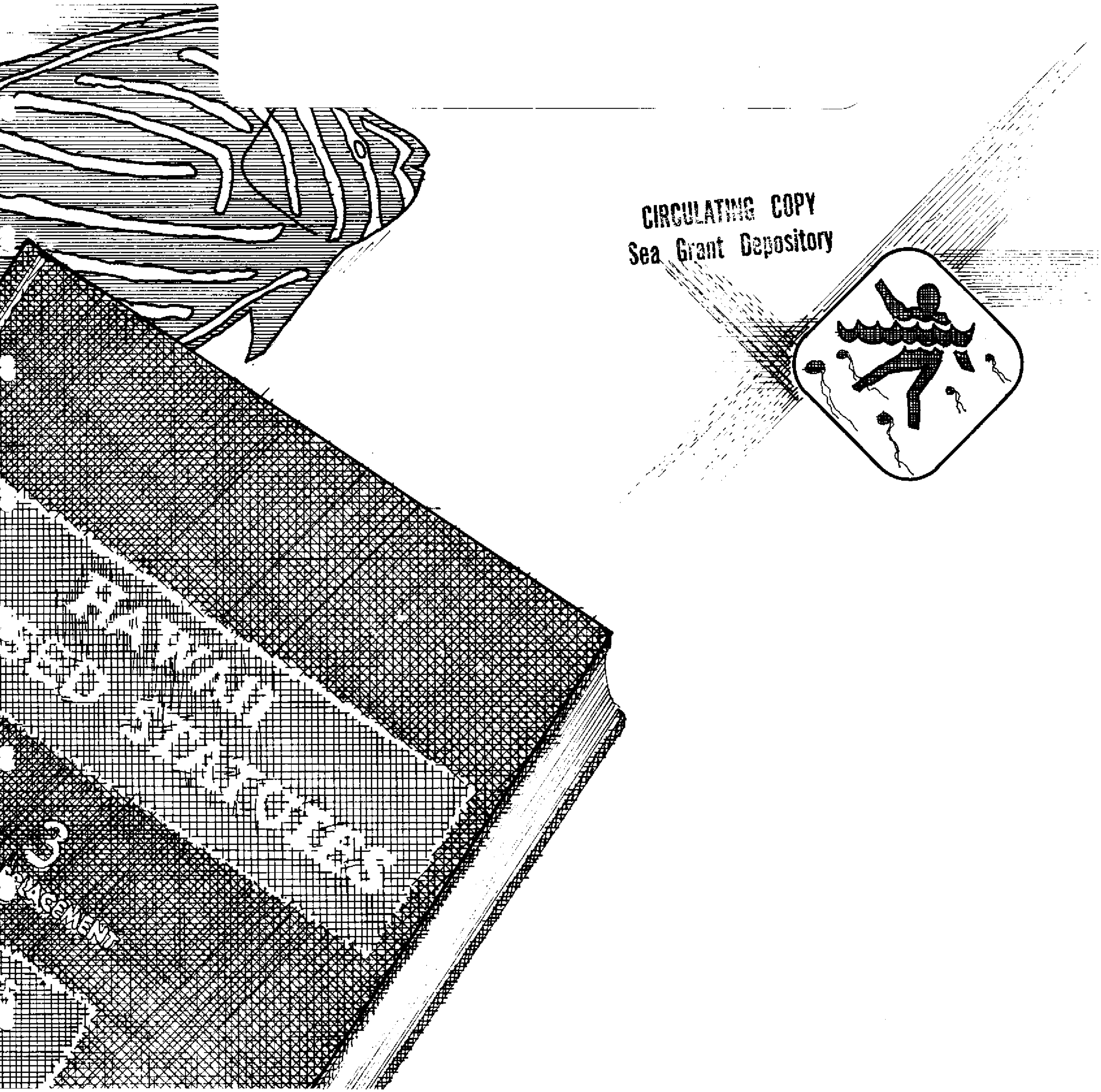
HAWAU-T-89-005 C2

RISK MANAGEMENT
in Ocean Recreation



$2.00

WARNING SIGNS: WHY DO THEY FAIL?

Ross L. Pepper

August 1989

UNIHI-SEAGRANT-RM-89-02
UH Sea Grant College Program
Honolulu, Hawaii

This report is funded by project PM/M-2j, "1985–87 Biennium Consultation on the Legal and Scientific Aspects of Risk Management in Open Water Recreational Areas" by the University of Hawaii Sea Grant College Program under Institutional Grant No. NA85AA-D-SG082 from NOAA Office of Sea Grant, Department of Commerce. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

Cover designed by Hirata/Nonaka Creative Advertising
Cover photos by Mike Tsukamoto

About the Author

Ross L. Pepper is an assistant professor of law in The William S. Richardson School of Law, University of Hawaii, Honolulu, HI 96822.

The National Sea Grant College Program is a network of institutions working together to promote the wise use, development, and conservation of the nation's coastal, marine, and Great Lakes resources. Provisions of the National Sea Grant College and Program Act of 1966 called for the creation of Sea Grant Colleges, and in October 1972, the University of Hawaii was designated one of the first five Sea Grant Colleges in the nation. Locally, Sea Grant is a unique partnership of university, government, and industry focusing on marine research, education, and advisory/extension service.

TABLE OF CONTENTS

INTRODUCTION

Every year consumer products are associated with millions of accidents in the United States. More than 10 million injuries requiring emergency room treatment were reported in 1985 (CPSC 1985). Each year the number of accidents continues to reach new highs. Furthermore, new products based upon increasingly complex technological innovations will be introduced to consumers, resulting in an increase in the exposure to hazards (Marinissen, Johan, Molenbroek, and Schoone-Harmsen 1986). Finally, there seems to be an increase in the sensation-seeking and risk-taking attitudes and behavior for an increasing segment of western society, which produces an increased exposure to a variety of potential hazards. For example, river rafting, hot-air ballooning, and jet skiing and parafoiling in coastal waters have all increased in popularity and availability, resulting in potentially hazardous situations both for the consumer as well as for innocent victims.

It is obvious that injury and death due to product-related accidents is a broad societal problem. Many recognize that more practical steps must be taken to reduce or prevent accidental death and injury and make the environment safer for all citizens.

There are many safety-engineering approaches to the reduction of accidents. Some of these approaches have focused on designing safer products, while others have been directed toward understanding consumer's risk-taking behavior (Brems 1986). A third approach has been directed toward providing warnings to the consumer in an effort to influence his/her behavior with respect to potentially hazardous products or situations. Historically, this has been the most popular approach. However, there is no evidence that warnings have any effect on behavior. People do not heed warning signs (McCarthy, Finnegan, Krumm-Scott, and McCarthy 1984). Even when a warning is carefully written and presented and the consumer understands the risk involved and has the knowledge to avoid the hazard, his behavior is frequently unchanged (Karnes and Leonard 1986). It is curious that the least effective approach, the use of warning signs and messages employed to alter the behavior of the consumer, continues to be the most widely used despite overwhelming evidence of its ineffectiveness.

Several important consequences must be considered with regard to the extensive use of warning labels. The first is that the court system has arrived at legal decisions which are often based upon simplistic, intuitively supported assumptions, rather than decisions firmly anchored by scientifically supported facts. The prevailing court position is that warnings are easy to employ and are low-cost alternatives. The long-term result of these court decisions has had several negative results. First, the emphasis on the use of warnings has resulted too often in other safety engineering approaches being ignored, and second, the overapplication of warnings may have resulted in the general reduction in effectiveness for all warnings (Twerski, Weinstein, Donaher, and Piehler 1976). A second consequence of an overemphasis on the use of warnings is that the complexity of the entire safety-warning process has largely gone unappreciated (Kantowitz and Sorkin 1983).

THE TRADITIONAL APPROACH TO RESEARCH

Research of warnings probably started with Aristotle's observations that his colleagues paid no attention to admonitions about drinking wine while sitting in hot baths. Until quite recently, the emphasis of research has been largely directed toward factors involved in the physical characteristics of warnings. Professional and industrial associations have generated standardized formats for warning and accident-prevention signs. In industry, the most widely used standards are the American National Standard Institute's (ANSI) "Specifications for Accident Prevention Signs" (Z35.1-1973) and FMC Corporation's "Product Safety Sign and Label System" (1980). The objective of these publications is to minimize the proliferation of nonstandard formats and to provide criteria for a uniform recognition of hazards.

The traditional approach to warning is steeped heavily in expert opinion, based upon intuition, common sense, and personal experience. The standards referred to above are products of the traditional approach. Very little quantitative data support the assumptions that underlie the sanctioned standards.

DEFINITIONS

A significant issue with respect to the safety-warning process has to do with definitions. What constitutes a proper definition for a layman is not acceptable to an attorney. The definition accepted by safety-engineering specialists would not be acceptable to either the attorney or the layman. However, this problem will not be addressed in this report other than to indicate that the problem exists. For the purposes of this report, Dorris and Purswell's (1977) definition of a warning message will be used. The definition, which is acceptable to members of the scientific community concerned with the warning process, is as follows:

1. The message must be received
2. The message must be understood
3. The message must be acted upon appropriately

CURRENT RESEARCH

Message Construction

The current research emphasis is directed toward variables influencing the construction of the warning message. For example, Leonard, Mathews, and Karens (1986) studied the effects of signal words which are based on ANSI standards. These signal words are assumed to be effective components in a warning message, and their effectiveness should be related to the strength of the word employed. The authors found there was no difference in the perception of risk associated with different signal words (caution, warning, danger). Additionally, size and color of the signal word had no effect on risk perception, despite ANSI guidelines for these features of a warning. However, when statements of the consequences of disregarding the warnings were employed in the message, the warning was effective in altering the perception of risk.

McCarthy et al. (1984) conducted a brief survey of the warning literature and concluded there was no compelling evidence that warning signs act to modify consumer behavior. Godfrey, Rothstein, and Laughery (1985) did show warning signs were effective in modifying the behavior of office workers in regard to the use of a telephone, a copy machine, a drinking fountain, and a doorway. However when the cost of heeding the warning was high, compliance decreased markedly.

Ursic (1984) evaluated the use of safety-warning messages on several brands of hair dryers and bug killers. He reported that the presence of a warning had a positive impact on a person's perception of the effectiveness of a product, but despite the use of standard signal words, large size letters, and pictograms, there was no subsequent brand recognition nor recall of the safety information presented in the message.

Horst, McCarthy, Robinson, McCarthy, and Kromm-Scott (1986) reported on a survey of the product-warning literature conducted subsequent to the review by McCarthy et al. (1984). Horst's survey was directed toward research on the behavioral effects of warning systems. It includes the hammer study of Dorris and Purswell (1977) which showed that people pay no attention to warnings on familiar objects regardless of how severe the warning may be. The review also included studies which evaluated warning effectiveness for the following: road signs, stop signs, lawn mower safety campaigns, label reading, poison storage, seat belt use, smoking and saccharin use, restroom signs, and railroad crossing warnings. While the authors note that compliance does exist in many of these situations, in too many cases people take risks, even though they have adequate information about the extent of the risk.

Comprehension

Verbal Symbols

There continues to be a steady flow of research on specific issues in warning systems that go beyond the physical features of the warning message itself. The ability of the consumer to comprehend the message is an important area that requires much research. For example, even the use of the signal words that are required in order to meet ANSI Z35.1 standards (danger, caution, warning) have no empirical basis to show that they are effective nor do they decrease in their degree of signified severity. They also do not inherently correspond to different levels of hazards. Their literal definition in a dictionary conveys very different meanings. Further research is necessary before assuming these words can signify the level of a given hazard to the general population.

Collins, Lerner, and Pierman (1982) reviewed the literature on the perception of verbal symbols and reported that in 1976 more than 5 million people in the United States had difficulty understanding English; between 2 million and 64 million adults are functionally illiterate. This means that written warnings will not be meaningful to a large part of the United States population even if the warning is well designed. If technical terms are used, even fewer people will be able to understand the message.

Pyrczak and Roth (1976) found that many words used in directions for aspirin-type drugs could be read only by people with 11th or 12th grade reading abilities. Some words which gave difficulty are commonly used in warning messages (accidental, contact, immediately, persists, conditions, consult, affecting).

Nonverbal Symbols

Collins et al. (1982) has also reviewed the literature with regard to nonverbal symbols. While noting that nonverbal symbols can be more effective than words, they are frequently misunderstood. Collins et al. (1982) reported on a study in which symbols were used to convey 33 messages relating to hazards in an industrial setting. The warnings were related to the use of protective gear, first aid and emergency room equipment, prohibited action, and exits. A great deal of variability was found, with 18 to 58% of the people correctly identifying some of the "no exit" symbols. In contrast to these dismal findings, Collins (1983) later studied 72 mine safety symbols conveying a total of 40 messages. He was able to show that 34 out of 40 messages were correctly interpreted by 85% of the miners. It is possible that the characteristics of the particular industrial group under study has a profound effect on the amount of motivation that goes into both warning awareness and compliance. Miners work in extremely hazardous environments, and this undoubtedly plays a major role in the findings.

Easterby and Hakiel (1981) tested approximately 4,000 consumers on all known symbols pertaining to fire, poison, caustic, electrical, and general hazards. The comprehension of the best signs was only 20% when a strict criterion was employed. With a lax criterion, comprehension increased to 50%.

Great variability in comprehension studies is common. Collins and Lerner (1982) evaluated 25 fire-safety signs and found symbol comprehension to vary between nearly zero to 100%. The comprehension of symbols used in automobile dash panels (19 pictographs) did no better with only 6 out of 19 meeting a criterion of 75% recognition (Green and Pew 1978).

A general finding of all of these studies is that as the symbols become more abstract, poorer recognition and poorer comprehension result. While there has been considerable work done to understand the primitive or perhaps innate basis for some symbols (Marcel and Barnard 1979), much more work is needed to establish a taxonomy of symbols which can be employed with any degree of precision (Smith 1981).

MODELING: COMPREHENSIVE ANALYSES

There is a constant stream of research activity that continues to be directed toward important issues of the safety-warning process. In addition to specific areas of concern such as comprehension and risk assessment, there appears to be an increased realization that developing effective warning systems is a complex, multidimensional problem, involving many aspects of human behavior, including attention, perception, memory, and motivation. In order to obtain a degree of order and overall understanding of this broad field, increasing use of psychologically based models of behavior have begun to be employed.

Information-Processing

Robinson (1981) seems to be one of the first to introduce a formal model to analyze accident causation. Viewing the human as an information processor, Robinson argues that a very high number of accidents can be related to human information-processing limitations. Robinson's analysis does not take into account the contribution that motivation (frustration, anxiety conflict, excitement, risk-taking) appears to have in exposure to hazards.

The information-processing model is extremely valuable because of its comprehensive nature. Figure 1 is from Robinson (1981) and serves to illustrate both the simplicity of the model as well as the capacity it has to encompass all of the elements discussed in this review.

Communications-Persuasion

Another model presented by McGuire (1980) is a mixture of information-processing modeling and communications theory. Using this communications-persuasion model, McGuire views the warning process in the following way:

The five basic components of a warning are as follows:

1. the source of the message
2. the message
3. the channel by which the message is transmitted
4. the receiver of the message
5. the destination or type of behavior that the message aims to foster

To attain the goals of the warning, the following outputs within the receiver of the message must be elicited:

1. The receiver must be exposed to the message
2. The receiver must attend to the message
3. The receiver must react effectively to the message by expressing interest, liking, etc.
4. The receiver must comprehend the contents of the message

5. The receiver must yield to the argument
6. The argument and agreement must be stored and retained within the receiver
7. Information search and retrieval must be performed when the message's information is pertinent
8. The receiver must decide on an appropriate action on the basis of the retrieval
9. The receiver must behave in accordance with his decision
10. The appropriate behavior must be attached in the receiver's mind to the potential accident scene

McGuire interrelates these factors within an input/output matrix, in which one axis is specified by the specific factors defined by communications theory and the other axis is specified by the stages of the information-processing model. The factors defined by communications theory comprise the inputs to the communications process, while the stages of the information-processing model comprise the outputs. This modeling approach provides an elegant description of the steps involved in any particular communication, however, it provides no insight into how the input and output factors interact nor does it provide a detailed description of the product and its relation to safety.

Comprehensive Modeling Approach

Lehto and Miller (1986) have recently produced an excellent text which addresses warning systems at an advanced level. The authors clearly articulate the need to employ models that serve to isolate and define the basic elements that underlie safety-related information. The authors argue that to adequately understand the issues, the basic elements and corresponding methods of analysis must be organized within a conceptual model. The development of a conceptual model requires a thorough knowledge of information-processing theory, as well as a synthesis of existing modeling approaches.

By viewing the warning process in the context of a comprehensive model, as suggested by Lehto and Miller, the following advantages accrue:

1. The diverse elements of many types of warning situations can be organized into general or common features at various levels of complexity and detail
2. A logical framework for how these elements interact or operate together at various levels can be established
3. Appropriate guidelines which will encompass all elements of the system under consideration can be developed

Warning Tree Model: An Evaluation Methodology

There are many critical research issues that must be addressed. Some have been described earlier in this report. One pressing need is to develop an evaluation methodology that measures the effectiveness of a given warning in terms of safety-related behavior rather than in terms of intervening measures such as recall, recognition, or comprehension. There has been no attempt to combine or in any other way organize existing research findings into behaviorally meaningful measures of effectiveness.

Lehto and Miller (1986) suggest that a warning tree model will serve to both demonstrate the level of complexity of the evaluation process as well as suggest an evaluation methodology which can serve this function.

The activity that takes place within the human when information is transmitted is quite complicated. Also, because of the repetitive nature of many tasks, particular activities can occur in complicated sequences. The abstract version of the warning tree model does not attempt to illustrate this complexity. Instead, it assumes that the activities that occur within the human are simply outputs elicited by a stimulus and that these outputs occur in a simple linear sequence after a warning message is presented (Lehto and Miller 1986).

Computer Analysis

At this point, the reader may begin to feel overwhelmed by the breadth of the problem and the level of complexity that must be achieved in even the simplest analysis of warning messages. There is a high-tech solution on the way to aid weary safety-design engineers. Lehto (1984) has begun the design of an artificial intelligence (AI) rule-based system that employs knowledge, engineering, and the application of expert-systems technology. Called the General Safety Ergonomics Model (GSEM), its ability to specify safety analysis for almost any product is one of its most important features. This is because the very general product and task analysis procedures within the GSEM can define product, human, environment, and task fact network diagrams for almost any foreseeable product and use. Ultimately, this system will be implemented on a microcomputer and will provide relatively unskilled people with the tools to perform very complex design and analyses of warning system applications.

CONCLUSIONS AND RECOMMENDATIONS

After conducting this survey, we can return to the question posed at the outset: Warning Signs: Why Do They Fail? What we have observed in the technical literature is a history of the use of warning signs that has been motivated by circumstances other than the need for effective safety engineering. A fundamental assumption about warning signs is that once consumers are informed of a hazard they will act in responsible ways. The research fails to support this assumption. People are not likely to attend to warnings nor are they likely to comprehend the warnings they do attend to. Furthermore, even when they are knowledgeable about the hazards, they may not comply with the warning due to conflicting motivations.

The value of current research in the safety-warning field lies in its systems approach, in which a comprehensive analysis of all aspects of the consumer's behavior is included in formulating and developing an effective warning system.

REFERENCES

American National Standards Institute. 1972. Specifications for accident prevention signs. (ANSI Z35.1) New York, NY, American National Standards Institute. Cited as ANSI.

Brems, D. J. 1986. Risk estimation for consumer products. In *Proceedings of the Human Factors Society* 30th Annual Meeting, Santa Monica, California.

Collins, A. M., and N. D. Lerner. 1982. Assessment of fire-safety symbols. *Hum. Factors* 24(1):75–84.

Collins, A. M., N. D. Lerner, and B. C. Pierman. 1982. Symbols For Industrial Safety. *NBSIR* 82-2485, Washington D.C., National Bureau of Standards.

Collins, B. L. 1983. Evaluation of mine-safety symbols. In *Proceedings of the Human Factors Society* 27th Annual Meeting, Santa Monica, California.

Consumer Product Safety Commission, National Electronic Injury Survey System. 1985. Cited as CPSC.

Dorris, A. L., and J. L. Purswell. 1977. Warnings and human behavior: Implications for the design of product warnings. *J. Prod. Liability* 1:255–264.

Easterby, R. S., and S. R. Hakiel. 1981. Field testing of consumer safety signs: The comprehension of pictorially presented messages. *Appl. Ergonomics* 12(3):143–152.

FMC. 1980. *Product Safety Sign and Label Systems*. 3rd ed. Santa Clara: California FMC Corp. Cited as FMC.

Godfrey, S. S., P. R. Rothstein, and K. P. Laughery. 1985. Warnings: Do they make a difference? In *Proceedings of the Human Factors Society* 29th Annual Meeting, Santa Monica, California.

Green, P., and R. W. Pew. 1978. Evaluating pictographic symbols: An automotive application. *Hum. Factors* 20(1):103.

Horst, D. P., G. E. McCarthy, J. N. Robinson, R. L. McCarthy, and S. Kromm-Scott. 1986. Safety information presentation: Factors influencing the potential for changing behavior. In *Proceedings of the Human Factors Society* 30th Annual Meeting, Santa Monica, California.

Kantowitz, B. H., and R. D. Sorkin. 1983. *Human Factors: Understanding People-System Relationships*. New York: John Wiley & Sons, Inc.

Karnes, E. W., and S. D. Leonard. 1986. Consumer product warnings: Reception and understanding of warning information by final users. In *Trends in Ergonomics/ Human Factors III*, ed. W. Karwowski. Amsterdam: Elsevier Science Publ. B.V.

Lehto, M. R. 1984. A structured methodology for expert system development with application to safety ergonomics. Ph.D. dissertation, University of Michigan, Ann Arbor, Michigan.

Lehto, M. R., and J. M. Miller. 1986. *Warnings: Fundamentals, Design, and Evaluation Methodologies*, Vol. 1. Fuller Technical Publications, Ann Arbor, Michigan.

Leonard, S. D., D. Mathews, and E. W. Karens. 1986. How does the population interpret warning signals? In *Proceedings of the Human Factors Society* 30th Annual Meeting, Santa Monica, California, pp. 116–120.

Marcel, T., and P. Barnard. 1979. Paragraphs of pictographs: The use of non-verbal instructions for equipment. In *Processing of Visible Language*, 1, ed. P. A. Kolers, M. E. Wrolstad, and H. Bouma, pp. 501–518. New York: Plenum Press.

Marinissen, A. H., F. M. Johan, K. Molenbroek, and M. Schoone-Harmsen. 1986. A secure way to safer products. In *Proceedings of the Human Factors Society* 30th Annual Meeting, Santa Monica, California.

McCarthy, R. L., J. P. Finnegan, S. Krumm-Scott, and G. Z. McCarthy. 1984. Product information presentation, user behavior, and safety. In *Proceedings of the Human Factors Society* 28th Annual Meeting, Santa Monica, California.

McGuire, W. J. 1980. The communication-persuasion model and health-risk labeling. In *Product Labeling and Health Risks*. Banbury Reports 6. Cold Spring Harbor Laboratory.

Pyrczak, F., and D. H. Roth. 1976. The readability of directions on non-prescription drugs. *J. Am. Pharm. Assoc.* NS 16(5):242–243.

Robinson, G. H. 1981. Human performance limitations and accidents. *Hazard Prev.* 17:12–23.

Smith, S. L. 1981. Letter size and legibility. In *Information Design: The Design and Evaluation of Signs and Printed Material*, ed. R. Easterby and H. Zwaga, pp. 171–186. Chichester: John Wiley & Sons.

Twerski, A. D., A. S. Weinstein, W. A. Donaher, and H. R. Piehler. 1976. The use and abuse of warnings in product liability: Design defect litigation comes of age. *Cornell Law Rev.* 61:495.

Ursic, M. 1984. The impact of safety warnings on perception and memory. *Human Factors* 26(6):677–682.