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Effectiveness of Consumer Product Warnings: Design and Forensic Considerations

Michael S. Wogalter
North Carolina State University

Kenneth R. Laughery
Rice University

31.1 Introduction

Warnings have two main purposes. First, they are a method for communicating important safety or safety-related information to a target audience who can then make better, more informed decisions regarding safety issues. Second, warnings are ultimately intended to reduce or prevent health problems, workplace accidents, personal injury, and property damage. Warnings can be in the form of signs, labels, product inserts and manuals, tags, audio- and videotapes, face-to-face verbal statements, and so forth. Printed warnings are generally text and graphics. Auditory warnings may be verbal or nonverbal. In this chapter, we will describe factors generally applicable to all types of warnings, although examples are geared mostly toward visual warnings associated with products.

Although the topic of this chapter is warnings, it should be recognized that warnings are not the best method of controlling hazards and promoting safety. Even the best warnings are not always 100% reliable or effective. The classic *safety hierarchy* (design, guard, and warn) offers a context for the role of warnings. The best method of hazard control is to eliminate (or remove) the hazard. If the hazard is not present, then the likelihood of injury is greatly reduced. Reformulating paint to eliminate lead or removing a flammable propellant such as propane in pressurized spray cans is an example of a design alternative that would eliminate hazards associated with such products.

Hazards cannot always be eliminated. For example, one cannot eliminate all of the hazards associated with the use of chemical solvents. Likewise, one cannot remove all of the mechanical hazards related to power tools. For hazards that cannot be eliminated, the next best hazard control strategy is to guard against contact with the hazard. Guarding can take several forms. The debris shield on the back of a lawnmower is mechanical guarding. The "dead-man" switch on a lawnmower that shuts off the rotor when the handle is released is procedural guarding. Requiring a prescription for certain drugs is expert-referent guarding. Unfortunately, not all hazards can be eliminated or guarded against, so warnings are necessary.

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As noted earlier, warnings do not always accomplish their intended purpose; thus, an important issue is how to design warning systems that will maximize their effectiveness. A starting point for warning designs is guidelines such as those of the American National Standards Institute's Z535 document (ANSI, 2002). According to these guidelines, written warnings should possess four textual components:

- A signal word such as DANGER, WARNING, or CAUTION (with corresponding red, orange, or yellow color) to attract attention to the warning and give an idea of the level of hazard
- A hazard statement that briefly describes the nature of the hazard
- A description of the possible consequences associated with noncompliance
- Instructions for how to avoid the hazard

In addition, a pictorial symbol depicting the hazard, consequences, or appropriate or inappropriate behaviors is also recommended. Research has verified the importance of these components for enhancing warning efficacy (Wogalter et al., 1987; Young et al., 1995).

Table 31.1 shows a checklist of factors, based on guidelines, standards, and empirical research, that should be considered in designing effective warnings. Although this is not an exhaustive list, it lists a minimum set of factors that a product manufacturer should consider in the communication of warnings. Of course, these are considerations; for example, not all of the textual components in the table are necessary if members of the target audience are aware of the hazard and procedures needed to avoid injury. However, even with this knowledge, the presence of a warning may serve as a reminder by cuing pre-existing safety-related knowledge from long-term memory into conscious awareness (e.g., Young and Wogalter, 1990).

Warning design and effectiveness therefore comprises many factors and considerations. A conceptual model has been developed for purposes of analyzing and evaluating these various factors and considerations (Wogalter et al., 1999a). The model combines basic components of communication and human information processing theory. It is a useful tool for forensic specialists in analyzing the adequacy of warnings.

31.2 The Communication–Human Information Processing (C-HIP) Model

The communication–human information processing (C-HIP) model (Wogalter et al., 1999a) is a framework for showing information flowing from a source to a receiver whereby the latter then processes the information to subsequently produce behavior. The model is displayed in Figure 31.1. The conceptual stages of source, channel, and receiver are taken from communication theory (Lasswell, 1948; Shannon and Weaver, 1949). The receiver stage is broken down further into several human information processing substages prior to carrying out the compliance behavior. These substages are attention switch, maintenance, comprehension, beliefs and attitudes, and motivation.

At each stage of the model, information can be processed and flow through to the next stage, or it can produce a bottleneck that blocks or deteriorates/distorts the flow before the process ends in the desired behavioral compliance. Although the process might not go all the way to behavioral compliance, it still might effectively influence earlier processing stages. For example, information can positively influence comprehension about the hazard and be consistent with beliefs and attitudes but still not motivate compliance behavior. Such a warning cannot be said to be totally ineffective because it does produce better understanding and lead to more informed decisions. However, it is ineffective in the sense that it does not necessarily produce the desired safe behavior.

The C-HIP model can be particularly useful in diagnosing and understanding warning failures and inadequacies. If a source does not issue a warning, no information will be transmitted through a channel stage and thus nothing will be communicated to the receiver. Even if a warning is issued, it will not be effective if the channel or medium of transmission is poorly matched with the message, receiver, or environment. Each of the stages within the receiver can also produce a bottleneck preventing further processing. The receiver might not notice the warning in the first place. Even if the warning is noticed,

TABLE 31.1 Warning Design Guidelines

Warning component	Design guideline
Signal words	• According to ANSI Z535 (2002): • Danger — indicates immediately hazardous situation that will result in death or serious injury if not avoided; use only in extreme situations. Red should be used. • Warning — indicates potentially hazardous situation that may result in death or serious injury if not avoided. Orange should be used. • Caution — indicates potentially hazardous situation that may result in minor or moderate injury. Yellow should be used. • Notice — indicates important nonhazard information. Blue should be used.
Format	• Message panel should be high contrast, preferably black print on white background or vice versa. • Text should be left justified. • Consistently position component elements. • Orient messages to read from left to right. • Each statement starts on its own line. • Use white space or bullet points to separate statements or sets of statements. • Place most important warning statements at the top.
Wording	• Use as little text as necessary to convey the message clearly. • Remove unnecessary connector words, e.g., prepositions, articles. • Use short sentences rather than long, complicated ones. • Give information about the hazard, instructions to avoid hazard, and consequences of failing to comply • Be explicit — tell the reader exactly what to do or not to do. • Use short, familiar words. • Avoid using abbreviations unless they have been tested on user population. • Use active voice rather than passive voice. • Use concrete rather than abstract wording. • Avoid using words or statements that might have multiple interpretations. • Use multiple languages when necessary.
Pictorials/ symbols	• When used alone, symbols should have at least 85% comprehension scores, with no more than 5% critical confusions (opposite or "very" wrong answers) • Pictorials not passing a comprehension test should be accompanied by words. Symbols that produce critical confusions should be avoided. • Use bold shapes. Avoid including irrelevant details. • Prohibition (circle slash) should not obscure critical elements of symbol.
Font	• Warning must be large enough to be seen by the intended audience and across expected viewing distance. • Use mixed-case letters. Avoid using all caps except for signal words or for emphasis. • Use sans serif fonts (Arial, Helvetica, etc.) for signal words and larger text messages. • Use serif fonts (Times, Times New Roman, etc.) for smaller text messages.
Other	• Locate/position so that presentation is where it will be seen or heard. • Test to assure message will be seen, heard, and positively affect safety.

Source: According to ANSI Z535 (2002), Arlington, VA: National Electrical Manufacturers Association.

the individual might not direct attention to the warning. Even if the receiver examines the warning, he or she might not understand it. Even if the warning is understood, it might not be believed, and so on.

Although the processing described here is linear, there are feedback loops from later stages to earlier stages, as illustrated in Figure 31.1. For example, when a warning stimulus becomes habituated over time from repeated exposures, attention is less likely to be allocated to the warning on subsequent occasions. Here, memory (as part of the comprehension stage) affects an earlier stage of processing: attention. Another example is that some people might not believe that a product or situation is hazardous and consequently not look for a warning. A third example would be if a person did not understand the warning and therefore went back to attentional processes and read it again. These feedback or nonlinear effects between the stages of the information processing model provide a means by which later stages influence decisions at earlier stages.

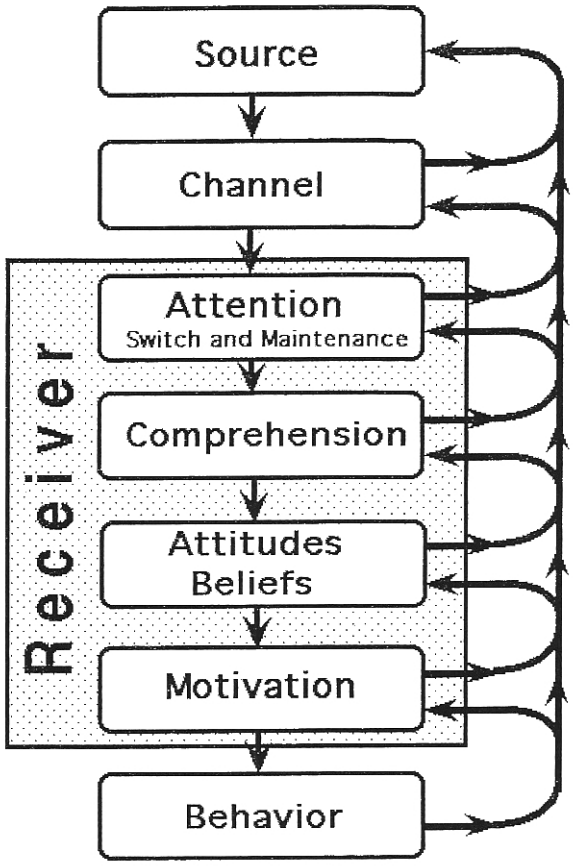

FIGURE 31.1 The communication–human information processing (C-HIP) model. (Adapted from Wogalter et al., 1999a.)

In the subsections that follow, each of the stages of the C-HIP model is described together with a brief description of influential factors. Table 31.2 shows a summary of some of the primary considerations associated with successful processing at each stage.

Source

The source is the originator or initial transmitter of the risk information. The source can be a person or an organization (e.g., company or government). Research shows that, given the same information, differences in the perceived characteristics of the source can influence people's beliefs about the relevance of the warning (Wogalter et al., 1999b). Information from a reliable, expert source (e.g., the Surgeon General) is given greater credibility (Wogalter et al., 1999b), which in turn may correct erroneous beliefs and attitudes (a stage of processing described later).

Channel

The channel is the way in which information is transmitted from the source to one or more receivers; the channel has two basic dimensions. The first concerns the media in which the information is embedded. Warnings can be presented on product labels, on posters, in brochures, as part of audio–video presentations, given orally, etc. The second dimension of the channel is the sensory modality used by the receiver to capture the information. This dimension is intimately tied to the medium in which the message is transmitted. Most commonly, warnings are received via the visual (printed text warnings and pictorial

TABLE 31.2 Methods and Influences of Communication–Human Information Processing (C-HIP) Stages

C-HIP stage	Methods and influences
Source	• Determination that hazard is not designed out or guarded • Credible, expert
Channel	• Visual (signs, labels, tags, inserts, product manuals, video, etc.) • Auditory (simple and complex nonverbal, verbal, live, electronic, chip, radio) • Other senses: vibration, smell, pain • Generally, transmission in more than one modality is better
Receiver	• Message delivered to • Consideration of demographics of target audiences (e.g., older adults, illiterates, cultural and language differences, persons with sensory impairments)
Attention switch	• High salience/conspicuity/prominence in clutter and noise • Visual: high contrast, large, proximal in time and space, presence of pictorial symbols • Auditory: louder and distinguishable from surroundings • Present when and where needed • Avoids habituation by changing stimulus
Attention maintenance	• Visual: legible font and symbols, aesthetic formatting, brevity • Auditory: intelligible voice • Enables encoding of message by examining/reading or listening to message
Comprehension/memory	• Enable informed judgment • Understandable message that provides necessary information to avoid hazard • Relate information to knowledge already in user's head • Explicitness enables elaborative rehearsal • Enable storage of information • Pictorials beneficial for demographic groups • Subsequently, warning cue reminds user of information • Comprehension testing needed to determine whether warning communicates intended/needed information
Beliefs/attitudes	• Affect receiver's earlier stages • Perceived familiarity reduces perceived hazard; perceived hazard reduces warning processing • Persuasive argument and excellent warning design needed when beliefs are seriously discrepant with truth
Motivation	• Energizes person to carry out next stage • Low cost (time, effort, money) for compliance • Perceived high cost for noncompliance • Benefited by explicitness and perceived injury severity • Affected by social influence, time stress, mental workload
Behavior	• Carrying out safe behavior; i.e., does not result in injury

symbols) and auditory (alarm tones, live voice, and voice recordings) modalities. There are exceptions: an odor added to flammable gases such as propane makes use of the olfactory sense, and a pilot's control stick designed to vibrate when the aircraft begins to stall makes use of the tactile sense.

Receiver

The receiver's mental activities can be categorized into a sequence of information-processing stages. For a warning to communicate information and influence behavior effectively, attention must be switched to it and then 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. If it is in disagreement, the warning must be adequately persuasive to evoke an attitude change toward agreement. Finally, the warning must motivate the receiver to perform proper compliance behavior. The next several subsections are organized around the stages of information processing that occur within the receiver.

Attention Switch

The first stage in the human information processing section of the C-HIP model concerns the switch of attention. An effective warning must initially attract attention. Generally, this must occur in environments that also have other stimuli competing for attention. Because many environments are cluttered, visual warnings must stand out from the background (i.e., be salient or conspicuous) in order to be noticed. This is particularly true when people are not actively seeking hazard and warning information. In many situations, people are focused on the tasks that they are trying to accomplish. Safety considerations, which can be part of one's background knowledge (stored in long-term memory), would tend to receive less attention under high task focus.

One way of making a visual warning more salient is to increase the print size and the print's contrast against the background (Barlow and Wogalter, 1993). Signal words and pictorials also tend to attract attention. In the U.S., current standards and guidelines such as ANSI Z535 (ANSI, 2002) recommend that warning signs and labels contain a signal word panel that includes one of the terms DANGER, WARNING, or CAUTION along with a specific color (red, orange, and yellow, respectively) and an alert symbol (a triangle surrounding an exclamation point). According to ANSI, these terms are intended to denote decreasing levels of hazard, respectively.

DANGER should be used for hazards in which serious injury or death will occur if warning compliance behavior is not followed, such as around high-voltage electrical circuits. WARNING is used when serious injury might occur, such as severe chemical burns or exposure to highly flammable gases. CAUTION is used when less severe personal injuries or damage to property might occur, such as getting hands caught in operating equipment. Research shows that lay persons often fail to differentiate between CAUTION and WARNING, although both are interpreted as connoting lower levels of hazard than DANGER (e.g., Wogalter and Silver, 1995). The term NOTICE, associated with blue color, is intended for messages that are important but do not relate to injuries. Pictorials and symbols used in communicating content information are also useful in capturing attention (Bzostek and Wogalter, 1999; Laughery et al., 1993a). One general symbol is the alert icon (triangle enclosing an exclamation point).

The placement of a warning in time and location is an important factor in facilitating attention switch. A warning, even a good one, not readily in view or not available at the time needed is less likely to be effective. Even though placement of warnings directly on a hazardous product is preferred (Wogalter et al., 1987), the available surface area on which warnings can be printed is sometimes limited. Methods are available to increase the surface area for print warnings (Barlow and Wogalter, 1991; Wogalter et al., 1999d). A related issue is that repeated and long-term exposure to a warning may result in a loss of attention-capturing ability (Wogalter and Laughery, 1996). This habituation can occur over time, even with well-designed warnings. Altering a warning's appearance by periodically changing its format or content can slow the habituation process.

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 value. For adequate processing of warning information to occur, attention must be maintained on the message (Wogalter and Leonard, 1999). With brief warnings, the message information might be acquired very quickly, sometimes as fast as a glance. For longer warnings to maintain attention, they must have qualities that generate interest and do not require much effort. If a warning contains large amounts of text, individuals may decide too much effort is required to read it and thus direct their attention to something else. Some of the same design features that facilitate the switch of attention also help to maintain attention (Barlow and Wogalter, 1991; Wogalter et al., 1993a). For example, large print not only attracts attention but also increases legibility, thus making reading less effortful and more likely.

Another factor that can influence attention maintenance is formatting. Visual warnings formatted to be aesthetically pleasing, with plenty of white space and coherent information groupings (Hartley, 1994), are more likely to attract and hold attention while the contents are examined and information is extracted (Vigilante and Wogalter, 1998). In general, bulleted lists are preferred to long paragraphs (Desaulniers,

1987; Wogalter and Post, 1989). Although aesthetically pleasing at a distance, full justification (the straight alignment of the beginning and ending words at both margins) is more difficult to read than "ragged right" (justification only of the left margin). In ragged right, the spacing between letters and words is consistent. Interest is also facilitated by the presence of well-designed pictorial symbols. Furthermore, research indicates that people prefer warnings that have a pictorial symbol to warnings without one (Kalsher et al., 1996; Young et al., 1995).

Comprehension

A warning that is attended to and examined has little value if the recipient does not understand its message. A warning message should give the receiver an appreciation of hazards and consequences and enable informed judgment. For this reason, warnings should state the message as explicitly as possible (Laughery et al., 1993b). For example, a warning for a solvent product that says "Use outdoors or only in a room where there is air exchange between windows" conveys more meaning than the statement "Use with adequate ventilation." The latter statement is vague and can be interpreted to mean something very different from what was intended by the product manufacturer. Similarly, a statement such as "Hazardous to your health" does not provide an appreciation of potential consequences in a situation in which breathing a toxic vapor may cause lung damage.

Whether a warning will be understood depends on characteristics of the warning and the receiver. To maximize comprehension, warnings should be written to take into account the lowest-level abilities in the target population. For warnings targeted to the general U.S. population, one cannot assume that every person who receives the warning can read English or is competent in a particular knowledge domain. For situations in which such factors are a concern, solutions may take several forms: complex messages may be written using simple, high-frequency terms and more detailed explanations; languages other than or in addition to English may be employed; and pictorial symbols may play a more important role.

With rising international trade, products increasingly are produced for highly diverse audiences. For such audiences, multiple languages and understandable pictorials can be useful. Pictorial symbols should be tested to determine their understandability. According to ANSI Z535.3, safety symbols or pictorials that are not accompanied by text should surpass a criterion of 85% correct in a comprehension test with no more than 5% critical confusions (opposite or unsafe interpretations). Pictorials not meeting this criterion can be used, but only if they are accompanied by text and the critical confusion level is minimal. The ISO standard for symbols or pictorials has a criterion of 67% with a somewhat different scoring system.

Even though the standards do not specify testing text, they should probably be evaluated with representative members of the target audience before being used to verify their suitability in doing the job of warning. Wogalter and colleagues (1999c) provide a methodology for iteratively testing warnings to ensure their comprehension. Testing will not only identify warnings that are difficult to understand, but also identify those whose meaning could to be misinterpreted. Misinterpretation (critical confusion) can be a more serious problem than simply a lack of comprehension. A warning that is not understood might simply be ignored, but a warning whose meaning is misinterpreted could potentially suggest hazardous behaviors.

Beliefs and Attitudes

If a warning successfully captures and maintains attention and is understood, it still might fail to elicit safety behavior due to discrepant beliefs and attitudes held by the receiver. Beliefs refer to an individual's knowledge of a topic that is accepted as true. Attitudes are similar to beliefs but have greater emotional involvement. According to the C-HIP model, a warning will be successfully processed at this stage if it concurs with the receiver's current beliefs and attitudes. The warning message will tend to reinforce what the receiver already knows and, in the process, make those beliefs and attitudes stronger and more resistant to change. If, however, the warning information does not concur with the receiver's existing beliefs and attitudes, they must be altered by the warning in order for it to be effective. Following is a brief description of how familiarity, hazard perceptions, and perceived severity of injury relate to beliefs and attitudes.

In general, when people believe that they are familiar with a product, task, or environment, they are less likely to search for warnings and less likely to attend to or read them (e.g., Godfrey et al., 1983;

Wogalter et al., 1991), even if they are noticed. Familiarity beliefs are formed from past similar experience in which at least some relevant information has been acquired and stored in memory. Familiarity produces the belief that everything that needs to be known about a product or situation is already known (Wogalter et al., 1991). A person who is familiar with a piece of equipment might assume that a new, similar piece of equipment operates the same way (which may not be true), thus reducing the likelihood that a warning would be read.

Hazard perception also influences warning processing at the beliefs and attitudes stage. It is related to familiarity in that familiar products tend to be perceived as less hazardous. Persons who do not perceive a product as hazardous are less likely to notice or read an associated warning (Wogalter et al., 1991, 1993b). Perceived hazard is also closely related to the expected injury's severity level. In other words, the greater the likelihood of injury, the more one perceives the hazard (Wogalter et al., 1991). Furthermore, even if the warning is read and understood, compliance may be minimal if the level of hazard is believed to be low.

If warning information does not conform to or is discrepant with existing beliefs and attitudes, then an effective warning must be sufficiently persuasive to change those beliefs and attitudes. This difficult task is facilitated if the information is presented in a form that will be noticed, read, and understood using the warning design characteristics discussed earlier. The message must be strong and persuasive to override pre-existing knowledge and experience and motivate compliance.

Motivation

If a warning is noticed, read, and understood, and concurs with a person's beliefs and attitudes (or brings about a change in discrepant beliefs and attitudes), the process moves to the motivation stage. To be effective at this stage, warnings must motivate the desired behavior. Motivation is affected by the cost of complying with a warning and the cost of noncompliance. The cost of complying with a warning may be in terms of money, time, and/or convenience. When people perceive the cost of compliance to be greater than the benefits, they are less likely to perform the behavior directed by the warning. The requirement to expend even a minimal amount of extra time or effort can reduce motivation to comply with a warning (Wogalter et al., 1987, 1989). One way of reducing the cost of compliance is to make the directed behavior easier to perform. For example, if hand protection is required when using a product, gloves might be enclosed with the product.

The costs of noncompliance with a warning can also have a powerful influence on compliance motivation. This effect is particularly true when the possible consequences of the hazards are severe. Possible injuries associated with noncompliance should be explicitly stated in the warning (Laughery et al., 1993b). Explicit injury-outcome statements such as "Can cause liver disease — a condition that almost always leads to death" provide reasons for complying and are preferred to general, nonexplicit statements such as "Can lead to serious illness."

Another factor influencing motivation to comply is social influence. If people observe others not complying with a warning to wear protective equipment, they may not believe it is necessary for them to do it (Wogalter et al., 1989). Similarly, observing others complying can have a positive influence.

Other factors that influence motivation to comply with a warning are time stress (Wogalter et al., 1998) and mental workload (Wogalter and Usher, 1999). In high-stress and high-workload situations, competing activities absorb some of the cognitive resources available for processing warning information and carrying out the compliance behavior. In conditions such as these, considerable emphasis on safety may be required to overcome the cognitive barriers.

Behavior

If sufficiently motivated, individuals are likely to carry out the warning-directed behavior. Behavioral compliance research shows that warnings can change behavior (e.g., Laughery et al., 1994; Cox et al., 1997). See Silver and Braun (1999) for a review of published research that has measured compliance with warnings under various conditions.

31.3 Discussion

The preceding review of factors influencing warning effectiveness was organized around the C-HIP model. This model breaks the processing of warning information into separate stages that must be completed successfully for compliance behavior to occur. A bottleneck at any given stage can inhibit processing at subsequent stages.

The basic C-HIP model can be a valuable tool in developing and evaluating warnings. By identifying potential processing bottlenecks, it can be useful in determining why a warning may or may not be successful in achieving safe outcomes. Its application, particularly in conjunction with empirical data obtained in various types of testing, can identify specific deficiencies in the warning system. For example, suppose a manufacturer finds that a critical warning on its product label is not working to prevent accidents. The first reaction to solving the compliance problem might be to increase the size of the sign so that more people are likely to see it. However, noticing the sign (the attention switch stage) might not be the problem. Potentially, user testing could show that all users report having seen the warning (attention switch stage), read the warning (attention maintenance stage), understood the warning (comprehension and memory stage), and believe the message (the beliefs and attitudes stage). Thus, the problem with the manufacturer's warning in this case is likely to be at the motivation stage; users are not complying because they believe the cost of complying with the warning (e.g., wearing uncomfortable personal protection equipment) outweighs the perceived likelihood of getting injured by not wearing the equipment. By using the model as an investigative tool, one can determine the specific causes of a warning's failure and not waste resources trying to fix the wrong aspect of the warning design.

For the forensic practitioner, the model has utility in providing assistance in determining the adequacy and potential effectiveness of a warning. To the extent that a warning fails to meet various design criteria, the model can be a basis for judging adequacy. The lack of signal words, color, and pictorials or a poor location can be a basis for opining about its adequacy regarding attention. A high reading level, the use of technical terminology, or the omission of critical information may be a basis for its inadequacy regarding comprehension. The failure to provide explicit consequences information in circumstances in which the outcome of noncompliance may be catastrophic is not consistent with adequacy regarding motivation.

Considerations such as these, in conjunction with information obtained in discovery for a particular case, can also be useful in formulating opinions regarding why a warning may not have been successful in a particular instance. For example, the deposition testimony of an injured plaintiff that contains statements such as "I didn't notice the warning," "I thought I was supposed to do this (a wrong action)," or "I didn't realize I could get injured this seriously" may provide a basis for opinions regarding how a different warning may have been effective. On the other hand, the adequacy of the warning may be judged not to be a casual factor in the outcome to the extent that design criteria are met, the content regarding hazards and consequences is explicit and understood, and the person made an informed decision to "take the risk."

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