CHAPTER SEVEN

Factors influencing the effectiveness of warnings

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7.1 INTRODUCTION

The basic goal of safety programmes and hazard analysis is to prevent personal injury and property damage. Warnings, the topic of this chapter, are one of several methods that can be used to defend against harmful outcomes. Warnings may be delivered by signs, on labels, in product manuals, and in other ways described later. The two principal purposes of warnings are to communicate information about potential hazards effectively and to reduce unsafe behaviour that might otherwise occur without their presence. However, warnings are not the best injury-prevention strategy to use (by themselves), particularly if other more effective methods can be employed instead of, or in addition to, warnings.

Several other hazard prevention methods are generally preferred over warnings if they can be properly incorporated into a product/task/environment system. Four hazard prevention methods, in their order of preference, are indicated. The first and best defence against injury is to remove or design out the hazard so that users are not exposed to the danger. Substituting a safe chemical for one known to cause injury is one example of hazard removal. Another way to remove a hazard is to ban a dangerous product from being sold, or if the product has already been purchased, to issue a recall to make a retrofit design change or to exchange the product for a better-designed one.

However, for some equipment, products, environments and jobs, there is no practical way to remove all of the potential hazards and still have a functional product. One example of this is the common power lawnmower which inherently has mechanical, heat, chemical and/or electrical hazards. When hazards cannot be

removed, the next best defence against accidents and injury is to guard against them, or in other words, to place some kind of barrier between people and the hazard. For example, many current lawnmowers have a 'dead man' switch that automatically shuts down the blade when the handle is released. This is a procedural guard. Also, many lawnmowers have a shield that drags on the ground behind the mower to prevent debris from flying out in the operator's direction. This is an equipment guard.

Whereas potential accidents can frequently be avoided through proper design and guarding, there are still many kinds of products/tasks/environments for which the hazards cannot be eliminated by these methods. In such cases, the third line of defence against hazards is to educate and train individuals who may use or come in contact with the hazard. Proper training can ensure that employees and users know about the hazards and ways to avoid them (Racicot and Wogalter, 1995). However, there are many situations where formal education and training may not be possible or practical. This is true for consumer products, where manufacturers have limited control over the behaviour of users of their product. In such cases, hazard control is often accomplished through warnings.

Warnings are similar in several ways to the other hazard-control methods. The most obvious connection is with educational/training programmes in which the intention is to communicate knowledge about the hazards and how to avoid them. In addition, warnings can also be considered a type of guard that lacks the usual solid physical barrier often associated with guards. It is a kind of informational guard. Warnings can also serve in combination with the other methods as an additional (redundant) control strategy, as a reminder to persons who already 'know' about the hazard, and to prevent product misuse. By themselves, warnings are the least preferable method to control against accidents and injury, mainly because they are the least reliable. There are many points at which they might fail. People may not see or attend to them, may not understand them, may not produce the appropriate attitudes and beliefs and/or may not motivate people to comply with them. Therefore, they should be considered as a last line of defence and not as a replacement for good design, guarding and education/training. The other methods, particularly the first and second – designing out and guarding against the hazard – are better methods of hazard control.

Thus, warnings are necessary when other hazard-control methods cannot be effectively employed. Given this state of affairs and the fact that warnings are not totally reliable, the principle question is: How can warnings be designed to maximize their effectiveness? The remainder of this chapter addresses this question.

Research has suggested that warnings should contain certain elements:

- a signal word such as 'Danger' and 'Caution' that enables people to recognize that the message is a warning, that a hazard is present, as well as providing information on the hazard level (with 'Danger' signalling more serious and probable injury than 'Caution');
- a description of the hazard, e.g. in the case of a no diving sign, a statement such as 'Shallow water' provides information about the specific danger involved;

- a description of the consequences that could occur if the person fails to obey the warning's directions, e.g. 'You can be permanently paralysed';
- the directions or instructions, i.e., the specific actions that should or should not be done, e.g. 'No diving'.

These four basic elements of warnings are probably a minimum standard. This chapter will discuss factors that go beyond these components. In addition, despite what has just been stated not all warnings need to have all four of the above mentioned components. These are special cases. How one might go about determining the necessary characteristics of warnings will be described later when testing is discussed. However, at this juncture two examples will be mentioned to illustrate the point. One is a sign for wet floors. The consequences statement 'You may slip and fall' is already well known by everyone and so it does not add anything new to what people already know. Another example is the common 'Stop' sign. Here there is nothing more than one word telling the instruction of what to do (plus a distinctive eight-sided shape and red colour). Other statements are not necessary because everyone knows them. Except for these and a limited number of other cases, warnings should generally have all of the four above mentioned components to give people an appreciation of the hazards and to enable them to make informed decisions. Warnings should be designed to match the abilities of the persons to whom they are directed (Laughery and Brelsford, 1991). The warning designer must be careful not to assume that people know as much about the hazard as they do (Laughery, 1993). What may seem obvious to some people, may not be obvious to others. More will be said about the information transmission mission of warnings later.

Beyond providing information, a second major purpose of warnings is to change behaviour. The intent is to redirect people away from unsafe acts that they might otherwise do without the warning. The behavioural purpose of warnings is probably more important than the informational purpose, because ultimately it is more vital to have people avoid the hazard than it is for them to know about it and still get hurt. For example, it is more desirable to ensure that children avoid a hazard than it is for them to understand its nature. Nevertheless, both the informational and behavioural purposes of warnings are important. In recent years, a growing body of research has revealed many factors that influence both aspects.

7.2 A HUMAN INFORMATION PROCESSING MODEL OF WARNING EFFECTS

Much of the research on warnings can be organized into coherent units using a theoretical model derived from cognitive psychology. This approach divides people's mental processes into a sequence of stages. Figure 7.1 shows a fairly simple human information processing model. This scheme is not only useful in organizing the factors that influence the effectiveness of warnings, but also can be used to explain why a warning message might fail to achieve the previously mentioned goals of

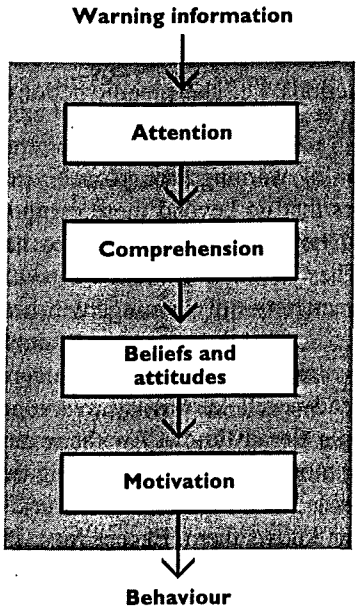

Figure 7.1 A human information processing model showing a sequence of stages leading to compliance behaviour.

informing people about the hazard and promoting safe behaviour. As the model shows, before behavioural change can occur (the last stage), processing of the warning must successfully pass through several earlier stages.

Initially the warning must capture attention; that is, it must be noticed. Then, the message contained in the warning must be comprehended. The warning must also agree with the person's attitudes and beliefs. Further, the message must motivate the user to comply with the directed behaviours. The fact that this model proceeds in a temporal sequence implies that there are potential 'bottlenecks' that could prevent the process from being completed. If the warning is not noticed in the first place, the information in the warning will not pass on to any subsequent stages, and of course, behaviour will not be changed. Even though a warning may capture attention, it may not be effective if the message is not understood by the user. Merely examining and reading the warning does not necessarily mean people comprehend it. People must understand all of the words and the grammar, and properly interpret any accompanying symbols and pictorials. But even if the warning is noticed and understood, the process will go no further if the warning does not adequately influence the person's beliefs and attitudes in the appropriate direction, which can be quite difficult to do if the warning is communicating information that is in opposition to the person's existing beliefs and attitudes. Finally, even if the processing of the warning is successful up to this point, the warning will not be behaviourally effective if it does not motivate or energize the user to perform the appropriate safe actions.

Thus, the stages are potential bottlenecks, which could cause processing to stop, preventing it from going further and modifying behaviour. The following sections describe the factors that influence warning effectiveness at each stage of the model.

7.3 EFFECTIVENESS FACTORS AT EACH STAGE

Most warnings are transmitted visually (e.g. signs and labels) but may also be transmitted by the other sensory modalities (e.g. auditorily via tones and speech, olfactory via odours, and kinesthetically via vibration). This chapter will focus on the visual modality.

7.3.1 Attention

Most environments are cluttered, so in order for warnings to be seen they must possess characteristics that facilitate their standing out from the background (Wogalter *et al.*, 1993c). In other words, they should be conspicuous or salient relative to their context (Wogalter *et al.*, 1987; Young and Wogalter, 1990; Sanders and McCormick, 1993).

Warnings should be of high contrast relative to the background (dark ink on light background, or vice versa) (Barlow and Wogalter, 1993; Sanders and McCormick, 1993). They should have large, legible bold-faced alphanumeric characters. The specific sizes of the printed letters should be based on visual angle which is a function of the actual feature size and the distance from the viewer (at least 5 to 10 degrees of arc on the retina and greater is preferred). Other variables important for adequate size include the characteristics of the target population (discussed below), whether or not movement is involved (and how fast and in what direction), and the illumination conditions, among others (Sanders and McCormick, 1993).

Another factor is placement. A general principle is that warnings should be located close to the hazard, both physically and in time (Wogalter *et al.*, 1987; Frantz and Rhoades, 1993; Wogalter *et al.*, 1995a). A warning describing the potential for a hydrogen gas explosion placed on a car battery or attached to booster cables is much more likely to be noticed at the proper time than a warning in the car owner's manual.

The inclusion of certain kinds of information in the warning can also increase its ability to gain attention. These features include: a signal word (e.g. 'Danger', 'Caution') (Chapanis, 1994; Wogalter and Silver, 1990, 1995) that is paired with a signal icon (a triangle enclosing an exclamation point) (Laughery *et al.*, 1993a; Wogalter *et al.*, 1994a), and a graphic pictorial (e.g. Jaynes and Boles, 1990; Laughery *et al.*, 1993a). The colours red, orange and yellow are commonly used in warnings to indicate different levels of hazard (from greater to lesser, respectively) (Bresnahan and Bryk, 1975; Collins, 1983; Chapanis, 1994; Kalsher *et al.*, 1995; Wogalter *et al.*, 1995b); however, the choice of colour should also depend on the

environment in which the warning is placed (Young, 1991). A red warning in an environment that is also largely red will not stand out.

There are several kinds of situations where the amount and type of information that can be placed on a warning is constrained. A common reason is limited space (e.g. on the label of a small container), but such constraint may also be due to warning distance and speed of movement (such as in traffic signs). Several alternatives can be considered. One is to include all the necessary information in the warning regardless of the resulting size. Another alternative is to leave out information. This may be acceptable if there is a more complete and readily accessible warning elsewhere (e.g. an accompanying manual). Some research has shown that a well-located brief persuasive safety sticker can be effective in getting users to read a set of longer, more detailed warnings in the accompanying instruction manual (Wogalter *et al.*, 1995a). Another solution is to increase the size of a product label or sign so that there is more surface area upon which to print more information or use larger type or both (Barlow and Wogalter, 1991; Wogalter *et al.*, 1993b; Wogalter and Young, 1994; Kalsher *et al.*, 1996).

Warnings should have properties that allow them to be seen in degraded conditions such as low illumination, smoke, or fog (e.g. Lerner and Collins, 1983). In addition, warnings should be adequately lit (by directed or back-lighting) and/or have good reflectance so that they are visible under reduced-light conditions (Sanders and McCormick, 1993).

Another important concern in developing noticeable warnings is the characteristics of the target population. Some of the target persons may have reduced sensory capabilities. If individuals with vision or hearing impairments (e.g. older adults) are expected to be part of the target audience (which is often the case), their capabilities and limitations should be taken into account when designing the warning, as for example by making the signs or labels larger (Laughery and Brelsford, 1991). To increase the likelihood that safety information will be conveyed to individuals who have sensory deficits, it is particularly important that the warning be composed of the conspicuity features discussed above. Another strategy is to present the warning information redundantly in two or more modalities (e.g. visually and auditorily) when practical and/or possible (Wogalter and Young, 1991; Wogalter *et al.*, 1993c). Redundant presentation also has the advantage of capturing the attention of target persons occupied with other tasks that monopolize one modality but not the other.

An important issue with respect to attention getting is habituation. Over time, a warning will attract less attention. However, a warning with many conspicuity features will habituate at a slower rate than a warning without them. There are also other ways to counter habituation. The main one is stimulus change which is achievable by modifying the visual characteristics of an existing warning every so often so that it looks different. New ways to counter habituation have been provided by recent technology such as the ability to electronically control warning exposure so that presentation occurs when needed (e.g. with motion sensors). Sophisticated detection and control systems can enable sign personalization (e.g. using the targeted individual's name) and variable presentation schedules (cf. partial reinforcement) (Wogalter *et al.*, 1994b; Racicot and Wogalter, 1995).

Another way to counter habituation, as well as to capture attention more generally, is to use interactive warnings. Users physically interact in some way with the warning while performing a task (such as moving the warning in order to use a piece of equipment). Theoretically, interactive warnings serve to break into the habitual performance of a familiar task (i.e., interrupting a well-learned behavioural script), causing the individual to attend to the warning (Lehto and Papastavrou, 1993). Over time even interactive warnings will habituate, but the process is slowed down (Frantz and Rhoades, 1993; Duffy *et al.*, 1995; Wogalter *et al.*, 1995b; Conzola and Wogalter, 1996; but also see Hunn and Dingus, 1992).

Related to the habituation issue is standardization (Vigilante and Wogalter, 1996). Recently, there has been an increased push for the development of design standards for warnings. There are positive aspects for standardization (e.g. people will know that the sign or label is a warning when they see it). However, the downside is that standardization may promote similarity in appearance which in turn is likely to facilitate habituation-type problems. That is, having a standard look conflicts with habituation countermeasures. If all warnings have a similar style, then changes made only to the content may go unnoticed. People may think that they already know the information because it looks similar to what they have seen previously. Clearly, standardization entails trade-offs regarding attention; this is an issue that needs to be addressed in research.

Lastly, in order to ensure that the warning gains attention, it is important that it is tested with a representative sample of the target population. Evaluation may take many forms such as:

- collecting numerical ratings or rankings of various potential warning designs;
- evaluating legibility for different designs presented at varied distances and under degraded conditions;
- measuring reaction time to displays with and without a warning;
- assessing memory to the signs (which if they remember them indicates that they must have looked at them);
- recording looking behaviour (e.g. direction and duration of gaze).

The best evaluations are those that most closely replicate the conditions and tasks of the risk situation. Thus, measurement of looking behaviour in the actual environment with a hidden video camera is a more valid assessment than questionnaire ratings.

7.3.2 Comprehension

If the warning captures attention, then the next important processing stage that must be completed is comprehension. Understandable warnings are necessary to give individuals an adequate appreciation of the hazard so that they can make informed judgements.

One common – but frequently erroneous – assumption by persons who have control over the design or selection of warnings is that everyone in the target audience

understands the hazard as well as he or she does. This assumption should be avoided because those in control of the design or selection of warnings are usually not representative of the target audience. Target audiences often have a wide range of mental and physical characteristics. What seems 'common sense' to some persons may not be 'common sense' to others (Laughery, 1993).

Safety communications should *not* be written at the average or median-level percentile person because this will exclude approximately 50 per cent of the people below that point. Rather warnings should be written so that they are understandable for the lowest level of the target audience that can practically be reached (Laughery and Brelsford, 1991).

What are some reasonable assumptions that we can make? If the at-risk target audience includes people who do not have strong language skills (including children, the less educated, and those lacking robust knowledge of the language in which the warning is written), then generally it can be assumed that they will not understand complex verbal messages. In general, if there are two or more terms or statements that mean the same thing, then the best one (with all other aspects being equal) will be comprised of short, frequently-used (common) terms.

In addition, there are some other convenient methods to determine (albeit only approximately) the understandability of textual messages. Various readability formulae are available that are based on frequency-of-use counts, word and sentence length, etc. (though some of the formulae need to be adapted for shorter length, non-punctuated text; see Silver *et al.*, 1991). Moreover, there are teacher workbooks which contain terms that are appropriate for different ages (Silver and Wogalter, 1991). Another rough method is to have a sample of the target audience give numerical understandability ratings for various exemplary messages. However, these methods are only an approximation of what is possibly adequate. They can serve to eliminate poorly written messages, but they do not indicate whether people will actually understand them. Actual testing of the material using a representative sample of the target population (as will be described in more detail later) is the best method of determining whether people understand the message.

Another important comprehension factor is explicitness. Explicit messages contain specific information detailing what the hazard is, giving definitive instructions on what to do or how to avoid the hazard, and giving the consequences of not complying (Laughery *et al.*, 1993b; see also Trommelen and Akerboom, Chapter 9). Warnings that state 'Use in a well-ventilated area' or 'May be hazardous to health' do not convey much useful information because they are too vague. More specific messages like 'Use in a room with forced air or with at least two open windows' or 'Can cause lung cancer which almost always leads to death' are preferred because they tell what the necessary conditions are for use, what the particular problem is, and the potential outcome. Trommelen and Akerboom (Chapter 9) found that explicit warnings for child-care products were not only preferred and the instructions remembered better by participants, but also the products were perceived as more hazardous and the potential injuries more severe than products without explicit warnings.

Pictorials can be another useful way to increase understanding of the hazards. Pictorials are covered more extensively in other chapters in this book, but some brief mention here is appropriate because they can be an important component of warnings. Pictorials can illustrate the hazard, the instructions and/or the potential consequences. Well-designed pictorials have the ability to communicate large amounts of information at a glance and can be useful in reaching persons who cannot read a printed verbal message, either because of vision problems (e.g. with older adults) or because they do not possess good verbal skills or knowledge of the language being used in the warning (e.g. foreign visitors, illiterates, the less educated, children) (Lerner and Collins, 1980; Collins, 1983; Zwaga and Easterby, 1984; Boersema and Zwaga, 1989; Laux *et al.*, 1989).

Sometimes pictorials are contained within a circle surround (indicating a permitted or recommended situation) and sometimes with a slash through it or an X (indicating prohibition of the depicted situation). In various warning systems, other surround shapes have been designated certain meanings (e.g. octagon, triangle, rectangle, etc.). However, with a few exceptions such as the octagonal stop sign or the triangular yield sign, it is not clear that people know (or even learn over time) what the shapes mean without training. This may be due to the fact that surround shapes are inconsistently used across various systems.

The best way, and perhaps the only way, to determine whether the warning will be comprehended is to test it on a representative sample of the target audience to determine whether they understand it (Lerner and Collins, 1980; Wogalter *et al.*, 1987). Such sampling was performed by Dewar and Arthur (see Chapter 8). They developed and evaluated a set of multi-panel pictorials for a variety of hazards near hydroelectric stations. They sampled individuals from various target populations including illiterates, older people, natives, etc. Their tests revealed that most of the pictorial messages were well understood by the individuals tested. Dewar and Arthur's good sampling of individuals likely to be near the hydroelectric station strengthens the contention that the pictorials will be beneficial in communicating the intended messages in the field.

The testing can involve different methods. The best is an open-ended response test (as used by Dewar and Arthur, see Chapter 8) where participants are shown a verbal warning or pictorial and asked what it means to them. The difficulty of this method lies mainly in grading the responses after data collection is completed. Often people do not clearly express what they mean so scoring is partially based on interpretation. Responses can be scored using various criteria from strict to lenient (see, for example, Young and Wogalter, 1990, for a description) and/or judged as completely or partially correct, etc. Two independent judges should evaluate the responses (without knowledge of conditions if it is an experiment) using agreed-upon criteria to provide a measure of reliability.

Other common testing techniques involve multiple choice or matching tests where the correct responses are mixed together with incorrect (distractor) responses. These methods are less desirable than the open-ended method because the results are strongly dependent on the distractor alternatives that are provided. Moreover,

these tests are less realistic in the sense that they do not reflect the kinds of retrieval operations that people perform with real-world warnings (i.e., we do not normally choose from distractor answers in trying to understand a warning). Other tests include rankings and ratings, but these tests only tell which of the group of alternative versions may be better; they do not provide strong evidence on whether the message is truly understandable under realistic conditions.

If the testing shows that a substantial number of people do not understand the message, or worse, misunderstand it (i.e., a critical confusion), then this suggests that the warning should be redesigned and retested. One example illustration of misunderstanding is the phrase 'low birth weight' that appears in some cigarette warnings in the USA. This message is intended to admonish pregnant women not to smoke because their babies might be born prematurely, etc. However, some women have interpreted the phrase to mean that smoking can help keep their weight down in the late stages of pregnancy. Had this phrase been tested with a representative sample of women of child-bearing age, before it was put on packages, this misinterpretation would likely have been noted, and another less ambiguous phrase used instead. Testing can also be used to collect data on how a warning can be improved if a new or redesigned warning should be necessary.

As mentioned earlier, well-designed pictorials can potentially communicate large amounts of information at a glance. However, it is also true that poorly designed pictorials may communicate nothing (other than perhaps that a warning is present) or worse, the wrong message (Lerner and Collins, 1980; Laux *et al.*, 1989). So, like verbal messages, pictorials can be misinterpreted. Consider a pictorial that accompanied the verbal warnings for Acutane (Roche Dermatologics, Nutley, NJ), a drug for severe acne that also causes severe birth defects in babies of women taking the drug just before or during pregnancy. The pictorial shows a side-view, outline shape of a pregnant woman within a circle-slash surround. The intended meaning is that women should not take the drug if they are pregnant, or if they are not pregnant, to take precautions against getting pregnant. However, some women have incorrectly interpreted the pictorial to mean that the chemical might help them to avoid getting pregnant. Again, early testing using a representative sample of the target audience (women of child-bearing age) would have provided information about this misinterpretation. Also, input from test participants can be used to generate ideas for new designs (if the testing reveals that one is needed). Of course, the new designs should be tested to ensure that they are understandable (Wolff and Wogalter, 1993; Magurno *et al.*, 1994). The process may require several rounds of iterative test and design that should continue until an adequate level of comprehension is achieved (see Dewar and Arthur, Chapter 8).

7.3.3 Beliefs and attitudes

Given that a warning has been attended to and understood, then the next major stage concerns beliefs and attitudes. Beliefs refer to an individual's knowledge of a topic that they accept as true (regardless of its actual veracity). Beliefs are used to

form opinions, expectations and judgements. Attitudes are similar except there is more emotional involvement. Given their similarity, beliefs and attitudes are grouped into one stage for the purposes of the current model. This was an arbitrary decision as beliefs could have been grouped with the previous stage and attitudes as a separate emotional component.

This processing stage has not garnered as much research as the two earlier stages, but beliefs and attitudes can strongly influence whether a warning will be effective. Among the factors that affect warning processing at this stage are familiarity and perceived hazard–risk.

It is important to note that beliefs and attitudes can also affect processing at earlier stages. For example, individuals who believe something is safe may not look for a warning, and even if they notice it they may not examine it further. This effect reveals that the flow of information through the model's stages is not linear. Indeed it is likely that all stages of processing feed back onto each other (in a loop fashion). The idea that later stages affect earlier stages was alluded to in the discussion of the effect of habituation at the attention stage where repeated exposure produces knowledge which has a negative effect on noticeability.

Similarly, people who frequently use the same product or perform the same task will tend to believe that there is less risk than perhaps they should. This familiarity effect has been noted in numerous research studies (e.g. Godfrey *et al.*, 1983; Wogalter *et al.*, 1991, 1995a) that indicate that people more familiar with a product/equipment or task are less likely to read a warning. Of course, familiarity does not invariably result in unsafe behaviour. Indeed, familiarity frequently produces safer behaviour, because more is known about the situation. Nevertheless, such beliefs are likely to make it difficult to get people to read warnings for a similar, but more dangerous product than they are accustomed to (Godfrey and Laughery, 1984). In such cases, stalwart intervention steps such as making the product appear dramatically different from the old product and/or interactive warnings might help to break into people's set beliefs and attitudes.

Another important factor associated with beliefs and attitudes is hazard–risk perception. Persons who do not perceive something is hazardous will be less likely to notice or read a warning. Even if they read it, they may not comply if they are not convinced of the hazard. Hazard–risk perception is closely related to familiarity. As people become more familiar with something they generally perceive it to be less hazardous. However, research (e.g. Wogalter *et al.*, 1991, 1993a) suggests that the hazard–risk perception is more closely tied to precautionary intent than familiarity.

Even more intimately tied to hazard–risk perception are people's beliefs in how severely they might be injured. In fact, research (e.g. Wogalter *et al.*, 1991, 1993a) suggests that people's notions of how hazardous a product is, is almost entirely based on how seriously they think they could be injured. At the same time, people apparently do not readily consider the likelihood or probability of those injuries in making hazard–risk judgements (Wogalter and Barlow, 1990; Young *et al.*, 1990, 1992). More will be said about injury severity in the next processing stage, which concerns motivation.

Lastly, if a warning message is in opposition with existing beliefs and attitudes, then it is likely that it will be ignored. The basis of the discrepant beliefs may be due to several factors such as familiarity and hazard–risk perception. In such cases, it is necessary that the message be sufficiently persuasive to change beliefs and attitudes. Doing this in practice is very difficult because people may not look for or read a warning in the first place (due to existing beliefs and attitudes, for example). This problem is noted in a study by Wogalter *et al.* (Chapter 10) assessing compliance to a car battery jumper cable warning. The hazard associated with jump starting a car is explosion from a spark igniting hydrogen gas released by the batteries. To avoid this hazard there is a sequence of cable connections that avoids having a spark produced near the battery (by making the last connection to a ground, e.g. a metal portion of the engine). However, most people believe (erroneously) that the batteries should be connected pole-to-pole (positive to positive and negative to negative). Enhanced warnings increased the number of people doing the cabling accurately, but without such enhancements or no warning, virtually everyone did it wrong. Thus, it becomes critical that the warnings possess attention-getting features and comprehension characteristics so that there is some chance of relaying a persuasive argument to convince the individual to comply. Considerable social psychology research has dealt with persuasion (Chaiken and Eagley, 1976), but additional work on warnings is needed (McGuire, 1980; Wogalter *et al.*, 1989). Persuasion is also linked to the next stage, motivation.

7.3.4 Motivation

A warning that is noticed, understood, and that successfully fits with the individual's beliefs and attitudes also needs to motivate people to comply with its directives. One of the critical determinants of compliance motivation is the concept of 'cost' which can be distinguished in two ways: cost of compliance and cost of non-compliance.

People are usually motivated to comply with warnings because of the associated potential negative consequences (costs) of not complying, including physical injury to themselves and others, property damage, or monetary loss. In industrial or public settings (or other controlled situations), cost of non-compliance can refer to fines or penalties levied by supervisors or government agencies for unsafe behaviours.

The cost associated with compliance can also be a strong motivator. Compliance usually requires some action in response to the warning message involving time, effort and/or money. If people perceive the cost of complying to be greater than the expected benefits of not complying, then they are less likely to comply. The following studies illustrate how motivation can be affected by cost. In one field experiment (Wogalter *et al.*, 1987), people's behaviour was observed responding to a warning posted on a broken door. The warning either directed people to use an adjacent door (low cost) or a different set of doors roughly 60 metres away (high cost). The results showed that most people obeyed the warning in the low cost condition (94 per cent), but it was totally ignored when cost was high (0 per cent).

This finding was supported in another study, in which people performed a mock chemistry task (Wogalter *et al.*, 1989) in which a warning directed participants to wear a mask and gloves. The mask and gloves were either located on the table where they performed the task (low cost) or the items were located in an adjacent room (high cost). When located nearby, 73 per cent of the people used the protective equipment. However, when located more distantly, less than 17 per cent used them. These studies demonstrate that as cost of compliance increases, the effectiveness of a warning decreases. Sometimes the expenditure of even a minimal amount of effort can dissuade a person from complying with a warning.

Costs of compliance can be minimized in several ways. In a hazardous workplace compliance costs can be reduced by providing at no expense the required safety equipment, reducing effort needed to use this equipment (Wogalter *et al.*, 1987, 1989), and ensuring the equipment is comfortable (Casali and Lam, 1986).

Whereas cost of compliance may decrease warning effectiveness, its effects can be facilitated by increasing the cost of non-compliance. The negative outcomes described in a consequences statement can convey the cost of non-compliance. To maximize its effect, the consequence statement should use explicit language telling users exactly (specifically) what can result if they do not comply (Laughery *et al.*, 1993b). In addition to providing a better understanding of the nature of the hazard, explicit consequences give users an appreciation of the potential injury severity that might result. Perceived injury severity is a major factor in motivating people's precautionary intentions (Wogalter and Barlow, 1990; Wogalter *et al.*, 1991; Young *et al.*, 1990, 1992). Being explicit about severe injury motivates people as they generally want to avoid such outcomes.

In opposition to the notion of giving explicit severe consequences, is the suggestion from the marketing literature that warnings that promote too much fear arousal will be less effective than warnings that promote a more moderate level of fear arousal. This has been called the 'boomerang' effect because it implies that a strong warning (e.g. one that conveys disastrous consequences) will turn people off, causing them to ignore the warning. However, if the consequences are permanent paralysis, severe burns from a caustic substance, or death, should this not be expressed in the warning even though the information may provoke relatively high arousal? As stated earlier, it is important to give people a fair account of the nature of the hazard and potential consequences of not complying; therefore, toning down or leaving out critical information in order to reduce fear arousal would seem inappropriate. In fact, high fear arousal is probably an important motivating force for warning compliance.

Another motivator of warning compliance is social influence. Research (Wogalter *et al.*, 1989) shows that if people see other people comply with the warning, they will be more likely to comply themselves. Likewise, if they see someone else not comply, they are less likely to comply. Social influence is an external factor with respect to warnings (as opposed to an internal factor such as its design). There are other important external factors. Time pressure frequently causes stress which restricts people's processing and could result in a failure to notice a warning (Magurno and Wogalter, 1994). The effects of these non-design factors illustrate the need for

a systems approach that considers influential environmental and personal factors present in the risk situation.

7.4 SUMMARY AND ADDITIONAL COMMENT

This chapter has given a broad overview of some of the most important issues in the design and implementation of warnings. As discussed at the outset, warnings are but one method of hazard control. There are other, usually more effective methods (e.g. design out the hazard, ban the product or outlaw the situation, guard against the hazard) to protect against accidents and injuries.

The overview indicates that:

- warnings should be designed so that they will be noticed and examined;
- the information presented should be understandable by their intended population;
- the message should have persuasive elements to change incongruent attitudes and beliefs;
- the warning should motivate people to comply.

The first two stages are very important and have received the most attention in the warning research literature. Both are necessary but not sufficient conditions for warning effectiveness. The last two stages, attitudes/beliefs and motivation, are as important as the other two but are much less researched.

How do you know whether the warning has the right combination of desirable features to support high levels of compliance? Many of the factors discussed in this chapter can be designed into a warning without a great deal of decision making, but others will be more difficult because trade-offs must be made. One potential conflict is the principle of explicitness which says that the warning should give specific information regarding the hazard and consequences. This rule will, in some situations, conflict with other warnings design principles, for example, adequate print size. This is a problem when the explicit wording is lengthy while at the same time there is limited surface area to print the information and/or persons must be able to read the material at an adequate distance. Therefore, there is a decision to be made regarding print size versus explicitness. Another related trade-off is between brevity and explicitness. In making compromises, how does one know the best solution? Answers come from testing the warning to confirm (or disconfirm) whether the trade-offs are successful.

Testing can be carried out in several ways, from subjective ratings to actual behavioural compliance and can be directed at specific intermediate stages of information processing. Thus, the model can help to reveal the location of the problem (i.e., bottleneck). With this information, adjustments can eliminate the obstacle. Several rounds of iterative testing might be necessary until an adequate warning is developed that successfully passes through all of the stages.

Two additional points should be noted. One is that measurement of warning effectiveness should continue after the warning is in place. As already discussed,

over time the warnings will become less effective due in part to habituation, but also because people and situations change over time. Also, after the warning is in use, there may be opportunities to collect data that could not otherwise be obtained in short-duration studies.

The other point concerns time. Because some products and equipment have very long expected lifespans, it is important to make sure that the materials comprising the warning (e.g. pigments, glue, etc.) are sufficiently durable to last as long as or longer than the product's anticipated life. Also, operator manuals that accompany most products when purchased new are frequently not transferred to subsequent owners (Rhoades *et al.*, 1991; Wogalter and Baneth, 1994). Given that second-hand owners need to know about product safety, maintenance, repair etc., it is important that they have access to this information. One way to facilitate availability is to permanently attach a label to the product with the manufacturer's complete address and telephone number so that people can request a replacement manual (Wogalter and Baneth, 1994).

Lastly, by considering the warning factors described in this chapter, hazard communications can be developed that can increase people's knowledge about hazards, but even more importantly, they can be used to reduce unsafe behaviour and decrease accidents and injury.

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REFERENCES

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

BARLOW, T. and WOGALTER, M. S. (1993) Alcoholic beverage warnings in magazine and television advertisements. *Journal of Consumer Research* **20**, 147–156.

BOERSEMA, T. and ZWAGA, H. J. G. (1989) Selecting comprehensible warning symbols for swimming pool slides. In: *Proceedings of the Human Factors Society 33rd Annual Meeting*, pp. 994–998. Santa Monica, CA: Human Factors Society.

BRESNAHAN, T. F. and BRYK, J. (1975) The hazard association values of accident-prevention signs. *Professional Safety* January, 17–25.

CASALI, J. G. and LAM, S. T. (1986) Over-the-ear industrial hearing protectors: an assessment of comfort issues. In: *Proceedings of the Human Factors Society 30th Annual Meeting*, pp. 1428–1432. Santa Monica, CA: Human Factors Society.

CHAIKEN, S. and EAGLEY, A. H. (1976) Communication modality as a determinant of message persuasiveness and message comprehensibility. *Journal of Personality and Social Psychology* **34**, 605–614.

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

COLLINS, B. L. (1983) Evaluation of mine-safety symbols. In: *Proceedings of the Human Factors Society 27th Annual Meeting*, pp. 947–949. Santa Monica, CA: Human Factors Society.

CONZOLA, V. C. and WOGALTER, M. S. (1996) Compliance and recall of operator manual instructions: the use of supplemental voice and print directives and warnings. In: MITAL, A., KRUEGER, H., KUMAR, S., MENOZZIE, M. and FERNANDEZ, J. E. (Eds), *Advances in Occupational Ergonomics and Safety I*. Amsterdam: IOS Press.

DUFFY, R. R., KALSHER, M. J. and WOGALTER, M. S. (1995) Interactive warning: an experimental examination of effectiveness. *International Journal of Industrial Ergonomics* **15**, 159–166.

FRANTZ, J. P. and RHOADES, T. P. (1993) A task analytic approach to the temporal placement of product warnings. *Human Factors* **35**, 719–730.

GODFREY, S. S. and LAUGHERY, K. R. (1984) The biasing effects of product familiarity on consumers' awareness of hazard. In: *Proceedings of the Human Factors Society 28th Annual Meeting*, pp. 388–392. Santa Monica, CA: Human Factors Society.

GODFREY, S. S., ALLENDER, L., LAUGHERY, K. R. and SMITH, V. L. (1983) Warning messages: will the consumer bother to look? In: *Proceedings of the Human Factors Society 27th Annual Meeting*, pp. 950–954. Santa Monica, CA: Human Factors Society.

HUNN, B. P. and DINGUS, T. A. (1992) Interactivity, information and compliance cost in a consumer product warning scenario. *Accident Analysis and Prevention* **24**, 497–505.

JAYNES, L. S. and BOLES, D. B. (1990) The effects of symbols on warning compliance. In: *Proceedings of the Human Factors Society 34th Annual Meeting*, pp. 984–987. Santa Monica, CA: Human Factors Society.

KALSHER, M. J., WOGALTER, M. S. and RACICOT, B. M. (1996) Pharmaceutical container labels: enhancing preference perceptions with alternative designs and pictorials. *International Journal of Industrial Ergonomics*, **18**, 83–90.

KALSHER, M. J., WOGALTER, M. S., BREWSTER, B. and SPUNAR, M. E. (1995) Hazard level perceptions of current and proposed warning sign and label panels. In: *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, pp. 351–355. Santa Monica, CA: Human Factors and Ergonomics Society.

LAUGHERY, K. R. (1993) Everybody knows: or do they? *Ergonomics in Design* July, 8–13.

LAUGHERY, K. R. and BRELSFORD, J. W. (1991) Receiver characteristics in safety communications. In: *Proceedings of the Human Factors Society 35th Annual Meeting*, pp. 1068–1072. Santa Monica, CA: Human Factors Society.

LAUGHERY, K. R., VAUBEL, K. P., YOUNG, S. L., BRELSFORD, J. W. and ROWE, A. L. (1993b) Explicitness of consequence information in warnings. *Safety Science* **16**, 597–613.

LAUGHERY, K. R., YOUNG, S. L., VAUBEL, K. P. and BRELSFORD, J. W. (1993a) The noticeability of warnings on alcoholic beverage containers. *Journal of Public Policy and Marketing* **12**, 38–56.

LAUX, L. F., MAYER, D. L. and THOMPSON, N. B. (1989) Usefulness of symbols and pictorials to communicate hazard information. In: *Proceedings of the Interface 89*, pp. 79–83. Santa Monica, CA: Human Factors Society.

LEHTO, M. R. and PAPASTAVROU, J. D. (1993) Models of the warning process: important implications towards effectiveness. *Safety Science* **16**, 569–595.

LERNER, N. D. and COLLINS, B. L. (1980) *The Assessment of Safety Symbol Understandability by Different Testing Methods*. PB81–185647. Washington, DC: National Bureau of Standards.

LERNER, N. D. and COLLINS, B. L. (1983) Symbol sign understandability when visibility is poor. In: *Proceedings of the Human Factors Society 27th Annual Meeting*, pp. 944–946. Santa Monica, CA: Human Factors Society.

MAGURNO, A. B. and WOGALTER, M. S. (1994) Behavioral compliance with warnings: effects of stress and placement. In: *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, pp. 826–830. Santa Monica, CA: Human Factors and Ergonomics Society.

MAGURNO, A., WOGALTER, M. S., KOHAKE, J. and WOLFF, J. S. (1994) Iterative test and development of pharmaceutical pictorials. In: *Proceedings of the 12th Triennial Congress of the International Ergonomics Association*, Vol. 4, pp. 360–362.

MCGUIRE, W. J. (1980) The communication–persuasion model and health-risk labeling. In: MORRIS, L. A., MAZIS, M. B. and BAROFSKY, I. (Eds), *Product Labeling and Health Risks: Banbury Report 6*. Coldspring Harbor, NY: Coldspring Harbor Laboratory.

RACICOT, B. M. and WOGALTER, M. S. (1995) Effects of a video warning sign and social modeling on behavioral compliance. *Accident Analysis and Prevention* **27**, 57–64.

RHOADES, T. P., FRANTZ, J. P. and HOPP, K. M. (1991) Manufacturers' product information: is it transferred to the second owner of a product? In: *Proceedings of the Interface 91*, pp. 100–104. Santa Monica, CA: Human Factors Society.

SANDERS, M. S. and MCCORMICK, E. J. (1993) *Human Factors in Engineering and Design* (7th edn). New York: McGraw-Hill.

SILVER, N. C. and WOGALTER, M. S. (1991) Strength and understanding of signal words by elementary and middle school students. In: *Proceedings of the Human Factors Society 35th Annual Meeting*, pp. 580–594. Santa Monica, CA: Human Factors Society.

SILVER, N. C., LEONARD, D. C., PONSI, K. A. and WOGALTER, M. S. (1991) Warnings and purchase intentions for pest-control products. *Forensic Reports* **4**, 17–33.

VIGILANTE, W. J. JR and WOGALTER, M. S. (1996) The ordering of safety warnings in product manuals. In: MITAL, A., KRUEGER, H., KUMAR, S., MENOZZIE, M. and FERNANDEZ, J. E. (Eds), *Advances in Occupational Ergonomics and Safety I*. Amsterdam: IOS Press.

WOGALTER, M. S. and BANETH, R. C. (1994) Availability of owner's manuals for 'second-hand' consumer products. In: *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, pp. 447–450. Santa Monica, CA: Human Factors and Ergonomics Society.

WOGALTER, M. S. and BARLOW, T. (1990) Injury likelihood and severity in warnings. In: *Proceedings of the Human Factors Society 34th Annual Meeting*, pp. 580–583. Santa Monica, CA: Human Factors Society.

WOGALTER, M. S. and SILVER, N. C. (1990) Arousal strength of signal words. *Forensic Reports* **3**, 407–420.

WOGALTER, M. S. and SILVER, N. C. (1995) Warning signal words: connoted strength and understandability by children, elders, and non-native English speakers. *Ergonomics* **38**, 2188–2206.

WOGALTER, M. S. and YOUNG, S. L. (1991) Behavioural compliance to voice and print warnings. *Ergonomics* **34**, 79–89.

WOGALTER, M. S. and YOUNG, S. L. (1994) Enhancing warning compliance through alternative product label designs. *Applied Ergonomics* **24**, 53–57.

WOGALTER, M. S., GODFREY, S. S., FONTENELLE, G. A., DESAULNIERS, D. R., ROTHSTEIN, P. R. and LAUGHERY, K. R. (1987) Effectiveness of warnings. *Human Factors* **29**, 599–612.

WOGALTER, M. S., ALLISON, S. T. and MCKENNA, N. A. (1989) Effects of cost and social influence on warning compliance. *Human Factors* **31**, 133–140.

WOGALTER, M. S., BRELSFORD, J. W., DESAULNIERS, D. R. and LAUGHERY, K. R. (1991) Consumer product warnings: the role of hazard perception. *Journal of Safety Research* **22**, 71–82.

WOGALTER, M. S., BREMS, D. J. and MARTIN, E. G. (1993a) Risk perception of common consumer products: judgments of accident frequency and precautionary intent. *Journal of Safety Research* **24**, 97–106.

WOGALTER, M. S., FORBES, R. M. and BARLOW, T. (1993b) Alternative product label designs: increasing the surface area and print size. In: *Proceedings of the Interface 93*, pp. 181–186. Santa Monica, CA: Human Factors Society.

WOGALTER, M. S., KALSHER, M. J. and RACICOT, B. M. (1993c) Behavioral compliance with warnings: effects of voice, context, and location. *Safety Science* **16**, 637–654.

WOGALTER, M. S., JARRARD, S. W. and SIMPSON, S. W. (1994a) Influence of signal words on perceived level of product hazard. *Human Factors* **36**, 547–556.

WOGALTER, M. S., RACICOT, B. M., KALSHER, M. J. and SIMPSON, S. N. (1994b) The role of perceived relevance in behavioral compliance in personalized warning signs. *International Journal of Industrial Ergonomics* **14**, 233–242.

WOGALTER, M. S., BARLOW, T. and MURPHY, S. (1995a) Compliance to owner's manual warnings: influence of familiarity and the task-relevant placement of a supplemental directive. *Ergonomics* **38**, 1081–1091.

WOGALTER, M. S., MAGURNO, A. B., CARTER, A. W., SWINDELL, J. A., VIGILANTE, W. J. and DAURITY, J. G. (1995b) Hazard association values of warning sign header components. In: *Proceedings of the Human Factors Society 39th Annual Meeting*, pp. 979–983. Santa Monica, CA: Human Factors and Ergonomics Society.

WOLFF, J. S. and WOGALTER, M. S. (1993) Test and development of pharmaceutical pictorials. In: *Proceedings of the Interface 93*, pp. 187–192. Santa Monica, CA: Human Factors Society.

YOUNG, S. L. (1991) Increasing the noticeability of warnings: effects of pictorial, color, signal icon and border. In: *Proceedings of the Human Factors Society 35th Annual Meeting*, pp. 580–584. Santa Monica, CA: Human Factors Society.

YOUNG, S. L. and WOGALTER, M. S. (1990) Effects of conspicuous print and pictorial icons on comprehension and memory of instruction manual warnings. *Human Factors* **32**, 637–649.

YOUNG, S. L., BRELSFORD, J. W. and WOGALTER, M. S. (1990) Judgments of hazard, risk, and danger: do they differ? In: *Proceedings of the Human Factors Society 34th Annual Meeting*, pp. 503–507. Santa Monica, CA: Human Factors Society.

YOUNG, S. L., WOGALTER, M. S. and BRELSFORD, J. W. (1992) Relative contribution of likelihood and severity of injury to risk perceptions. In: *Proceedings of the Human Factors Society 36th Annual Meeting*, pp. 1014–1018. Santa Monica, CA: Human Factors Society.

ZWAGA, H. J. G. and EASTERBY, R. S. (1984) Developing effective symbols for public information. In: EASTERBY, R. S. and ZWAGA, H. J. G. (Eds), *Information Design: The Design and Evaluation of Signs and Printed Material*, chap. 15, pp. 277–297. New York: Wiley.