Communication-Human Information Processing (C-HIP) Model in Forensic Warning Analysis

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Abstract. A model that combines human information processing with communication theory is described: the Communication-Human Information Processing (C-HIP) model. Emphasized are the factors that can influence processing at various stages. Bottlenecks in the process can reduce warning effectiveness. The C-HIP model can be used (e.g., by manufacturers) to assess warning utility. Human factors and ergonomics (HF/E) experts can use it as a method to systematically structure their warning analyses.

Keywords: Forensic · C-HIP model · Warning
Human information processing

1 Introduction

Warnings are used to convey hazard information to consumers for the purpose of reducing or avoiding injury or property damage (e.g., Laughery and Wogalter 2006; Wogalter et al. 2012. Typically, this information is visually displayed with text and/or graphics (e.g., symbols) on labels adhered to a product or a container, but it can also be in the form of inserts, product manuals, or on signs for environmental and facility hazards (Conzola and Wogalter 2001). Warnings need to be noticeable, legible, understandable, memorable, believable and motivating to facilitate goals of comprehension and compliance behavior. This article focuses its description of the C-HIP model as it relates to the processing of consumer product warnings. The basic principles are also applicable to signs and other kinds of warnings for environmental and facility hazards.

2 Communication-Human Information Processing (C-HIP) Model

When design and guarding do not control all of the hazards of a product (or environment or situation), warnings are needed. Warnings are intended to influence people and serve as an important means of hazard control. Because of this, it is important to describe the processes involved. A model is presented that combines the basic stages of

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a communication model (source, channel, and receiver) with human information processing approach (Wogalter 2006).

The basic C-HIP model is usually described as a linear, sequential process in which warning information should successfully flow from the beginning to the end, from the source to behavior and through the stages in between. This process is represented by the straight arrows going from the top to the bottom stages in Fig. 1. There can be "bottlenecks" in the process of moving down the stages; such processing difficulties would reduce or prevent the warning's effectiveness. The more complete C-HIP model is more complicated in that it includes arrows in the reverse direction to represent feedback loops in which the "later" stages can influence processing at "earlier" stages. The current version of C-HIP has two stages: Switch and Maintenance (e.g., cf. Wogalter 2006).

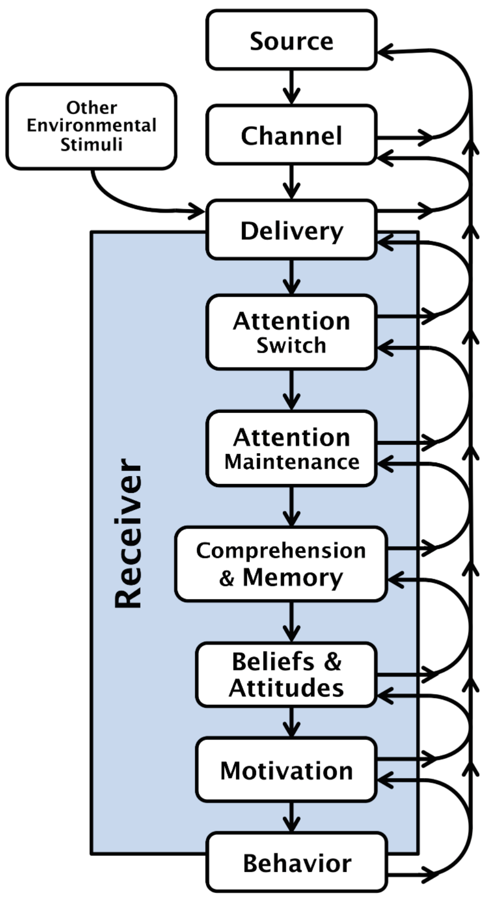

Fig. 1. Communication-human information processing (C-HIP) model.

Starting from the top of Fig. 1, the stages of the C-HIP model are described in separate sections below.

2.1 Source

The source is an entity that determines the necessity of warnings. That determination may be derived from the use of hazard analysis, data, industry standards, consumer reporting, physics/chemistry principles, or legal requirements) and if a warning is needed, the source transmits the warning. The source could be a government agency, a manufacturer, importer, trade group, or a particular person. The source is considered to have superior knowledge, at least in comparison to consumers. If hazards are incompletely controlled by design and guarding, then effective warnings should be provided so that people are informed about the hazards and what to do to avoid them.

2.2 Channel

Warnings can be given in many different ways including on-product labels, inserts, manuals, tags, web pages, public service announcement, etc. They can be given visually, auditorily or through other sensory modalities. The multiple modes and methods of dissemination for a product are together called the warning system (Laughery and Hammond 1999). Generally, providing information in more than one form (format and/or modality) is better because it can reach more people in more situations with greater impact (Cohen et al. 2006; Mazis and Morris 1999).

2.3 Delivery

Effective warnings need to reach the target audience who may be affected by the hazard. Warnings can be sent out but *never* succeed at arriving to relevant at-risk persons (Wogalter 2006b). For example, a company could print thousands of brochures with warnings but if those brochures are never distributed then their effectiveness is nil. Another example is public service announcements (PSAs) that are only broadcast in the early morning hours when most people are asleep; these warnings will have little impact on those not tuned in at the time. Delivery likelihood is greater when there is more than one presentation method (Cohen et al. 2006).

2.4 Environmental Stimuli

Other environmental stimuli (the context) can affect warning processing. Other stimuli compete with warnings for attention. A warning with a high level of salience (prominence or conspicuousness) makes it more likely that a warning will be attended to as opposed to attending to other things. Warnings can be salient in some environments and not in others. (Salience is discussed in more detail in the Attention Switch stage).

2.5 Receiver

Generally it is desirable to reach as many persons at risk as possible. Some of the persons at risk may require warnings with enhanced characteristics. For example, older adults with perceptual, cognitive and physical declines may not be able to read warnings in very small print or under low illumination, yet these characteristics may not present a problem for younger adults (Wogalter and Vigilante 2003; Mayhorn 2005). Warnings intended for trained, sophisticated healthcare professionals may be different than those given to ordinary consumers. The wide range of skills and abilities in the general population usually means that warnings for the ordinary consumer are capable of reaching the lowest denominator of capabilities (or those with the greatest limitations), inasmuch as feasible, so as to maximize its reach.

2.6 Attention Switch

Attention switch is the process where a person changes his/her attention *to* something else such as to a warning *from* something else (Wogalter and Vigilante 2006). It is related with the concepts of salience, conspicuousness, prominence, noticeability and attention-gettingness. Characteristics that benefit attention switch are increased size, high contrast, relative distinctiveness (e.g., different color from surroundings), apparent movement and other distinguishing characteristics. Graphics such as symbols can help promote attention switch.

In general, attention switch is directed to the most salient information at a given time. Warning processing competes with other ongoing task processing, including current and immediately-upcoming processing. If the warning is highly salient, it will be more likely to cause a switch to itself than if it were not salient. A warning in an environment with many "eye-catching" stimuli can reduce the likelihood that attention will switch to a warning, yet the same warning appearing in a plain, bland context is more likely to be seen.

2.7 Attention Maintenance

After switching to a warning stimulus, attention must be held for some length of time so that adequate information is acquired from it. Some of the main factors that enable maintenance attention include (a) having adequate print size (not extremely small or large), (b) high contrast (print to background), 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 having relatively low density/detail. Environmental exposure can cause degradation of the warning, reducing legibility.

The warning needs to be "attractive" and interesting enough so that people will stick with it long enough to extract adequate information instead of switching attention prematurely to other information. The reason for this is that the warning competes with other stimuli and processes or tasks, which could pull (switch) attention away from the warning through the attention switch mechanism discussed earlier. Good design makes it more likely that information is acquired quickly during the time attention is maintained on the warning. This relates directly with the next stage of processing.

2.8 Memory and Comprehension

While attention is being maintained on a warning, other processes may occur concurrently, including memory formation and comprehension. During this time, the material may be encoded which can produce new memory. If the material is highly technical or there is not much pre-existing knowledge of the subject matter, then the resulting memory formation may be minimal (at least in the short term), because people are likely to switch attention to something else. Another example of limited warning processing is when individuals are not skilled with the language used in the warning. If the individual already knows much of the information in the warning then processing it will be easier. In this case, the warning cues existing memory/knowledge (although not much new information will be acquired from the warning). Easy to process information is readily assimilable with the person's existing knowledge. If the information cannot be accommodated easily (without needing considerable time and effort), it will be less likely to hold attention. Generally, people will tend to maintain their attention longer when the warning has some moderate level of new and useful information. Warning designers should try to make the information easy to encode. This can be accomplished by ensuring some association with what the individual already knows.

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. Comprehension provides informed consent about risks.

The "gold standard" method for assessing comprehension is open-ended testing of the content. Probes or cues can be used to elicit other knowledge in memory (Brantley and Wogalter 1999).

If a warning does not produce adequate understanding, then there are methods to improve its performance. Usability type testing involving iterative prototype design-test development cycles can be used to improve comprehension (Wogalter et al. 2006).

Not every hazard needs to be warned about. One classic example is a knife. Virtually all adults know that knives can cut and cause harm, and so a warning is probably unnecessary [except that caretakers would need to warn young children].

Explicitness is another comprehension-related concept. In general, it is better to give specific information (e.g., can cause liver failure) than general information (e.g., may cause health problems) (Laughery and Smith 2006). Ambiguity and lack of clarity of text and graphics can slow processing and in some circumstances produce incorrect interpretations.

Habituation is a memory-related concept where repeated exposures over time to a stimulus produce memory (Thorley et al. 2001; Kim and Wogalter 2009), but as it does, attention is reduced. A negative effect of habituation (such as seeing a standardized warning format repetitively over time) is that attention may not be allocated to a similar-appearing warning for a different hazard. Accordingly, warnings that look similar to the habituated warning can evoke inadequate attention. Warning design standards, such as the ANSI (2007) Z535.4, promote uniformity, which could lead to a similar looking warning not eliciting adequate attention. Habituation is an example where a "later stage," in this case memory, influences an "earlier" stage, attention, as illustrated by the feedback loops in Fig. 1.

2.9 Beliefs and Attitudes

Beliefs are comprised of knowledge based on vast experiences gained throughout life (DeJoy 1999; Riley 2006). Attitudes are similar except they also have an affective component. Beliefs and attitudes are overall assumptions about how things work and are assumed to be true.

It is easier to process information that is consistent with existing beliefs. Inconsistent information is more difficult to accommodate and may result in incomplete processing.

People are more likely to read warnings for products believed as hazardous and the converse is true as well—they are less likely to read warnings concerning products that they believe are relatively safe (Wogalter et al. 1991; Wogalter et al. 1993). Another relevant factor is familiarity (Wogalter et al. 1991). Familiarity beliefs will tend to reduce the likelihood to look for or read warnings (Wogalter et al. 1991). This is an example of how a “later” stage in the C-HIP model affects an “earlier” stage (as in feedback loops in Fig. 1). To overcome existing, incongruous beliefs, the warning needs to be prominent and persuasive.

2.10 Motivation

Users might progress through all of the previous stages, yet compliance might not occur due to inadequate motivation. Several factors influence motivation. Cost of compliance is one factor. Warning-directed behavior might not be performed because it is too effortful, takes too much time or costs too much money (Wogalter et al. 1989; Wogalter et al. 1987).

Social influence is another factor. If other people comply with a warning, then individuals are more likely to comply as well. The converse is also true (Wogalter et al. 1989). Motivation is can also influenced by time stress (Wogalter et al. 1998), and mental workload (Wogalter and Usher 1999). Being in a rush or involved with other tasks tends to reduce compliance.

2.11 Behavior

Compliance behavior is sometimes considered the ultimate measure of warning effectiveness (e.g., Wogalter et al. 1987). Safe behavior can be increased in likelihood in the presence of well-designed warnings. Because measuring objective levels of compliance behavior can be difficult (e.g., Wogalter et al. 1987), subjective evaluations are sometimes used as indicators of compliance. Virtual and augmented reality can potential provide a realistic experience while not exposure to actual harm (Duarte et al. 2014; Vilar et al. 2014).

3 Relevance to Manufacturers and Forensic HF/E Experts

One of the basic goals of warnings is to convey safety information. In the C-HIP model, warning information must be processed through several stages without impediments or bottlenecks that would block its progression. The flow of information must be successfully completed but may be prevented at particular stages from doing so. C-HIP is useful in several ways. It serves to organize the considerable body of research that has accumulated in the last three decades in the human factors and ergonomics (HF/E) literature. It can be used as a tool to evaluate warnings. Influential factors for each stage of the C-HIP model can be used as an assessment checklist of warning effectiveness (see Lenorovitz et al. 2012; Wogalter 2019).

The C-HIP model can be helpful in determining why a warning is not working and can suggest improvements. Knowing what is causing a problem with a warning's processing saves money, effort, and time, which is useful because efforts can be focused on producing a better warning. A good way to assess the effectiveness is to ask several people to use (or assemble or install) a product (with a warning attached or given in an accompanying ancillary materials). If during this testing it turns out that participants only briefly gazed at the warning but soon thereafter look away to something else, then this finding would suggests a problem at the attention maintenance stage. The C-HIP model gives some insight on how the warning should be improved (at least in part). 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 at the switching attention stage (particularly if this pattern happens consistently with other participants). The problem appears to be that the warning did not hold attention after the switch event and thus efforts can be focused at improving the process at the maintenance stage.

To take this example further, participants might be asked later, "Why did you not pay attention to (read) the warning?" The participants' responses can offer some insight as to why they did not maintain attention to the warning. Suppose for this example, several participants say that they did not read it all because the print was too small and dense. If so, then how to fix the warning is straightforward. There may be other alternative responses and other potential fixes. Even after the attention maintenance problem is fixed, there may be other bottlenecks such as in the comprehension or motivation stages, but the C-HIP model offers guidance on fixing those problems as well. Detective work like this can ascertain and target specific problems, and thus potentially reducing costs associated with warning development.

The model also offers guidance in forensic HF/E analysis of injury events with regard to the warning system involved. It offers a systematic, structured way to analyze the warnings and their characteristics. It is a systematic method that can be applied to numerous situations, involving a multitude of product warnings and signage. It is therefore a useful tool for HF/E experts in forensic settings.

Although the C-HIP model was developed for warning processing, it is also a general model that can be applicable to other domains of risk disclosures such as informed consent forms, credit card terms, and software licenses (Wogalter et al. 1999b) and to warnings presented via other modalities, such as audition (Cohen et al. 2006).

It also could be used for explaining or structuring the processing of information in other HF/E domains, human-technology interaction.

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