Homeland Security Safety Symbols: Are We Ready?

"Terrorism forces us to make a choice. We can be afraid. Or we can be ready."
— Secretary Tom Ridge, U.S. Department of Homeland Security

BY CHRISTOPHER B. MAYHORN, MICHAEL S. WOGALTER, & JENNIFER L. BELL

The September 11, 2001, terrorist attacks on the World Trade Center and the Pentagon had a profound effect on the U.S. public's perceived sense of domestic security and safety. In response to this demonstrated vulnerability to attack, Congress passed the Homeland Security Act of 2002 (Public Law 107-296), which created the U.S. Department of Homeland Security (DHS). Among numerous other strategic objectives, this organization seeks to promote public education and emergency preparedness should further attacks occur.

On February 19, 2002, DHS unveiled a $100 million national public service advertising campaign titled "Preparing Makes Sense. Get Ready Now," which is supported by the Advertising Council. The centerpiece of the campaign is a Web site (*http://www.ready.gov*) designed to inform citizens how to prepare for national emergencies and how to respond to specific scenarios that might occur during a nuclear, chemical, or biological terrorist attack. "Preparing Makes Sense" employs pictorial safety symbols to communicate the nature of the hazards and the behavior necessary to avoid injury. For instance, a number of symbols are associated with radiological protective actions (e.g., reducing exposure and finding shelter) that can be taken following a terrorist attack involving nuclear materials. Although details concerning the origin and methodologies used in the design of the DHS symbols are scarce, one source states that "content came primarily from the Federal Emergency Management Agency, the Red Cross, and military experts" (Jackson, 2003).

In this article, we first describe the general benefits and limitations of pictorial safety symbols. Next, we evaluate one form of the efficacy of the DHS pictorial safety symbols by testing the comprehension of these symbols. Finally, we describe how human factors/ergonomics research methodology might be employed to improve the effectiveness of the symbols and further the goals of DHS. (A related study is described on page 12.)

BENEFITS AND LIMITATIONS OF PICTORIAL SAFETY SYMBOLS

One approach to warning design uses pictorial symbols to supplement or replace text warnings (Dewar, 1999). An everyday example of a pictorial warning is the "no smoking" symbol. When this symbol is encountered at a gas station, most people know that it means not to smoke, light a match, or flick a butane lighter while pumping gas because an open flame or a spark might trigger a fire or an explosion. This mundane symbol helps to avoid hazards in the environment that might lead to injury or death by attracting people's attention (Kalsher, Wogalter, & Racicot, 1996; Sojourner & Wogalter, 1998). The "no smoking" symbol also reminds people to behave safely by cueing their existing knowledge within memory (Leonard, Otani, & Wogalter, 1999).

Another benefit associated with the use of symbols is that people who cannot understand printed text warnings might be able to comprehend pictorial safety information. Safety symbols also make it possible for individuals who are illiterate or not conversant in the language of the safety information text to be warned of hazards in the surrounding environment. Given the increasing cultural diversity of the U.S. population, the use of pictorial safety symbols has the potential to be "culturally neutral" (Edworthy & Adams, 1996).

Ideally, pictorial safety symbols offer a number of benefits that should enhance public safety behavior through effective communication of hazard-related information. However, there are limitations to the use of safety symbols that, in some instances, detract from their effectiveness as warnings. Symbols that bear a resemblance to actual objects or procedures are generally more understandable than symbols that do not (Dewar & Arthur, 1999). For instance, pharmaceutical labels designed to communicate the necessity of taking the medication twice daily in the morning and at night might be more effective if depictions illustrate the action of taking a pill in conjunction with some indication of time of day (e.g., sun or moon).

Even when pictorial symbols are understood, they may be interpreted in a literal, more limited domain. For instance, a person who encounters the "no smoking" symbol may make the literal interpretation that smoking cigarettes is not allowed but fail to realize that *all* sources of flame and sparks are dangerous at places such as the gas station. Abstract concepts that can be visualized only with difficulty, such as radiation and biohazard or even the concept of time, are often difficult to convey pictorially (Hicks, Bell, & Wogalter, 2003; Leonard et al., 1999).

Past research indicates that symbols may not be understood by members of the at-risk population at levels expected by the symbol designers (Schroeder, Hancock, Rogers, & Fisk, 2001; Wolff & Wogalter, 1998). Therefore, it is important that comprehension testing be conducted to determine the effectiveness of proposed symbols *before* they are implemented for use. Published standards have provided guidance for warning designers by quantifying what level of comprehension constitutes an acceptable symbol. An American national standard (ANSI Z535.3; National Electrical Manufacturers Association, 2002) requires that at least 85% of the answers from a sample of 50 or more people should correctly identify the message content being communicated by a pictorial safety symbol. The International Organization for Standardization (ISO 3864-1984) requires a 67% rate of comprehension for safety symbols to be judged acceptable. Furthermore, the sample should generate no more than 5% critical confusions, which are defined as answers that are opposite to the intended concept or wrong answers that could lead to behavior resulting in death or injury (ANSI Z535.3).

Given the importance of the Homeland Security initiative, in the next section we describe a comprehension study we conducted to test the understanding of a sample of the at-risk population for the message content being conveyed by the DHS pictorial safety symbols.

A TEST OF THE HOMELAND SECURITY SAFETY SYMBOLS

We planned a comprehension study of the DHS safety symbols to address the likelihood that the American public would be able to effectively use the symbols to avoid injury or death in the event of a terrorist attack. Given the abstract nature of many of the symbols, we expected the results to demonstrate some degree of confusion for the message content being conveyed by the symbols.

We enlisted 57 people (28 men, 29 women) representing a range of ages and races from the Raleigh-Durham, North Carolina, area to serve as participants. They were age 18–84, with an average of 38.1 years. The sample was 78.9% Caucasian, 15.8% African-American, and 5.3% Hispanic-American. The participants were tested in groups of three to five for their comprehension of a set of 24 of the pictorial symbols (Figure 1) developed by DHS.

There are limitations to the use of pictorial safety symbols that, in some instances, detract from their effectiveness as warnings.

Instructions were given in both oral and written form. Following completion of the consent form and a brief demographic questionnaire, participants answered open-ended questions to test their comprehension of the safety symbols. Open-ended procedures are considered to be more ecologically valid than other types of test methods (e.g., multiple choice) because they mimic the cognitive operations that people might undergo when they encounter safety symbols in the real world. That is, when people encounter a safety symbol, they do not select from a set of alternative answers; instead, they generate meaning from the symbol in much the same fashion as is being tested with the open-ended procedure. Because symbols are supposed to cue existing knowledge in memory, unfamiliar message content is interpreted through the use of contextually based infer-

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Figure 1. Department of Homeland Security safety symbols and participant feedback data related to comprehension and critical confusion.

Safety Symbol	Message Content	% Correct Comprehension	% Critical Confusion	# Participant Design Suggestions
	Tap on pipe or on wall so that rescuers can hear you.	7.0%	0.0%	34
	Use a whistle if one is available. Shout only as a last resort – shouting can cause a person to inhale dangerous amounts of dust.	12.3%	86.0%	24
	If the door is not hot, brace yourself against the door and slowly open it.	15.8%	64.9%	26
	If you see signs of a chemical attack, try to define the impact area or where the chemical is coming from.	33.3%	21.1%	27
	Avoid unnecessary movement so that you don't kick up dust.	42.1%	15.8%	24
	Use the back of your hand to feel the lower, middle, and upper parts of closed doors.	45.6%	31.6%	27
	In the event of a biological attack, public health officials may not be immediately be able to provide information on what you should do. However, you should watch TV, or check the Internet for official news as it becomes available.	47.4%	35.1%	31
	Many sick or dead birds, fish or small animals are also cause for suspicion.	47.4%	40.4%	26
	If you catch fire do not run.	59.6%	28.1%	15
	Seek emergency medical attention.	63.2%	5.3%	11
	If possible use a flash light to signal your location.	63.2%	7.0%	10
	Time: Minimizing time spent exposed will also reduce your risk.	63.2%	15.8%	24

(Figure 1. continued)

Safety Symbol	Message Content	% Correct Comprehension	% Critical Confusion	# Participant Design Suggestions
	If your eyes are watering, your skin is stinging, you are having trouble breathing or you just think you have been exposed to a chemical, immediately strip and wash. Look for a hose, fountain or any source of water.	71.9%	12.3%	24
	Stop, drop and roll.	78.9%	8.8%	6
	Do not go back into a burning building, and carefully supervise small children.	78.9%	3.5%	23
	Shielding: If you have a thick shield between yourself and radioactive materials, more of the radiation will be absorbed by the thick shield, and you will be exposed to less.	82.5%	10.5%	16
	Get away from the substance as quickly as possible.	42.1%	15.8%	24
	Do not use elevators.	84.2%	3.5%	8
	It would be better to go inside a building and follow your plan to "shelter-in-place."	84.2%	10.5%	9
	Use a wet cloth to cover nose and mouth.	96.5%	0.0%	8
	Wash with soap and water, but do not scrub the chemical into the skin.	98.2%	1.8%	24
	Take shelter against your desk or a sturdy table.	98.2%	0.0%	5
	Exit the building as quickly as possible.	98.2%	1.8%	9
	Do not open the door if it is hot. Look for anther way out.	100.0%	0.0%	2

ence. Furthermore, previous research suggests that test methods such as multiple-choice tests artificially inflate symbol comprehension scores (Wolff & Wogalter, 1998).

Each participant encountered each of the 24 DHS symbols twice in two phases. During Phase 1, participants received a 25-page test booklet that contained one pictorial safety symbol per page. Symbols were approximately 3 × 3 inches (7.3 cm × 7.3 cm) in size. Each page contained a text description to convey the situational context in which such a symbol might be encountered and two open-ended comprehension questions ("Exactly what do you think this symbol means?" and "What action would you take in response to this symbol?").

Our participants believed that 19 of the 24 DHS pictorial safety symbols are unacceptable for communicating hazard-related information.

For example, the first symbol presented in Figure 1, designed to convey "Tap on pipe or on wall so that rescuers can hear you," was accompanied by text that described the situational context as something encountered when "you are trapped in debris following an explosion." The inclusion of context was designed to further heighten the ecological validity of the open-ended procedure because real-world safety symbols usually exist in contexts that provide cues to their meaning, thereby heightening comprehension (Wolff & Wogalter, 1998). Overall, the procedure we used is consistent with the guidelines in the ANSI Z535.3 safety symbol standard (National Electrical Manufacturers Association, 2002). The first page encountered during Phase 1 included a practice symbol ("no smoking") to illustrate the task, but the remaining pages of the test booklet were randomized for each participant.

Following the completion of Phase 1, participants received another 25-page booklet with the same symbols, one per page, in a different random order (except for the first practice symbol). In the Phase 2 booklet, we provided the intended message content of each symbol and asked participants to suggest ways that the design of each pictorial symbol could be improved. They were told to proceed through their booklets with no time restriction in the page order given and not to change earlier answers. All participants were thoroughly debriefed once data collection was completed. The experimental sessions lasted about 45 minutes.

Two independent raters scored the open-ended responses. Interrater reliability, which was determined by dividing the number of judgments when the raters agreed by the total number of judgments, was 90.2%.

COMPREHENSION RESULTS

Figure 1 illustrates the percentage of correct responses per symbol in ascending order. Compared with the ANSI Z535.3 85% correct criterion, our participants believed that 19 of the 24 DHS pictorial safety symbols (or 79%) are unacceptable for communicating hazard-related information. Using the more lenient guidelines of ISO 3864, which require 67% comprehension (and which also uses a slightly different method of scoring, not performed here), 12 of the 24 DHS symbols (or 50%) are unacceptable. The three symbols with the lowest rates of comprehension are intended to illustrate the need to (a) "tap on a pipe or wall" to attract rescuers when trapped in debris (7.0%); (b) "use a whistle if one is available" but not to yell when trapped in debris (12.3%); and (c) determine the source of a chemical attack because "many sick or dead birds, fish or small animals are cause for suspicion" (33.3%).

Figure 1 also includes the percentage of critical confusions (when a participant guessed the opposite of the intended meaning). Compared with the ANSI Z535.3 recommendation that acceptable symbols have no more than 5% critical confusions, 16 of the 24 symbols tested had critical confusion levels above 5%. The three symbols with the highest critical confusions were those meant to illustrate (a) "use a whistle if one is available" but not to yell when trapped in debris (86.0%); (b) "if the door is not hot, brace yourself against the door and slowly open it" (64.9%); and (c) "many sick or dead birds, fish or small animals are cause for suspicion" (40.4%).

Figure 2 lists some of the qualitative comments that illustrate participants' incomplete understanding of these three particular symbols. As these sample responses indicate, participants thought they should yell when trapped under rubble, violently open a door (not mentioning to check whether the door is hot because of fire), and keep animals out of the water when a chemical hazard is detected.

SUGGESTIONS TO IMPROVE SYMBOL COMPREHENSION

Why was symbol comprehension so low and the frequency of critical confusions so high? Perhaps the message content was questionable or counterintuitive. Consider being trapped in debris as illustrated in the "use a whistle if one is available" symbol. If a whistle is available – which is a questionable assumption – would a person trapped under rubble have the freedom of movement to reach into his or her pocket, bring the whistle to the mouth, and blow? Is it feasible *not* to yell for help, especially if injured?

Abstract concepts that hinder visualization are difficult to convey. If a person is trying to exit a building and encounters the symbol "if the door is not hot, brace yourself against the door and slowly open it," a symbol may fail to effectively convey the need to proceed slowly. As there is no indication of heat (e.g., flames or the color red), people may not understand that they need to check the door for heat before they open it. The symbol "many sick or dead birds, fish or small animals are cause for suspicion" is equally abstract because a course of action is not clear. The symbol depicts a person "thinking" but does not convey any sense of urgency or action, such as evacuating the area.

What, if anything, can be done to improve comprehensibility of the symbols? Examination of the 435 feedback suggestions for improving symbol design elicited during

Figure 2: Qualitative examples of critical confusions.

Safety Symbol	Message Content	Examples of Critical Confusions
	Use a whistle if one is available. Shout only as a last resort – shouting can cause a person to inhale dangerous amounts of dust.	Yell when you hear a whistle. Blow a whistle or yell to get attention. When you hear a whistle, yell for help.
	If the door is not hot, brace yourself against the door and slowly open it.	Use your body to break down the door. OK to use exit. Push or break down door to exit. Door is the way to safety. Use door. Push your way out of doors. Use force to get through blocked doors.
	Many sick or dead birds, fish or small animals are also cause for suspicion.	Avoid eating fish or fowl. Drink only bottled water and breathe through a filter. Catch and release the fish. Do not shoot the birds. No animals or fish in water.

Phase 2 provided insight and demonstrated participants' willingness to share their opinions regarding their understanding of the DHS symbols. The total number of suggestions made by each participant for all the DHS symbols ranged from 0 to 20, and the mean number of design suggestions made per participant was 7 ($SD = 5.1$). As indicated in Figure 1 (pages 8–9), multiple suggestions were received for each of the symbols ($M = 18.1$, $SD = 9.3$), but the number of comments per symbol ranged from 2 to 34. We conducted a Pearson product-moment correlation to examine the relationship between symbol comprehension and the number of suggestions. Results of this test revealed that the number of participant design recommendations increased as symbol comprehension decreased, $r\ (24) = -.72$, $p < .001$. This significant negative correlation illustrates the willingness of participants to make comments when they realize that they do not fully understand a safety symbol.

Despite the large number of design suggestions, the quality of those suggestions varied considerably – for example, the symbol meant to illustrate the necessity of not running if you catch fire. As Figure 1 illustrates, 59.6% of the participants correctly comprehended the meaning of this symbol, and in Phase 2 it elicited 15 suggestions for improvement. The qualitative comments were useful in identifying the source of participants' misunderstanding of this symbol, but few specific comments might be used to improve the physical design of the symbol. Of the limited number of design ideas that might be implemented during future iterations to improve this symbol, all focused on clarifying (a) that the person depicted by the symbol was on fire and (b) changing the attributes of the negation (i.e., slash placed over another symbol) symbol to illustrate not running.

Two suggestions that provided sufficient detail for altering the symbol to clarify that the person was on fire included "more fire on the individual and no background fire" and "make the guy look like he is more on fire." Three suggestions that might be implemented to improve the use of the negation symbol included "the slash should be across the person," "make sure that the man is visible above the crossbar," and "diagonal is too covered." Guidelines already exist to improve the legibility of pictorial symbols using the negation symbol (see Murray, Magurno, Glover, & Wogalter, 1998). Therefore, the utility of collecting qualitative design recommendations from participants for the purpose of developing or modifying symbol design was limited to identifying general sources of misunderstanding, but they did not appear useful as design solutions for this group of symbols.

The participants' design recommendations, though insightful and accurate, would be very difficult to execute and may not result in better DHS symbols.

Low comprehension and the high percentage of critical confusions in this study, in conjunction with the number of qualitative design comments from participants, suggest the need for further testing and redesign of these pictorial symbols, or perhaps the elimination of some of the symbols because the concepts to be communicated are not amenable to pictorial communication. In the latter case, simplified text (perhaps tested in Spanish as well as English) would be preferred.

HF/E CAN AID IN SAFETY SYMBOL IMPROVEMENT

It is unclear whether redesign would result in more usable symbols given the complex and abstract nature of the messages these symbols are designed to communicate. To illustrate, Figure 1 indicates that participants made 26 design suggestions for the symbol meant to depict opening a door

What Does Code Red Mean?

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The U.S. Department of Homeland Security developed the Homeland Security Advisory System (HSAS) as a means to disseminate information regarding the risk of terrorist acts. HSAS communicates a series of warnings in the form of five graduated threat conditions that utilize three distinct attributes: colors, words, and phrases. As the table below illustrates, each of these attributes is composed of five components that are ordered to communicate five distinct threat levels. The purpose of this additional study was to determine the effectiveness of HSAS as a means of public hazard communication by empirically assessing people's understanding of the system.

Our 57 participants (see page 7 in the accompanying article) were given a set of index card labels and asked to rank the colors, words, and phrases from most threatening to least threatening. During color label sorting, 57.9% of them erred by deviating from the correct order illustrated in the table below. When examining the specific errors made, we found that the most frequent errors occurred when participants thought the blue threat condition was less threatening than the green condition (78%). Another source of error resulted from participants confusing the orange with the yellow threat condition (12.1%). Together, these two categories of confusion account for more than 90% of the color-sorting errors.

The word-sorting task revealed somewhat better results: only 33.3% of the sample deviated from the correct order. Participants most frequently confused the guarded condition with the low condition (42.1%) and less frequently confused the elevated with the guarded condition (21.1%). Together, these two categories of confusion account for more than 63% of the errors during word sorting.

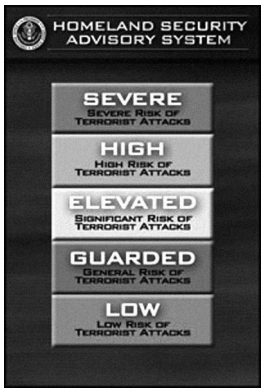
Participants were the most accurate when asked to order the descriptive phrases, compared with the other sorting tasks. In the phrase-sorting task, 26.3% deviated from the correct order. Participants most frequently confused "Significant risk of terrorist attacks" with "High risk of terrorist attacks" (26.7%) and less frequently confused "Severe risk of terrorist attacks" with "High risk of terrorist attacks" (13.3%). Together, these categories of error accounted for 40% of the errors during phrase sorting.

The error-laden results of the three sorting tasks provide converging evidence that HSAS may not be an effective hazard communication tool. These results are not surprising when considered in the context of previous work within the human factors/ergonomics warnings literature (Laughery, Wogalter, & Young, 1994; Wogalter, Young, & Laughery, 2001). For instance, the results of the color-sorting task are consistent with previous research: Although the color red consistently connotes the presence of a hazard, orange and yellow are not readily differentiated on the hazard continuum (Chapanis, 1994). Colors such as red and yellow suggest greater levels of hazard than other common colors, such as green and blue, but research indicates that people do not perceive blue to be more hazardous than green (Braun & Silver, 1995; Rashid & Wogalter, 1997). Thus, participants' poor performance on the color-sorting task was predictable.

Had human factors/ergonomics professionals been consulted on the design of HSAS, the misunderstandings associated with color coding of threat levels might have been avoided, resulting in a more effective hazard communication tool. Similar confusions in the word- and phrase-sorting tasks might also have been avoided in light of extensive research demonstrating that people frequently have difficulty distinguishing one signal word from another, such as "danger," "warning," and "caution" (Braun, Kline, & Silver, 1995; Leonard, 1999). The designers of HSAS might have avoided the use of this attribute entirely.

At the very least, HSAS should have been tested prior to deployment to determine whether the public could distinguish among the five threat levels. Had this testing occurred and the findings reflected the confusion revealed in the present results, alternative attributes such as numbers (i.e., 1–5) or percentages (e.g., 80%) might have been explored as a means to disambiguate the threat levels.

The Homeland Security Advisory System



HSAS Attributes and Organization of Components from Most Threatening (top) to Least Threatening (bottom)

Colors	Words	Phrases
Red	Severe	Severe risk of terrorist attack
Orange	High	High risk of terrorist attack
Yellow	Elevated	Significant risk of terrorist attack
Blue	Guarded	General risk of terrorist attack
Green	Low	Low risk of terrorist attack

slowly. Representative comments included "show open slowly" and "use arrow differently to indicate slow." Of the 24 design suggestions for the symbol meant to illustrate not yelling when trapped under debris, representative comments included "Nothing to indicate that yelling is the last resort" and "Number the action steps." Because each of these symbols is meant to communicate a set of actions (i.e., multiple propositions) that should be initiated in sequence, the complexity of the message content exceeds what is acceptable for a single symbol (Dewar & Arthur, 1999). Moreover, message content is dependent on the abstract concept of time, which is not readily visualized; thus, the utility of using a pictorial symbol in these two instances is not recommended (Leonard et al., 1999).

The participants' design recommendations, though insightful and accurate, would be very difficult to execute and may not result in better DHS symbols. Had DHS conducted some form of preliminary testing before these safety symbols were deployed for use by the public, they might have discovered that these are two instances in which pictorial symbols are not amenable for the job intended.

One source of concern with the current DHS education framework is that it is available only on the Internet.

As Hancock and Hart (2002) recently illustrated, human factors/ergonomics professionals possess skills and expertise that can be applied in a number of technical areas, such as airport security and emergency response to advance counterterrorism efforts. Given the low comprehension rates and high percentage of critical confusions associated with the current DHS safety symbols, HF/E professionals might be of service in pictorial warning design and evaluation. They have at their disposal well-established, psychometrically validated methods that produce more effective hazard communication (see Wogalter, DeJoy, & Laughery, 1999, for a review). Here we describe how these methods might be used to improve the DHS pictorial safety symbols.

Selection of concepts through precursor testing. The process for developing effective pictorial warnings is often expensive, inefficient, and time-consuming (Wolff & Wogalter, 1993). Research shows that concept concreteness is positively correlated with how well people comprehend the meaning of pictorials (McDougall & Curry, 2000). Recent work by Hicks et al. (2003) indicated that precursor tests of concept concreteness and ease of visualization can be used to predict the likelihood of designing a successful pictorial warning symbol. Thus, preliminary testing of concepts should allow designers to identify instances in which abstract, nonconcrete concepts would result in incomprehensible symbols.

Because many of the DHS symbols were designed to convey information concerning abstract concepts, precursor testing might have identified cases when the likelihood of developing an effective pictorial symbol was low. Not only would DHS have avoided wasting valuable time and money on the development of incomprehensible symbols meant to convey abstract message content, the agency also might have identified more concrete concepts to enable it to concentrate efforts on designing useful safety symbols.

Iterative comprehension testing and rapid prototyping. Once concrete concepts have been identified, prototype symbols should be developed and tested for comprehension with a sample of the at-risk population (as described in the current study). Symbols that do not meet acceptable levels of comprehension should be redesigned based on feedback from the earlier test participants and retested for comprehension in an iterative process (design, test, redesign, test, etc.) until a satisfactory level of comprehension is reached. Rapid prototyping is one method used to conduct iterative testing, whereby prototype warnings are continually redesigned and improved based on the evaluations of test participants (Wogalter, Vigilante, & Conzola, 1999).

Training via an awareness campaign. Although we have focused on the comprehension of pictorial warnings in this article, it is important to realize that the development of pictorial symbols is only one component of the DHS warning system. For the DHS public education framework to be successful, the public must first be aware of it. Of the 57 participants tested in our study, only one had previously encountered the DHS safety pictorials, but not on the official Web site. If people are to recognize and activate preexisting safety information when they encounter a pictorial symbol, initial training in the form of exposure to the material may be necessary to ensure that people first learn specific safety information. When they encounter pictorial symbols during real-world tasks, the symbols could then serve to cue access to previous knowledge, thereby guiding their behavior (Leonard et al., 1999).

Clearly, recognition and use of the DHS pictorial symbols requires that the public be informed that this information is available. This dependency on previous knowledge suggests that DHS should initiate a public awareness campaign that will inform the public where to access and become familiar with this information.

One source of concern with the current DHS education framework is that it is available only on the Internet. Although Internet access is growing, not everyone has direct access to DHS safety information. It might be useful if this information were made available through other media, such as paper copies at the local post office or television advertisements.

ARE WE READY?

The Department of Homeland Security is faced with the Herculean task of preparing the public for future terrorist incidents. The DHS Web site asks, "Are we ready?" Based on the results of the symbol comprehension study described in this article, it appears that the answer is "Not yet." Pictorial symbols cannot address every concept, and sometimes text

warnings are more appropriate. Knowledge of these limitations might have informed the design of the current symbols and resulted in the development of a more effective hazard communication system.

For something as important and serious as safety in times of national emergencies, unambiguous warnings are essential for safety promotion and injury prevention. With the active assistance of human factors/ergonomics professionals, DHS should come closer to accomplishing the strategic goals of fostering public education and preparedness, thereby depriving the terrorists of their most effective tools: disorder and fear.

REFERENCES

Braun, C. C., Kline, P. B., & Silver, N. C. (1995). The influence of color on warning label perceptions. *International Journal of Industrial Ergonomics*, *15*, 179–187.

Braun, C. C., & Silver, N. C. (1995). Interaction of signal word and colour on warning labels: Differences in perceived hazard and behavioural compliance. *Ergonomics*, *38*, 2207–2220.

Chapanis, A. (1994). Hazards associated with three signal words and four colours on warning signs. *Ergonomics*, *37*, 265–275.

Dewar, R. E. (1999). Design and evaluation of public information symbols. In H. J. G. Zwaga, T. Boersma, & H. C. M. Hoonhout (Eds.), *Visual information for everyday use: Design and research perspectives* (pp. 285–303). London: Taylor & Francis.

Dewar, R. E., & Arthur, P. (1999). Warning of water safety hazards with sequential pictographs. In H. J. G. Zwaga, T. Boersma, & H. C. M. Hoonhout (Eds.), Visual information for everyday use: Design and research perspectives (pp. 111–117). London: Taylor & Francis.

Edworthy, J., & Adams, A. (1996). *Warning design: A research prospective*. London: Taylor & Francis.

Hancock, P. A., & Hart, S.G. (2002). Defeating terrorism: What can human factors/ergonomics offer? *Ergonomics in Design*, *10*(1), 6–16.

Hicks, K. E., Bell, J. L., & Wogalter, M. S. (2003). On the prediction of pictorial comprehension. In *Proceedings of the Human Factors and Ergonomics Society 47th Annual Meeting* (pp. 1735–1739). Santa Monica, CA: Human Factors and Ergonomics Society.

International Standards Organization. (ISO). (1984). *International standard for safety colours and safety signs* (ISO 3864). Geneva, Switzerland: Author.

Jackson, W. (2003). On Ready.gov, HSD reaches out to the public. *Government Computer News*, *22*(5). (Available at *http://www.gcn.com/22_5/news*)

Kalsher, M. J., Wogalter, M. S., & Racicot, B. M. (1996). Pharmaceutical container labels and warnings: Preference and perceived readability of alternative designs and pictorials. *International Journal of Industrial Ergonomics*, *18*, 83–90.

Laughery, K. R., Wogalter, M. S., & Young, S. L. (1994). *Human factors perspectives on warnings: Selection from Human Factors and Ergonomics Society Proceedings, 1980–1993*. Santa Monica, CA: Human Factors and Ergonomics Society.

Leonard, S. D. (1999). Does color of warnings affect risk perception? *International Journal of Industrial Ergonomics*, *23*, 499–504.

Leonard, S. D., Otani, H., & Wogalter, M. S. (1999). Comprehension and memory. In M. S. Wogalter, D. M. DeJoy, & K. R. Laughery (Eds.), *Warnings and risk communication* (pp.149–187). London: Taylor & Francis.

McDougall, S. J. P., & Curry, M. B. (2000). Exploring the effects of icon characteristics on user performance: The role of icon concreteness, complexity, and distinctiveness. *Journal of Experimental Psychology: Applied*, *6*, 291–306.

Murray, L .A., Magurno, A. B., Glover, B. L., & Wogalter, M. S. (1998). Prohibitive pictorials: Evaluations of different circle-slash negation symbols. *International Journal of Industrial Ergonomics*, *22*, 473–482.

National Electrical Manufacturers Association. (2002). *Criteria for safety symbols* (American National Standards Institute Z535.3-Revised). Rosslyn, VA: Author.

Rashid, R., & Wogalter, M. S. (1997). Effects of warning border color, width, and design of perceived effectiveness. In B. Das & W. Karwowski (Eds.), *Advances in occupational ergonomics and safety*, *1997* (pp. 455–458). Amsterdam: IOS Press.

Schroeder, D. G., Hancock, H. E., Rogers, W. A., & Fisk, A. D. (2001). Phrase generation and symbol comprehension for 40 safety symbols. In *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting* (pp. 1479–1480). Santa Monica, CA: Human Factors and Ergonomics Society.

Sojourner, R. J., & Wogalter, M. S. (1998). The influence of pictorials on the comprehension of and recall of pharmaceutical safety and warning information. *International Journal of Cognitive Ergonomics*, *2*, 93–106.

U.S. Department of Homeland Security. (2003). Preparing makes sense. Get ready now. (Available at *http://ready.gov*)

Wogalter, M. S., Young, S. L., & Laughery, K. R. (2001). *Human factors perspectives on warnings, Volume 2: Selections from Human Factors and Ergonomics Society Proceedings, 1994–2000*. Santa Monica, CA: Human Factors and Ergonomics Society.

Wogalter, M. S., DeJoy, D. M., & Laughery, K. R. (1999). *Warnings and risk communication*. London: Taylor & Francis.

Wogalter, M. S., Vigilante, W. J., & Conzola, V. C. (1999). Applying usability engineering principles to the design and testing of warning messages. In *Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting* (pp. 921–925). Santa Monica, CA: Human Factors and Ergonomics Society.

Wolff, J. S., & Wogalter, M. S. (1998). Comprehension of pictorial symbols: Effects of context and test method. *Human Factors*, *40*, 173–186.

Wolff, J. S., & Wogalter, M. S. (1993). Test and development of pharmaceutical pictorials. *Interface '93: Humanizing Technology, Proceedings of the Eighth Symposium on Human Factors and Industrial Design in Consumer Products* (pp.187–192). Santa Monica, CA: Human Factors and Ergonomics Society.

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