WARNING! Sign and Label Effectiveness

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The purpose of warnings is twofold. The first goal is to inform people so they appreciate potential hazards. The second goal is to change behavior, that is, to redirect people away from performing unsafe acts that they might otherwise perform. With today's technology, warnings have become increasingly necessary. Products, equipment, tools, and the environment have become more complex; how they work, their composition, and their inherent hazards are frequently not obvious.

Until the past decade, relatively little empirical research on warnings had been reported—probably because warning research is difficult to do. Some of the difficulties are these:

- Direct behavioral observation of warning effects is time- and labor-intensive because the critical events are infrequent and sporadic.
- Allowing hazardous situations to occur in order to study them poses serious ethical concerns.
- Laboratory studies that permit good experimental control may not be generalizable to other settings. Creating believable risk situations (that are actually safe) in the laboratory is challenging.

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In part as a result of these difficulties, research on warnings has proceeded on several methodological fronts employing a variety of techniques. Research has been conducted in the laboratory and in the field and has measured subjective judgments, comprehension, memory, behavioral intentions, and compliance.

STAGES OF INFORMATION PROCESSING

Research on warnings can be organized using an information processing framework. In this article, we adopt an information processing model consisting of a sequence of stages: attention, comprehension, attitudes and beliefs, motivation, and behavior. The basic model is shown in Figure 1. Although this model has limited utility in describing complex mental processes, it is useful in organizing warning research.

In the linear sequence, for a warning to be successful, it must capture attention and be understood. It should agree with existing attitudes and beliefs or be adequately persuasive to evoke a change toward agreement. Finally, the message must motivate the user to comply. Each stage can produce a bottleneck, potentially preventing information from being processed at subsequent stages. For example, a warning that is not comprehended will have little or no influence on beliefs and attitudes, motivation, and behavior.

Much of the research reported to date has focused on attention and comprehension, with a modest amount of effort directed at motivational considerations and relatively little at the role of beliefs and attitudes. Most work on warnings appears in the human factors-ergonomics literature, and much of this research has an applications orientation with the goal of designing more effective warnings.

Warnings are usually transmitted visually (e.g., with signs and labels) or auditorily (e.g., with sounds and speech). Sometimes hazard information is conveyed by other modalities, such as olfaction (e.g., odor added to natural-gas lines to aid leak detection) or touch (e.g., vibrating aircraft control sticks to warn of an impending stall). But these are unusual cases. In this article, we focus on visual warnings. Reviews of auditory warnings can be found elsewhere.[1]

ATTENTION

Most environments are cluttered and noisy, so in order to attract attention, warnings must be conspicuous or salient relative to their context.[2] Principles from basic research on selective attention indicate that factors such as novelty, size, illumination, contrast, and location (both spatial and temporal) affect salience. Additional factors that may help capture attention include a signal word (e.g., "DANGER," "CAUTION"), a signal icon (e.g., triangle enclosing an

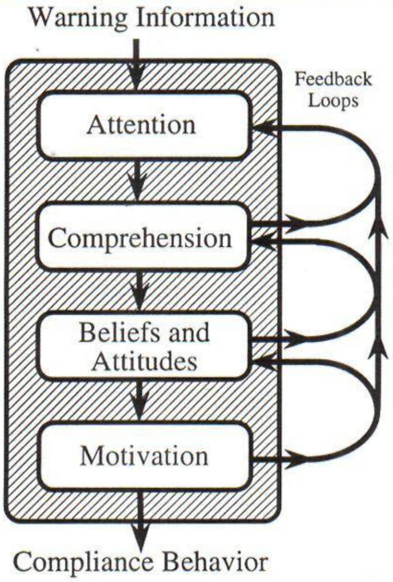

Fig. 1. A human information processing model showing a sequence of stages leading to behavior complying with a warning. The model includes feedback to earlier stages.

exclamation point), color (e.g., red is associated with stop and danger in many cultures), or a picture (referred to in the warnings literature as a *pictorial*) illustrating the hazard or consequences.[3] For example, one study measuring the time it took people to find warnings on alcoholic beverage labels showed that a warning that was colored red and included a signal icon (triangle enclosing an exclamation point) and pictorial (circle and slash over a car and cocktail glass) was noticed significantly faster (2.07 s) than a warning without these features (2.80 s).[4]

Often, there is limited space on labels for warnings. One alternative is to squeeze in information regardless of the resulting print size. Another alternative is to leave out information and refer to more complete information in another accessible location (e.g., a printed instruction sheet or manual that accompanies the product). Research indicates that a well-located, brief, persuasive safety directive can be effective in getting users to look at more detailed warnings in an accompanying instruction manual.[5] This approach, however, includes some cost in terms of convenience and time—a serious problem that we address in the section on motivation.

Persons with limited sensory capabilities are of particular concern in designing warnings. If individuals with vision or hearing impairments (e.g., the elderly) are part of the target audience, their capabilities and limitations should be considered (e.g., a larger display might be appropriate). Multimodal presentation (including sound) has shown benefits; it provides redundant cues so that a person occupied by a task employing one modality can receive the information conveyed through another. For example, a field experiment conducted at a shopping mall showed that more people avoided a "wet floor" area when the warning was conveyed through both print and voice (76%) than print (42%) or voice (64%) alone.[6]

An important issue related to attention is habituation: Over time and repeated exposure, a warning will attract less attention despite having many of the salience features already discussed. There are several ways to retard habituation, however. One way is to alter the characteristics of an existing warning from time to time so that it looks different. Another way is provided by recent technology: Warnings can be controlled dynamically by electronics. Sophisticated presentations personalize (e.g., use the targeted individual's name) and vary presentation patterns to delay habituation.[7] Another method of countering habituation is to use interactive warnings, in which the targeted individual has overt physical contact with the warning and is thereby interrupted in performing a familiar task.[8] The interruption serves to call attention to the task and the warning. One study using an incidental task (in which the true purpose of the study is not revealed initially) showed that participants using electrical extension cords with a warning attached to a plastic outlet cover more often connected them to equipment properly (48%, or 29 out of 60) than did participants with a warning lacking interactivity (6.7%, or 2 out of 30).

A related issue is the recent call by industry groups for a standard warning format. The potential benefit is twofold: People will more easily recognize that a section of a sign or label is a warning when they see it, and a standard format decreases development costs. The disadvantage is that standardization promotes similar appearances and conflicts with countermeasures to retard habituation.

COMPREHENSION

The next stage in the model is comprehension. Product and warning designers often assume incorrectly that everyone at risk understands the hazard as well as the designers themselves do.[9] In fact, the target audience (which frequently ranges widely in mental abilities and experience) may not know the information the designers consider "common sense." Moreover, safety communications should not be written at the average comprehension level of the target audience. Rather, warnings should be understandable to the least-skilled people who can practically be reached. Illiteracy and non-English readers and speakers, of course, pose special problems.

What are reasonable assumptions about comprehension, and what principles can be applied? Generally, individuals with low language ability (children, the poorly educated, non-English readers or speakers, etc.) will not understand warning messages that are written at high reading levels, use technical terms, or describe complex concepts. Thus, one obvious principle of warnings design is to use simple language, to keep the reading level as low as possible, and to minimize technical terminology. The appropriate content depends, however, on the target audience. For example, it may be appropriate for a pharmaceutical company marketing birth control pills to provide different warnings to prescribing physicians than to end users.[10]

Two factors that have been researched extensively are explicitness and the use of pictorials. Explicit messages tell specifics about the hazards, give definitive instructions on what should or should not be done, and explain the consequences for not complying.[11] "Use adequate ventilation" or "May be hazardous to health" are vague messages; comprehension can be improved by using instead 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."

Pictorials can often be used to depict the hazard, the potential consequences, or what to do or not do to avoid the hazard. In addition to capturing attention, well-designed pictorials can communicate large amounts of information in a glance and reach persons who cannot read verbal print messages.[12] However, it is also true that poorly designed pictorials may communicate nothing–or worse, may communicate the wrong message. For example, the verbal warnings for ACUTANE® (Roche Dermatologics, Nutley, New Jersey), a drug that is used to treat severe acne and that also causes severe birth defects, are accompanied by a side-view, outline shape of a pregnant woman within a circle-slash surround. The intended message is that women should not take the drug if pregnant, and women who are not pregnant should take stalwart precautions against getting pregnant if they take the drug. However, some women have incorrectly interpreted the pictorial to mean that the chemical will help them to avoid getting pregnant—a potentially disastrous confusion. In general, pictorials have been used in warnings with varied levels of success.

BELIEFS AND ATTITUDES

In research on warnings, the factors related to beliefs and attitudes have been less frequently examined than the factors related to attention and comprehension. Influential factors at the beliefs-and-attitudes stage include familiarity and perceived hazard. However, before we describe these two influences, we should note that beliefs and attitudes can affect earlier stages of information processing as well. For example, an individual who believes a product or a piece of equipment is safe is less likely to look for a warning than is someone who has doubts about safety. As this example illustrates, in the model shown in Figure 1, the flow of information through the stages is not linear. Probably all of the processing stages influence earlier stages, as shown in the feedback loops on the right side of the figure.

Product familiarity reduces the level of hazard perceived and the likelihood of reading warnings. This familiarity effect derives from beliefs formed from prior exposures and the accumulation of knowledge about the object or task.[13] Conversely, low familiarity leads to more looking, reading, and complying. Even though increased familiarity reduces a warning's effectiveness, familiarity does not necessarily produce unsafe behavior as it generally means the person knows how to deal with the hazards. Nevertheless, beliefs can sometimes be erroneous; people can be overconfident in believing that they know enough to use a product safely. When people are likely to be familiar with a product, it may be necessary to increase the label's salience so they will notice the warning and maybe change their beliefs appropriately.

Hazard perception is closely related to familiarity. The less people perceive a product or task to be hazardous, the less likely they are to notice, look for, or read a warning. But even if they read the warning, they still may not comply with its directives if it does not convince them of the hazard. Research suggests that people's notions of product hazard are almost entirely based on how severely they believe they could be hurt, not necessarily how probable the injuries are.[14]

MOTIVATION

If a warning is noticed, is understood, and fits with a person's beliefs and attitudes, then the remaining element essential to safe behavior is that the warning must motivate (activate) the person to comply with its directives. A critical determinant of motivation is the cost of compliance. Cost can be any expenditure of effort, time, and money. If a person perceives the costs of complying to be greater than the benefits of complying, he or she is less likely to comply than if the benefits appear to outweigh the costs. The required expenditure of even a minimal amount of extra time or effort can reduce compliance dramatically. For example, in a laboratory study in which participants mixed and measured various chemicals, a warning requiring the use of protective equipment (mask and gloves) was complied with significantly less often (17%) when this equipment was 25 feet (8 m) away from the worktable as opposed to being at hand (73%).[15]

Although the cost associated with compliance is a potential hindrance to a warning's effectiveness, the effects of this cost can be counteracted by increasing the perceived cost associated with noncompliance. One motivator is an explicit statement describing the potential negative outcomes that can result if the warning is ignored. Explicit statements provide an appreciation of the potential severity of injury, and this understanding is a major determinant of precautionary intent and actions.[13,14]

Social influence is another motivational factor affecting compliance.[15] One set of experiments showed that if people see another person comply with a warning, they are more likely to comply (e.g., 15 of 18 people, or 83%, donned mask and gloves when a confederate donned them) than if they see another person not comply (3 of 19 people, or 16%, wore the mask and gloves when the confederate failed to put them on). This factor also illustrates the importance of not only warning design, but also personal and environmental factors.

SUMMARY AND IMPLICATIONS

Several implications can be drawn from this broad overview of some of the important issues in the design and implementation of warnings: Warnings should be designed so that they will be noticed and examined, they should be understandable by as large a portion of their intended audience as possible, the message should have persuasive elements to ensure correct beliefs and attitudes, and warnings should motivate people to comply. Attention and comprehension have been considered extensively in research; attitudes and beliefs and motivation are less well researched, and deserve more attention because of their influence on warnings' effectiveness.

We have focused on the factors that improve or maximize warnings' effectiveness. It should be noted, however, that some reports in the literature question the effectiveness of warnings.[16] As can be seen in the data cited in this article, warnings do not always lead to high rates of compliance. Thus, one should not rely on them as the only basis for injury control. Foremost, one should try to design out the hazard, such as by using a safer chemical in a cleaning solution instead of a more dangerous one. However, sometimes hazards cannot be completely designed out, so another strategy is to try to guard against them, such as by having a cover around the sharp blades of a food processor. The point is that because warnings are not 100% reliable, they should not be considered a substitute for good design or safeguards. Warnings are necessary when other hazard-control methods are not possible or practical, or may serve as adjuncts.

How does one know whether a particular warning will be effective? An assessment of effectiveness can, to some extent, be obtained by testing the warning. Testing may involve exposing the warning to a representative sample of the target population and assessing noticeability, readability, comprehension, behavioral intentions, and behavioral compliance. Such efforts pose significant methodological challenges, but the potential value of the results in reducing injury warrants including testing as an integral part of the warning design process.

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Notes

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Recommended Reading

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On the Neural Computation of Utility

Peter Shizgal and Kent Conover

The self-stimulating rat presents a compelling spectacle. Having been trained to press a lever that triggers intense, continuously available stimulation of a "hot" site in the medial forebrain bundle, the rat works the lever in a frenzied, insatiable fashion, even at the cost of forgoing its sole daily opportunity to obtain food. The ardor and determination shown by the rat suggest that obtaining additional stimulation has become an extraordinarily important goal. That this should be so is perplexing. If one were to insert a test probe into the central processing unit of a computer and deliver trains of current pulses, one would hardly expect to inject meaningful data. How could a signal meaningful to a rat arise from delivery of synchronous stimulation via a stout wire crudely inserted into the intricate fabric of the brain? If the induced neural activity is somehow meaningful, what natural signal does it mimic?

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On the basis of experiments on the relationship between the rewarding effects of electrical brain stimulation and gustatory stimuli,[1,2,3] we have proposed a new account of the nature of the electrically evoked signal. In this essay, we flesh out our account by considering the phenomenon of brain stimulation reward (BSR) in relation to the computational processes involved in goal selection. By so doing, we address the function of the underlying neural circuitry and the question of how the electrical stimulation produces an apparently meaningful effect.

Central to our formulation is the concept of utility, which we have borrowed from economics. We assume our rats to be rational consumers insofar as they will prefer, under nonsatiating conditions, an alternative that provides more of a given appetitive goal object (e.g., food) over an alternative that provides less. The relative utility of two different goal objects will depend not only on their abundance but also on the physiological state of the consumer and the ecological context in which the goal objects are embedded. In effect, we treat utility as a subjective estimate of the potential contribution of a goal object to fitness. The more accurate the estimate, the more adaptive are the choices that take the utility value into account.

In natural settings, the goals competing for behavior are complex, multidimensional objects and outcomes. Yet, for orderly choice to be possible, the utility of