Computer-Aided Development and Display of Warnings

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Abstract. This article describes the several ways computers can assist in the delivery of warnings. There are four discussion points. Current product information can be delivered via the Internet. Computer software and hardware is available to assist in the design, construction, and production of visual and auditory warnings. Various detection sensors can be used to recognize instances where a warning might be delivered. Warning presentation can be modified to fit the conditions and persons.

1. INTRODUCTION

Computers have changed how tasks are performed at work and in other activities. Technology has enabled the conceptualization and production of many new products and environments. Some of these new products and environments have hazards that are not readily apparent or obvious. When hazards cannot be controlled by eliminating them or effectively guarding against them, people need to be warned and instructed on how to avoid being hurt or damaging property.

Warnings are usually delivered via various printed media such as sticker labels, posted signs or placards, product manuals, package inserts and so forth. However warnings encompass a much larger domain of communications that include auditory, tactual, and olfactory stimuli. Technology has also made it possible to electronically produce and control warnings. This article describes some of the ways computers can involved with the dissemination of warnings.

2. DELIVERY

Typically, most products and equipment are accompanied by paper documentation such as labels and owner's manuals which usually have one or more warnings. Sometimes these materials are thrown away or placed in a location separate from the product (Wogalter, Vigilante, and Baneth, 1998). When it comes time to repair, maintain, etc., the owner's manual cannot sometimes be found. Moreover, when products and equipment are sold used, they are sometimes not accompanied by the owner's (instruction) manual. Thus, necessary information may not be available when it is needed. Potentially, one could contact the dealer or manufacturer to send a

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replacement manual, but this process can be costly in terms of time, effort, and money. Because of these costs, people may not get a replacement manual, and even if they did, the manual might not be received before something having some degree of risk has to be done with the equipment. A potential alternative is to access the relevant material on the Internet. If a replacement owner's manual (and possibly other information) is posted to the web, then consumers wanting it could view information on the screen or can print it on paper. This ability would give companies the opportunity to make corrections, updates, etc. to the information that originally accompanied the product.

Currently, most computer software and hardware is accompanied not only by hard-copy documentation, but also by a computer disk or CD with more current documentation in soft-copy form. Sometimes web site addresses are provided with the material and sometimes software is supplied that is able to access the manufacturer's web site. Additionally, some computer companies provide software that can automatically retrieve updates from the manufacturer's web site. While computer hardware and software comprise a particular category of products that are especially enabled to make use of the above-mentioned information delivery methods, the methods themselves are suggestive of alternative ways that other kinds of product manufacturers might use to deliver information to consumers . Several issues related to Internet delivery of product information are discussed by Young, Wisniewski, Tallman, Schiller, Frantz, and Rhoades (2000). Through the Internet, manufacturers can provide current documentation for both newer- and older-model products. Newer products might be substantially different from older products. In order to deliver the appropriate information, the entire information base should be compartmentalized and tagged so that appropriate sections of the database can be selected for retrieval. Thereby, given the particular product model (and probably the serial or identification number), relevant information can be determined depending on the owner's particular product. In practice this may mean including parts of the original documentation and some newer updated information substituted for some of the outdated documentation. Information about irrelevant features (those not in the particular product) would be eliminated before the download. The benefit of such a system is a reduction of the total material obtained by users--which may make it more likely that the more relevant material will be read.

A further benefit of computer-based delivery is that it can be transformed to voice presentation using the quickly-improving technologies of optical character recognition (OCR) and synthesized/digital voice presentation. Thus, blind persons could potentially benefit from electronic voice presentation. This kind of presentation could also benefit non-blind individuals who would be provided information in a salient, attention-getting form and would also benefit those who would not otherwise read through the material. Conzola and Wogalter (1999) showed that a speech warning presented when a product box was opened promoted compliance to a greater extent than a printed warning.

Another benefit is that information could be supplied world wide, enabling populations using different languages to have potential exposure to the material. For example, the supplied product could have a section of the labeling with various language translations together with Internet URL addresses or toll-free fax-back phone numbers to obtain information in their preferred language. Inexpensive devices are available to read bar codes representing URL addresses, thus providing yet another way to gain access to a relevant web site.

3. DESIGN

Most warnings are traditionally paper based or are simple auditory tonal cues such as buzzers, sirens, etc. Typically, when a sign is needed, it is ordered from a sign-making retail establishment or mail-order company, a catalog of already-made signs, or is produced by an internal department of larger companies. Now, computers, color printers, and conventional word processing and graphics software enable the development and construction of warnings by relatively novice computer users. Nevertheless, the quality of the warnings produced will likely be based on the individual's knowledge of the (a) hazard, (b) associated aspects of the situation, (c) principles of warning design, and (d) characteristics of the target audience for whom the warning is designed. Also in recent years, specialized "canned" software programs have been offered by various vendors. These programs produce warning designs based on (a) Occupational Safety and Health Administration (OSHA, 1994) rules which U.S. employers must use to protect their employees, and (b) the American National Standards Institute's (ANSI, 1998) safety warning standard (color, sign, symbol, label and tag), as well as other warning design sources. These specialized software programs can quickly produce signs that comply with regulations, standards, and guidelines. However, there is limited flexibility in the kinds of warning signs that these specialized programs can produce. Greater flexibility is enabled when warnings are produced using more generalized graphics software which allow a multitude of design components to be imported into the warning from other sources (e.g., pictorial symbols).

The potential to produce a warning does not mean that the result will be a good warning. Conformance with OSHA regulations or ANSI standards will not necessarily mean that the warning will be effective in its intended function. What these and other other software products can do for the warning designer is produce numerous potential (prototype) signs and labels which should be followed by tests to determine their relative effectiveness. Thus, such systems can be used to produce prototypes that can serve as stimuli in validation testing (e.g., on noticeability, understandability, believability, etc.) to determine their measurable utility. Thus, it is preferred that warning construction software allow design modifications reflective of the iterative testing outcomes.

4. DETECTION

Computers can be used in conjunction with detection and sensing devices to (a) detect when an animate or inanimate target is present, and (b) to detect when a hazard is present.

4.1. Presence of a target

Numerous kinds of detection devices are available to sense the presence of a person, animal, vehicle, etc. These include photoelectric beam interruption, and motion, heat, and weight detectors, among others. Wogalter, Kalsher, and Racicot (1993) used an infrared photoelectric detection device to initiate warning presentation when individuals enter a high risk area. Connected to a computer and with appropriate programming, a system could then control presentation of warning information. Future, more sophisticated systems could be used to identify specific targets. For example, automotive vehicles could be made identifiable by bar coding the license plate, or by using a low-level transmitter whose signal could be picked up by sensing devices in or around the road way. The vehicle's history could be accessed, and as a consequence, certain kinds of warning information could be presented to the motorist in one or more ways, such as being transmitted to an external electronic sign or to an on-board presentation system (e.g., a navigation or radio receiver system). Global positioning satellite (GPS) devices could be used to present warning information relevant to the vehicle's location, speed, and heading. Likewise, individuals could be tracked in ways similar to the vehicular examples described above. Individuals carrying with them these sorts of systems in miniaturized form could relay information on identity and associated personal characteristics and preferences. With the appropriate sensing input, computers could decode this information and then present warnings specifically designed for the person (or a machine, such as a vehicle or robot). Wogalter, Racicot, Kalsher and Simpson (1994) discuss how relevance plays a role in warning effectiveness. They provide empirical results showing that a personalized warning (using an individual's name) was more effective than an impersonal warning (using the signal word "Caution" instead of the name).

4.2. Presence of a hazard

Detection devices can also be used not only to sense the presence of an at-risk target, but also to sense the presence of a hazard. For example, moisture detectors can be used to signal the presence of ground saturation. This information, combined with information on the occurrence or potential occurrence of heavy rainfall, could be used to indicate the need for a flash flood watch or warning. Likewise, detection of (a) certain kinds of weather conditions could signal the potential for tornadoes, (b) reduced atmospheric ozone could signal the presence of excessive solar radiation, (c) a severe oceanic earthquake could signal a tidal wave, and (d) the presence of methane gas in mines could signal the need for respirators and the situation's explosive potential, and so forth These are only a few examples where sophisticated sensors can be used to detect the presence of hazard or related cues.

5. DYNAMIC MODIFICATION

Computers allow warnings to be changed. Therefore, rather than a static sign, computers can allow the flexibility of dynamically changing the physical characteristics and message content of warnings.

5.1. Physical change

A major correlate of warning effectiveness is perceived hazardousness. People are more likely to read warnings on products that they believe are more hazardous than those that they perceive to be less hazardous (Wogalter, Brelsford, Desaulniers, and Laughery, 1991). Hazard perceptions can be influenced by the warning's visual (Wogalter, Kalsher, Frederick, Magurno, and Brewster, 1998) and auditory (Barzegar and Wogalter, 1998; Edworthy and Hellier, 2000) characteristics. For example, adding red, orange or yellow to a black and white warning sign increases the level of perceived hazard relative to adding the colors blue or green (Smith-Jackson and Wogalter, 2000). Dynamically changing the color of a warning on an electronic display screen could be used to signal a changed level of danger. Combinations of features like different colors with different signal words could be used to calibrate the level of the hazard appropriate for the situation (Braun, Sansing, Kennedy, and Silver, 1994). Likewise with computer controlled auditory displays, sounds and voices with certain characteristics could generate different levels of urgency that are appropriately mapped to the hazard level involved (Edworthy and Hellier, 2000). Furthermore, the sound and voice characteristics could be changed as appropriate to fit the actual hazard level (Hollander and Wogalter, 2000).

5.2. Message content

Computers can also control the message content presented. On many major busy urban highways, massive electronic display boards have been erected with the intention of informing motorists of conditions ahead. Sometimes hazardous conditions are described and alternative routes are suggested. Currently, these information signs are low resolution alphanumeric displays. Bruyas (1997a, b) has suggested some ways of determining understandable graphic symbols with minimal features for use on such displays. Similar techniques could be used in work settings where information is delivered by dynamic LED (light-emitting diode) signs that "roll" information across a matrix of illuminated dots. The trend of reduced cost of high-resolution flat screen video displays is likely to result in their common use as changeable signage.

5.3. Habituation

As stated earlier, the physical characteristics and message content of a warning can be changed dynamically to fit the level of risk. Another reason for changing a warning is to compensate for cognitive changes in individuals over time (e.g., from experience). For example, once any kind of stimulation is learned as a result of one or repeated exposures, less attention is given to this stimulation upon subsequent exposures. If the desire is to lengthen the duration of a warning's stimulus value in gaining attention, the warning should be changed over time. A dynamic computer controlled warning could do this. Warning modifications can be based on what many people or single individuals may see or hear depending on the conditions. For example, a warning that states "Bridge freezes before the road" is intended to warn people about icy road conditions on bridges in very cold weather. However, the sign is usually permanently installed and visible in summer conditions when freezing is irrelevant. Together with temperature detection devices, the sign could present the information only during cold weather conditions. More sophisticated systems could identify particular persons to "individualize" the warning (Wogalter et al., 1994). For example, if a sign has already been presented to a person earlier, the warning could be changed in its physical features and/or message content when presented subsequently. An additional possibility is to program the presentation in accordance with a partial reinforcement schedule so that habituation process is slowed yet at the same time there is some retraining to maintain knowledge of the hazard in memory.

6. CONCLUSION

In this article, ways in which computers can be used to assist in the communication of warning information are discussed. The topics include delivery, design, detection, and dynamic modification. Currently available technologies and likely future developments were discussed. The promise of more effectively delivered hazard communication is envisioned. In the future, there will not necessarily be more warnings, but rather better, more effective warnings. These are warnings delivered at the proper time and appropriate place under applicable conditions befitting the target.

Although this article has dealt with computers and warnings, there are aspects of these two domains which this article did not discuss--in particular, the use of computers in warning research. Computers have been used in different ways to conduct (e.g., Cox, Hoyner, and Krshna, 1995), collect (e.g., Bzostek and Wogalter, 1999) and analyze data (e.g., Cox, Wogalter, Stokes, and Murff, 1997). Research methodology involving warnings and computers is necessarily a topic for another article.

Lastly there is one other issue related to computer-aided delivery of warnings that has not been discussed thus far in this article. It concerns warning intrusiveness. Warnings by their nature need to be attention-getting. Failure to be attention-getting can lead to extremely severe consequences. Edworthy and colleagues (see e.g., Edworthy and Adams, 1996; Edworthy, Hellier, and Stanton, 1995) advocate matching the urgency of the warning to the dangerousness of the situation. False alarms, attempts to turn off the warnings, and habituation might be diminished by effectively matching the situation with the perceived urgency of the warning. The actualization and operationalization of such mapping could be performed using computers, sensors and software that assess sensor input together with the appropriate data base to decide what degree of warning intrusiveness is needed. Electronic detection and tracking in hazardous workplaces and public roadways is probably doable, but implementation in home and personal environments may not be. While one ponders how intrusive we would like warnings to be, it is interesting to note that advertisements have been historically much more intrusive than warnings. Arguably, the reverse should be true.

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