CHAPTER TWO

Organizing Theoretical Framework: A Consolidated Communication-Human Information Processing (C-HIP) Model

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Much of this book is organized around a sequential or stage model of the warning process that incorporates aspects of two existing models: the communication and the human information processing frameworks. Processing begins with the presence of warning (or other) information. From communication theory, the model takes the concepts of source, channel, and receiver. From information processing theory, the model decomposes the receiver component into the stages of attention, comprehension, attitudes and beliefs, motivation, and behavior. The receiver must notice the information and understand it. The message must be consistent with the person's attitudes and beliefs, or sufficiently persuasive to change them and to motivate the person to carry out the directed behavior (i.e., comply with the warning). This model is useful in (a) organizing the substantial amount of warning-related research that has been generated in the last 15 or so years, and (b) pinpointing the reason or reasons why a specific warning failed to produce adequate levels of behavioral compliance. Although earlier models describe the information processing stages as an invariant linear sequence, this chapter puts forth the proposition that later stages can influence earlier stages through feedback loops, and that in some instances entire stages can be skipped.

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2.1 INTRODUCTION

When hazards are associated with products, equipment, and/or environments, steps must be taken to produce a system that will minimize injuries to people and damage to property. Chapter 1 by Laughery and Hammond describes several basic steps that should be carried out. These steps, in order of priority, are (a) eliminate the hazard through design changes or other modifications, (b) physically or procedurally guard against the hazard, and (c) warn those at risk about the hazard. Warnings, therefore, carry a heavy burden in situations where a hazard cannot be eliminated or adequately guarded at its source. Warnings are intended to keep people from engaging in unsafe behavior, and often this involves rerouting or stopping people from doing what they would otherwise do. The complexity and difficulty of modifying human behavior are substantial, but a considerable amount of psychological research shows that safety related behavior can be changed by warnings and that there are a number of factors that influence the success or failure (effectiveness) of warnings. In this chapter, we describe a model or theoretical framework for classifying and exploring the various factors influencing warning effectiveness. This chapter describes the model in general terms while subsequent chapters provide detailed discussions of each stage.

2.2 ORGANIZING THE LITERATURE

A considerable body of warning-related research has been reported in the last 15 years or so. This research has made use of a broad array of techniques and performance measures, and because of its diversity, organizing this work is a challenging task. We employ a hybrid or composite model involving multiple stages to help pull this literature together. This model combines the basic communication model with the human information processing framework. A representation of this communication-human information processing (C-HIP) model is shown in Figure 2.1.

From the communication model, C-HIP takes three major components: source, channel, and receiver. The first two of these components are reviewed in Chapter 5 by Cox and Chapter 6 by Mazis and Morris, respectively, and the third stage of the communication model, the receiver, is the connecting point for the human information processing model. In other words, the receiver stage of the communication model is the superordinate category that incorporates a number of information processing stages: attention/noticeability, comprehension and memory, attitudes and beliefs, motivation, and behavior. These stages are discussed in detail in Chapters 7 through 11. Although these two frameworks are fairly standard and derive from the well established disciplines of communications and cognitive psychology, we do not know of any theoretical treatment that has combined them into a single consolidated model.

It should be pointed out that existing, extensive research and theory associated with the two frameworks has produced many refinements. The model depicted in Figure 2.1 is somewhat simplified and idealized for heuristic purposes. For example, the model in the figure does not show the basic concept of 'noise' and how it affects the communication process. Noise (random changes to the message) can affect any of the stages and is an important element of the communication process. We did not include noise and other potential elements in the model because it would make the figure unnecessarily complex. We have chosen instead to address these nuances and refinements in the discussions of

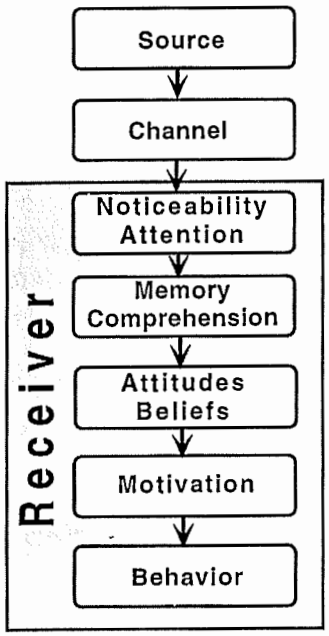

Figure 2.1 Communication-human information processing (C-HIP) model.

the specific stages of the model. For example, the effects of background noise coincident with auditory warnings and cluttered surroundings frequently associated with visual warnings is discussed in Chapter 7 by Wogalter and Leonard. Likewise, many details about human information processing are omitted from the figure but are discussed within the chapters. We believe the C-HIP model captures a broad range of relevant warning-related processes in a simple and straightforward representation, and it is useful in organizing the diverse factors that influence warning effectiveness.

2.3 THE C-HIP STAGES

In the following paragraphs, we offer a brief overview of each stage of the model. Also, these overviews provide a preview of the upcoming chapters (5–11).

The *source* is the originator or initial transmitter of hazard and risk information. Characteristics of the source influence the effectiveness of the warning. There are many possible sources, such as manufacturers, the federal government, nonprofit public service organizations, and industry trade organizations. The perceived credibility (or lack thereof) of the source may add to (or detract from) the impact of the message. Because there is so little source-related research in the warnings domain, Cox in Chapter 5 extracts theory and research from the communication and social-persuasion literatures in discussing potentially relevant factors such as expertise, likeability and trustworthiness, among others.

The *channel* concerns the way the message is transmitted from the source to receivers. Warnings can be transmitted through one or more sensory modalities: visual, auditory, kinesthetic, olfactory, and so forth. The channel also involves the media used to present the material. Depending on the medium, more than one sensory modality might be

involved. A video warning, for example, could relay information to both the auditory (nonverbal alarms, speech) and visual (alphanumeric text, pictorials) senses. Each of the senses has its own characteristics that could be considered to be beneficial or disadvantageous depending on the message, the environment, and tasks involved. In other words, different media might be more or less effective in different situations. Long complex messages are not conveyed well via the auditory channel because they may overwhelm attentional capacity and memory. Long warning messages are not a good idea in the first place but, if used, they can be conveyed more effectively through the visual print medium (assuming attention is given to them). Short, easy-to-understand messages are quite effectively conveyed by voice. Mazis and Morris in Chapter 6 discuss these issues using research from both the warning and non-warning domains.

The next group of chapters focuses on the processes that occur within the receiver. A sequence of mental operations starts with the information's arrival at the senses. The receiver's first operation is *attention*. Wogalter and Leonard in Chapter 7 discuss the factors important for capturing and maintaining attention, which include the characteristics of the message itself and its immediate surroundings. Context or background factors are important because they enable the warning to stand out (i.e., be salient, prominent, conspicuous). In addition to the composition of the warning itself, other situational or environmental variables can influence *noticeability*, including physical location, stress level, and ambient noise conditions, among others. Once attention is captured, it needs to be maintained to extract information. Factors that facilitate the maintenance of attention include legibility and brevity.

The next processing stage is *comprehension and memory*. Chapter 8 by Leonard, Otani and Wogalter describes the factors that facilitate understanding and retention of warning messages. Issues such as whether warning message text and pictorial symbols can be understood by the targeted group are examined. Strategies that can be useful in developing prototype warnings are described. Comprehension testing as a necessary step in the development of warning messages is emphasized. In addition, factors that influence comprehension, including storage and retrieval of warnings from memory are presented.

The next two stages of the model are *attitudes and beliefs* (Chapter 9) and *motivation* (Chapter 10). These two chapters, discussed by DeJoy, describe various potentially relevant individual-differences factors. Research on the highly influential factors of perceived hazard and familiarity is described. The motivation chapter describes factors that energize users to comply with warnings, and these include cost of compliance, explicit consequences, and anticipated injury severity.

The last stage is *behavior*. Correct, safe behavior is the ultimate desired outcome. Silver and Braun in Chapter 11 review the factors that have been shown to influence behavioral intention and compliance, both positively and negatively.

2.4 BOTTLENECKS AT THE STAGES

At the outset of this chapter, we noted that other kinds of hazard control techniques are preferred over warnings. If the hazard can be eliminated or guarded, then these measures ought to be incorporated into the system before warnings are considered. Generally, these more direct control strategies are more reliable than warnings in preventing harm. Warnings are best used to handle residual risk, or that which remains after reasonable design and engineering measures have been taken. Warnings are inherently less reliable because of inherent limitations and complexities of human beings.

Another major purpose of the C-HIP model is that it helps to identify potential points of failure. The model can help explain how a warning message might fail to promote safe behavior. Before safe behavior can occur, the warning information must pass through several points or stages. This path is traced by the linear route from the source stage to the behavior stage as shown by the downward arrows in Figure 2.1.

Ignoring feedback for a moment, for a warning to be effective in influencing behavior, information must pass through each of the preceding stages. In a nutshell, the process starts with the warning information moving from the source through some channel to arrive at the receiver. The receiver must then notice and attend to the warning. Once it has been attended to, it must be understood, and the information must, in turn, be consistent with the person's attitudes and beliefs. Motivation is the last stage before behavior is achieved. Sufficient motivation must be present or induced to produce the appropriate behavior.

As described thus far, the C-HIP model proceeds in a linear, temporal sequence. However, each stage of the model is a potential 'bottleneck' that could prevent the process from being completed. If the source does not communicate a warning about a hazard, then clearly, persons at risk will not receive the information and there will be no subsequent behavior change (assuming there are no other opportunities to acquire information about the hazard from other sources). Even if the source attempts to convey a warning, the warning could be ineffective if the channel used to transmit the message is inappropriate or inadequate. Again, hazard information transmitted but not received produces little or no processing in persons at risk. Suppose the source does transmit the warning information and it moves successfully through one or more appropriate channels. The warning could be unsuccessful if the receiver does not attend to it. This end result is the same as a warning that was never transmitted by the source or one that was sent using an inappropriate channel. As a consequence, the information will not move forward to any subsequent information processing stages in the receiver.

To be effective, a warning needs to capture and maintain attention. But even if the warning is attended to, it may not be effective if the message is not understood. Merely examining and reading the warning does not necessarily mean that people comprehend it. People must understand the meaning of the printed words and symbols (i.e., properly interpret the printed language and graphics) comprising the message. Of course, we are assuming that the basic content of the warning message itself is adequate for the task at hand. However, even if the information is understood, the process will go no further if the message does not fit with the person's current beliefs and attitudes. For processing to continue in the face of antagonistic attitudes and beliefs, the warning itself must be sufficiently persuasive to change or overcome those beliefs and attitudes. Failing this, the processing stops prematurely before behavior change. But even if the person believes the message, the message still may be inadequate if it does not motivate or energize the user to perform the appropriate safe actions.

Thus, the C-HIP model shows that each stage in the sequence is a potential bottleneck that could cause processing to stop, thus hindering the warning from ultimately modifying behavior. Chapters 5–11 describe in greater detail the factors that influence warning effectiveness both positively and negatively at each stage of the model.

2.5 MODEL AS AN INVESTIGATIVE TOOL

The C-HIP model is useful also as an investigative or diagnostic tool for discovering why a particular warning does not fulfill the goal of promoting safe behavior. For example,

when a warning for some consumer product, piece of industrial equipment, or hazardous environment fails to produce adequate levels of safe behavior, it could be that it lacks sufficient salience (i.e., it fails to be noticed and attended to). One solution might be to add or change features that increase the warning's conspicuousness. The warning might also have failed because people did not understand it. Making the warning more understandable to the target audience might remedy the low compliance rate.

The model can help differentiate which of the stages is causing a bottleneck. For example, it might be noted by a manufacturer that a warning is failing to influence behavior. The manufacturer might assume that the failure is due to a lack of warning conspicuousness resulting in a decision to enhance its prominence. However, this change might not solve the problem. Using measurements assessing attention to the warning, it might be found that virtually all people noticed the warning (so therefore the lack of conspicuousness is not the root of the problem), but rather the warning failed because people did not understand the message. Another example is that people might see and understand the message (as assessed by attention and comprehension measures), but just do not believe the message. Through systematic testing one can find out why a warning is not working. Thus the C-HIP model provides a framework for systematically analyzing why a particular warning application failed to produce its intended effects.

Typically, after a warning is found not to work in the field, most attempts to remedy the problem involve either adding prominence-type features or altering the content of the warning message. These particular fixes will be helpful only to the extent that the limited effectiveness is related to the warning not being noticed or to some critical piece of information not being present. However, as noted above, it is possible that the warning is adequate in terms of both salience and comprehension, and the reason for the low rate of compliance is traceable to discordant attitudes and beliefs with respect to the message being conveyed or inadequate motivation to carry out the directed behavior. In such cases, the obstacle is at the beliefs and attitudes stage or the motivation stage. For example, a person may ignore or discount the warning message because they believe that it does not apply to them personally. This perception might arise from being highly familiar with the task, activity, or environment in question and confident that any related hazards pose very little personal risk. When such discordances in beliefs and attitudes exist, the warning needs to be sufficiently persuasive to convince these individuals to take note of and heed the warning.

Finally, a warning may be physically apparent, understandable, and consistent with beliefs and attitudes, but it still might not be behaviorally effective if it does not motivate people to exert the effort to comply with it. In such situations, the warning might be inadequate in terms of conveying how badly they could be hurt or the effort required to comply may be greater than people are willing to expend in this particular situation. Beliefs or expectations about threat provide much of the initial motivation for compliance, but compliance might ultimately be a cost–benefit decision, in which the benefits of compliance (typically injury prevention) are weighed against the costs or barriers associated with performing the indicated precautions.

Thus, the model can help pinpoint the reasons for the failure of a warning to produce the desired end result: safe behavior. This model can be particularly useful in applied settings where determining the cause of the failure and then rectifying it needs to be targeted precisely and cost-effectively. With knowledge of the factors that influence each stage of the model, and a little detective work, the model can be used retroactively to diagnose and remedy failures. It can also be used proactively to guide the design of new warnings.

2.6 FEEDBACK PROCESSES: INFLUENCE OF LATER STAGES ON EARLIER STAGES

Up to this point, we have described warning information as flowing through a linear sequence of stages. Original conceptions of the warning process have advanced the simplistic view that for warnings to influence behavior the information must go successfully through each of the stages. For the most part, this early version of the model was a logical perspective. In order to read a product label, the person needs to have noticed it in the first place. To understand and remember the warning, one must have examined (read) it. In other words, certain types of processing must logically occur before others. Indeed there is early research (e.g., Strawbridge, 1986; Friedmann, 1988; Otsubo, 1988) reviewed by DeJoy (1989) that shows systematic declines in the percentage of people seeing the warning, reading and remembering the warning, and behaviorally complying with the warning. These results support the simple, linear model with bottlenecks. The decrements are caused by processing being impeded at different stages, which decreases the percentage of people who ultimately comply with the warning. While this model appears to concur with some data, the simple, linear conception of the warning process is almost certainly not true for several reasons.

First, some of the data used to support the simple linear model may not have measured what they purported to measure. Although behavioral compliance and memory were measured objectively in the above cited studies, the measures of seeing and reading the warning were derived from data collected by post-task questionnaires. Post-experimental questionnaires such as these can sometimes be inaccurate in reflecting what actually occurred during exposure to the warning. Did people who said they saw and/or read the warning really do so? Extraneous factors such as participants' interpretation of the questions, whether they actually can remember what they did and when they did it, social desirability, and other demand characteristics can all affect how people answer the questions. Objective measures such as eye movement recording or looking behavior would provide more objective assessments of seeing and reading behavior. With objective measures of performance, we would be more confident of these stage-related decrements, and would have a firmer handle on what actually occurred once the research participants were exposed to the warning.

A second problem with the simple linear model is that it assumes that the perceptual and cognitive processing of warnings occurs within a single (or short duration) point in time upon initial exposure. The individual was essentially viewed as a passive recipient of the warning. We take a broader and more interactive view of the processing that occurs, including the fact that people have different levels of preexisting knowledge and experience. Prior to being exposed to a particular warning, people may have varying levels of familiarity with the tasks and environment involved and may have been exposed to information related to the hazard from multiple sources. These factors (and others) enter into the equation of the warning process, and consequently make it more complex than the simple linear model would suggest.

A third problem with the simple linear model is that later stages can influence how warning information is processed at earlier stages. This is illustrated in Figure 2.2 by the arrows pointing back from the later stages to the earlier stages of the model. These pathways are feedback loops. These additions to the model are related to the second problem cited above—that people's preexisting knowledge and experience often influence how warning information is processed at a given point in time. Two examples of this feedback mechanism will serve to illustrate this. First, repeated exposure to a particular

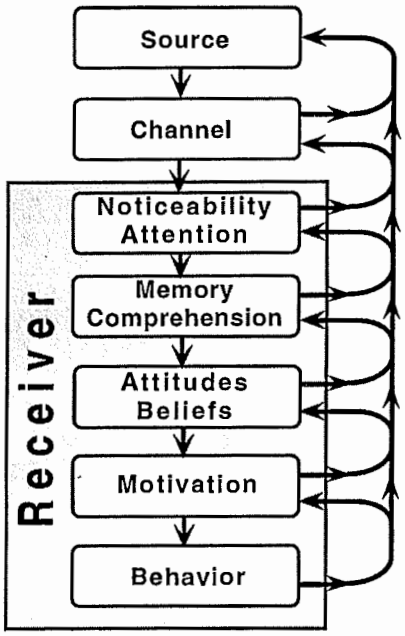

Figure 2.2 Communication-human information processing (C-HIP) model with feedback loops illustrating that later stages influence earlier stages.

warning creates memory. With enough exposure, the warning stimulus becomes habituated, and this reduces the likelihood that a person will look at the warning in the future. Here, preexisting knowledge affects attention or, in other words, a later stage (comprehension and memory) influences processing of an earlier stage (attention). A second example of feedback concerns the effects of beliefs and attitudes on attention. Individuals who assume something is safe may not look for a warning. Even if they notice one, they may not examine it further. Here again, preexisting knowledge, a later stage, influences attention, an earlier stage of processing. Although we have noted only two examples on how later stages of processing affect earlier stages, we believe that all of the stages probably influence each other. The major point is that in most instances the information flow through the model's stages is neither simple nor linear.

2.7 BYPASSING STAGES

The simple linear model is limited also in that it requires the warning information to be processed at each stage before compliance is achieved. It is possible that not all of the stages are needed for safe behavior to occur. As we noted in the above section, people have different levels of preexisting knowledge about the hazard and the warning material. They might have heard about the hazard in the media or from their work supervisor prior to coming into contact with a particular warning. For someone who has some knowledge of the hazard and/or the warning message, the warning stimulus itself might serve simply as a timely cue that elicits safe behavior without going through much further processing. That is, complete processing of the warning is not necessary to produce the desired end result. For example, highly knowledgeable individuals might only need to catch a glimpse of a pictorial symbol (and no other parts of the warning) and know what they need to do.

This is true for a sign containing a directional arrow on the roadway or 'slippery when wet' self-standing floor placard. In the first case, you go in the direction that the arrow is pointing and in the other case you avoid the area. While there may be printed material on the sign accompanying the pictorial symbol, one does not have to read it, or read it completely, to know what to do. Therefore, in some situations some people might not fully examine a warning but still engage in the safe behavior. This analysis also suggests the possibility that the actual rate of compliance with a warning could be greater than the number of people who actually read the warning. Thus the 'funneling down' process suggested by the traditional linear model may not always occur.

2.8 SUMMARY AND IMPLICATIONS

This chapter has provided a brief overview of the C-HIP model. The model is useful in organizing the diverse warnings research literature that will be described in more detail in Chapters 5 through 11. We have shown how the model is useful in determining why a warning might fail to achieve the goal of changing behavior, and how cost-effective corrections may be made by pinpointing the stage(s) where the compliance process breaks down. We have also described some of the problems and limitations of the simple linear model, specifically that later stages might affect earlier stages of processing and that some stages might be skipped altogether. Although the chapters are organized around the basic or traditional model, it will become obvious that the processes involved are complex and that the model displayed in Figure 2.1 provides only a simplified heuristic view of the warning process. Nevertheless, we believe the linear model possesses many positive aspects. Among them is that it provides a useful tool for organizing the literature, for making predictions about effectiveness, and for tracking down why a warning has failed to influence behavior.

REFERENCES

DEJOY, D.M. (1989) Consumer product warnings: review and analysis of effectiveness research. In *Proceedings of the Human Factors Society 33rd Annual Meeting*. Santa Monica, CA: Human Factors Society, pp. 936–940.

FRIEDMANN, K. (1988) The effect of adding symbols to written warning labels on user behavior and recall. *Human Factors*, 30, 507–515.

OTSUBO, S.M. (1988) A behavioral study of warning labels for consumer products: perceived danger and use of pictographs. In *Proceedings of the Human Factors Society 32nd Annual Meeting*. Santa Monica, CA: Human Factors Society, pp. 536–540.

STRAWBRIDGE, J.A. (1986) The influence of position, highlighting, and imbedding on warning effectiveness. In *Proceedings of the Human Factors Society 30th Annual Meeting*. Santa Monica, CA: Human Factors Society, pp. 716–720.