CAUTION: Your Safety Warnings May Not Be Working

Research Links
Accident Scenario
Training to Improved Warning Comprehension

How Can Companies Maximize Warning Effectiveness?
CAUTION: Your Safety Warnings May Not Be Working

Safety warnings are everywhere – on machinery, road signs, medication bottles, electronics, cleaning solutions, and food items...the list goes on. In the workplace, safety warnings are meant to help workers make decisions to avoid actions that could lead to injury, illness, or even death. They are an important, and often required, part of a company’s overall safety strategy. But are workplace safety warnings effective in mitigating risk? Not always.

Studies suggest that warning compliance rates are low, ranging anywhere from 17 to 37 percent.1 “There are many possible reasons for this,” says Mary Lesch, Ph.D., cognitive researcher at the Liberty Mutual Research Institute for Safety. “The warnings may be improperly designed or placed, or they can become overly familiar, such that they are no longer noticed or thought about. Or, despite the warnings, some people may simply choose to engage in risky behaviors.” Lesch also notes that workplace factors such as time pressures, distractions, and cultural differences may hamper a worker’s ability to process a warning, which may contribute to noncompliance (see chart right).

Traditionally, safety warning research has examined how warning variables (such as font size, color, and use of symbols) and receiver characteristics (such as age, gender, and risk-taking behavior) impact warning effectiveness. “These studies provide good information for the design and implementation of more effective warnings,” Lesch explains. “However, at the Research Institute, we take the issue a step further by investigating the cognitive processes that underlie the effects of these variables.”

Researchers in the Institute’s Center for Behavioral Sciences apply cognitive and psychological theories to study how individuals process safety warnings. “The essential question underlying our research is this: How can we maximize the effectiveness of workplace safety warnings in the face of cognitive responses to factors such as multitasking, distraction, or aging?” says Lesch.

“With the information we gain, we hope to develop recommendations for improving warning comprehension so that workers have the information they need to make better safety decisions,” notes Lesch. “If we’re successful, workers will suffer fewer injuries and employers will experience reduced losses.”
An individual’s ability to process warnings involves four basic human information processing components: notice, encode, comprehend, and comply. A failure of any one of these components increases the likelihood that a warning will be ineffective.  

Among the many factors that have been shown to influence these processes are warning variables (such as font size, color, explicitness, and use of symbols) and receiver characteristics (such as age, gender, vision, familiarity, and risk-taking style). And, while many studies examine the impact of these variables on warning effectiveness, Institute researchers focus their studies on the underlying mechanisms that mediate the effects of such variables, such as memory and cognition.

Accident Scenario: Ear Protection Required

As a construction worker, your work environment contains a lot of noise. You’ve been instructed to wear ear protection and to get your hearing checked once a year. You usually wear ear protection, but sometimes it gets in the way, and you don’t bother with it. You sometimes have ringing in the ears or they feel like they’re stuffed up. You didn’t really worry about it because it goes away eventually. But, you just had your annual exam, and the news wasn’t good – you have a hearing loss. The technician explained that repeated exposures to loud noise can lead to permanent, incurable hearing loss. In the future, you’ll be more careful to wear ear protection when working in noisy environments.

Research Links

More than a decade ago, the Liberty Mutual Research Institute began conducting research on workplace safety warnings. Early studies focused on individual warning components, examining how features, such as font size, color, and format, affect a warning’s effectiveness. The findings from that research were incorporated into recommendations for improved warning design. Today, the Institute applies a more contemporary, behavioral research approach, by examining the underlying cognitive processes that affect warning comprehension. The information gained is used to develop strategies to help businesses get the most out of their safety warnings.

“Successful transmission of the safety message is only one part of the risk communication puzzle,” explains Institute Research Scientist Mary Lesch, Ph.D. “It’s critical that workers understand what the warning means, are able to recall that information quickly, and are thinking about the relevant safety information at the time of risk.” One way to help maximize warning effectiveness is through training. “Our early research in this area suggested that relatively simple training conditions can dramatically improve warning comprehension in terms of accuracy and speed of response,” notes Lesch.

In 2003, Liberty Mutual researchers set out to further test training effectiveness. Forty-four, working-age adults participated in a study, which compared the effects of two training methods on workers in two different age groups. Half of the participants comprised a younger group (ages 20-35) and half comprised the older group (ages 50-70). Prior to training, researchers administered a pretest to both groups to test their comprehension of 92 workplace safety symbols. On separate trials, each symbol was paired with either a correct explanation of the symbol’s meaning or an incorrect, but plausible, explanation. Researchers measured the participants’ response accuracy and timing for each symbol presented. They also asked participants to rate their confidence in their answers on a scale of 0 (not at all confident) to 5 (certain).

Following the pretest, participants were divided into two mixed-age groups and were presented with either verbal label training or accident scenario training. The
verbal label training paired safety warning symbols with labels to describe their meaning. The latter training paired symbols with real-world accident scenarios that illustrated the nature of the hazard, the required or prohibited actions, and the possible consequences of failure to comply. Immediately after training, researchers administered a post test which measured participants’ response accuracy, speed, and confidence. Two weeks later, another post test was administered to measure how long the benefits of training lasted.

The findings, presented in “A Comparison of Two Training Methods for Improving Warning Symbol Comprehension” (Applied Ergonomics, Vol. 39, pp. 135-143, 2008), indicated that both training conditions improved performance. However, the accident scenario training increased comprehension to a greater extent (36%) than the verbal label training (30%). Furthermore, participants responded to warnings more quickly following the accident scenario training and were more confident in their responses.

With respect to the age comparisons, the study found no differences in comprehension for older and younger groups prior to training, however younger adults did tend to respond more quickly. After training, younger participants showed greater improvement than older adults in terms of accuracy and composite confidence scores. However, older adults improved their reaction times to a greater extent than younger participants (most likely due to the much slower reaction times for older adults on the pre-training test). Therefore, younger participants appeared to benefit to a greater extent from the training. Benefits persisted for both groups at the two-week follow-up.

To further examine the benefits of accident scenario training, researchers conducted another more focused study in 2004. “In the 2003 study we just looked at the use of accident scenario training to reinforce the meaning of the symbol. This time, we wanted to examine whether such training improved people’s understanding of required or prohibited actions or of what might happen as a result of failure to comply.” As in the prior study, participants (48 working-age adults) took a pretest in which 34 warning symbols were paired with both correct and incorrect, but plausible, meanings. After that, participants received accident scenario training on all of the symbols. Immediately following and two weeks after training, our researchers measured comprehension across three knowledge types (verbal label, required/prohibited actions, and potential consequences of failure to comply).

In addition to the comprehension measures, researchers examined whether the training had shifted people’s perceptions of control. “We wanted to determine if accident scenario training increased the participants’ sense of being able to prevent an injury through compliance,” states Lesch. “This is an important measure, because if people don’t believe their actions will prevent an accident, they may not comply.” Researchers also examined ratings on intent to comply and perceived hazard. “A lot of research shows that perceived hazard is a strong predictor of compliance….so we wanted to find out if accident scenario training impacted hazard perceptions.”

According to the findings presented in “Warning Symbols as Reminders of Hazards: Impact of Training” (Accident Analysis and Prevention, Vol. 40, No. 3, 2008), training benefits were observed on all dependent measures. Comprehension improved from 43 to 82 percent correct, reaction times were reduced by about two seconds and level of confidence in correct responses increased by 23 percent. Ratings of perceived hazard, intent to comply, and perceived control over accident/injury involvement also increased. These benefits, which persisted at the two-week follow-up, suggest that accident scenario training can be used to help prevent accidents and injuries by ensuring that responses to warnings are “sure and swift.”

Lesch, principal investigator on the study, explains the benefits of this research in real-world terms: “When people see a warning, it is critical that they not only understand it, but understand it right away. The milliseconds that are saved in reaction time could very possibly save a life.”
Remembering to be Afraid:
Applying Theories of Memory to the Science of Safety Communication

What does memory have to do with safety communications? More than you might think. According to a Research Institute literature review published in *Theoretical Issues in Ergonomics Science* (Vol. 6, No. 2, 2005), applying psychological theories of memory to warning research can yield valuable insights on how to maximize warning effectiveness.

The review argues that warnings may be more effective as reminders of the presence of a known hazard than as a means of educating or persuading. For example, many Americans know that individuals below a certain weight and height should not sit in airbag-facing seats. However, they may not remember this fact, or the specific height and weight restrictions, without prompting. A well-designed and appropriately-placed warning serves to remind vehicle operators and riders of this known hazard each time they enter the car.

How can the function of warnings, as reminders, be optimized? The review findings suggest the need for more research that incorporates psychological theories of memory to investigate this question. Such studies would take into account what we already know about memory and find ways to improve people’s ability to be thinking about warning information at the most relevant time – when deciding whether or not to engage in a potentially risky behavior. The review also suggests the importance of measuring speed of recall, in addition to accuracy, in attempting to assess warning effectiveness.

Does Culture Matter?
A Cross-Cultural Comparison of Perceived Hazard in Response to Warning Components

The American National Standards Institute (ANSI) recommends the use of specific colors, signal words, and symbols for use in hazard warnings. In today’s global marketplace, many experts advocate international standards for hazard warning components. However, cultural differences in language and perception may lead to misunderstandings that increase injury risks.

To further investigate this issue, Institute researchers launched a cross-cultural study with Tsinghua University in China. In this study, 43 Chinese and 41 American participants rated the hazard level of various ANSI-recommended warning components. Researchers found that the Chinese and the American groups varied significantly with respect to perceived hazard associated with different colors (see chart right). For example, contrary to the typical American response, Chinese participants perceived a significantly higher degree of hazard with green rather than yellow. These and other findings suggest that current warning standards may not be equally effective across different populations.
To gain a field perspective on warning symbols and their use in the workplace, we spoke with Paul Myers, a technical director with Liberty Mutual Loss Control Advisory Services. A 29-year veteran in the area of risk management and loss control, Myers offered some interesting insights into the role of workplace warnings in a company’s overall safety strategy and provided several research-based tips for maximizing warning effectiveness and compliance.

**Q** Why are safety warning signs important in the workplace?

**A** It is not always possible to eliminate or “design-out” injury risks associated with workplace systems and processes. In fact, the Consumer Products Safety Commission estimates that product-design regulations can, at best, address about 80 percent of all consumer product-related injuries.¹ With that fact in mind, safety communications, including safety warnings, should be an integral part of a company’s comprehensive safety strategy.

**Q** What is the specific role of safety warning signs in a company’s safety strategy?

**A** The way a company addresses risk includes the following hierarchy of control options:

- **Elimination** of the risk through design.
- **Substitution** of less-hazardous materials, processes, tools, or equipment.
- **Engineering controls** including guards, safety devices, ventilation systems, enclosures, etc.
- **Warnings** to inform workers of a hazard and how to avoid it.
- **Administrative controls** including training, feedback, and work procedures.
- **Personal protective equipment** such as eye protection, hard hats, gloves, etc.

When elimination, substitution, and engineering controls are not viable, or their use does not reduce risk to an acceptable level, then warnings need to be used.

Companies should recognize that, although warnings are relatively low on the hierarchy of control strategies, their use is an important and necessary part of the inte-
grated combination of solutions that will help reduce the risk of hazards.

**Q** What are some of the specific challenges companies face in getting workers to comply with safety warnings?

**A** Probably the biggest obstacle to safety warning compliance is over-familiarity. That is, people tend to tune out safety messages after they have been exposed to them for a period of time. This is especially true when employees have never experienced or witnessed the negative consequence of a hazard. Our research has demonstrated that accident scenario training can help improve employees’ responses to warning signs (see page 3). This type of training pairs pictographs with real-world accident scenarios written in the second person to personalize the scenario.

For this type of training, a company can use actual accident scenarios from its own past loss experience or borrow from the following online resources:

- Occupational Safety and Health Administration’s Accident Report Fatal Facts
- National Institute for Occupational Safety and Health Alerts and Fatal Assessment and Control Evaluation (FACE)
- U.S. Department of Labor Mine Safety and Health Administration Safety Hazard Alerts
- Centers for Disease Control’s Morbidity and Mortality Weekly Report

Workers also tend to ignore warnings when they believe that the cost of compliance is greater than the risk of non-compliance. For example, office workers are likely to ignore a “Safety Glasses Required” warning posted on the door to the plant if they have to return to their desk to retrieve their safety glasses. However, if the plant keeps a supply of reusable safety glasses at the entry point to the plant, the likelihood of warning compliance will increase.

Increasingly, language and cultural differences also provide an obstacle to warning compliance. Experts suggest that nearly 150 foreign languages are spoken in the United States, and more than 23 million Americans speak a language other than English in their homes. The American National Standards Institute (ANSI) recommends the use of pictographs to better communicate a warning sign’s hazard information across language barriers. However, our research shows that different cultures may perceive symbols meanings differently. Clearly, more research is needed in this area.

**Q** What are some “best practices” companies can implement to help improve the effectiveness of safety warnings?

**A** Research suggests that the following best practices can improve warning effectiveness, and should be implemented whenever possible:

- Use pictographs in addition to written warnings to increase understanding and comprehension.
- Locate the warning sign so that physical interaction is required.
- Provide accident scenario training to improve comprehension and reaction to the warning message while reducing the impact of familiarization.
- Use multiple methods to convey the warning: operator manuals, standard operating procedures, job safety analysis, etc.
- Reduce the cost of complying with the warning.
- Increase the cost of not complying with the warning.
- Use multimodal formats to present the warning: visual, auditory, and tactile.


Answers to test, page 5: 1. d) Pressurized system 2. d) Refrigerate, don’t freeze 3. b) Don’t open before vehicle stops 4. c) Do not operate with guard removed 5. b) Do not take if you may be pregnant
Dear Readers,

Safety warnings are part of the fabric of modern-day living. At home, at work, and in any number of places in between, such communications are intended to help prevent actions and decisions that can lead to injury, illness, and even death. Yet, despite all good intentions, studies show that safety warnings are often ineffective.

This issue highlights the Research Institute’s ongoing program in hazard communication, which aims to improve the design and effective use of workplace warning signs. From early studies examining the impact of simple training interventions on warning comprehension; to investigations of the role of memory, age, and culture; to explorations of sophisticated “accident scenario training” methods, our research helps inform the interventions and strategies that help companies improve warning effectiveness.

Y. Ian Noy, Ph.D.
Vice President and Director

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