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Personalization of warning signs: The role of perceived relevance on behavioral compliance

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Abstract

Research suggests that compliance to a highly visible posted warning sign is significantly lower than the same warning located within a set of task instructions. One possible reason for this finding is that the participants believed that the posted sign was not directed to them and not relevant to the particular task they are doing compared to the within-instructions warning. One purpose of the present research was to compare the influence of a personally relevant sign (displaying participants' name) to a more conventional impersonal sign (displaying the signal word CAUTION) on behavioral compliance. A second purpose was to examine the influence of a dynamic versus a static display. A sign composed of programmable light-emitting diodes (LEDs) exhibited the warning using special effects (apparent motion) or it was exhibited continuously. A third purpose was to examine the effect of sign placement in a cluttered environment. The wearing of protective equipment as directed by the warning during a chemistry laboratory task was measured. The results showed that participants more frequently wore the protective equipment when a warning was present than when it was absent. The personalized sign significantly increased warning compliance compared to the impersonal sign. No effect of dynamic presentation was found, and the only effect of sign placement was on task-accuracy judgments. The effect of personalization is explained in terms of the special alerting feature of one's own name and enhanced perceived relevance when there is no ambiguity as to whom the message is directed to. Implications for flexible control of warnings using available technology are discussed.

Relevance to industry

Warnings are often used as a means of communicating information about dangers and how to avoid injury. In the present research, message personalization was found to improve warning compliance. The paper describes an automatic-individualized warning system composed of electronic detectors linked to a personnel database that would display certain messages to specific individuals at optimal times.

Keywords: Warning; Signs; Visual displays; Safety; Hazard control; Personal protection

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1. Introduction

Providing safer conditions for employees is a central goal and a major challenge for accident prevention programs. Workplace accidents and injuries can be a result of many factors: the work tasks themselves, employees' behavior (e.g., failure to use protective gear), unsafe work environments (e.g., the presence of noxious chemicals), and improperly maintained or poorly designed equipment. According to statistical data, reported job-related injuries have increased over the last decade (e.g., Ansberry, 1989). This increase in recorded injuries has been attributed to a variety of factors including greater employee workloads caused by escalating competition in a tighter world-wide economy. Many companies are using fewer employees who are less experienced and who must produce at a faster rate and work longer hours (Milkovich and Boudreau, 1991). Together these factors, along with better reporting procedures and increased availability of workman's compensation, have produced the conditions amenable to the higher injury rates observed in recent years.

As a result of increased reporting of work-related injuries, the Occupational Safety and Health Administration (OSHA) has applied more rigorous enforcement of stricter safety standards. OSHA holds employers responsible for workplace safety even if accidents result from employees' failure to follow company policy with regard to safety procedures. For example, even if an employee refuses to wear OSHA-required safety gear and is injured, the company may be held responsible. In 1986, OSHA initiated a standard called 'Right to Know' which requires companies to inform employees of any hazardous substances they might use in the course of their work, as well as the danger of exposure and the proper action to take if exposed (Milkovich and Boudreau, 1991). Although OSHA has intervened to enhance workplace safety, and while many companies have initiated training programs to improve employee compliance with safety procedures, these measures do not guarantee that employees will perform the appropriate safety behavior on the job. In recent years, empirical studies have been conducted by Human Factors/Ergonomics researchers that address ways of better communicating hazard messages that persuade targeted individuals to comply with the warning directives.

Research indicates that the effectiveness of warnings can be improved by making the message components more conspicuous (i.e., noticeable or salient). For example, empirical studies have shown that the addition of conspicuous print (Young and Wogalter, 1990), pictorials and icons (Jaynes and Boles, 1990; Young and Wogalter, 1990), voice (Wogalter and Young, 1991), and other enhancements (Wogalter et al., 1987) increase behavioral compliance to warnings, as well as facilitate intermediate measures of warning effectiveness such as seeing, understanding, and remembering the warning. Thus, research indicates that enhancing warning conspicuity increases the probability that it will be noticed, which in turn tends to increase the likelihood that it will be read and complied with.

Another factor that influences warning effectiveness is the medium or channel used to communicate the message (e.g., Barlow and Wogalter, 1993). While there is a growing body of research on compliance to warnings conveyed via product-labels and in-task instructions, research on compliance to posted warning signs has been relatively limited except in studies concerned with transportation-related warnings (e.g., traffic signs). Recently, Wogalter et al. (1992, 1993a) showed that large highly visible posted warning signs produce significantly lower behavioral compliance than the same (but smaller) warnings embedded as part of a set of task instructions. Moreover, the results also showed that adding features intended to enhance the salience of the sign, such as a strobe light and pictorials, failed to increase compliance compared to a sign without the feature enhancements. Wogalter et al. (1992, 1993a) speculated that the sign's lowered compliance (compared to the within-instructions conditions) was possibly due to participants' belief that the sign was not specifically directed to them or that the warning was not relevant to the tasks that they were performing. One purpose of the present study was to examine whether perceived relevance is a factor that could influence compliance to a posted sign.

One way of manipulating perceived relevance is to personalize the warning by adding a person's name to the message. The appearance of one's own name might alleviate any belief that a sign is intended for someone else or for another task situation. If an increase in compliance is found with a sign having the individual's name (personalized sign) compared to a sign without the name (conventional impersonal sign), then this finding would support Wogalter et al.'s (1992, 1993a) speculation that perceived relevance to the person and the task influences people's willingness to comply to posted warning signs.

However, even if an effect of warning personalization is found, it is important to comment on the applicability to real-world work environments. That is, how practical, suitable, or even feasible is it to have personalized warning signs in the workplace? Clearly, personalization is not easily accomplished with conventional printed signs. However, recent technological advancements have assisted in making personalization possible. In the present study, a newly developed sign apparatus is employed that allows multiple messages to be displayed over time and this capability includes personalization. Specifically, the sign is composed of a large array of programmable light-emitting diodes (LEDs) which can be controlled by an attached keypad or a remote computer. Besides the potential benefit of having the flexibility to personalize a message (or present any number of multiple messages) as described above, these signs are capable of presenting information in apparent motion created by on–off sequences of the LED array (i.e., special effects). Previous research (e.g., Crawford, 1963) has shown that target detection and visibility is enhanced by stimulus movement in an otherwise static visual array. Thus, the presentation of a warning message using a dynamic display might make the sign more salient and attention-getting, which in turn may enhance behavioral compliance to the message compared to the same message presented in a static display. However, the possible value of a dynamic verbal message display has not yet been evaluated in an empirical study. Thus, a second purpose of the present research was to examine whether a dynamic display of a warning message produces greater compliance than a more conventional static display of the same warning message.

Finally, a third purpose of the experiment was to examine whether placement of the warning sign in a cluttered environment influences compliance. Wogalter et al. (1992, 1993a) and Laughery et al. (1993) found that visual noise in the surrounding area of a warning reduces compliance. The present experiment examined a somewhat different question: Given that an environment is highly cluttered, are there more suitable locations than others? A warning surrounded by relatively less background clutter should be more noticeable, and therefore more likely to be read and complied with compared to more background clutter. The current study examined the effect of three sign placements in a highly cluttered room on warning compliance behavior.

In summary, the effects of a personalized message, display motion, and sign placement on warning effectiveness was examined. The most important measure of effectiveness is behavioral compliance. In this experiment, compliance was determined by observing whether or not participants wore the required safety equipment (mask and gloves) as directed by the warning while performing a laboratory chemistry task. In addition, several other dependent measures were collected in a post-task questionnaire including whether participants saw the warning and protective equipment, and whether they could recall the warning's content, as well as ratings of perceived hazard, carefulness, and task-performance accuracy.

2. Method

2.1. Participants and design

One hundred fifty-six undergraduate students from Rensselaer Polytechnic Institute (RPI) participated for credit in their introductory psychology course. The experiment was a 2 Personalization (Impersonal: presence of the signal word CAUTION versus Personal: presence of the individual's own name) × 3 Placement (A, B, C) × 2 Display Motion (Static, Dynamic) between-subjects design. A thirteenth condition with No Warning served as the control group. Twelve students were randomly assigned to each condition.

2.2. Materials and apparatus

In the Impersonal Warning (signal word) condition, the following message was displayed on the sign:

CAUTION! IRRITANT
Use Mask and Gloves

In the Personalized Warning condition, the signal word (CAUTION) was removed and was replaced by the participant's first name. Names were obtained from the research board posted in the RPI Psychology Department where participants sign up for research projects. The names were programmed into the sign message before participants entered the laboratory facilities. If the name was longer than eight characters, then a shortened version of the name (usually a conventional nickname or the last name) was used. A representation of the personalized sign is shown below:

[participant's name]! IRRITANT
Use Mask and Gloves

A programmable sign (Alpha ES-440A EZ Key II, Adaptive Micro Systems Inc., Milwaukee, Wisconsin, USA) was used to display the warning messages. This LED sign can be programmed to show different messages with the included keypad or can be connected to a computer. It can simultaneously display a maximum of two lines of 18 two-inch (5.1 cm) characters. The outside dimensions of the sign apparatus were 100.1 cm × 20.3 cm × 10.2 cm in length, height, and depth, respectively. Fig. 1 shows the sign as it was presented for one participant in the personalized sign condition.

In static mode, the text of the warning was displayed continuously. In the dynamic mode, the message was displayed in apparent motion with four preprogrammed special effects (scrolling, explosion, snowing, and flashing). The duration of each special effect was approximately 1 s followed by 4 s of continuous on-time. Every 5 s another special effect was shown resulting in a total cycle time of 20 s for all four special effects.

The experiment took place in a large room that was a former chemistry teaching laboratory. The room contained several laboratory sinks and counters, Bunsen-burner connections, storage cabinets, etc. Moreover, this room was highly cluttered with various kinds of electronic equipment, paper, various containers, and other materials on tables, metal carts, and shelves.

The warning sign apparatus was placed in one

Fig. 1. The LED warning sign display for one participant (named Lisa) in the personalized sign condition.

of three locations. In Position A, the sign was on the laboratory counter where the participant performed the chemistry task. In this position, the sign was at a distance of approximately 4.5 m to the left and on the same counter top as the work table where the participant performed the chemistry task. In Position B, the sign was placed at a more distant 5.5 m location to the left of the participant on another counter top in the room at the same height. This position was somewhat less cluttered than the other two placements. In Position C, the sign was approximately 2.5 m in front (but slightly to the left) of the participant in an area of the room that was more cluttered than the other two locations. In the control (no warning) condition, the sign was present in one of the three positions an equal number of times (4) but the apparatus was turned off so that no message was shown.

2.3. Procedure

The laboratory materials were similar to those described in Wogalter et al. (1987, 1989). Actual chemistry laboratory equipment was used including triple-beam balances, beakers, flasks, and graduated cylinders. A large supply of plastic gloves and face masks were available on a laboratory table along with the other materials and equipment. Also present was a set of written instructions that directed participants to weigh, measure, and mix several chemical substances and solutions in a particular order. The substances and solutions were available in large glass containers which were labeled with an alphanumeric character to disguise their true nature. The chemicals were actually harmless: water, cooking oil, and powdered soap combined with food coloring. Fig. 2 shows the laboratory workstation area.

At first, individual participants entered a room adjacent to the laboratory room described above. They were seated and given a consent form to read. The contents of the form described the study as investigating the procedures involved in a chemistry laboratory demonstration task. After signing the form, participants were told that they would be performing a set of chemistry procedures in the next room and then were led to another area of the room where they were shown how to use a triple-beam balance to measure small quantities of material. Next, participants were told that in the adjacent room they would be receiving a set of instructions directing them to measure and mix various chemicals in a specified order. Participants were told that they should try to complete the set of steps as quickly and as accurately as possible. They were also told that once they began the task they should not ask the experimenter any questions and that if any problems arose they should recheck the instructions and do the best that they could.

Participants accompanied the experimenter to the doorway of a second room which contained the chemistry materials, equipment, and task instructions. The experimenter told participants to enter the room and begin. The experimenter stood in the doorway with a clipboard and stopwatch, and appeared to be recording the time required by the participant to complete each step of the instructions. In fact, the only real data recorded was whether participants complied with the warning (wore mask and gloves) before they began to mix the substances and solutions. After 5 minutes had elapsed, the participants were told to stop doing the task and were brought to the first room where they were asked to complete a questionnaire.

Among the various items on the questionnaire, participants were asked whether they saw: (a) any masks, (b) any gloves, and (c) a warning of any kind. For these questions, 'yes' answers were given a score of '1', and 'no' answers were given a score of '0'. If they reported that they had seen a warning, they were requested to write the specific content of the warning message. Recall of the warning was scored using a lenient criterion. If the participant's answer stated something about an irritant, and/or the need to wear mask and gloves, the response was counted as correct (given a score of '1'; otherwise the response was given a score of '0').

The questionnaire also requested ratings on the three following items: (a) 'How *hazardous* were the chemicals?' (b) 'How *careful* were you in the task?' and (c) 'How *accurate* were you in

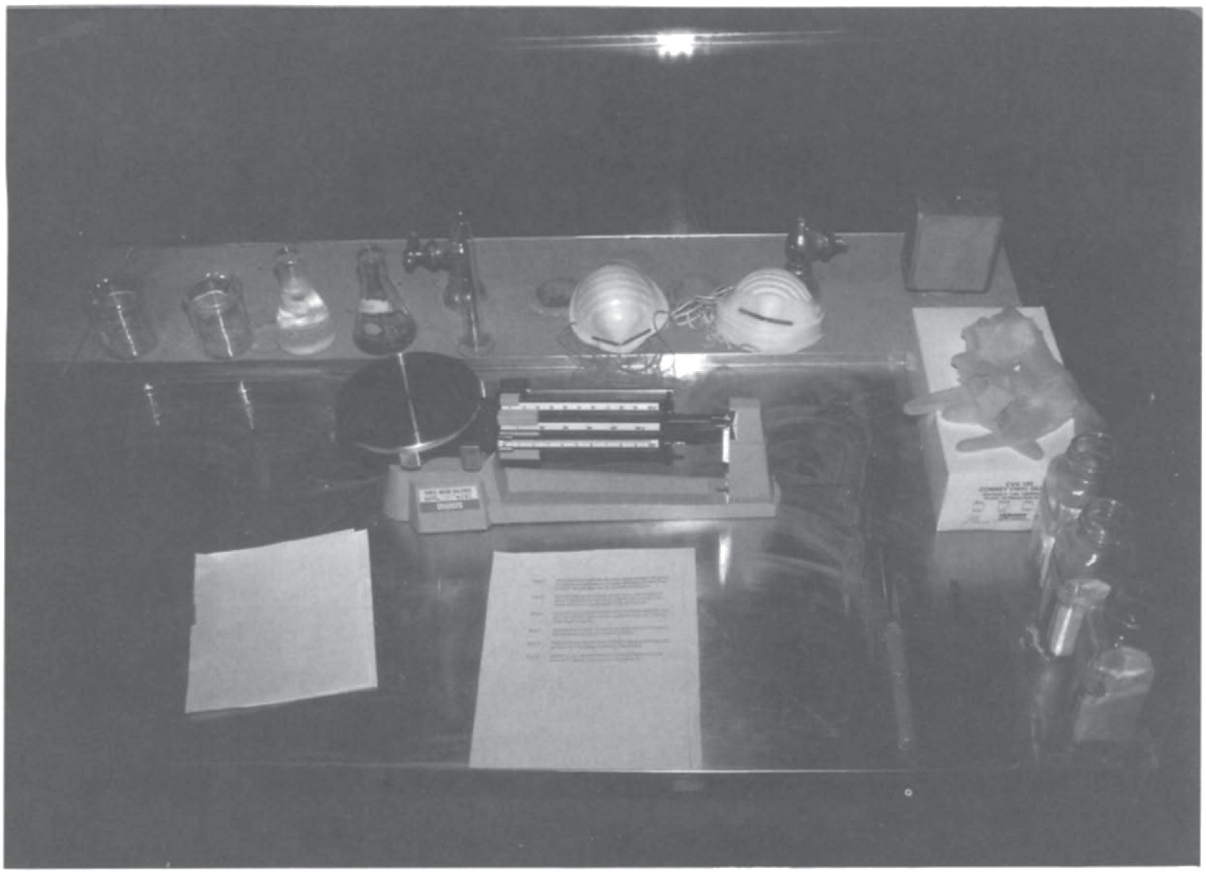

Fig. 2. The laboratory workstation with the mock chemicals, chemistry apparatus, and protective equipment (masks and gloves) available.

the task?' All three rating scales were Likert-type 8-point scales verbally anchored at the two ends with (0) 'not at all' to (7) 'very'. After completing the questionnaire, participants were debriefed regarding the true purpose of the study and thanked for their participation.

3. Results

3.1. Behavioral compliance

Behavioral compliance was defined as the donning of protective equipment (mask and gloves). Compliance was scored on a 3-point scale with '2' indicating the wearing of both kinds of protective equipment, '1' indicating the wearing of either the mask or gloves, and '0' indicating that neither the masks nor the gloves were worn.

An overall one-way between-subjects analysis of variance (ANOVA) on the compliance scores for all 13 conditions of the experiment showed a significant effect, $F(12, 143) = 2.25$, $p < 0.05$. A contrast between the No Warning (Control) condition and a composite of the 12 warning-present conditions was significant, $F(1, 154) = 5.13$, $p < 0.05$. Participants exposed to a warning were more likely to wear protective equipment ($M = 0.80$, $n = 144$) than participants not exposed to a warning ($M = 0.17$, $n = 12$).

The 12 warning conditions (excluding the Control condition) were analyzed using a 2 Personalization (Impersonal, Personal) × 3 Placement (A, B, C) × 2 Display motion (Static, Dynamic) between-subjects factorial ANOVA. The ANOVA showed a main effect of Personalization, $F(1, 132) = 7.88$ $p < 0.01$. Participants exposed to the personalized sign ($M = 1.01$) showed significantly greater compliance than participants exposed to the impersonal sign ($M = 0.58$).

The ANOVA also showed a small main effect of Placement, $F(2, 132) = 3.45$, $p < 0.05$. Although Placement A ($M = 1.08$) appeared to produce higher compliance than Placements B ($M = 0.65$) and C ($M = 0.67$), the Newman-Keuls multiple-range test showed none of the paired comparisons were significant ($ps > 0.05$). Furthermore, the ANOVA showed no main effect of Display Motion, or any significant interactions.

3.2. Post-task questionnaire

Analysis of the questionnaire data produced statistically significant effects for three items. First, reports of seeing a warning showed a significant effect in a chi-square test among the 13 conditions, $\chi^2(12, N = 156) = 25.18$, $p < 0.05$). The only reliable contrast among conditions was the expected finding that more participants reported seeing a warning when it was present ($M = 0.61$) than when it was absent ($M = 0.00$), $\chi^2(1, N = 156) = 16.82$, $p < 0.001$.

Second, the recall scores showed a significant effect, $\chi^2(12, N = 156) = 22.82$, $p < 0.05$. As expected, participants exposed to a warning ($M = 0.52$) more often recalled its content than participants not exposed to a warning ($M = 0.00$), $\chi^2(1, N = 156) = 11.88$, $p < 0.001$. Also, a contrast between the personal and impersonal sign conditions showed a significant effect of Personalization, $\chi^2(1, N = 144) = 10.03$, $p < 0.01$. Participants exposed to the personalized sign ($M = 0.61$) more often recalled the warning than participants exposed to the impersonal (signal word) sign ($M = 0.36$).

Third, a one-way ANOVA on the accuracy ratings yielded a significant effect, $F(12, 143) = 2.59$, $p < 0.01$. Participants exposed to a warning ($M = 5.12$) rated themselves as being significantly more accurate in performing the chemistry task than participants not exposed to a warning ($M = 3.33$), $F(1, 154) = 8.58$, $p < 0.01$. A $2 \times 3 \times 2$ ANOVA on the accuracy-rating data of the 12 warning-present conditions yielded two significant main effects. One was Personalization, $F(1, 132) = 10.74$, $p < 0.01$. Participants in the personalized sign conditions ($M = 5.65$) rated themselves as more accurate than participants in the impersonal sign conditions ($M = 4.60$). The other main effect was for Placement, $F(2, 132) = 3.12$, $p < 0.05$. Subsequent comparisons using the Newman-Keuls test showed that participants with the sign in Position B ($M = 5.65$) gave significantly higher accuracy ratings than participants with the sign in Position C ($M = 4.67$). Position A ($M = 5.06$) was intermediate, but did not significantly differ from the other two placements.

Of those participants who reported seeing a warning, 84.1% recalled its content and 58.0% complied with it by donning both masks and gloves. Also, participants who reported seeing a warning were more likely to report seeing both pieces of protective equipment than participants who did not report seeing a warning (80.7% versus 35.3%), $\chi^2(1, N = 156) = 33.19$, $p < 0.0001$.

Finally, the questionnaire data showed no significant differences among conditions using the ratings of perceived hazard, carefulness, and reports of seeing the masks and gloves ($ps > 0.05$).

4. Discussion and conclusions

The results indicated that a personalized sign (with the participant's name) increased compliance compared to an impersonal sign. Personalization presumably increased the directive's relevance to the participant and to the task that they were performing. This result supports the suggestion by Wogalter et al. (1992, 1993a) that one reason for the relatively low level of compliance of a highly-visible posted sign (with and without the visual enhancements of a strobe and pictorials) is that people tend to believe that a sign is not expressly relevant to them or the task that they are performing. By adding the individual's name to personalize the warning (as opposed to the impersonal sign with a signal word), participants would have difficulty concluding that the warning is not directed to them and that it is not important to perform the safety behaviors.

Another recent experiment by Racicot and Wogalter (1992) provides additional support for the influence of perceived relevance on warning compliance. In that study, a short video showing a warning sign along with an actor modeling the required safety behaviors produced greater compliance compared to a same-length video of the warning sign alone. Because the model was shown in a context similar to the situation in which the research participants found themselves, the video-modeling warning was probably perceived to be more relevant to them and the task than the static sign-only condition.

Nevertheless, there is another explanation for the personalization finding. Research in the auditory information processing literature indicates that one's own name is a particularly good way to capture people's attention (Moray, 1959). However, virtually all of this research has been performed using information transmitted in the auditory modality. If the personalization effect in the present experiment is considered similar to the effects found in earlier auditory-attention research, then this not only suggests generalization to the visual modality, but also that people's names may be useful as a way to alert individuals to other (non-warning) visual displays.

Also, the results indicate that an individual's own name has greater alerting value than the signal word CAUTION. This is an interesting finding because the intended purpose of signal words is, in part, to alert people that a hazard/warning is present (e.g., Wogalter and Silver, 1990). However, one potential benefit of signal words that is not provided by an individual's name is that they can also provide an indication of the level of hazard involved. For example, current standards and guidelines (Westinghouse, 1981; FMC; 1985; ANSI, 1991) recommend that the signal word DANGER be used to indicate a hazard of greater likelihood and severity than the term CAUTION (see also, Wogalter and Silver, 1990). Possibly, had this experiment used a stronger signal word than CAUTION such as DANGER, greater compliance might have been produced in the impersonal sign condition. However, given that the term CAUTION is supposed to convey a level of hazard greater than other non-signal word terms (such as a person's name), then it would be expected that individuals in the signal word conditions would perceive the situation to be more hazardous, that they would be more careful while performing the task, and that they would more likely comply with the warning by wearing the protective equipment than participants in the non-signal word conditions. This, however, was not found. Compliance was greater in the non-signal word personalized sign condition. Moreover, the questionnaire data yielded no differences between conditions for perceived hazard or carefulness.

The present research also supports another conclusion by Wogalter et al. (1992, 1993a). In that research, they showed that increasing the physical salience of certain features of the warning sign did not increase compliance. More specifically, no effect was found for the addition of a strobe light or pictorials to an otherwise visible sign without those features. In the present experiment, a feature that appeared to add salience – a dynamic LED display – produced no additional effect over a static LED display. In a review of the warning literature, DeJoy (1989) came to a similar conclusion: adding individual salient features to warnings does not always translate into increased compliance. Multiple methods of enhancement may be necessary before seeing substantial compliance gains.

The sign placements in the cluttered room had been expected to show differences in compliance. While an overall ANOVA showed a small significant effect, none of the subsequent paired comparisons was significant (as sometimes happens). On the surface, this failure to find an effect of placement does not conform with several previous studies (e.g., Wogalter et al., 1987, in press) in which warning location produced significant effects on compliance behavior. However, in the present experiment, it was probably the case that none of the placements were sufficiently different from one another. The least cluttered location was still fairly cluttered. That is, the experiment lacked adequate power to evaluate the effects of location on compliance. Nevertheless, location did produce an effect using the accuracy ratings. The farthest, least cluttered, location produced the highest levels of reported accuracy. An explanation for this finding is not obvious, particularly when no other dependent variables showed this effect, and no previous warning study has reported an accuracy effect. Further research is necessary to determine whether the effect is reliable (i.e., not due to chance) and whether reported accuracy reflects actual task accuracy.

Although the insertion of individuals' names into warning messages may appear difficult to implement in practice, new and available technology has made its use feasible. In fact, systems could be developed in which the presentation could be done automatically, and thereby mitigate certain problems that have been cited at various times in the warnings literature. One such problem is warning habituation (e.g., Wogalter and Silver, 1990) whereby the stimulus configuration in the environment is repeatedly exposed which eventually becomes so familiar that the individual no longer gives conscious attention to it on subsequent exposures. A warning system that individualizes message presentation might delay the onset of habituation. One possible way to accomplish this is to use a detection system that remotely scans the name tags or cards of individual employees and visitors entering safety-sensitive areas as they move through a workplace. Combined with a computer, this detection system could be programmed to present a warning to particular individuals below some criterion level of experience each time they enter a hazardous area (e.g., new employees or visitors to a workplace).

Moreover, the system could present warnings less frequently to others above some criterion level of experience/exposure to the warning. Also, a procedure could be implemented to track the number of times each individual has been warned, including the schedule of exposure, thus allowing for a more precise reinforcement-type schedule with intermittent and unpredictable subsequent presentations to serve as reminders. However, implementation becomes more complex when several people of varied levels of warning exposure travel as a group into safety sensitive areas. In such cases, one possible method would be to have the system evaluate the extent (and histories) of prior warning exposure of all members of the group, and in particular, who the least exposed individual is. Whether a message should be presented at that time would be based on the history of that least exposed individual. Regardless of whether a message is presented or not, a record of who entered the area would be added to the data base to update the system and used in subsequent determinations of whether to present the warning in subsequent encounters.

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