Interscience.

Laughery, K. R., Wogalter, M. S., & Young, S. L. (Eds.). (1994). *Human factors perspectives on warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993*. Santa Monica, CA: Human Factors and Ergonomics Society.

Laughery, K. R., Young, S. L., Vaubel, K. P., & Brelsford, J. W. (1993). The noticeability of warnings on alcoholic beverage containers. *Journal of Public Policy and Marketing, 12*, 38-56.

Laux, L. F., & Brelsford, J. W. (1989). Locus of Control, risk perception, and precautionary behavior. In *Proceedings of Interface 89* (pp. 12-124). Santa Monica, CA: Human Factors Society.

Lehto, M. R., & Miller, J. M. (1986). *Warnings: Volume 1. Fundamentals, design and evaluation methodologies*. Ann Arbor, MI: Fuller Technical.

Lesch, M. F. (2003). Comprehension and memory for warning symbols: Age-related differences and impact of training. *Journal of Safety Research, 34*, 495-505.

Lim, R. W., & Wogalter, M. S. (2003). Beliefs about bilingual labels on consumer products. *Proceedings of the Human Factors and Ergonomics Society, 47*, 839-843.

Lust, J. A., Celuch, K. G., & Showers, L. S. (1993). A note on issues concerning the measurement of self-efficacy. *Journal of Applied Social Psychology, 23*, 1426-1434.

McGuire, W. J. (1980). The communication-persuasion model and health-risk labeling. In L. A. Morris, M. B. Mazis, & I. Barofsky (Eds.), *Banbury Report 6: Product labeling and health risks* (pp. 99-122). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory.

Miller, J. M., & Lehto, M. R. (2001). *Warnings & safety instructions: Annotated and indexed* (4th ed.). Ann Arbor, MI: Fuller Technical.

Rogers, W. A., Lamson, N., & Rouseau, G. K. (2000). Warning research: An integrative perspective. *Human Factors, 42*, 102-139.

Silver, N. C., & Braun, C. C. (1999). Behavior. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 245-262). London: Taylor & Francis.

Smith-Jackson, T. L., & Wogalter, M. S. (in press). Application of mental models approach to MSDS design. *Theoretical Issues in Ergonomics Science*.

Sorkin, R. D. (1987). Design of auditory and tactile displays. In G. Salvendy (Ed.), *Handbook of human factors* (pp. 549-576). New York: Wiley.

Thorley, P., Hellier, E., & Edworthy, J. (2001). Habituation effects in visual warnings . In M. A. Hanson (Ed.), *Contemporary ergonomics 2001* (pp. 223-228). London: Taylor & Francis.

Vigilante, W. J., & Wogalter, M. S. (2005). Assessing risk and benefit communication in direct-to-consumer medication web site advertising. *Drug Information Journal, 39*, 3-12.

Westinghouse Electric Corporation (1981). *Product safety label handbook.* Trafford, PA: Author.

Wogalter, M. S., Allison, S. T., & McKenna, N. (1989). Effects of cost and social influence on warning compliance. *Human Factors, 31*, 133-140.

Wogalter, M. S., Barlow, T., & Murphy, S. (1995). Compliance to owner's manual warnings: Influence of familiarity and the task-relevant placement of a supplemental directive. *Ergonomics, 38*, 1081-1091.

Wogalter, M. S., Brelsford, J. W., Desaulniers, D. R., & Laughery, K. R. (1991). Consumer product warnings: The role of hazard perception. *Journal of Safety Research, 22*, 71-82.

Wogalter, M. S., Brems, D. J., & Martin, E. G. (1993). Risk perception of common consumer products: Judgments of accident frequency and precautionary intent. *Journal of Safety Research, 24*, 97-106.

Wogalter, M. S., DeJoy, D. M., & Laughery, K. R. (1999a). Organizing framework: A consolidated communication-human information processing (C-HIP) model. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 15-24). London: Taylor & Francis.

Wogalter, M. S., DeJoy, D. M., & Laughery, K. R. (Eds.). (1999b). *Warnings and risk communication.* London: Taylor & Francis.

Wogalter, M. S., & Dingus, T. A. (1999). Methodological techniques for evaluating behavioral intentions and compliance. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 53-82). London: Taylor & Francis.

Wogalter, M. S., Godfrey, S. S., Fontenelle, G. A., Desaulniers, D. R., Rothstein, P. R., & Laughery, K. R. (1987). Effectiveness of warnings. *Human Factors, 29*, 599-612.

Wogalter, M. S., Jarrard, S. W., & Simpson, S. W. (1994). Influence of signal words on perceived level of product hazard. *Human Factors, 36*, 547-556.

Wogalter, M. S., Kalsher, M. J., Frederick, L. J., Magurno, A. B., & Brewster, B. M. (1998). Hazard level perceptions of warning components and configurations. *International Journal of Cognitive Ergonomics, 2*, 123-143.

Wogalter, M. S., Kalsher, J. J., & Racicot, B. (1993). Behavioral compliance with warnings: Effects of voice, context and location. *Safety Science, 16*, 637-654.

Wogalter, M. S., Kalsher, M. J., & Rashid. R. (1999). Effect of signal word and source attribution on judgments of warning credibility and compliance likelihood. *International Journal of Industrial Ergonomics, 24*, 185-192.

Wogalter, M. S., & Laughery, K. R. (2005a). Effectiveness of consumer product warnings: Design and forensic considerations. In I. Noy & W. Karwowski (Eds.), *Handbook of human factors in litigation* (pp. 30.1-30.14). London: Taylor & Francis.

Wogalter, M. S., & Laughery, K. R. (2005b). Warnings. In G. Salvendy (Ed.), *Handbook of human factors/ergonomics* (3rd ed.). New York: Wiley.

Wogalter, M. S., & Leonard, S. D. (1999). Attention capture and maintenance. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp. 123-148). London: Taylor & Francis.

Wogalter, M. S., Magurno, A. B., Dietrich, D., & Scott, K. (1999). Enhancing information acquisition for over-the-counter medications by making better use of container surface space. *Experimental Aging Research, 25*, 27-48.

Wogalter, M. S., Magurno, A. B., Rashid, R., & Klein, K. W. (1998). The influence of time stress and location on behavioral compliance. *Safety Science, 29*, 143-158.

Wogalter, M. S., Racicot, B. M., Kalsher, M. J., & Simpson, S. N. (1994). The role of perceived relevance in behavioral compliance in personalized warning signs. *International Journal of Industrial Ergonomics, 14*, 233-242.

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., Sojourner, R. J., & Brelsford, J. W. (1997). Comprehension and retention of safety pictorials. *Ergonomics, 40*, 531-542.

Wogalter, M. S., & Usher, M. (1999). Effects of concurrent cognitive task loading on warning compliance behavior. *Proceedings of the Human Factors and Ergonomics Society, 43*, 106-110.

Wogalter, M. S., & Vigilante, W. J., Jr. (2003). Effects of label format on knowledge acquisition and perceived readability by younger and older adults. *Ergonomics 46*, 327-344.

Wogalter, M. S., & Young, S. L. (1991). Behavioural compliance to voice and print warnings. *Ergonomics, 34*, 79-89.

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

Wogalter, M. S., Young, S. L., Brelsford, J. W., & Barlow, T. (1999). The relative contribution of injury severity and likelihood information on hazard-risk judgments and warning compliance. *Journal of Safety Research, 30*, 151-162.

Wogalter, M. S., Young, S. L., & Laughery, K. R. (Eds.). (2001). *Human factors perspectives on warnings, Volume 2: Selections from Human Factors and Ergonomics Society Annual Meetings 1993-2000.* Santa Monica, CA: Human Factors and Ergonomics Society.

Wolff, J. S., & Wogalter, M. S. (1998). Comprehension of pictorial symbols: Effects of context and test method. *Human Factors, 40*, 173-186.

Young, S. L., Brelsford, J. W., & Wogalter, M. S. (1990). Judgments of hazard, risk and danger: Do they differ? *Proceedings of the Human Factors Society, 34*, 503-507.

Young, S. L., Laughery, K. R., Wogalter, M. S., & Lovvoll, D. (1999). Receiver characteristics in safety communications. In W. Karwowski & W. S. Marras (Eds.), *The occupational ergonomics handbook*, (pp. 693-706). Boca Roton, FL: CRC Press.

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

Zwaga, H. J. G., & Easterby, R. S. (1984). Developing effective symbols for public information. In R. S. Easterby & H. J. G. Zwaga (Eds.), *Information design: The design and evaluation of signs and printed material.* New York: Wiley.