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CHAPTER 36

WARNINGS AND RISK PERCEPTION

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36.1 INTRODUCTION

During the past several decades there has been an increasing concern for public safety in the United States. This concern has been manifested in many ways. One such manifestation is the much greater use of safety communications, warnings, to inform people of hazards and to provide instructions as to how to deal with them so as to avoid or minimize undesirable consequences. Warnings are used to address environmental hazards as well as hazards associated with the use of products.

In addition to the increase in general concern for safety, there is another factor that has influenced the greater use of warnings, namely, litigation. The need for and adequacy of warnings has been an increasingly prevalent issue in product liability and personal injury litigation.

As might be expected, the greater attention to and deployment of warnings has been accompanied by regulations, standards, and guidelines as to when and how to warn. Also, there has been a substantial increase in research activity on the topic. Human factors specialists, or ergonomists, have played a major role in this research and the technical literature that has resulted.

A topic that is closely associated with warnings is risk perception; that is, people's knowledge and/or understanding of hazards and their consequences. Risk perception is closely related to warnings, since when and how to warn is obviously a function of the knowledge people have about hazards and the factors that influence this knowledge.

The purpose of this chapter is to review the important principles and facts that have evolved on the topic of warnings and to discuss criteria and procedures for developing and testing warnings.

36.2 BACKGROUND

In this section several terms are defined and the role of warnings in the broader context of hazard control is discussed.

36.2.1 Definitions

It is important to establish a few definitions for terms that will be used in this chapter, particularly the concepts of hazard, danger, and risk perception. These terms are sometimes used in different ways with different meanings; hence, we want to be clear as to their meaning in this context.

Hazard is defined as a set of circumstances that can result in injury, illness, or property damage. Such circumstances may include characteristics of the environment, of equipment, and of a task someone is performing. From a human factors perspective, it is important to note that circumstances also includes characteristics of the people involved. These people characteristics encompass abilities, limitations, and knowledge.

Danger is a term that is used in a variety of ways. In this chapter it is viewed as the product of hazard and likelihood; that is, if one has quantified values of hazard and likelihood, multiplying these quantities would give a value for danger. Note, that an implication of this definition is that if either value is zero, there is no danger. If the hazard and its consequence is serious but will not occur, there is no danger. Similarly, if the probability of an event occurring is high, but there will be no resulting undesirable consequences, there is no danger.

"Risk" is a term that has had many definitions in a variety of contexts. *Risk perception* encompasses a broad notion of safety awareness. It concerns the overall awareness and knowledge regarding the hazards, likelihoods, and potential outcomes of a situation or set of circumstances.

36.2.2 Hierarchy of Hazard Control

In the field of safety there is a concept of hazard control that includes the notion of a hierarchy or priority scheme (Sanders and McCormick, 1993). This hierarchy defines a sequence of approaches to dealing with hazards in order of preference. The sequence is (1) design it out, (2) guard, and (3) warn. The notion of a design solution is that the first preference is to eliminate the hazard through alternative designs. If a nonflammable solvent can be used for some cleaning task, such a solution is preferable to wearing protective equipment or warning about the flammable hazard being near an ignition source. Of course, often it is not possible to eliminate hazards. Guarding, physical or procedural, is a second line of defense and has as its purpose preventing contact between people and the hazard. Barriers and protective equipment are examples of physical barriers, whereas designing tasks in such a way to keep people out of a hazard zone is an example of a procedural guard. However, like alternative designs, guarding is not always a feasible solution, and the third line of defense is warning. Warnings are third in the priority sequence because influencing behavior is sometimes difficult, and seldom foolproof. There is another implication of this priority scheme; namely, warnings are not a substitute for good design or adequate guarding. Indeed, warnings are properly viewed as a supplement, not a substitute, to other approaches to safety (Lehto and Salvendy, 1995).

In addition to the above three-part hierarchy, there are other steps or approaches that may be effective in dealing with hazards. Generally, they fall into the same category as warnings in that they are means of influencing the behavior of people. Training and personnel selection are examples. Another approach that includes elements similar to procedural guarding and warnings is supervisory control. These three approaches are particularly applicable to hazards in the context of job performance.

36.3 RISK PERCEPTION

This chapter does not provide a review of research and theory on risk perception. For a review of this topic see Fischhoff (1989) and Slovic, Fischhoff, and Lichtenstein (1982). Our approach here is to note how risk perception considerations enter into decisions regarding the design, implementation, and effectiveness of warnings.

36.3.1 System Context

As noted earlier, an important factor in the hazards associated with any situation or product is the perception or knowledge of the people involved. Later in this chapter we discuss the purposes of warnings, but generally the goal is to influence behavior by providing information. Obviously, the information that people have from past experiences or that they glean from the existing situation or circumstances is relevant to the issue of what needs to be warned. Thus, an understanding of risk perception is important in decisions about when, where, what, and how to warn.

36.3.2 Awareness and Knowledge

The distinction between awareness and knowledge is important in understanding issues of risk perceptions and how they map on to warnings design and effectiveness. The difference is analogous to a distinction made in cognitive psychology between short-term memory (sometimes thought of as what is currently in consciousness) and long-term memory (one's permanent knowledge of the world). The point here is simply that people may have information or experience in their overall knowledge base that at a given time is not part of what they are thinking about—awareness. In the context of safety or coping with hazards, it is not enough to say that people know something. Rather, it is important that people be aware of (thinking about) the relevant information at the critical time. This distinction has important implications for the role of warnings as reminders and is further addressed later in this chapter.

There are many ways in which people can become aware and knowledgeable about hazards, consequences, and appropriate procedures or behaviors. Warnings, training, and direct supervisor inputs are among them, and it is the first of these that this chapter addresses. There are others. Experience, of course, is one way that people may acquire such safety knowledge. "Learning the hard way" by having experienced an incident or knowing about someone else who has had such experiences can certainly result in such knowledge. Such experiences, on the other hand, do not necessarily lead to accurate knowledge of hazards and consequences, because they may result in overestimating the degree of danger associated with some situation or product. Similarly, the lack of such experiences may lead to underestimating such dangers, or not thinking about them at all. Nevertheless, experience clearly plays an important role in risk perception.

Another source of information about dangers is the situation or product itself. In the law there is a concept of "open and obvious." The point here is that the appearance of a situation or product or the manner in which it functions may communicate the nature of the safety problem. Moving mechanical parts such as chain-driven sprockets may be an example of an open and obvious pinch point hazard. Even more obvious may be the hazard and consequence of a fall from a height in a construction setting. Of course, many safety problems are probably not open and obvious, such as some specific chemical hazards and consequences associated with solvents.

A final point to be noted regarding risk perception concerns the problem of overestimating what people know or are aware of. To the extent it is incorrectly assumed that people have information and knowledge, there may be a tendency to provide inadequate warnings. Thus, it is an important part of job, environment, and product design to take into account people's understanding and knowledge of hazards and their consequences. A further analysis and discussion of this issue can be found in a paper by Laughery (1993).

36.4 WARNINGS

In this section we discuss the purpose(s) of warnings, warnings as communications, and the concept of a warning system. Then, following a discussion of some general criteria for warnings, eight criteria for warnings design are presented and discussed.

36.4.1 Purpose of Warnings

The purpose of warnings can be stated at several levels. Most generally, warnings are intended to improve safety, that is, to decrease accidents or incidents that result in injury, illness, or property damage. At another level, warnings are intended to influence or modify people's behavior in ways that improve safety. At still another level warnings are intended to provide information that enables people to understand hazards, consequences and appropriate behaviors, which in turn enables them to make informed decisions. This latter point places warnings squarely in the category of a communication, which, of course, they are.

There are two additional points to be noted regarding the purpose of warnings, both of which are related to warnings as communications. First, warnings are a means of shifting or assigning responsibility for safety to people in the system, the product user, the worker, etc., in situations where hazards cannot be designed out or adequately guarded. This point is not to say that people do not have safety responsibilities independent of warnings; of course they do. Rather, a purpose of warnings is to provide the information necessary to enable them to carry out such responsibilities. The second point regarding the communication purpose concerns an issue that has received little attention in the technical literature; namely, people's right to know. The notion is that even in situations where the likelihood of warnings being effective may not be high, people have the right to be informed about safety problems confronting them. Obviously this aspect of warnings is more of a personal, societal and legal concern than a human factors issue, and although it is not addressed further in this chapter, it is a matter that is related to the overall purposes of warnings.

36.4.2 The Communication Model

As noted above, warnings can properly be viewed as communications. In this context it is useful to note the typical communications model or theory, because it has implications for the design and implementation of warnings. A typical and basic model is shown in Figure 36.1.

The model includes a sender, a receiver, a channel or medium through which a message is transmitted, and the message. The receiver is the user of the product, the worker, or any other person to whom the safety information must be communicated. The message, of course, is the safety information to be communicated. The medium refers to the channels or routes through which information gets there. Understanding and improving these components of a safety communication system increases the probability that the message will be successfully conveyed.

However, the communication of safety information often is not so simple as Figure 36.1 might imply. Frequently more than one medium or channel may be available and/or involved, multiple messages in different formats and/or containing different information may be called for, and the receiver or target audience may include different subgroups with varying characteristics. An example of such a warning situation would occur when a product with associated hazards is being used in a work environment. Figure 36.2 illustrates a communication model that might be applicable.

This figure reflects a much more complex situation than Figure 36.1. In addition to the sender (manufacturer) and receiver (end user), other people or entities may be involved such as distributors and employers. Further, each of these entities may be both receivers

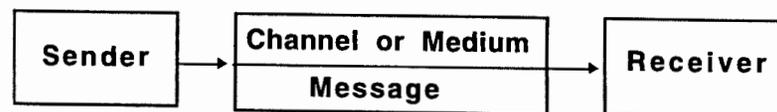


Figure 36.1 Simple communication model.

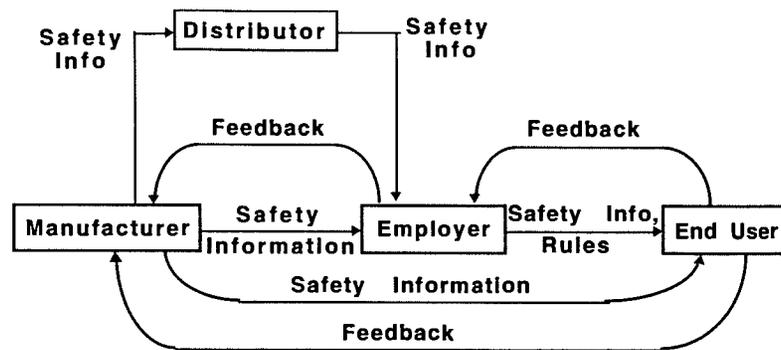


Figure 36.2 Complex communication model.

and senders of safety information. There are also more routes through which warnings may travel such as from the manufacturer to the distributor to the employer to the user, from the manufacturer to the employer to the user, or directly from the manufacturer to the user (as on a product label). The warnings may take different forms such as communications of information or rules that an employer sets to govern the behavior of employees. Thus, there are circumstances in which the warning or warning system is much more complex than a sign or label for transmitting safety information from a sender to a receiver.

36.4.3 Concept of a Warning System

The notion of warnings being a sign or a portion of a label is much too narrow a view of how such safety information gets transmitted. The concept of a warning system is that a warning communication for a particular setting or product may consist of a number of components. In the context of the communication model presented in Figure 36.2, these components may include a variety of media and messages. An example or two can help make the point.

A warning system for a product off the drug store shelf, such as NyQuil, may consist of several components: a printed statement on the box, a printed statement on the bottle, and a printed package insert. In addition, it may include verbal warnings in television advertisements about the product. A warning system for tires and rims that may be mismatched with a resulting potential explosion might consist of a number of components. Examples are: warnings in raised lettering on the sidewall of the tire, a temporary tread label on new tires, stickers or stamping on the rim, statements on wall posters in places where tires are mounted, statements in tire and rim product catalogs and manuals, statements in handouts that accompany sales of tires and rims, verbal statements by employers of people who mount tires, etc. Another example would be warnings for a solvent used in a work environment for cleaning parts. Here the components might include printed on-product labels, printed flyers that accompany the product, statements in advertisements about the product, verbal statements from the salesperson to the purchasing agent, and material safety data sheets provided to the employer.

An important point regarding warning systems is that the components may not be identical in terms of content or in terms of purpose. For example, some components may be intended to capture attention and direct the person to another component where more information is presented. Similarly, different components may be intended for different target audiences. In the example of the solvent given above, the label on the product container may be intended for everyone associated with the use of the product including the end user, while the information in the material safety data sheet may be directed more to the industrial toxicologist or safety engineer working for the employer.

36.4.4 General Criteria for Warnings

The most important general criterion for warnings is that their design should be viewed as an integral part of the overall system design process. Frantz, Rhoades, and Lehto (in press) address this issue in their excellent paper on how to go about developing product

warnings. Whereas in the field of safety warnings are a third line of defense behind design and guarding, they should not be considered for the first time after the design (including guards) of the environment or product is fixed. Too many warnings are developed at this stage of design, the afterthought phenomenon, and their quality and effectiveness often reflect it. Further, warnings based on unrealistic and untested assumptions or expectations about the target audience are destined to be ineffective, and in this sense they are no substitute for good design.

In this section three general criteria for warnings will be presented: (1) when and what to warn; (2) how to prioritize warnings, and (3) whom to warn.

36.4.4.1 When and What to Warn?

There are several principles or rules that guide when a warning should be used. They include:

1. A significant hazard exists.
2. The hazard, consequences, and appropriate safe modes of behavior are not known by the people exposed to the hazard.
3. The hazards are not open and obvious; that is, the appearance and function of the environment or product do not communicate them.
4. A reminder is needed to assure awareness of the hazard at the proper time. This concern is especially important in situations of high task loading or potential distractions.

36.4.4.2 Prioritizing Warnings

In a later section we address criteria for designing a warning. Here the concern is what hazards to warn about when multiple hazards exist. How are priorities defined in deciding what to include or delete, how to sequence them, or how much relative emphasis to give them? To some extent the criteria overlap the above rules about when and what to warn. Certainly when the hazard is already known and understood or when it is open and obvious warnings may not be needed. Other considerations include:

1. *Likelihood*: The more likely an undesirable event is to occur, the greater the priority that it should be warned.
2. *Severity*: The more severe the potential consequences of a hazard, the greater priority that it should be warned. If a chemical product poses a skin contact hazard, a higher priority would be given to a severe chemical burn consequence than if it were a minor rash.
3. *Practicality*: There are occasions when limited space (a small label) or limited time (a television commercial) does not permit all hazards to be addressed in a single component of the warning system. As a general rule, unknown hazards leading to more severe consequences and/or those more likely to occur would have priority for the primary warning component, such as on the product label, whereas those hazards with lower priority would be addressed in other warning components, such as package inserts or manuals.

36.4.4.3 Whom to Warn

The general principle regarding who should be warned is that it should include everyone who may be exposed to the hazard and everyone who may be able to do something about it. There are occasions when people in the latter category may not themselves be exposed to the hazard. An example would be the industrial toxicologist who receives warning information regarding a product to be used by employees and defines job procedures and/or protective equipment to be employed in handling the material. The physician who prescribes medications that have contraindication and side effect hazards is another example.

There are, of course, situations and products where the target audience is the general public, that is, everyone. Hazards in the public environment or many products on the shelf of a drugstore or hardware store are examples. Other warnings may be directed to a very specific audience. Warnings about toxic shock syndrome in the use of tampons would be directed primarily to women of child bearing age. Warnings about contraindications associated with prescriptive medications, as noted above, may be directed pri-

marily to physicians. If warnings are to be effective, it is imperative that the characteristics of the target audience be taken into account.

Clearly target audiences, the receivers of warnings, may differ. Laughery and Brelford (1991) discussed several dimensions along which intended receivers may differ.

Demographic Factors

A number of studies have shown that gender and age may be factors in how people respond to warnings. With regard to gender, results indicate a tendency for women to be more likely than men to look for and read warnings (Godfrey, Allender, Laughery, and Smith 1983; LaRue and Cohen, 1987; Young, Martin, and Wogalter, 1989). Similarly, there are research results that show women are more likely to comply with warnings (Desaulniers, 1991; Goldhaber and deTurck, 1988; Viscussi, Magat, and Haber, 1986;). These findings may have implications where hazards associated with products or environments are more likely to be encountered by one of the sexes. If one is attempting to influence the safety behavior of men, the task may be more difficult.

Age has also been examined as a receiver variable in some research on warnings. Although results are mixed, there is a trend that people older than 40 are more likely to take precautions in response to warnings (Desaulniers, 1991). On the other hand, some research (Collins and Lerner, 1982; Easterby and Hakiel, 1981; Ringseis and Caird, 1995) has shown that older subjects have lower levels of comprehension for safety signs involving pictorials. Results such as these suggest that older people may be more influenced by warnings, but greater attention to issues of comprehension may be necessary.

Familiarity and Experience

Numerous studies have explored the effects of people's familiarity and experience with a product on how they respond to warnings associated with the product. Results indicate that the more familiar people are with a product the less likely they are to look for, notice or read a warning (Godfrey et al., 1983; Godfrey and Laughery, 1984; LaRue and Cohen, 1987; Otsubo, 1988; Wogalter, Allison, and McKenna, 1991). Some research has also examined the effects of familiarity on compliance (Goldhaber and deTurck, 1988; Otsubo, 1988). The results have shown that greater familiarity is associated with a lower likelihood to comply with warnings. Clearly, products that are used repetitively or used in highly familiar environments pose special warning challenges.

Competence

There are many dimensions of receiver competence that may be relevant to the design of warnings. For example, sensory deficits might be a factor in the ability of some special target audiences to be directly influenced by a warning. The blind person would not be able to receive a written warning, nor would the deaf receive an auditory warning. Further, what would be open and obvious to the normal person may not be obvious to the blind person. Opposite the sensory end of the sequence of events associated with warning effectiveness is output or behavior. If special equipment is required to comply with the warning, it must be available or obtainable. If special skills are required, they must be present in the receiver population. To some extent these sensory and behavioral limitations of receiver populations are obvious; although it is not difficult to find examples of warnings that violate such considerations—especially in the behavior domain where instructions frequently given are, at best, difficult to carry out. "Avoid breathing fumes" when using a toxic solvent in an environment where respirators are not available is an example.

Three characteristics of receivers related to cognitive competence are important in warning design: technical knowledge, language, and reading ability. The communication of hazards associated with medications, chemicals, and mechanical devices is often technical in nature. If the target audience does not have technical competence, the warning may not be successful. The level or levels of knowledge and understanding of the audience must be taken into account. This point is discussed further in a later section.

The issue of language is straightforward, and it is increasingly important. Subgroups in the American society speak and read languages other than English, such as Spanish. As trade becomes more international, requirements for warnings to be directed to non-English readers will increase. Ways of dealing with this problem include warnings stated in multiple languages and the use of pictorials.

Reading ability is another target audience characteristic whose importance is obvious. Yet, high reading levels such as a grade 12 are not uncommon for warnings intended for

individuals with lower reading abilities. The usual recommendation for general target audiences is that the reading level be in the grade 4–6 range. Clearly, if comprehension of a warning is to be achieved, reading levels must be consistent with reading abilities of receivers. A discussion of reading level measures and their application to the design of instructions and warnings can be found in Duffy (1985). An additional point on reading ability concerns illiteracy. There are estimates that 16 million functionally illiterate adults exist in the American population. If so, successfully communicating warnings may require more than simply keeping reading levels to a minimum. Although simple solutions to this problem do not exist, pictorials, speech warnings, special training programs, etc., may be important ingredients of warning systems for such populations.

There are a few general principles that apply when taking receiver characteristics into account during the design of warnings:

Principle 1. Know thy receiver. Gathering information and data about relevant receiver characteristics may require time, effort, and money, but without it the warning designer and ultimately the receiver will be at a serious disadvantage.

Principle 2. When variability exists in the target audience, design warnings for the low-end extreme. Do not design for the average.

Principle 3. When the target audience consists of subgroups that differ in relevant characteristics, consider employing a warning system that includes different components for the different subgroups. Do not try to accomplish too much with a single warning.

Principle 4. Market test the warning system. Despite the designer's knowledge of receiver characteristics and efforts to apply that knowledge, warnings generally should be market tested. Such tests may consist of "trying it out" on a target audience sample to assess comprehension and behavioral intentions. This principle is addressed in a later section.

36.4.5 Criteria for Designing Warnings

In this section we present eight criteria for designing warnings. To some extent, the choice of eight such rules or guidelines, as well as the manner in which the design considerations are partitioned, is arbitrary. Others who have worked and written on the topic (Lehto and Miller, 1986; Ryan, 1991) have a somewhat different list of criteria. Although the specific terminology and/or number of criteria may differ, however, there is generally high agreement as to what factors or design issues are relevant. Indeed, a publication by the National Safety Council in 1928 outlined a set of criteria for warnings design that maps very closely onto the eight criteria presented here.

The eight criteria are attention, hazard information, consequences information, instructions, comprehension, motivation, brevity, and durability. In the sections that follow, each will be defined and discussed.

36.4.5.1 Attention

Warnings should be designed so as to attract the attention of the target audience. Except when they are in an information-seeking mode, people typically do not look for warnings; hence, "warnings have to look for people." Also, many environments and labels are cluttered and noisy, so in order for warnings to be seen or heard, they must be designed so as to stand out from the background (Wogalter, Kalsher, and Racicot, 1993a). In other words, they should be conspicuous or salient relative to the context (Sanders and McCormick, 1993). There are several factors that influence the conspicuity or salience of a warning. Standard human factors guidelines for displays are relevant here.

Contrast

Print warnings should have high contrast with the background, dark on light or vice versa. Color can also be important in achieving contrast. There is another dimension that is related to contrast that has to do with context; specifically, to the extent that warnings are separated from other information, such as on a sign or label, they may be more salient (Godfrey et al., 1991).

Size

Within some reasonable limits, bigger is generally better. However, context plays an important role with regard to size effects on salience. On a sign or label, an important

factor is not just the size of the warning, but rather its size relative to other information in the display. Product labels with a bold warning where there are three other information items in larger print are not a good design if one wants the warning to be noticed.

Location

The issue of location concerns several different aspects of warnings design. Within the context of a sign or label there are a few guidelines. First, given that people tend to scan left to right and top to bottom, warnings should be located near the top or to the left, depending on the overall design of the display. Certainly, other things being equal, a warning should not be buried at the bottom. Another consideration is task related. Warnings should be located near other information that will be needed to perform a task. For example, there are warnings on sidewalls of tires regarding hazards in mounting tires on rims. One kind of information that people usually need about a tire is its size. Thus, locating the warning near the size would increase its likelihood of being noticed. Sequencing information in a label can also be important. Wogalter et al. (1987) showed warnings were more likely to be noticed and complied with if they were ahead of or above use instructions than if they followed the instructions.

Another type of location consideration concerns warning systems with multiple components. A general principle is that warnings should be located close to the hazard, both physically and in time (Frantz and Rhodes, 1993; Wogalter, Barlow, and Murphy, 1995). A warning on the battery of a car regarding a hydrogen gas explosion is much more likely to be noticed at the proper time than a warning in the car manual. A verbal warning given 2 days ago to a farm worker using a hazardous pesticide is less likely to be remembered and effective than one given immediately before the product is used. Related to the concern about warning locations, however, is the fact that at times practical considerations limit the options. A small container such as on some over-the-counter medications may simply not have room for all of the information that should go into the warning. A solution here is to capture attention to the fact that there is a hazard by putting some minimum critical information on a primary label and directing the user to additional warning information in a secondary source such as an owner's manual, a package insert or (better yet) another label in another conspicuous location. Wogalter et al. (1995) have shown that such a procedure can be effective.

Signal Words

Signal words are used in warnings to capture attention. They are also intended to communicate information about the level of the hazard. The most common words used are "CAUTION," "WARNING," and "DANGER," with danger representing the most hazardous circumstance and caution the least. These three terms are also the most widely recommended for this purpose (American National Standards Institute, 1991; Chapanis, 1994; FMC Corporation, 1985; Westinghouse Electric Corporation, 1981). Further, where it is feasible to incorporate color into the warning, the different words are paired with specific colors: CAUTION (black print on a yellow background); WARNING (black print on an orange background; and DANGER (red print on a white background or vice versa). Of course, the selection of color would also be governed by the context in which the warning is presented (Young, 1991). One would not want to put a red and white warning on a red surface. Many of the guidelines or recommended design practices pair signal words with a signal icon, a triangle enclosing an exclamation point. Figure 36.3 shows an example of an icon and signal word that represents a typical portion of a warning.

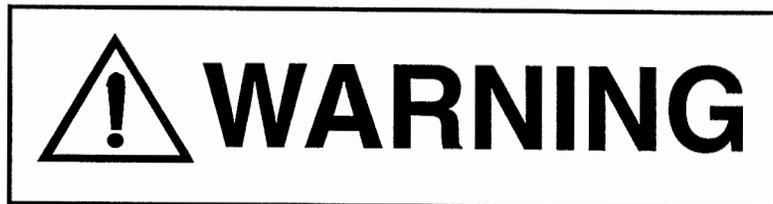


Figure 36.3 Icon and signal word.

Pictorials

The role of pictorials in warnings to communicate information is discussed in a later section. However, pictorials are also very effective in attracting attention (Jaynes and Boles, 1990; Laughery, Young, Vaubel, and Brelsford, 1993a).

Habituation

An important factor regarding attention to warnings is a psychological concept called *habituation*. Repeated exposure to a warning over time may result in its attracting less attention. Even a well-designed warning incorporating the features outlined above may become habituated. Although there are no easy solutions to this problem, one approach that may have some utility is to have warnings that vary from time to time. Rotational warnings such as on cigarette packages is an example of such an approach.

Auditory Warnings

Auditory warnings usually have as their primary purpose to attract attention. One advantage of such warnings over visual warnings is that auditory signals are omnidirectional, so the receiver does not have to be looking at a particular location to be alerted. Like print warnings, their success on the attention criterion is largely a matter of salience. Auditory warnings should be more intense and distinctively different from expected background noise. Often auditory warnings are used in conjunction with visual warnings, with the auditory serving to call attention to the need to read or examine a visual or written warning that contains specific information.

36.4.5.2 Hazard Information

A warning should contain a description of the hazard(s). The point here is to tell the target audience what the safety problem is; what can go wrong. Generally this information is specific to the environment or product. Examples are:

Toxic fumes
Slippery floor
Nip point, your hand could be caught
High voltage (7200 V)

These verbal or written statements communicate hazard information. Increasingly, pictorials are also being used to communicate such information, often in conjunction with the printed verbal message. Figures 36.4a, 36.4b, 36.4c, and 36.4d show examples of pictorials whose purpose is to indicate the presence of hazards.

A general principle here is that the hazard should be spelled out in the warning. As discussed earlier, however, there are exceptions to this principle. Where a hazard is known from previous experience or general knowledge or where the hazard is open and obvious, a warning may not be needed. Where these conditions do not exist, however, hazard information is an important part of the warning (Wogalter et al., 1987).

An issue in warnings design concerns what to warn about when there are multiple hazards associated with some situation or product. This issue was addressed earlier in the section on prioritizing warnings. As noted, in addition to existing knowledge and the open and obvious concepts, other considerations in deciding what to warn about are the likelihood of an undesirable event, the severity of the potential outcomes, and practical matters such as space. There is an additional consideration that has not been mentioned, namely, "overwarning."

The concept of overwarning applies at two levels. At a general level it concerns the extent to which our world is filled with warnings to a degree that people do not attend to them or become highly selective, attending only to some. If we "put warnings on everything," do we so inundate people with such information that they tune it out? Whereas this notion has face validity, there has been little or no research on the topic to support it. The concept of habituation is not relevant here, since habituation concerns repeated exposure to the same warning. Also, cognitive overload (overloading the receiver's ability to process the information) is not the concern, because the issue is not a matter of many warnings being presented simultaneously. Perhaps it should be called the warnings ubiquity effect. Nevertheless, however we label it, overwarning may indeed be a valid concern, and unnecessary warnings should be avoided.

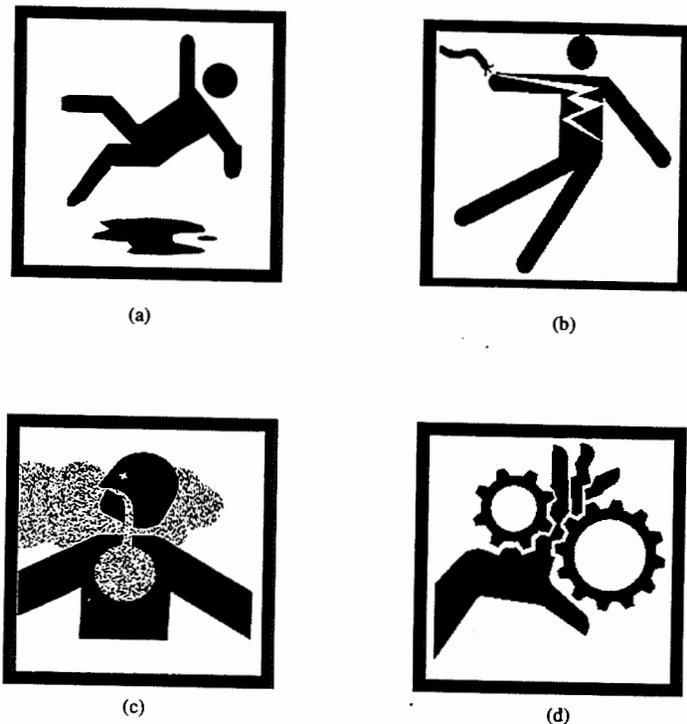


Figure 36.4 Examples of pictorials conveying hazard information. (a) Slippery Floor; (b) Electricity, (c) Toxic Fumes, (d) Pinch Point.

On another level, overwarning also applies to specific situations or products. If there are 10 hazards associated with a product, does one warn about all of them? Of course, an appropriate answer to this question is that in such circumstances the better course of action would be to redesign the product. However, when to redesign is not the primary focus of this chapter. Putting too many warnings or having a warning with too many hazards listed on a single label may discourage the product user from attending to them. A guideline here is that if there are more than three or four hazards, include the three or four having highest priority (most likely to occur, most serious consequences, least likely to be known, etc.) in the primary warning system component, such as on the product label. The remaining hazards can then be addressed in secondary components such as package inserts, manuals, etc. This approach may not always be a satisfactory solution, but it is one way of possibly addressing multiple hazard situations. Certainly if knowledge of the hazards is necessary for safety, omitting warning about some of them because there are “too many” is not an acceptable approach. “Keeping them a secret” is hardly a solution. Finally, there is another concern about omitting hazards while addressing others; namely, the presumption of safety as a result of omission. If a warning for a toxic solvent includes information about ingestion and inhalation hazards but says nothing about a skin contact hazard, the user may assume that since it is omitted, there is no skin contact problem.

36.4.5.3 Consequences Information

Consequences information concerns the nature of the injury, illness or property damage that could result from the hazard. Hazard and consequence information are usually closely linked in the sense that one leads to the other; or, stating it in the reverse, one is the outcome of the other. In warnings, statements regarding these two elements should generally be sequenced. An example would be:

Toxic Fumes
Inhaling Fumes Can Lead to Severe Lung Damage

There are occasions or situations when the hazard information is presented and understood, it may not be necessary to state the consequences in the warning. This point is related to the open and obvious aspects of hazards. For example, a sign indicating “Slippery Floor” probably does not need to include a consequence statement “You Could Slip and Fall.” It is reasonable to assume that people will correctly infer the appropriate consequence. Although it is desirable to keep warnings as brief as possible (the brevity criterion is discussed in a later section), there is a potential problem with omitting consequence information; specifically, people may not make the correct inference regarding injury, illness or property damage outcomes. Thus, it is important in designing warnings to assess, if necessary, whether people will correctly infer consequences (Young, Wogalter, Laughery, Magurno, and Lovvoll, 1995). If unsure on this issue, the designer should include the consequence information.

A common shortcoming of warnings is that the consequences information is not explicit; that is, it does not provide important specific details. The statement “May be hazardous to your health” in the context of a toxic fumes hazard does not tell the receiver whether he or she may develop a minor cough or suffer severe lung damage (or some other outcome). This issue will be discussed in the section on the comprehension criterion.

As a general rule, written warnings (signs and labels) are organized with an attention getting icon and signal word at the top, then hazard information, and then instructions. For purposes of getting and holding the receiver’s attention, however, there are situations where it is desirable to put consequences information near the beginning of the warning (just after the icon and signal word) in larger and bolder print (Young et al., 1995). This is particularly true for severe consequences such as death, paralysis, severe lung damage, etc. Hence, the above hazard and consequence statements might be better presented as:

Inhaling Fumes Can Lead to Severe Lung Damage
Toxic Fumes

The point is that knowing about severe consequences can be a motivational factor in attending to and complying with the warning message, a consideration that will be further discussed in the section on motivation.

Pictorials can also be used to communicate consequence information. Figure 36.4a actually communicates both hazard information (slippery floor) and consequence information (fall). Figure 36.5a represents an explosion (typically the explosion symbol would be in red), and Figure 36.5b shows a figure in a wheel chair indicating paralysis.

36.4.5.4 Instructions

A point to be noted at the outset of this section concerns the distinction between warnings and instructions. Our distinction is that warnings are communications about safety, whereas instructions may or may not concern safety. “Keep off the grass” is an instruction that generally has nothing to do with safety (unless the grass is infested with poisonous snakes, in which case the statement alone clearly would not be an adequate warning). Instructions on how to assemble a toy do not concern safety and have nothing to do with warnings. When instructions are concerned with safety information or safe behavior, then they can be viewed as part of a warning. In short, warnings include instructions, but not all instructions are part of a warning.

In addition to getting people’s attention and telling them what the hazard and potential consequences are, warnings should instruct people about what to do or not do. Typically, but not always, instructions in a warning follow the hazard and consequence information. An example of an instructional statement that might go with the above hazard and consequence statements is:

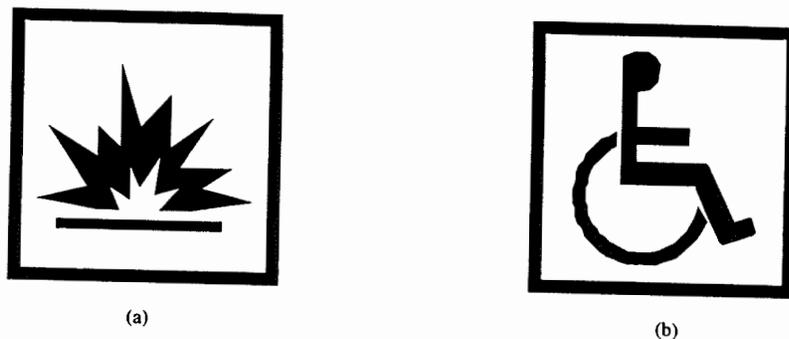


Figure 36.5 Examples of pictorals conveying consequence information. (a) Explosion, (b) Paralysis.

Inhaling Fumes Can Lead to Severe Lung Damage
Toxic Fumes
Always Wear a Type 1234 Respirator When Using This Product

This instruction assumes, of course, that the receiver will know what a type 1234 respirator is and have access to it.

There are two problems that commonly occur with instructional information in warnings. One problem is that the information is not explicit; that is, sufficient detail is not provided to enable the receiver to carry out the necessary safe procedures. The classic example here is "Use with adequate ventilation." Does this statement mean open a window, use a fan, or something much more technical in terms of volume of air flow per unit time? Obviously the instruction is not clear. We address this issue in the next section on comprehension.

The second problem commonly encountered in warnings is that instructions are given that are inconvenient, difficult, or occasionally impossible to carry out. "Do not breathe fumes" clearly cannot be accomplished by stopping breathing. "Always have two or more persons to lift" is not possible if no one else is around. "Wear rubber gloves when handling this product" may be inconvenient if the user does not have them and the hardware store is 2 miles away. The means by which people can safely function in a situation or use a product safely should be as simple, easy and convenient as possible. This issue is discussed further in a later section on cost of compliance.

Pictorals can be used to communicate instructions. Figure 36.6 shows examples of instructional information that are used in warnings. Figure 36.6a communicates that the receiver should wear goggles in this environment or in using this product. Figure 36.6b indicates something that the receiver should not do—smoke. Note that the latter pictorial uses the common negation symbol, a circle containing the pictorial with a slash through it. The circle and slash would be in red.

36.4.5.5 Comprehension

The hazard, consequence, and instruction criteria for warnings concern the kinds of information that are normally included in a warning. Comprehension is a criterion that concerns the extent to which the information in the warning is understood by the receiver. In an earlier section on whom to warn, we discussed characteristics of receivers (target populations) that need to be taken into account in designing warning systems. In this section the focus is on the design characteristics of warnings that are important for receiver comprehension.

A common but often wrong assumption of people who design warnings is that the members of the target audience will understand the hazards, consequences, and instructions as well as they do. Designers of warnings should not make such assumptions because

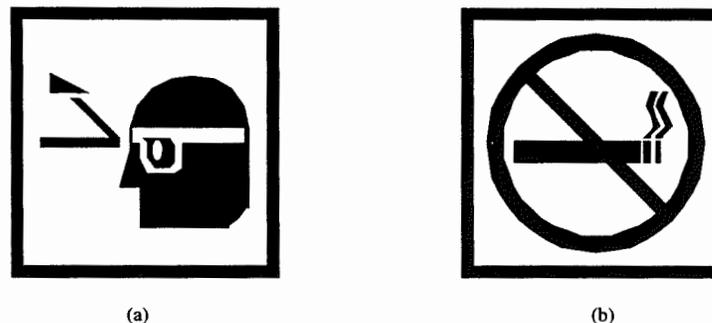


Figure 36.6 Examples of pictorals conveying instructional information. (a) Wear Goggles, (b) Do Not Smoke.

the designers are not representative of the target audience, a population that often has a wide range of mental competence and experience. What is common knowledge to the warning designer is not necessarily common knowledge to the members of the target audience (Laughery, 1993).

Design for the Low End Principle

When there is variability in the target population for the warning, which is almost always the case (especially when the audience is the general public), the applicable design principle is to design for the low-end extreme. Safety communications should not be written at the level of the average or median percentile person in the target audience, since they will present comprehension problems for those at lower competence, experience and knowledge levels.

Reading Level

Given the information to be communicated, reading levels for written language warnings should be as low as is feasible. As noted earlier, a grade 4–6 range is usually recommended. There are readability formulas based on word frequency of use, length of words, number of words in statements, etc., that are used to estimate reading grade level (Duffy, 1985). Although these formulas have limitations, they can be useful as a preliminary guide in achieving a warning that will be understood.

Technical Information

Many hazards and consequences are technical in the sense that a full and complete understanding would require an appreciation of technical information. 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 substance are examples. Although there are circumstances in which it is appropriate to communicate such information (e.g., to the toxicologist on the staff of a chemical plant or the physician prescribing medicine), as a general rule it is neither necessary nor useful to communicate such information to a general target audience. 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. The end user of the toxic material typically does not need to know its chemical content (such as benzene) or its density in the atmosphere. Rather, he or she needs to be informed that the substance is toxic, what it can do in the way of injury or illness, and how to use it safely. Where there are multiple groups within the target audience (the toxicologist and the employee, the physician and the patient, the parent and the child), different components of the warning system can and often should be used to communicate to the different groups.

Explicitness

An important design principle relevant to warning comprehension is explicitness (Laughery, Vaubel, Young, Brelsford, and Rowe, 1993b). Explicit messages contain information

that is sufficiently clear and detailed to permit the receiver to understand at an appropriate level the nature of the hazard, the consequences, and the instructions. The key here is the word "appropriate." As noted above, technical details may not be necessary and at times may be detrimental. The bigger and more common problem, however, is that warnings are frequently not detailed or specific enough. The following two examples are warnings with hazard, consequence and instructional statements that are not sufficiently explicit.

Dangerous Environment
Health Hazard
Take Precautionary Measures

Mechanical Hazard
You Could Be Injured
Exercise Care

Alternatives to the above that would be considered more explicit and appropriate are:

Toxic Fumes
Breathing Fumes Can Lead To Severe Lung Damage
Always Wear Type 1234 Respirator In This Area

Moving Parts, Pinch Point Hazard
Your Hand Could Be Caught In Rollers and Severely Crushed
Do Not Operate Without Guard X In Place

Pictorials

Pictorials are increasingly employed in the design of warnings. Guidelines such as American National Standards Institute (ANSI) (1991) and FMC (1985) place considerable emphasis on their use. Pictorials are particularly useful in helping to increase comprehension (Boersema and Zwaga, 1989; Collins, 1983; Dewar, 1994; Laux, Mayer, and Thompson 1989; Wolff and Wogalter, 1994; Zwaga and Easterby, 1984). Obviously they can contribute to understanding warning messages for target audiences where illiterates or non-English readers are included. They can be useful where there are time constraints, such as traveling on a highway, because well-designed pictorials can cue large amounts of knowledge in a glance. Also, people who have difficulty reading print, such as the elderly, may be able to see a pictorial.

While pictorials can be very useful in the comprehension of warning information, comprehension is also a primary concern or criterion for pictorials. In some pictorials the symbol or picture directly represents the information or object being communicated and will be understood if the person recognizes the symbol or picture. Figure 36.4a is an example. In other pictorials the symbol may be recognized, but its meaning has to be learned. People may recognize a skull and crossbones, but the fact that it represents a poison hazard would have to be learned. Some pictorials are completely abstract, such as the symbols for biohazard and radioactivity hazard shown in Figure 36.7, and must be learned to be understood. As a general principle, pictorials containing symbols or pictures



Figure 36.7 Simple pictorials representing biohazard and radioactive hazard. (a) Biohazard; (b) Radioactive Hazard.

ences. Pictorials where the meaning of the symbols must be learned may be useful for special target audiences.

What is an acceptable level of comprehension for pictorials? This question has been addressed in the ANSI (1991) standard which suggests a goal of 85% comprehension by the target audience. There are two criteria that seem relevant here. The first is simply that the pictorial should be designed to accomplish the highest level of comprehension attainable. If 85% cannot be achieved, it may still be useful depending on the alternatives. A second criterion is that the pictorial not be misinterpreted or communicate incorrect information. Wogalter (1994) cites an interesting example of a misinterpretation of a pictorial that was part of a warning for the drug Acutane. This drug is used for severe acne, but causes birth defects in babies of women taking the drug during pregnancy. The pictorial shows a side-view outline shape of a pregnant woman within a circle-slash negation sign. The intended meaning of the pictorial is that women should not take the drug if they are pregnant. However, some women incorrectly interpreted the pictorial to mean that the drug might help in preventing pregnancy.

Auditory Warnings

The comprehension of auditory warnings depends on whether the signal is nonverbal (sirens, tones, bells) or verbal (speech or voice). Nonverbal auditory warnings can be further divided into simple and complex. Simple nonverbal auditory warnings are usually used as alert (attention-getting) signals after which the visual modality can then be employed to access further information (Sanders and McCormick, 1993; Sorkin, 1987). Complex nonverbal signals are composed of sounds of differing (sometimes dynamic) amplitude, frequency, and temporal patterns. Their purpose is to communicate different types or different levels of hazards. They can transmit more information than simple auditory warnings, but the listener must know what the code means. Training must be given for the meaning to be deciphered. Only a limited number of complex signals should be used, because people are limited in discriminating and remembering them (Banks and Boone, 1981; Cooper, 1977).

Complex warning messages can also be transmitted via voice (speech). In recent years voice chips and digitized sound processors have been developed making voice warnings feasible for a wide range of novel approaches and applications. Recent research indicated that voice warnings under certain circumstances can be more effective in transmitting information than printed signs (Wogalter, 1993a; Wogalter and Young, 1991). There are, however, some problems inherently associated with voice warnings. Time to transmit speech messages requires longer durations than simple auditory warnings or reading an equivalent message. Comprehension can also be a problem with complex voice messages. To be effective, voice messages should be intelligible and brief. Nevertheless, this medium for communicating safety information would appear to have considerable potential.

36.4.5.6 Motivation

The motivation criterion concerns the notion that warnings should motivate people to

appear to be important in the extent to which people are motivated to read and comply with warnings.

Risk Perception

One of the important factors in whether people will read and comply with warnings is their perception of the level of hazard and consequences associated with the situation or product. The greater the perceived level, the more responsive people will be to warnings (Wogalter, Brelsford, Desaulniers, and Laughery, 1991; Wogalter, Brems, and Martin, 1993b). In a sense, this factor can be viewed as a perceived cost of noncompliance; if I do not comply, what might happen to me. There are several things that can influence the risk perception or cost of not complying including familiarity and severity of consequences.

Familiarity

The "familiarity effect" states simply that the more familiar people are with a situation or product, the less they perceive associated hazards and the less likely they are to read or comply with a warning (Godfrey and Laughery, 1984; Godfrey et al., 1983; Goldhaber and deTurck, 1988; Wogalter et al., 1991). This "familiarity breeds contempt" notion, however, should not be overemphasized for at least two reasons. First, people more familiar with a situation or product may have more knowledge about the hazards and consequences as well as an understanding about how to avoid them. Second, people in situations or using products more frequently are exposed to the warnings more often, which increases the opportunity to be influenced by them. Nevertheless, where familiarity is a factor, it should be realized that stronger warnings or perhaps other efforts will be required.

Severity of Consequences

Intimately tied to risk perception or perceived cost of noncompliance are people's beliefs in how severely they might be injured. Research (Wogalter et al., 1991, 1993b) indicates that people's notions of hazardousness are almost entirely based on the seriousness of the potential outcome. Further, people do not readily consider the likelihood or probability of such events in making hazardousness judgments (Wogalter and Barlow, 1990; Young, Brelsford, and Wogalter, 1990; Young, Wogalter, and Brelsford, 1992). These findings emphasize the importance of clear, explicit consequences information in warnings. Such information can be critical to people's risk perception and thus be a major factor in driving compliance.

Cost of Compliance

The cost associated with compliance can be a strong motivator. Generally, compliance with a warning requires that people take some action. Usually there are costs associated with taking action. These costs may be in the form of convenience, time, effort, or money. Several studies have shown that such costs play a major role in whether people comply (Dingus, Hathaway, and Hunn, 1991; Wogalter et al., 1987, 1989).

Obviously in one sense the issue of compliance can be viewed as a tradeoff between the perceived cost of noncompliance and the perceived cost of compliance. The designer of the system wants to minimize the cost of noncompliance by designing a safer system and one that forgives human error or in this instance, noncompliance. But the warning designer does not want to induce noncompliance by failing to adequately warn about the hazards and consequences. Thus, it is critical that warnings contain clear explicit hazard and consequence information. Similarly, the designer wants to minimize the cost of complying with warnings so as to increase the likelihood that people will perform safely.

Social Influence

Another motivator of warning compliance is social influence. Research (Wogalter et al., 1989) has shown that if people see others comply with a warning, they are more likely to comply themselves. Similarly, seeing others not comply lessens the likelihood of complying. Social influence is a motivational variable that is an external factor with respect to warnings in that it is not part of the design. However, it does have an effect and should be kept in mind when considering motivational factors.

36.4.5.7 Brevity

Within the need to communicate required information, warnings should be as brief as possible. Two statements should not be included if one will do, such as in the slippery floor example cited earlier. Longer warnings or those with nonessential information are less likely to be read and they may be more difficult to understand. Obviously, this criterion should not be interpreted as a license to omit important information.

36.4.5.8 Durability

The durability criterion simply states that warnings should be designed to last as long as needed. There are circumstances in which durability is typically not a problem. A product off the shelf of a drug store that will be completely and immediately consumed is an example. On the other hand, products with a long life, such as cars, lawn mowers, etc., may present a challenge. Similarly, situations where warnings are exposed to weather, such as on construction sites, or extensive handling, such as on some containers, may pose durability problems.

There are several approaches to meeting the durability criterion. One solution, of course, is to make signs or labels with materials that will meet the requirements. Another is to have procedures for detecting when a replacement warning is needed and then replacing it. This approach can be useful in circumstances such as on construction sites or other work environments.

Some components of warning systems are particularly susceptible to not meeting the durability criterion. Package inserts and manuals are examples of components that get lost or discarded. Such factors should be taken into account in considering the role of such components in the overall warning system. Of course, some warning components are not intended to be durable. Tread labels on new tires that contain warnings or spoken warnings at a point of purchase are examples.

36.4.6 Criteria for Assessing Effectiveness of Warnings

In this section we will discuss issues associated with the effectiveness of warnings, and more specifically, criteria for assessing or evaluating their effectiveness. The question of effectiveness has received a great deal of attention in the technical literature in recent years, and, indeed, there has been some disagreement on issues associated with the topic. Examples of publications that contain discussions of the warnings effectiveness issues are McCarthy, Finnegan, Krumm-Scott, and McCarthy (1984), DeJoy (1989), Lehto and Papastavou (1993) and Wogalter (1994). Additional papers on the topic can be found in a collection by Laughery, Wogalter, and Young (1994).

36.4.6.1 Direct and Indirect Effects

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; he or she reads it, hears it, is instructed about it by an employer, etc. This communication route is what we usually think about when we design warnings. But warnings can also accomplish their purposes indirectly. An example is the woman who has not read the warning about toxic shock syndrome on the tampons box, but learns about it in a conversation with her neighbor. The employer or physician who reads the warnings about products with which they are concerned and then verbally communicates the information to the employee or patient are other examples. The print and broadcast news media may pick up warning information and disseminate it in ways that expose and influence people who have not seen it directly.

An example of where the concept of an indirect effect was taken into account in the design of a product warning concerned a herbicide used in agricultural settings. Given that significant numbers of farm workers in parts of the United States read Spanish but not English, there was reason to put the warning in both languages. However, there were space constraints on the product container. One aspect of the solution was to include a statement on the label in Spanish indicating that the product was hazardous and that the user should have someone translate the warning before using the product. This procedure may or may not have been the most effective way of addressing the problem, but the point here is that it was an effort to take advantage of an indirect communication to have the warning be effective.

There are situations where we rely on indirect communications to transmit warning information. Employers and physicians are examples already noted; adults who have

responsibility for the safety of children are another important category. In the design of warning systems, it is important to take into account such communication routes.

36.4.6.2 An Information-Processing Model as a Context for Assessing Effectiveness

In this section a simplified model of the human information-processing system is introduced to serve as a basis for organizing the discussion of effectiveness. Its purpose is to assist in analyzing how or why warnings may fail or, conversely, what they have to accomplish to succeed. In many respects the model here is similar to, although simpler than, the information-processing model employed by Lehto and Miller (1986) and by Lehto and Papastavrou (1993) in their analyses of warnings effectiveness. A diagram of the model is shown in Figure 36.8.

The model describes the warning process in terms of human information-processing stages. Six stages are included, starting with the presentation or existence of the warning information and ending with the safe behavior. There are two basic concepts to be noted about this model. First, for the warning to be effective, it must be successful at each of these stages. This is the weak-link-in-the-chain phenomenon; if the warning is not successful at any one stage, it fails. Given that the warning information is presented, the receiver must notice and attend to it. Next, having been attended to, the message must be understood. Having been understood, the warning needs to agree with people's existing attitudes and beliefs, or if not, it must be sufficiently persuasive to change them. Next, it must motivate people to comply and perform the appropriate behaviors. Finally, the individual must be capable of carrying out the behaviors. If the warning is not noticed, or if it is not understood, or if it is rejected on the basis on existing attitudes and beliefs, or if it does not motivate one to act, or if it requires behavior that cannot be carried out, then it fails.

The second concept is that the model represents a serial processor; that is, the warning information flows through and affects the various stages sequentially. There are no feedback loops such as one from motivation to attention that would allow for a person having read the warning to be motivated to go back and read it again to gain additional information or enhance comprehension. Clearly the serial model is an oversimplification, but it is useful in considering warning effectiveness issues.

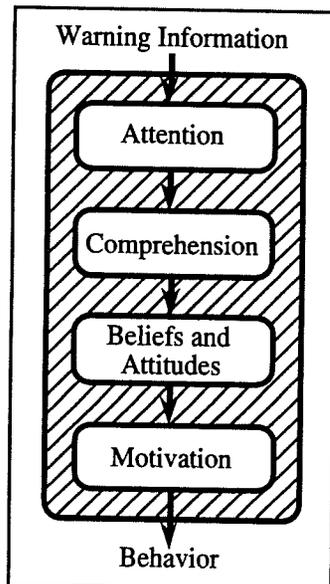


Figure 36.8 A human information-processing model of stages leading to compliance behavior.

The serial model has important implications for assessing the effectiveness of warnings. Given that the overall purpose of warnings includes influencing or modifying people's behavior, one might assume that assessing warning effects on behavior is the approach to be taken. And it is. But there are other useful methods or levels of assessing warnings. For example, if it can be determined that a particular warning is not likely to be noticed, then it is not effective. If it is not understood, then it is not effective. If it is not believed, it is not effective. Finally, if it does not provide sufficient motivation to act, it is not effective.

The implications of the above assessment logic are important for evaluating the effectiveness of a warning. Determining whether or not a warning will influence behavior is usually a difficult assignment at best. In addition to ethical problems of exposing people to hazards, actual field studies testing warnings are likely to be time consuming and costly. Certainly where feasible, such studies are desirable. Also, laboratory or other controlled simulations of warning situations can be useful in assessing behavioral effects, but such approaches, while important, leave open questions of generalizability. The implication of the model is that warnings can and should be tested at several levels. Studies that examine the effects of warnings on attention, comprehension, beliefs and attitudes, and motivation to comply can be valuable as part of the process of designing and assessing warnings. For example, such studies can help in isolating why a warning is not effective. A behavioral study that shows people do not comply with a warning may not tell us whether it failed because it was not noticed, or because it was not understood, or because it was not believed, or because it failed to motivate. Studies employing attention, comprehension, risk perception, or behavioral intention measures can provide such information, which, in turn, can be useful in developing alternative warning designs that are effective. If a warning is noticed and understood, there may be no need to try to increase its conspicuity or lower its reading level. Instead, one may want to reconsider factors such as the cost of compliance.

Studies carried out to evaluate the potential effectiveness of a warning must, of course, incorporate appropriate principles of research design. The selection of subjects to be representative of the target population, avoiding confounding by extraneous variables, and guarding against contamination by expected outcomes are a few of the more salient factors that must be considered. For a more complete discussion of approaches to evaluating warning effectiveness, see Wogalter and Dingus (in press) and Young and Lovvoll (in press).

Warning Information

Obviously warning information has to be presented if it is to be effective. One point to be noted here is that assumptions about the target audience having preexisting knowledge or that the hazard is open and obvious should be made with care. Thus, at this level it is possible and at times important to assess the *need* for a warning by determining what knowledge people have about relevant hazards or whether the hazard is correctly recognized without a warning.

Attention

In the section on criteria for warnings design, a number of factors that influence the noticeability of warnings were presented and discussed. One means of assessing a warning with respect to attention is simply to determine the extent to which the design meets the criteria. If no signal word is used, no color employed, the print is small, the message is embedded in other types of information, etc., then the effectiveness of the warning may be questioned. More direct techniques are available for studying the attention-demanding properties of warnings such as studies employing reaction time or memory measures. While more difficult to carry out, eye movement analysis can also be a useful tool.

Comprehension

Like attention, one method of assessing comprehension of a warning is to evaluate it against the criteria discussed earlier. If the reading level is high, technical language is used, or the statements are vague and nonexplicit, then the warning is not likely to be understood. Carrying out studies to assess the extent to which a warning is understood probably has one of the best cost-benefit ratios of any procedure in the warnings design process. Relative to behavioral studies, comprehension can be assessed easily, quickly and at low cost. Well established methodologies involving memory tests, open-ended

response tests, interviews, etc., are applicable. Such studies can be exceptionally valuable in determining what information in the warning was or was not understood as well as what might be done in the way of redesign to increase the level of comprehension.

Beliefs and Attitudes

Beliefs concern the extent to which information in a warning is accepted as true. Attitudes are similar to beliefs except more emotion or feeling is involved. People may understand the information in a warning, but if it is rejected as not true or irrelevant, then the warning will not be effective. This circumstance can be a problem where people's experiences with a situation or product results in their believing it is safer than it is. It can also be a problem when people believe that their own abilities or competence will enable them to overcome the hazard, such as the young adult male who believes he can safely do a shallow dive into the shallow end of a swimming pool. Here again, studies can be carried out to determine the extent to which members of the target audience accept the warning as true or valid as well as whether or not it applies to them. Negative results on these dimensions would indicate the warning is not likely to be effective.

Motivation

Some of the major factors that influence motivation to comply with warnings have been discussed in the section on criteria for warnings design. Among the most important were the cost of compliance and the cost of noncompliance (severity of the potential injury, illness, or property damage). If the warning calls for actions that are inconvenient, time consuming, or costly, there is a likelihood they will not be effective unless the consequences of noncompliance are very bad or undesirable. Motivation can be assessed by obtaining measures of behavioral intentions from members of the target audience. Although such measures will generally reflect higher levels of compliance than will actually occur, they can be useful for determining whether or not the warning is likely to be effective.

Behavior

As noted earlier, actually determining what people will do in the context of a warning is a very desirable measure of its effectiveness. Although such studies are generally difficult to execute, in situations where negative consequences of an ineffective warning are high, the effort may be warranted.

36.4.7 Warnings as Reminders

As noted earlier in this chapter, one role of a warning is to serve as a reminder. There are occasions when the target audience has knowledge of the hazards, consequences, and appropriate modes of behavior, but that knowledge is not always sufficient. They must be aware of, thinking about, this knowledge or information at the proper time. No one knew better than the three-fingered punch press operators of the 1920s that their hand should not be under the piston when it stroked. Yet, such incidents occurred.

There are several circumstances in which warning reminders are useful and/or needed. Some of the more noteworthy are:

1. A hazardous situation or product (that is not open and obvious) is encountered infrequently, and forgetting may be a factor.
2. Distractions occur during the performance of a task or the use of a product.
3. Heavy task loads exceed attentional capacity.

When warnings are intended only to function as reminders, it generally is not necessary to provide the same amount of information that would normally be required. Here the emphasis should be more on noticeability, getting the person's attention. Auditory warnings can be useful, such as the buzzer in an automobile reminding occupants to fasten the seat belt. Dynamic warnings such as flashing signs are also potentially beneficial because of their ability to capture attention. The key point in considering the need for reminder warnings is to keep in mind the fact that hazard knowledge on the part of a target audience does not guarantee that that knowledge will be available when needed.

36.5 SUMMARY AND CONCLUSIONS

In recent decades warnings have become increasingly important in the field of safety. Approaches to dealing with environmental or product hazards are generally prioritized such that first one tries to solve the problem by design, then by guarding, then by warning. Thus, in the domain of safety, warnings are viewed as a third but important line of defense.

Warnings can be properly viewed as communications whose purposes include informing and influencing the behavior of people. Warnings are not simply signs or labels. They can include a variety of media through which various kinds of information get communicated to a broad spectrum of people. The use of various media or channels and an understanding of the characteristics of the receivers or target audience to whom the warning is directed are important in the design of effective warnings. The concept of a warning system with multiple components or channels for communication to a variety of receivers is useful in this regard.

The design of warnings can and should be viewed as an integral part of systems design. Too often it is carried out after the environment or product design is completed, a kind of afterthought phenomenon. Warnings cannot and should not be expected to serve as a cure for bad design.

Eight criteria can be defined that are useful in the design and assessment of warnings. They are:

Attention—Warnings should be designed so as to attract attention.

Hazard information—Warnings should contain information about the nature of the hazard.

Consequence information—Warnings should contain information about the potential outcomes.

Instructions—Warnings should instruct about appropriate and inappropriate behaviors.

Comprehension—Warnings should be understood by the target audience.

Motivation—Warnings should motivate people to comply.

Brevity—Warnings should be as brief as possible.

Durability—Warnings should last and be available as long as needed.

Of course, a specific criterion may not always be relevant. For example, a fire alarm does not have to state a consequence, and durability may not be a concern for a product off the drugstore shelf that is to be used immediately.

The issue of warning effectiveness has received a great deal of attention in recent years, especially means by which effectiveness can be assessed. Several criteria can be employed in assessing warnings, including whether they capture attention, are understood, are consistent with or capable of modifying beliefs and attitudes, motivate people to comply, and result in people behaving safely. The assessment of warning effectiveness employing approaches such as these can and should be part of the warning design process.

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