Factors that Influence the Effectiveness of Warning Signs and Labels

Michael S. Wogalter, Ph.D.
Professor of Psychology
North Carolina State University - Wogalter@NCSU.edu

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Factors influencing warning effectiveness are organized around a communication-human information processing (C-HIP) model. It starts with a source relaying a warning message through media. At the receiver, processing begins when attention is switched and then maintained. Processing continues with successive stages of comprehension, beliefs and attitudes, motivation, and ending with behavior.

1. Introduction

Warnings have three main purposes. First and foremost, they are a method for communicating important safety or safety-related information to a target audience. Second, they attempt to promote safe behavior and reduce unsafe behavior. Third, warnings are ultimately intended to reduce or prevent health problems, workplace accidents, personal injury, and property damage.

There are many kinds of warnings. Warnings can be in the form of signs, labels, product inserts and manuals, lock out tags, audio and video tapes, admonishments from caregivers or supervisors, handouts distributed at safety training meetings, auditory alarms, and so forth. Printed warnings are generally text and graphics. Auditory warnings may be both verbal and nonverbal. In this paper, a model is described that is generally applicable to all types of warnings. Examples are geared mostly toward warnings found on posted signs and product labels.

While the topic of this presentation is warnings, it must be admitted that warnings are not the best method of controlling hazards and promoting safety. Even the best warnings are not always reliable or 100% effective. The best method of hazard control is to eliminate (or remove) the risk. If the risk is not present then the likelihood of injury is greatly reduced. For example, redesigning a workplace process by having machines, instead of humans, transport hazardous materials, reduces workers' exposure to the hazard, making it much less likely that they will be injured. Similarly, it may be possible to remove a dangerous chemical from a cleaning fluid by substituting a safer chemical. The substitution eliminates the hazard and consequently the risk of injury. Of course before any change is actually implemented there needs to be some forethought about how the change might impact the entire system or process so that no new hazards are created in designing out the original hazard.

Unfortunately, hazards cannot always be eliminated. For example, one cannot eliminate all of the hazards associated with chemical solvents if the company manufactures 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 by people and property. Wearing protective equipment such as a full-face respirator with an independent air supply separates an employee from hazardous solvent vapors. Similarly, a plexiglass shield placed around a high-speed saw to guard workers from flying debris.

Unfortunately, not all hazards can be removed or guarded against. In such cases warnings are necessary. As stated earlier, warnings are not the best method of hazard control because they do not always accomplish their intended purpose. Thus, an important issue is how to design warning systems that will maximize their effectiveness. One purpose of this paper is to

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describe some of the factors that affect (increase and decrease) warning effectiveness.

A starting point for warning designs is standards and guidelines such as those of the American National Standards Institute's Z535 document (ANSI, 1998). According to these guidelines warnings should posses four textual components: (1) a signal word such as DANGER, WARNING or CAUTION to attract attention to the warning and give an idea of the potential level of hazard, (2) a hazard statement which briefly describes the nature of the hazard, (3) a description of the possible consequences associated with non-compliance, and (4) 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 the above-mentioned components for enhancing warning efficacy (Wogalter *et al*., 1987; Young *et al*., 1995). Not all of the components are necessary if virtually all members of the target audience know all of the information in the warning. However, while a warning having information already know to the target audience may appear to have little or no utility, its presence could serve as a reminder by cuing pre-existing safety-related knowledge from long-term memory into awareness (e.g., Young and Wogalter, 1990).

The remainder of this article is based on a conceptual model that combines basic components of communication and human information processing theory. While considering the stages, examples of issues and factors pertaining to warnings are presented.

2. C-HIP Model

The Communications-Human Information Processing (C-HIP) model (Wogalter et al., 1999) is a framework for showing information flowing from a source to a receiver whereby the latter then processes the information to subsequently produce behavior. Figure 1 shows a depiction of the model. 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 sub-stages: Attention Switch and Maintenance, Comprehension, Beliefs and Attitudes, and Motivation to carry out the compliance behavior.

Each stage of the model can allow information to "flow through" to the next stage, or it can produce a bottleneck which blocks the flow before the process ends in the desired behavioral compliance. While 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 yet not produce an effect on beliefs and attitudes or affect motivation or change behavior. Such a warning cannot be said to be totally "ineffective" as it does produce better understanding. However, it is ineffective in the sense that it does not necessarily produce the desired safe behavior.

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 by a source, it will not be effective if the channel or medium of transmission is poorly matched with the message, the receiver, or the 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 they notice the warning, the individual might not direct attention to the warning. Even if the receiver examines the warning, he or she might not understand the warning. Even if the person understands the warning might not believe the warning's message. Or, they might not be motivated (or energized) to take action.

Although the processing described above is linear, there are feedback loops from later stages to earlier stages as illustrated in Figure 1. An example is that 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 the content of a warning or believe that a product or situation is hazardous. As a consequence they might not look for a warning. These feedback or nonlinear effects among the stages of the information-processing model provide a means by which later stages influence decisions at earlier stages.

In the sections that follow, each of the stages of the C-HIP model is described together with a brief description of influential factors.

2.1 Source

The source is the originator or initial transmitter of the risk information. The source can be a person(s) or an organized entity (e.g., the company or the government). Before the source actually transmits a warning there must be a recognized need for the warning. 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 positive, familiar, expert source is given greater credibility, which in turn possibly leads to changes in beliefs and attitudes about the information presented. One might expect that a government agency whose prime focus is safety is likely to publish accurate, truthful materials including warnings about real hazards than an organization that would make profits from the distribution or sale of the hazardous product. Warnings attributed to the former organizations compared to the latter, therefore, are likely to be perceived as more credible. Research (Wogalter *et al*., 1999c) indicates that government agencies and medical organizations that have a good reputation can influence beliefs in favor of the message that they present.

2.2 Channel

The channel concerns the way information is transmitted from the source to one or more receivers. There are two basic dimensions of the channel. One concerns the media in which the information is embedded. Warnings can be presented on posters, in brochures, on product labels, as part of audio-video presentations, given orally, etc. The other dimension of the channel is the sensory modality used by the receiver to capture the information. This dimension is intimately tied to the media in which the message is transmitted. Most commonly, warnings are received via the visual (printed text warnings and pictorial symbols) and auditory (alarm tones, live voice and voice recordings) modalities. There are exceptions: an odor added to very flammable gases like propane makes use of the olfactory sense, and a pilot's control stick that is designed to vibrate when the aircraft begins to stall makes use of the tactile sense.

2.3 Receiver

The receiver's mental activities can be categorized into a sequence of information processing stages. For a warning to effectively communicate information and influence behavior, it must first cause attention to be switched to it and then attention needs to be maintained long enough for the receiver to extract the necessary information from the warning. Next, the warning must be understood, and must concur with the receiver's existing attitudes and beliefs. 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 sections are organized around the stages of information processing that occur within the receiver.

2.4 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. Since 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 they are trying to accomplish, and while safety considerations may be part of their background knowledge (stored in long-term memory), task completion (and not warning and hazard information) is most likely the focus of their attention.

One way by which a visual warning can be made more salient is by increasing 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 those put forth by the American National Standards Institute's Z535 document (ANSI, 1998) recommend that warning signs and labels for hazards contain a signal word panel that includes 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 where serious injury or death will occur if the warning compliance behavior is not followed such as around high voltage electrical circuits. WARNING is to be used when serious injury might occur, such as severe chemical burns or exposure to highly flammable gases. CAUTION is to be used when less severe personal injuries or damage to equipment might occur, such as getting hands caught in operating equipment. Research shows that laypersons often fail to differentiate between the latter two terms, although both are interpreted as being lower in connoted hazard than DANGER (Wogalter and Silver, 1995). Additionally, research has shown that pictorials are useful in capturing attention (Bzostek and Wogalter, 1999; Laughery et al., 1993).

The placement of a warning is also very important. For example, warnings directing the use of personal protective equipment should be displayed prominently on or near each entrance to a restricted area. In areas that are large or dispersed, flashing lights may be the best way to attract attention.

Unfortunately, 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.

2.5 Attention Maintenance

Individuals might 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 further processing of warning information to occur, attention must be maintained on the warning's 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 need to have qualities that generate interest, and do not require much effort. If a warning contains large amounts of text, individuals may decide that too much effort is required to read it, and they turn 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*., 1993b). 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 that are 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 extracted (Vigilante

and Wogalter, 1998). In general, bulleted lists are preferred to paragraphs of text (Desaulniers, 1987; Wogalter and Post, 1987). Full justification (the straight alignment of the beginning and ending words in at both margins), while aesthetically pleasing at a distance, is more difficult to read than "ragged right"(justification of only the left) margin where the spacing between letters and words is consistent. Interest is also facilitated by the presence of well-designed pictorial symbols. In addition, research indicates people prefer warnings that have a pictorial symbol to warnings without one (Kalsher et al., 1998; Young et al., 1995).

Even though placement of warnings directly on a hazardous product is preferred (Wogalter *et al.*, 1987, the available surface area on which to print warnings is sometimes an issue. Detached (physically separate from the product) documentation such as product manuals provides more space to print warning information.

2.6 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 risks and enable informed judgment. For this reason, warnings should state their messages as explicitly as possible (Laughery *et al.*, 1993a). For example, a warning for an industrial solvent that says, "Use only under an exhaust hood with a fan capable of moving 5000 cubic meters of air per minute." conveys more meaning than the statement "Use with adequate ventilation." The latter statement is vague and can be interpreted to mean something very different than what was intended by the solvent manufacturer. Whether a warning will be understood depends on characteristics of both the warning and the receiver. To maximize comprehension, warnings should be written considering the lowest-level abilities in the target population. For warnings targeted to the general population, one cannot assume that every person who receives the warning can read or has been formally educated. For situations where this is a concern, complex messages might need to be re-written using simple, frequently encountered terms which may involve adding explicit explanations. At the same time, the message should be as concise as possible (while still communicating all of the pertinent information). Thus, there is a tradeoff between brevity and completeness.

Increasingly multinational companies are hiring highly diverse work forces. In addition, products are shipped throughout the world. To reach all members of the target audience, it might be necessary to present warning information in multiple languages or to use understandable pictorial symbols. Pictorial symbols can be used to complement warning text, or when a pictorial symbol is readily recognized and understood, it can be used without text. In many settings, the pictorial symbols used are so readily understood they are rarely accompanied by text.

Whether warnings are presented by language or by symbol they should always be tested with representative members of the target audience before being put into use. Wogalter *et al*. (1999a) provide a methodology for iteratively testing warnings to ensure their comprehension. Not only will testing 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 dropped from further cognitive consideration, but a warning whose meaning is misinterpreted could potentially suggest hazardous behaviors.

2.7 Beliefs and Attitudes

If a warning successfully captures and maintains attention and is understood, then 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 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, then in order to be effective a warning must change those beliefs and attitudes. In the next several paragraphs, we describe below how familiarity, hazard perceptions, perceived likelihood of injury, 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 thus are less likely to attend to them) or read them even if they see them (e.g., Godfrey *et al*., 1983; Wogalter *et al*., 1991). Familiarity beliefs are formed from past similar experience where 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 certain piece of equipment might assume that a new, similar piece operates the same way (which may not be true) and thus might not attend to warning information and might perform unsafe behaviors.

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 being hazardous are less likely to notice or read an associated warning (Wogalter *et al*., 1991; Wogalter *et al*., 1993a). And even if they do read the warning and know its content, they might not comply if they believe the level of hazard is 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 the person's beliefs and attitudes. While bringing about this change is not an easy task, it 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 enough to override pre-existing knowledge and experience. Wogalter *et al*. (1995) showed that an appropriately placed, interactive warning can be successful in overcoming people's familiarity beliefs and influence them to read and comply with warnings.

2.8 Motivation

If a warning is noticed, read, understood, and concurs with a person's beliefs and attitudes (or is strong enough to change discrepant beliefs and attitudes), the process moves to the motivation stage. To be effective at this stage warnings must motivate the desired behavior. An important factor influencing motivation is the balance between the cost of complying with a warning and the cost of non-compliance. 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 in an industrial facility hearing protection is required, warning signs should be posted at each entrance demanding that the proper equipment be worn and instructing where to get the equipment. Earplugs or other hearing protection should be available near the signs so that minimal effort is required to comply. Comfort and proper fit are key factors in cost of compliance. If workers and visitors to the facility find protective equipment to be bothersome, they will be less likely to wear it (Casali and Epps, 1986).

The costs of non-compliance with a warning can also have a powerful influence on compliance motivation. Possible injuries associated with

non-compliance should be explicitly stated in the warning (Laughery *et al*., 1993). Explicit injury outcome statements such as "Can cause liver disease – a condition that almost always leads to death" give reasons for complying and are preferred to general statements such as "Can lead to serious illness."

Another factor influencing motivation to comply is social influence. If less experienced workers observe more experienced workers not complying with a warning to wear protective equipment, they may not believe safety is taken seriously and will be less likely to engage in compliance behavior themselves (Wogalter *et al*., 1989).

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 emphases on safety may be required to overcome the cognitive barriers.

2.9 Behavior

If sufficiently motivated then individuals will 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 concise review of published research that has measured compliance with warnings under various conditions.

3. Discussion and Conclusions

This article reviewed some of the factors that can influence the processing of warning information. The review was organized around the C-HIP model that breaks the processing of warnings into separate stages that must be completed successfully for compliance behavior to occur. A bottleneck at any given stage can prevent processing from occurring at subsequent stages.

The basic C-HIP model can aid in determining why a warning does not work by identifying potential processing bottlenecks. Suppose that in an industrial setting it is observed that a critical warning sign is not working (as indicated by the fact that some people are not complying with it). The first reaction to solving the compliance problem might be to increase the size of the sign so more people are likely to see it. But noticing the sign (the attention switch stage) might not be the problem. Potentially, user testing could show that workers report that they have all seen the sign (attention capture stage), and that they have read it (attention maintenance stage) and understood it (comprehension and memory stage), and that they believe the message (the beliefs and attitudes stage). The problem with the warning may actually be at the motivation stage—the workers are not complying because they believe the cost of complying with the warning (wearing ill-fitting and uncomfortable personal protection equipment, for example) outweighs the perceived slight probability of getting injured by not wearing the equipment.

By using the model as an investigative tool and testing a warning at different stages, 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.

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