3

Communication-Human Information Processing (C-HIP) Model

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CONTENTS

Warnings are used to communicate important hazard information to consumers so as to avoid injury or property damage (e.g., Laughery & Wogalter, 2006; Wogalter, Laughery, & Mayhorn, 2012). Typically, this information is visually displayed as a label with text and/or graphics (e.g., pictorial symbols) adhered to a product or a container, but it can also be in the form of inserts, product manuals, or on signs and placards, etc. for environmental and facility hazards (Conzola & Wogalter, 2001). The format and content of warnings are critical. Generally, research indicates that warnings are usually more effective if they contain certain kinds of content, such as giving the nature of the hazard, instructions on how to avoid the hazard, and an indication of the potential severity of consequences if the hazard is not avoided (e.g., Rogers, Lamson, & Rousseau, 2000; Wogalter et al., 1987). Furthermore, warnings need to be noticeable, legible, understandable, memorable, believable, and motivating to facilitate goals of comprehension and compliance behavior. This chapter primarily focuses on a model that gives a general description of how consumer product warnings may be processed. While the focus is on consumer product warnings, similar principles apply to signs and other kinds of warnings for environmental and facility hazards. The principles can also be extended to risk disclosures such as informed consent forms, credit card terms,

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and software licenses (Wogalter, Howe, Sifuentes, & Luginbuhl, 1999). Moreover, similar principles apply to warnings presented in other modalities as well (Cohen, Cohen, Mendat, & Wogalter, 2006). This chapter mainly focuses on visual warnings, but relevant differences in the early processing of auditory information are mentioned where they have the most relevance. Later, more internal processing tends to be modality independent.

The purpose of this chapter is to describe the Communication-Human Information Processing (C-HIP) model more completely than it is described in other chapters. Some chapters discuss it in more detail than others and occasionally, its mention is absent. Sometimes an earlier, simpler version of C-HIP is used in the case studies' HFE analyses. Some authors used the larger model, whereas others invoked only some of the stages, usually because only parts were relevant to the particular case study. This chapter's stand-alone description of the C-HIP could be useful as a reference point when chapters cite the model but do not explain it fully. In those cases, this chapter serves as a way to fill in or bridge gaps. This chapter also serves the purpose of updating the model.

Communication-Human Information Processing (C-HIP) Model

As described in Chapter 2 (Wogalter, 2019), when design and guarding do not control all hazards of a product (or environment or situation), warnings are usually needed. Warnings are intended to influence people and serve as an important means of hazard control. Because of their relevance in this hazard-control role, it is important to describe the processes that may occur. A model is described that combines the basic stages of a communication model (source, channel, and receiver) with human information processing approach (Wogalter, 2006; Wogalter, DeJoy, & Laughery, 1999).

The current C-HIP model (circa 2019) that is discussed in this chapter is shown in Figure 3.1. Initially, it will be described as a linear, sequential process in which warning information should successfully (and metaphorically) flow from the beginning to the end, from the source to behavior and the stages in between. This process is represented by the straight arrows going from the top to the bottom stages. "Bottlenecks" in the process of moving down the stages can result in warning failures. Bottlenecks can happen at any stage preventing further processing and reducing warning-effectiveness outcomes.

The complete C-HIP model is more complicated than the above-described linear, sequential-stages version. The more complex version is shown in Figure 3.1. It includes curved arrows going in the reverse direction to represent feedback loops (shown on the right side of the figure) showing that later stages can influence processing at earlier stages.

The C-HIP model presented in this chapter is somewhat different than previously presented (cf. Wogalter, 2006a; Wogalter et al. 1999). The main differences are in the Attention Switch, Attention Maintenance, and Comprehension/Memory stages. In the earliest versions of the C-HIP model, there was only one Attention stage, although later, the subparts of Switch and Maintenance have been distinguished in the accompanying text (e.g., Laughery, & Wogalter, 1997; Wogalter, & Laughery, 1996). Not only does the current version distinguish these two attention stages as distinct processes, but they are now described in relation to other models and theories of attention in the perception, cognition, and human factors research and theory literatures. For example, Attention Switch is described as a mechanism of continuous processing in which attention is switched to the most salient incoming external information (stimuli) or to internally

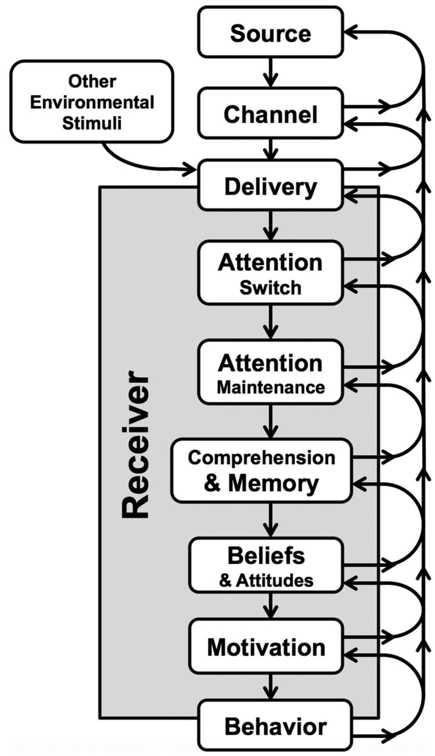

FIGURE 3.1
Communication-Human Information Processing (C-HIP) Model.

generated information from memory that is looped through the attention switch "mechanism." The other stage of attention in the C-HIP model, Attention Maintenance, is the mechanism where attention is held (focused on something over time) onto a stimulus such as warning so that adequate hazard information may be acquired (Wogalter, 2006b). It is also a limited capacity process. In its most basic form, it is "unstructured" energy. The basic idea is that when this unstructured energy is combined with information, it becomes "structured" energy. More about these processes are given in the model's Attention Switch and Maintenance sections.

C-HIP Model

Starting from the top of Figure 3.1, the stages of the C-HIP model are described in separate sections below. As mentioned above, the model is most simply and conveniently described as a linear model from top to bottom in the figure, and this is how it will be described in this chapter. However, at some points in this description, a few of the most relevant feedback influences of later stages on earlier stages will be mentioned.

Source

The source is an entity that transmits the warning. It could be a government agency, a manufacturer, importer, trade group, or a particular person. Generally, the source is considered to have superior knowledge and is usually assumed to have some credibility although sometimes not (Wogalter, & Mayhorn, 2008). The source determines the necessity for a warning, which should be derived through the use of hazard analysis, industry standards, consumer reporting, basic physics or chemistry principles, or legal requirements (e.g., Young, Frantz, & Rhoades, 2006). Some main considerations in the collection of data and decision making are described in Chapter 2 in this volume (Wogalter, 2019). From this information, the source determines what content of warning is needed (Cox, 1999; Cox, & Wogalter, 2006).

Channel

Warnings can usually be given in multiple ways, including on-product labels or embossments, inserts, manuals, web pages, etc. They can be given visually (e.g., in a printed label), auditorily, or through other sensory modalities. Within a given sensory modality, there are multiple ways of providing a warning, for example, on-product label, product manual, or information sheet enclosed with the product. The multiple modes and methods of dissemination are together called the warning system (Laughery, & Hammond, 1999). Generally, providing information in more than one form (format and/or modality) is better than a single form, as it has the potential to reach more people in more situations with greater impact (for reviews, see Cohen et al., 2006; Mazis, & Morris, 1999).

Delivery

Effective warnings need to reach the target audience that may be affected by the hazard. Warnings can be sent out by a source through one or more channels, but *never* succeed at arriving to relevant at-risk persons (Wogalter, 2006b). For example, a company could print thousands of brochures that include important warnings, but if those brochures are never distributed, they will not reach relevant persons such as end users at risk, resulting in those brochures having little utility. Another related point is worth mentioning. Different warning materials and methods may reach people at different points of contact with the product. For example, the outside label of a nonprescription medication is available for examination at the point of purchase, but not after the first use because external packaging is usually discarded (Cheatham, & Wogalter, 2002). Another example is warnings in public service announcements (PSAs) that are only broadcast between three and four in the morning. These will not have much impact on people not tuned in at the time. As mentioned in the Channel stage of the model, delivery likelihood is greater with more than one presentation method (Cohen et al., 2006).

Environmental Stimuli

People behave in environments with many things that could be potentially looked at, including other people, other aspects of the environment, the task that they are performing, and, sometimes, other warnings. These other sources of information compete with a particular warning for attention. A warning with a high level of salience (prominence or conspicuousness) makes it more likely that a warning will be attended to rather than other things. Salience depends somewhat on the recipient (a topic discussed later) and the environmental context. A warning might be salient in one environment and not in another. Commonly, the color red is recommended for warnings about dangerous hazards. Red can be salient in environments where different colors are used, but that same red warning in a largely red environment is likely to have relatively low salience (Wogalter, Mayhorn, & Zielinska, 2015; Zielinska, Mayhorn, & Wogalter, 2017). The effect of salience is discussed in more detail within the Attention Switch stage.

Receiver

While people have many characteristics in common, they also differ in numerous characteristics (Young, Laughery, Wogalter, & Lovvoll, 1999). Generally it is desirable to reach as many persons at risk as possible. Some of the persons at risk may have particular differences that require certain enhanced characteristics of warnings that others may not need. For example, older adults may not be able to read warnings in very small print or in low illumination, yet these characteristics generally do not present a problem for younger adults (Mayhorn, 2005; Wogalter, & Vigilante, 2003). Designing a warning for a product that only physically- and cognitively-able military personnel will use is different than designing a warning for a similar product that older adults with perceptual, cognitive and physical declines may use. Likewise warnings for medical devices that would be used only by trained, sophisticated healthcare professionals can be different than if those devices are used at home by lesser- or untrained caretakers. The wide range of skills and abilities in the general population usually means designing warnings for the lowest denominator of capabilities (or having the greatest limitations), inasmuch as feasible, so as to maximize its reach to more at risk persons.

Attention Switch

Attention switch is the process where a person moves, changes, or switches his/her attention *to* something such as a warning *from* something else (Wogalter, & Vigilante, 2006). It is associated with the concepts of salience (conspicuousness or prominence), noticeability, and attention gathering. Salient features benefit attention switch and are associated with larger size, high contrast, distinguishing color, relative distinctiveness, apparent movement, and other kinds of stimulus change. Graphics such as symbols (Mayhorn, Wogalter, & Laughery, 2015) can also help promote attention switch.

Earlier, it was discussed that whether or not a feature is salient depends on its environmental context, using color as the featured example. Another related concept is location or placement of the warning. A well-designed warning that is out of view is less likely to be "delivered" to a receiver and so it is unlikely to be effective. In general, the warning should be viewable when and where it is needed. Placed too close to the hazard (in terms of time and placement), a warning might be insufficient for hazard avoidance. Placed too distant from the hazard could result in a reduction of memory of the warning resulting in adverse impacts.

Attention is less likely to be switched to already well-examined ("habituated") stimuli where memory structure has already been formed from prior processing. This is discussed later in the Memory/Comprehension stage, as well as at a later point in the context of feedback loops.

In general, attention switch is directed to the most salient information at a given time. Processing of a warning competes with other ongoing task processing, including current and immediately upcoming processing. Thus, if the warning is highly salient, it will be more likely to cause a switch to it. A warning in an environment that has many "eye-catching" stimuli may not be looked at; yet the same warning appearing in a bland milquetoast context might be. If the warnings lack salience relative to other things in the environment (or other internal processing), then it will be less likely to cause a switch to itself. It also competes with other tasks the person may be doing including the continuation of an on-going task and non-stimulus-based internal processing of information. If these other kinds of processing are more salient than the warning, then the warning may not break into task processing until some later point (and in some circumstances may never do so).

How does attention switch to the most salient information, or in other words, how is the switch process conducted? In vision (with external stimuli), attention switch is "movement" from a foveal fixation on some stimulus to another stimulus sometimes outside the central visual field (retina's macular region). To be able to switch reasonably reliably (and it is not perfect), there is some peripheral pre-processing to determine probable importance or salience according perceptual features. This peripheral pre-processing enables some degree of determination of the relative salience of stimuli so that saccadic eye movements can be moved appropriately. To some extent, this kind of eye movement is reflexive and involuntary with its ability arising in part by built-in biological, developmental, and maturational epigenesis. In other words, certain stimuli have high salience because of their physical features, for example, big, colorful, high-contrast font for which the visual system is tuned to. This is not the whole story, however. Other significant things (salience produced by interest and based on prior processing and memory) can affect attentional focus and eye movements. Continuation of a task being run to completion can absorb attention and serve as a barrier. While some attention switch is reflexive and mostly involuntary, some of it is voluntary where attention is purposely focused on something or is part of continued information processing, such as search. This kind of salience is discussed in greater detail in later stages (Comprehension & Memory, Beliefs & Attitudes) in this chapter. Its effect here arises from feedback from a later stage to an earlier stage (attention switch). Generally, the most salient stimulus or process wins out and gets focused attention. Again, an important note to consider here is that there is not only competition between incoming external stimuli (e.g., other visual stimuli versus a particular warning), but also with internally-generated information processing such as search or other continuing tasks (which in itself is a form of salience). All of these drive what is done during ongoing processing. Thus, external incoming stimuli and internally generated stimuli are in competition with each other for attention switch.

A related factor in attention switch processing is distraction. Distraction occurs when other stimuli (generally, incoming external information) are more (sometimes substantially more) salient than the warning information. In effect, it pulls attention away from something like a warning toward the processing of something else. Thus, distraction caused by other salient things and tasks can reduce the likelihood that attention will switch to the warning.

Salience is relativistic and changes; it fluctuates over time and in its context. More about this process will be described in the next section.

Attention Maintenance

After switching to a warning stimulus, attention must be maintained for some length of time so that adequate information is acquired from it. The purpose of doing this is, of course, to stay safe and avoid the hazard. Physical characteristics of the warning stimulus itself and its surrounding context affect the ability to extract information from a warning stimulus. Some of the main factors enabling maintenance attention include having (a) adequate print size (not extremely small or large), (b) high contrast, and (c) distinguishable important/relevant details so as to enable the person to read or see the warning. Other factors include brevity, white space, and relatively low detail density. These physical characteristics enable information extraction.

Consider additional aspects that can have negative effects on (i.e., hurt) attention maintenance. Most are the opposite of those that benefit it. For vision, physical aspects that can reduce legibility include: small height or horizontally-compressed font (or in the case of symbols, where relevant determinative details cannot be seen easily), all uppercase print (mixed case print of the same spatial footprint is better), low contrast (figure to ground), high detail density, lengthy text, difficult to understand material that is technical, complex or provided in a language the user does not understand. Sometimes, poor legibility can result from environmental factors and exposure such as an abraded, faded, or aged label that has rendered the warning different and worse than the original.

For auditorily presented information, attention maintenances is reduced by unintelligible (or low intelligible) information such as low amplitude (i.e., low loudness), a high level of similar-frequency background noise like the warning signal (i.e., low signal to noise ratio), very fast (e.g., compressed), or very slow speech. Like with vision, there are other characteristics of the material (which interplay with later stages) such as message complexity, lengthy duration, and presentation in a language that is not understood.

The warning needs to be "attractive," and interesting enough so that people will stick with it long enough to extract adequate information from the warning to stay safe instead of switching attention prematurely to other information. The reason for the need for attractiveness/interestingness to keep attention on the material is that the warning competes with other stimuli and processes or tasks that the person may be doing that might pull attention away from the warning prematurely through the attention switch mechanism discussed earlier.

Good design would make it more likely that information is acquired quickly and adequately during the time attention is maintained on the warning so that negative outcomes are avoided. This ties in and relates directly to the next stage of processing.

Memory/Comprehension

While attention is being maintained on the warning, other processes can occur concurrently, including memory formation and comprehension. During the maintenance attention, encoding of the material may occur, or in other words, information may be acquired and new memory formed. If the material is highly technical and the individual does not have pre-existing knowledge of the subject matter then they are not going to get much out of it and will move on (i.e., switch attention) to something else. Another example is when the language used in a warning is not the language that the individual understands; if so, then only partial or no information may be acquired. Additionally, in the opposite sense, if the information is already known by the individual then not much new information will be acquired. With both extremes, the individual after a short time will not hold or maintain attention to material. The information needs to be assimilable with the person's existing knowledge. Information already known is perfectly assimilable and its reappearance can potentially trigger that information in memory and activate other memory and knowledge that is related to it (i.e., provide a cue to existing knowledge). Information that is not possible to accommodate easily without considerable time and effort will be less likely to hold attention. Generally, this is information that does not comport well with people's existing knowledge. People will maintain their attention because the warning has some moderate level of new and useful information. It is important that warning designers try to make the information easy to acquire into people's knowledge base. This can be accomplished by ensuring some relatedness with what people already knows. There are some limits to these statements and they will be discussed further in the next stage of the C-HIP model.

With warning comprehension, the goal is to understand, in an adequate way, information about the nature of the hazard, what to do to avoid the hazard, and the consequences if the hazard is not avoided. Understanding these aspects also provides informed consent about risks and forms a basis for appropriate decision-making given the circumstances. Comprehension is also one of the primary goals of warnings—to convey an understanding about the hazard.

A common but relatively weak way to assess the comprehension of text is through computerized readability scores. There are several available (e.g., Flesch, 1948) and they are easily determined. These algorithms have the intended purpose to predict the textual material's grade-school level, reading skill suitability, or appropriateness by factoring in several objective measures such as sentence length in terms of number of words, average number of letters of the words, and frequency of use of words in the language. Usually computer software is used to calculate readability scores on some minimum section length. However, these automated readability measures scores provide only rough guidance on its ease of comprehension as they are notorious for providing inaccurate measures of understanding. The "gold standard" method of assessing comprehension is to test how well participants understand the information using open-ended questioning about the content, based on some given context. This should be followed by contextual probes or cues to pull out other knowledge in memory that might not otherwise be yielded, sometimes also called a cognitive interview (Brantley, & Wogalter, 1999).

If a given a prototype warning does not accomplish the goal of providing adequate understanding as indicated by testing, then there are methods to improve the materials' performance. Usability type testing involving iterative prototype design-test cycles involving participants and domain experts can be used to revise its format and content to enable better understanding of the hazard-related content (Wogalter, Conzola, & Vigilante, 2006).

Not every hazard needs to be warned about. An example is the concept of "open and obvious" in the legal setting. If a product has a clear-cut hazard that almost all adults know about, then there may not be a need to warn about it. One classic example is knives. Even though knives are hazardous, there is no need to warn that they may be sharp, and can cut and injure. Virtually all adults know this, and so an on-product warning is considered unnecessary. Not everyone knows this, however. Young children would need to be warned by caretakers about the dangers of handling knives.

Warnings are needed for hazards that are not readily apparent, also called "hidden hazards." Like knives, scissors can be very sharp and dangerous and normally do not need a warning. However, Vredenburgh, Zackowitz, and Vredenburgh (2019, Chapter 8, in this volume) show that cues, pre-existing beliefs and expectations affect the perceived hazardousness of scissors intended for use by children. Lower perceived hazardousness suggests that less precaution is needed (Wogalter, Brelsford, Desaulniers, & Laughery, 1991; Wogalter, Brems, & Martin, 1993). In Vredenburgh et al. (2019) the scissors "looked" safe for children. Warnings are needed to make "hidden hazards" more apparent.

Another comprehension-related concept is explicitness. In general, it is better to give specific information (e.g., causes liver disease) than general information (e.g., may cause health problems) (Laughery, & Smith, 2006). Explicit warnings can be longer than general warnings, although this is not always true. Thus, while explicit warnings can improve comprehension, the tradeoff with length ought to be considered and may require a compromise. The reason is that extremely long warnings can reduce attention maintenance and result in incomplete information acquisition.

Another factor related is space available on the product on which to present all relevant/appropriate warnings. It is related to the length issue mentioned earlier. If lengthy, then a prioritization scheme could be useful in determining what makes it on a label and what may only go in ancillary/accompanying materials such as an owner's (product) manual. Prioritization can be done based on several measures: knowledge, severity, likelihood, and importance of hazards through judgments from experts and users (Vigilante, & Wogalter, 1997a,b). The highest priority information should go on warnings directly on products and lower priority ones might only go in the product manual, insert, or other ancillary material.

Another criterion for comprehendible (understandable) warnings is lucid, clear, and unambiguous wording. Ambiguity and lack of clarity can slow processing and, in some circumstances, produce an incorrect interpretation of the material, which could result in unsafe decisions and behavior. For example, consider a commonly used term in warnings for certain classes of chemicals: "Irritant." This word could be interpreted as something minor such as an itch resulting in redness and a mildly inflamed portion of the skin rather than it being interpreted the way it might be intended—a much more severe effect such as the potential for a serious allergic reaction requiring emergency transport and hospitalization.

Clarity is not only relevant for text, but also for graphics. According to the ANSI (2007b) Z535.3 standard for safety symbols, a symbol is considered acceptable for use without words when 85% of the tested sample of 50 participants provide answers indicating they understand the meaning of a symbol with no more than 5% critical confusions (opposite or very wrong or answers). For example, Mayhorn and Goldsworthy (2009) used the ANSI (2007b) Z535.3 procedure to measure understanding of various graphic symbols intended for use with medications about the risk of birth defects. The results show that some symbols produced serious critical confusion errors revealing that many women interpreted some symbols as indicating that it is for birth control, which is a dangerous interpretation that it is okay for use by sexually active persons. This highly incorrect interpretation could result in babies being born unintentionally with birth defects. Sometimes critical confusion errors may be the result of the test method used (e.g., multiple choice and matching, which tends to capture those kinds of errors by providing response alternatives). The best comprehension tests are open-ended assessments with graphics shown with appropriate contextual cues like those provided when the symbol is seen (Brantley, & Wogalter, 1999; Wolff, & Wogalter, 1998).

Related to this, it is important to pay attention to the responses that people give in comprehension tests. Let us consider for the moment, the highly common symbol showing a lit cigarette overlaid by a prohibition symbol (a red circle with a diagonal slash). This symbol's interpretation might seem clear, but not necessarily so. In an open-ended comprehension test, many people will give a literal interpretation of simply No Smoking is allowed. However, this symbol is sometimes used more generally with a broader, less literal interpretation, such as No Fire of Any Kind in the Area. Depending on the scoring criteria, several answers/interpretations could be scored as correct (or incorrect) in a test of comprehension. The literal interpretation is not correct if the point of the warning was to communicate specifically the idea of Danger, Flammables and Combustibles Present, and No Fire of Any Kind in the Area. Yet, the symbol is commonly used for this broader interpretation. Correct interpretation depends on knowing the necessary information about the hazard. Thus understanding or recognition of the underlying concept is important, which can be different than what the symbol may literally appear to mean. A better symbol for the conveyance of the warning that flammables and combustibles are present and no fire of any kind in the area would not be a symbol showing a prohibition of a lit cigarette.

It probably needs a roaring-fire symbol, as well as additional text or graphics. In order to know what material (text and graphics) to present, one needs to determine what the hazard is, the potential consequences, and how to avoid injury, and then make sure that this information is presented in an understandable fashion. Thus, when evaluating warnings, it is important to be concerned with the concept to be communicated, as opposed to the specific textual or symbolic warning being evaluated. While ANSI Z535 standard has methodology for testing comprehension of symbols, it has not suggested doing something similar for comprehension of text, although the method can easily be adapted to test text.

Habituation is a memory-related concept where repeated exposures to a warning over time produce memory of content (Kim, & Wogalter, 2009; Thorley, Hellier, & Edworthy, 2001). Habituation indicates that at least some memory has been formed. It also means that the warning is no longer perceived as salient as it once may have been. Attention to it may be limited in future exposures. A negative effect of this is that after something has been habituated (such as seeing a standardized warning) repetitively over time, attention may not be allocated to other similar-looking warnings for different hazards. In other words, warnings that look similar to the habituated warning can evoke inadequate attention. Most warning design standards, such as ANSI (2007a) Z535.4 promote uniformity (at least to some extent), which could lead to similar appearing warnings not eliciting adequate attention switch or maintenance. Habituation is an example where a later stage (memory) influences an earlier stage (attention) in the model. This kind of processing is indicated by the reverse direction feedback loop(s) in Figure 3.1, and will be discussed further later.

Beliefs and Attitudes

Beliefs are knowledge structures based on extensive experiences gained through a person's lifetime and stored in memory (DeJoy, 1999; Riley, 2006). Attitudes are considered similar to beliefs except they are more affective/emotive. Generally, beliefs are global memory structures that are accepted as "true." They are grand or overall assumptions about how things work or ought to work. It is the background knowledge that people have and is built of complex structures of experiential and conceptual memory.

It is easier and quicker to process warning information if the warning information is consistent with existing beliefs. Warning content that is inconsistent can be overlooked or ignored, but if attended to, information that is counter to existing beliefs will take considerably more effort to accommodate into memory. Information that does not fit with people's intentions or task at hand, or is deemed irrelevant, may result in it not being processed further.

Several additional factors play a role in beliefs-related processing. People are more likely to read warnings for products they believe are hazardous and the converse is true as well; they are less likely to read warnings concerning products that they believe are safe (Wogalter et al., 1993; Wogalter, Young, Brelsford, & Barlow, 1999). A related factor is familiarity (Godfrey, & Laughery, 1984; Mayhorn, Nichols, Rogers, & Fisk, 2004). Believing that that one is adequately familiar with a product will tend to reduce people's willingness to look for or read warnings (Wogalter et al., 1991). This is another example of how a later stage of processing affects an earlier stage in the C-HIP model, in this case, beliefs affecting attention. To overcome these negative effects, the warning's design is critical. The warning needs to be highly salient and persuasive to attract and maintain attention despite the person's tendency to ignore these warnings so that correct beliefs can be formed.

Motivation

Users might progress through all of the previous stages, yet compliance behavior might not occur due to inadequate motivation to carry out appropriate responses. There are several factors that can affect warning-related motivation. One is cost of compliance. Here a warning-directed behavior is not performed because it is too effortful, costs too much money, or takes too much time (Wogalter et al., 1987; Wogalter, Allison, & McKenna, 1989). Clearly, it is better to direct people to behave in ways that are easy to carry out.

Another factor is social influence or modeling. If people see other people comply with a warning, then they are more likely to comply as well. The converse is also true; if other persons are not complying, then this recruits other persons not to comply (deTurk, Chih, & Hsu, 1999; Wogalter et al., 1989).

Motivation is also affected by time, stress (Wogalter, Magurno, Rashid, & Klein, 1998), and mental workload (Wogalter, & Usher, 1999). Being in a rush or involved with other tasks reduces compliance likelihood.

Behavior

Compliance behavior is an ultimate measure of warning effectiveness (Wogalter et al., 1987). Sometimes safe behavior can occur spontaneously without a warning, but its likelihood increases in the presence of well-designed warnings. Behavioral compliance can be measured directly or indirectly (Kalsher, & Williams, 2006; Wogalter, & Dingus, 1999). Because measuring objective levels of compliance behavior can be difficult (e.g., Wogalter et al., 1987), many researchers opt to use subjective evaluations as proxies for compliance. That is, some studies use ratings of willingness to comply or precautionary intent as measures of compliance). Technology involving virtual and augmented reality could be applied to warning investigations. Potentially, technology could provide a realistic experience while not exposing participants to actual harm (Duarte, Rebelo, Teles, & Wogalter, 2014; Vilar, Rebelo, Noriega, Duarte, & Mayhorn, 2014; Wogalter, & Mayhorn, 2005).

Discussion/Conclusions

One of the basic goals of warnings is to convey safety information so that it is comprehended and complied with. According to the C-HIP model, warning information must be processed through several stages without impediments or bottlenecks that would block its progression. It is a flow of information through stages that must be successfully completed. If prevented from completing the path due to bottlenecks, successful processing may be blocked. C-HIP's utility manifests itself in several ways. It serves to organize the considerable body of research that has accumulated in the last 30-plus years. It can be used as a tool to evaluate existing warnings relative to known factors influential for effectiveness. Table 3.1 gives a summary of influential factors for each stage of the C-HIP model. These factors and associated characteristics can be used as a checklist in assessing the effectiveness of a warning. A similar set of factors and method of evaluation is given by Lenorovitz, Leonard, and Karnes (2012).

The C-HIP model can be helpful in determining why a warning is not working, and, at the same time, can suggest improvements. Knowing what is causing a problem with a warning's processing would save money, effort, and time to allow for more focused

TABLE 3.1

Influences and Methods of the Communication-Human Information Processing (C-HIP) Stages

C-HIP Stage	Influences and Methods
Source	• Usually, the source or sender is the product manufacturer, but it could also be an importer, distributor, or seller. It could also be a trade or industry association, government agency, etc. Credibility and expertness is usually implied. • Conducts hazard analysis (e.g., failure modes and effects, critical incident, fault tree, U.S. Consumer Product Safety Commission data, consumer/user reports including complaints, trade association and trade meetings, basic physics and chemistry, etc.). • Determines methods of hazard control in favored priority: (1) eliminate/design out, (2) guard against, or (3) warn about the hazard).

Channel	• One or more sensory modalities.
	  • In vision (via signs, labels, tags, inserts, product manuals, video, live, etc.).
	  • In audition (via simple and complex sounds, voice, synthesized).
	  • Other senses: vibratory, olfactory, haptic, pain.
	  • Generally, more than one modality is better.
	• One or more types of media.
	  • Print: on-product label, tag, manual, newsletter, brochure, poster/placard, billboard, electronic presentation, e.g., via TV or Internet.
	  • Sound: Nonverbal (simple and complex), voice (live, as part of video, sound only).
	  • Generally, transmission is better with more and varied types of media to reach target audience.

Other Environmental Stimuli	• Other persons, environmental stimuli, plus feedback from tasks concurrently carried out. • This input is ongoing and changing and competes with warnings for attention. • Other persons, environmental stimuli, feedback from tasks carried out, ongoing and changing. Competes with warning for attention.
Receiver	• People have many similarities, but people also have differences, and these can impact warning reception and processing. • Demographics of target audiences (e.g., older adults, language skills, culture, sensory impairments, prior sophisticated training, and education) can affect warning method and media used.
Attention Switch	• Visual: The more highly salient (conspicuous/prominent), the more likely to be seen in cluttered environments. Beneficial characteristics include large size, high contrast, color, relative distinctiveness, apparent movement, and stimulus change. • Presence of pictorial symbols and other graphics can aid noticeability. • Auditory: louder, distinguishable/distinctive frequencies from surrounding sound(s). • Warning should be presented, or available, when and where needed ("near" in time and space). Sometimes too close in time can be insufficient to respond to avoid hazard. Far ahead in time is associated with memory difficulties. • This process competes with other external stimuli (other people, environment, other warnings, etc.) and internal processing.
Attention Maintenance	• Holding attention by examining, reading, or listening to a warning over time. • Visual: legible print, high contrast, aesthetic formatting (outline bullet format with white space, brevity), pictorial symbols, and graphics. • Auditory: intelligible, distinguishable from other sounds, voice should not be monotonic, or message lengthy. • Language should comport with target audience's ability. • Processing has limited capacity and can be distributed to different tasks, and can be overloaded.

(*Continued*)

TABLE 3.1 (*Continued*)

Influences and Methods of the Communication-Human Information Processing (C-HIP) Stages

C-HIP Stage	Influences and Methods
Comprehension and memory	• Understanding adequate hazard related information, to enable informed decisions. • Brevity and completeness are both desired and competing characteristics. • Necessary warning information commonly includes (1) nature of the hazard, (2) severity of consequences, and (3) instructions on what to do to avoid hazard. Additional information, such as mechanism leading to harm, may mean that adjustments for cultural differences may be necessary. • Pictorials, graphics, and symbols can benefit understanding as a substitute or an additional component to warning text. • Message conveyance and apprehension is benefitted if warning is able to cue relevant, existing knowledge in users' heads. • Explicit descriptions enable elaborative processing for better understanding about concepts resulting in better storage of information in memory. • At subsequent exposures, a repeated warning can cue and activate associated memory, and in doing so strengthen associations and as a result is able to be more easily activated later. • Avoid habituation with stimulus change. • Analyze warning on whether it conveys necessary information. • Test after exposure to warning. Feedback provides input for redesign.
Beliefs/attitudes	• Enables overall (general) judgments based on accumulated memory. • Perceived hazard and familiarity are beliefs about products that affect warning processing. Low perceived hazard and high product-type familiarity reduce the likelihood that a warning will be looked for or read. • Persuasive, prominent warning is needed when beliefs are discrepant with truth (e.g., when perceived hazard is lower that actual hazard). If so, the warning should provide persuasive arguments to correct and adjust beliefs so it is closer to truth and enhance knowledge. • Beliefs can influence receiver's earlier stages such as attention (Note: feedback loops in full C-HIP model shown in Figure 3.1). • Measurement: Added value shown from pre- to post-design.
Motivation	• Energizes individuals to carry out or respond appropriately with safe behavior. • Low cost of complying with warning (as in expending effort, time, or money) is beneficial. High cost of complying reduces or inhibits. • Bolstered by explicit descriptions of hazard and severe injury. • Affected by other persons ("models") via social influence • Also influenced by time stress, workload (mental and physical), and situational constraints. • Measurement: Performance showing faster time/lower error rate, or use questionnaire.
Behavior	• Empirically carrying out safe behavior that does not result in injury or property damage. • Measurement: Behavioral compliance (by direct and indirect evaluation), or use questionnaire.

efforts on producing a better warning. For example, suppose there is a warning attached to a product and a few people are asked to interact with the product (e.g., assembling or installing it). This is a good way to find out usability problems. If, during this testing, it turns out that participants only briefly gaze at the warning but then almost immediately look away to something else, then this finding would suggest the warning needs to be improved. Briefly gazing and then looking away can be identified as a particular pattern of influence, and knowing this, could be useful in correcting the warning's performance. Here you know the warning was delivered and its presentation or availability led to a brief glance. This means that the warning had at least some effect of switching attention to it (particularly if this pattern happens consistently with other people). The problem is that the warning did not *maintain* or hold attention after the switch event.

To take this example further, participants might be asked why they did not read the warning. The responses can offer some clues as to why they did not maintain attention to the label. First, it needs to be mentioned at this point that this kind of questioning is informal (qualitative and subjective); it cannot be assumed that responses are going to be perfectly reliable because people will say things that they might not have actually done for a whole host of reasons that are beyond the scope of this example. However, some useful information may be gleaned. Participants' responses could probably be grouped into different categories. Some participants could say that they have seen a warning like that many times before, and did not need to read it again. Other participants might say that they did not read it because the print was too small or the print lacked contrast or something else indicative of illegibility. If so, then the methods of fixing the warning become apparent and straightforward. This particular pattern also means that other kinds of fixes are not necessary. For example, the warning does not need adjustment with respect to enhancing the attention switch process. Instead, work (time, effort, etc.) should be put into fixing the attention maintenance problem, such as increasing the size and/or contrast of the print. Detective work like this can focus the developmental cycle on building a better warning by ascertaining specific problems and fixing them appropriately. Many of the case studies in the present volume point out failure at specific stages in the C-HIP model.

Warnings are usually considered less reliable at preventing injury than methods intended to design out or guard against hazards. However, when used, warnings ought to be designed to be effective. Considerable research has examined numerous variables to determine factors that influence warning effectiveness. The Communication-Human Information Processing (C-HIP) model organizes a wide variety of research findings. It describes how people cognitively interact with warnings. Unless impeded ("bottlenecked"), warning information ought to flow from the source via channels to the receiver where attention, comprehension, and other processes lead to appropriate safe behavior. In discussing the stages of C-HIP model, influential factors were cited along with some techniques to assess their effectiveness at the stages (see Table 3.1). These influential factors are worth considering when developing and evaluating warnings. Additionally, the C-HIP model provides guidance to help track down where and why a warning is not working adequately, and suggest ways to correct the problem and thus potentially reducing costs.

Although the C-HIP model was developed for warning processing, it is also a general model that could be used for explaining or structuring other domains of person-machine processing, such as the effective use of and interaction with technology.

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