Contextual Considerations for the Development and Assessment of Product Warnings

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Abstract: This paper describes contextual factors that commonly influence and guide decisions about warnings, and the significance of these factors from a human factors and risk communication perspective. Individual warnings often appear within the context of a product's system of information, including such components as labels, manuals, training programs, technical support, service bulletins, websites, and other written or multimedia materials. In turn, the product's system of information is presented in a broader context of information provided by entities such as employers, dealers, training courses, regulatory agencies, and other product manufacturers. The information from these various sources is often influenced by standards, regulations, or other guidelines that address how an activity is performed, how hazards are to be controlled, and how or what information should be communicated by and to whom. These standards, regulations, and guidelines form frameworks for risk communication, which can be thought of as a basic structure for risk communication and/or hazard control that underlies how and when risk-related information is communicated. Considering the context in which a warning is provided, in terms of both systems of information and frameworks, is a useful part of the development and evaluation of warnings, and can be particularly important in dealing with human factors issues related to communication, such as limiting information load, noise, and false alarms. In contrast, ignoring context or going beyond or outside of established frameworks can undermine the benefits of the framework. The concepts described in this paper are useful for technical, legal, and regulatory personnel who participate in the development of warnings and the promulgation of standards and regulations about warnings, as well as for human factors and safety practitioners making and evaluating decisions about when and how to warn about different product hazards.

1. Introduction

Bringing a human-centered perspective to decisions about product warnings involves considering the context in which the information will be received. In particular, considering factors such as what information is expected to be conveyed about a particular hazard or activity, and how and by whom, can aid in the development of warnings that limit redundancy and information load, while complementing other sources of information. Some relevant contextual considerations have previously been addressed by Frantz, Rhoades, and Lehto (1999) in their description of a general process for designing and evaluating product warnings. This paper supplements that work by (1) more fully describing three common contextual considerations for the development and evaluation of warnings (warnings as part of a product's system of information, other sources of information available to the user, and relevant frameworks for risk communication), (2) providing a useful nomenclature for discussing these contextual considerations, and (3) providing a discussion of the human factors benefits of incorporating these contextual considerations into the warnings development process. In particular, this paper describes how considering these contextual factors can promote the development of warnings that limit redundancy, noise, and overall information load for the user, while also promoting consistency in how and by whom information about different hazards is conveyed.

2. Warnings as Part of a Product's System of Information

When developing or evaluating a particular product warning, it is useful to consider how the warning fits into the overall *system of information* provided by the manufacturer. The system of information might include such components as labels, manuals, training programs, technical support, service bulletins, websites, and other written or multimedia materials. Collectively, the components of a system of information can complement one another to achieve risk communication

objectives related to brevity, completeness, accuracy, and comprehensibility of warnings, even if all of these objectives are not achievable through a single medium. For example, while warning labels often contain limited information, more detailed information can often be found in other sources such as service manuals or Safety Data Sheets (SDSs). Widely recognized standards about product warnings incorporate this concept of a system of information (e.g., the Occupational Safety and Health Administration's [OSHA's] Hazard Communication Standard, the American National Standard for Hazardous Workplace Chemicals–Hazard Evaluation and Safety Data Sheet and Precautionary Labeling Preparation [ANSI Z400.1/Z129.1], and the American National Standards for Safety Signs and Colors [ANSI Z535 series]). Considering how a particular warning fits into the manufacturer's overall system of information can aid in decisions about what messages to provide and how to provide them, and can help to eliminate inconsistencies and excessive redundancies in information.

3. Other Sources of Information

Just as individual warnings are often part of a system of information provided by a manufacturer, a product's system of information is typically presented within a broader context of information provided by other entities such as other product manufacturers, employers, dealers, training courses, or regulatory agencies. For example, employer training and rules can be a significant source of information in occupational settings, as can warnings provided with other products involved in a particular task or activity, or training acquired while learning a trade. The availability of other sources of information has previously been identified as a relevant consideration in the development and evaluation of warnings (Frantz, Rhoades, & Lehto, 1999). In particular, it is often reasonable to limit information provided with a product if that information is expected to be available from other sources (e.g., a vehicle owner's manual does not recite all of the information presented in a driver's education course). As described below, *frameworks for risk communication* often set expectations for what information is going to be communicated by various sources.

4. Frameworks for Risk Communication

The various sources of information that are available to product users are often influenced by standards, regulations, or guidelines that address how an activity is to be performed, how hazards are to be controlled, and/or how or what information should be communicated by and to whom. These standards, regulations, and guidelines form *frameworks for risk communication*. Frameworks for risk communication can be thought of as a basic structure for risk communication and/or hazard control that underlies how and when risk-related information is communicated.

4.1 Examples of frameworks for risk communication

Some frameworks for risk communication are focused specifically on warnings and other risk communications. Examples of such frameworks include the regulations for consumer product labeling under the Federal Hazardous Substances Act, labeling regulations under OSHA's Hazard Communication Standard, or labeling standards like the American National Standard for Product Safety Signs and Labels (ANSI Z535.4).

Other frameworks for risk communication are focused on how hazards are to be controlled or how activities should be performed and may not specifically address warnings or other risk communications. Whether or not these frameworks specifically address warnings, they still influence risk communications by forming a context within which a particular activity or task is performed and by setting expectations for the types of information that are going to be provided by different sources. Consider, for example, the laws related to vehicle operation and licensure. Because of this framework, information provided in an owner's manual for a car or truck can be written with the expectation that drivers have the training and knowledge that is acquired during the licensure process, as well as the information available from local laws and road signage (e.g., speed limits, legal blood alcohol concentration [BAC] limit). While vehicle manuals might reference laws, they would not be expected to provide detailed information such as the speed at which to drive or the legal blood alcohol limit for operating a vehicle. This information comes from other sources that are influenced by the framework for risk communication that surrounds the activity of driving.

Examples of frameworks in occupational settings that focus primarily on hazard control are regulations related to the control of air contaminants (e.g., OSHA's Air Contaminants Standard, OSHA's Respiratory Protection Standard, OSHA's substance-specific standards). While these frameworks are not primarily focused on risk communication, they establish a context within which communications regarding air contaminants or respiratory protection would be received. For example, regulations might establish particular control measures that employers are required to implement including training, special work practices, or the use of respirators, and product warnings provided in these settings would be influenced by that context.

4.2 Common features of frameworks for risk communication

Frameworks addressing how hazards should be controlled or how activities should be performed generally do so from a number of perspectives, including laws, enforcement, and public health or workplace communications. To the extent that frameworks for risk communication specifically address warnings and other risk communications, they tend to include a number of common features. Generally, frameworks for risk communication:

- Designate sources and receivers of information (e.g., under OSHA's Hazard Communication Standard, the manufacturer or distributor provides an SDS to the employer, and the employer provides training to the employee)

- Designate channels through which messages are communicated (e.g., under OSHA's Hazard Communication Standard, certain messages are conveyed through labeling, and other information through a Safety Data Sheet [SDS])

- Designate thresholds for communicating information (e.g., current and historic OSHA regulations have included thresholds for when warnings about certain hazards must be provided)

- Standardize elements such as format, content (i.e., specific wording or symbols), and location of information (e.g., flammable vapor label standardization for water heaters), and designate thresholds for when certain elements should be used (e.g., regulations under FHSA include a threshold for when the word "poison" is used and when the skull and crossbones symbol is used; ANSI Z535.4 includes a threshold for when the signal word "Danger" should be used)

- Address risk communication within the context of other hazard control measures (e.g., National Highway Traffic Safety Administration [NHTSA] requirements for vehicle labeling are provided within the context of NHTSA requirements for vehicle design and laws related to vehicle operation; OSHA's substance-specific warning requirements occur within the context of regulations related to the control of the substance)

As will be described in the following section, these features bring order to risk communications and are generally beneficial to those disseminating and receiving risk communications.

4.3 Human factors benefits of frameworks for risk communication

The features of frameworks for risk communication described in Section 4.2 bring a number of human factors benefits to the risk communication process. In order to describe these benefits, it is helpful to consider the communication model proposed by Shannon and Weaver (1949) (see Figure 1), which has subsequently been used in the human factors literature to address risk communications (e.g., Lehto & Miller, 1986; Driver, 1987).

In this model, the primary entities involved in the communication process are "sources" and "receivers" of information, with receivers needing to distinguish between information of varying relevance ("signal" vs. "noise"). The method by which a message is transmitted and received is often referred to as a "channel."
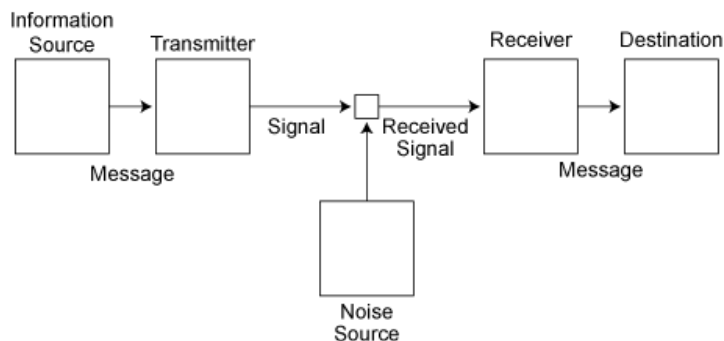

Figure 1: Model of Communication Adapted from Shannon and Weaver (1949).

By designating sources and receivers of information, and channels by which different messages should be communicated, frameworks for risk communication limit the information load placed on receivers and promote the provision of relevant messages from credible sources. For example, designating employers as a primary source of information to

employees allows for the provision of workplace-relevant information from a source that is proximate to workers, and has the ability to enforce workplace instructions. Such an approach greatly reduces the informational burden on employees, in contrast to a situation in which employees are tasked with filtering through information of varying relevance from numerous sources (e.g., occupational safety and health regulations, all manufacturer information for all products used in the workplace; see Young, Adams, and Shah, 2008 for further discussion). In addition to reducing the informational burden on receivers of information, standardizing the sources and channels through which certain types of messages are provided can also help those who are seeking information know where to look (e.g., employers know that chemical reactivity information can be found in an SDS and that OSHA regulations provide guidance on the control of air contaminants).

Similarly, by designating thresholds for communicating information, frameworks for risk communication limit information load while also reducing the potential for informational "noise" and false alarms. For example, providing information about potential low-level risks or suspected risks does not carry the same relevance as information about significant and established risks, and may be viewed as noise. Frameworks for risk communication often establish thresholds below which information about these types of risks should not be provided, thus limiting the potential for noise and false alarms. Research based in signal detection theory (Swets, Tanner, & Birdsall, 1961) supports the value of limiting noise. According to signal detection theory, persons receiving information varying in relevance (that is, the message may be either a valid signal or noise) will, after too many false alarms, shift their signal detection thresholds and begin to more frequently "miss" or fail to respond to truly relevant information (i.e., "signals" and not just "noise"). Specifically with respect to warning messages, acknowledged problems related to over-warning that have been reported in the literature include reduced attention to warnings generally, reduced attention to individual messages within warnings, reduced recall of certain warning messages, reduced credibility of warnings, and reduced ability to differentiate the relative magnitude of risks (Frantz, Rhoades, Young & Schiller, 1999).

By standardizing warning elements and designating thresholds for when particular elements should be used, frameworks for risk communication also bring a level of consistency to risk communications that allows for more meaningful communication. For example, indiscriminately applying words such as "danger" and "poison" on the labeling of hazardous substances would render these words meaningless. Standardized thresholds allow these words to maintain their meaning. By prescribing label location, frameworks for risk communication create a level of consistency that helps those seeking information to find it more easily (e.g., standardized locations for tire inflation pressure information and rollover warnings in passenger vehicles).

In addition to specific prescriptions for warnings and other risk communications found in frameworks for risk communication, it is important to note that these frameworks are often developed within the context of, and with consideration of, broader frameworks for how hazards should be controlled, how activities should be performed, and how other risks are communicated. Consider, for example, NHTSA regulations prescribing warnings in vehicle owner's manuals. Inherent in this framework are considerations of what information will be provided in other parts of the system of information (e.g., labels) and what information will be available to drivers from other sources. In this respect, considering a framework for warnings in a particular domain (e.g., vehicle owner's manuals) is one way of incorporating considerations related to the broader context of the activity and consideration of what information is expected to be available from other sources. As a result, considering frameworks for risk communication generally serves to limit the redundancy in information provided by different sources and helps to achieve consistency in messages within a given domain.

Providing information that is consistent with frameworks for risk communication is one way that those developing warnings and other risk communications can limit information load, noise, and false alarms while promoting the provision of relevant and meaningful information that complements information that is expected to be available from other sources.

4.4 Going "beyond" the framework

A question that might arise when consulting a framework during the development of a warning is whether there is more that should be done beyond providing information that is generally consistent with the framework. The answer to this question depends, in part, on what is meant by doing "more." Designations made by frameworks in terms of required text, thresholds for warning, and sources, channels, and receivers of information often represent a target rather than a minimum. If one views these designations as a suggested minimum to the point of disregarding the framework (e.g., saying "danger" whenever the framework calls for "warning"; warning below the threshold designated by the framework), then such attempts to do "more" can disrupt the order achieved by the framework, and can ultimately be damaging to risk communication.

An illustration of frameworks as a target can be found in frameworks surrounding alcoholic beverage warnings. Many countries currently have frameworks for risk communication surrounding alcohol consumption that include some form of mandatory or voluntary labeling of alcohol beverage containers. As shown in Table 1, the types of messages required vary by country, presumably reflecting the societal considerations of the individual countries. Additionally, countries have not generally taken the approach of including all potential messages, indicating a preference for warnings to be selective. The

United States, for example, considered addressing nine possible hazards before settling upon its current warning, which addresses four hazards (Kaskutas & Greenfield, 1991). Table 1 illustrates how a lack of selectivity in messages could pose the potential for information overload and noise, wherein the target messages judged to be most critical in a particular society could be "drowned out" by those that have been judged to be less relevant. While the alcohol beverage warnings shown in Table 1 do not attempt to inform users of all of the specific hazards, consequences, and risks associated with alcohol consumption, and generally do not target zero risk, they represent a target, not a minimum, for which messages should be provided.

Table 1: Example Alcohol Beverage Messages Mandated in Selected Countries (as of May 2015) (IARD, 2015).

Example Messages	Argentina	France	South Africa	Thailand	United States
"Drink in moderation."	X				
"Sale prohibited to persons under 18 years of age."	X				
"Drinking alcoholic beverages during pregnancy even in small quantities can have grave/serious consequences for the health of the baby." (or government-issued symbol)		Xs			
"Don't drink and walk on the road, you may be killed."			X		
"Alcohol increases your risk to personal injuries."			X		
"Alcohol is a major cause of violence and crime."			X		
"Alcohol is addictive."			X		
"Liquor drinking may cause less consciousness and death."				X	
"Liquor drinking is harmful to you and destroys your family."				X	
"According to the Surgeon General, women should not drink alcoholic beverages during pregnancy because of the risk of birth defects."					Xs
"Consumption of alcoholic beverages impairs your ability to drive a car or operate machinery, and may cause health problems."					Xs

X = similar concept not required by other countries in this table; Xs = similar concept required by some other countries in this table
Note: This table does not include all of the messages required in South Africa and Thailand.

4.5 Frameworks over time

As illustrated in the example of alcohol beverage warnings, frameworks for risk communication often reflect societal considerations (e.g., societal acceptance of different levels of risk, societal value placed on the performance of various activities, and accident/injury modalities that are prevalent in a given society). As a result, frameworks for risk communication not only vary from place to place, but also over time.

There has been an evolution over time both in frameworks that address how hazards should be controlled and how activities should be performed, as well as in frameworks that specifically address how risks should be communicated. Consider child occupant protection in vehicles in the United States as one example. Between the 1950s and the early 2000s, there was an evolution from having no seatbelts in cars, to the introduction of seatbelts in the mid-1960s, to the introduction of car seat laws (typically for children under 4 years/40 pounds) in the late 1970s through mid-1980s, to a NHTSA recommendation in 2000 for booster seats for children under 8 years/80 pounds, to a NHTSA recommendation in 2004 for booster seats for all children under 4'9." This is one example of a framework evolving over time, and it reflects, in part, an evolution of what was considered safe. There have been similar changes in other areas of transportation safety, such as the legal blood alcohol concentration (BAC) limit. In the state of Michigan, the legal limit was 0.15 in 1960, lowered to 0.10 in the early 1970s, and lowered to .08 in the early 2000s. Only recently has the National Transportation Safety Board (NTSB) proposed lowering the legal BAC limit to 0.05. A similar pattern is evident in occupational domains where there have been steadily increasing safeguards over the course of several decades. While the frameworks in the preceding examples do not necessarily address warnings or other risk communications explicitly, they establish a context within which such communications would be received (e.g., telling someone to put their 8-year-old child in a booster seat would have been received very differently in 1985 from how it would be today).

There have also been substantial changes over time to frameworks for risk communication that specifically address warnings and other risk communications. For example, the American National Standard for Product Safety Signs and Labels (ANSI Z535.4), which specifies formatting and colors for product warning labels, was not published until the 1990s. In occupational settings, changes in frameworks designating sources of information have resulted in manufacturers playing a larger role in communicating workplace-related information (e.g., through the introduction of OSHA's Hazard

Communication Standard in the mid-1980s). Thresholds for when to provide warnings have also changed, generally lowering over time, and effective in 2015, the framework for risk communication related to hazardous substances in the workplace was completely overhauled, requiring the use of signal words, pictograms, and specified text on labeling, where those elements had not previously been required.

It is natural for frameworks for risk communication to change over time due to a number of factors, including changes in what is considered safe by society. In some situations, those involved in the warnings development process might have a guess as to how a framework is going to change and might wish to revise warnings ahead of changes to the framework. However, as previously described, disregarding an existing framework can disrupt the order achieved by the framework and ultimately be damaging to risk communication.

5. Conclusions

Considering contextual factors is a useful part of the development and evaluation of warnings, and it can be particularly important in dealing with human factors issues related to communication. Frameworks for risk communication often set expectations, and are often based on expectations, of what information will be conveyed about a particular hazard or activity from various sources. As a result, considering frameworks for risk communication in the warnings development process is one method of incorporating considerations of applicable context and can yield benefits from a human factors and risk communication perspective. In particular, considering relevant frameworks promotes the development of warnings that limit redundancy, noise, and overall information load, promotes consistency in how and by whom information within a given domain is conveyed, and promotes the development of information that complements that available from other sources.

It is worth noting that the general process for designing and evaluating product warnings presented by Frantz, Rhoades, and Lehto (1999) includes activities that often take place in the development of risk communication frameworks (especially product-specific warnings frameworks). As a result, considering relevant frameworks for risk communication may also be a means of incorporating the considerations described by Frantz et al. into the warnings development process.

Overall, considering warnings in the context of a product's system of information, other sources of information available to the user, and relevant frameworks for risk communication can aid those involved in the warnings development process while promoting the development of communications that are beneficial to those seeking and receiving information.

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