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# Behavioral Compliance to Personalized Warning Signs and the Role of Perceived Relevance

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## ABSTRACT

Recent research has shown that compliance to a posted warning sign is much lower than the same warning located within a set of task instructions, even when the sign is highly visible. One possible reason for this finding is that participants' believe the sign to be less relevant to the task and to themselves than the within-instructions warning. One purpose of the present research was to examine whether a personalized sign (with the participant's name) is more effective than a more conventional impersonal sign (with the signal word CAUTION). A second purpose was to examine the influence of a dynamic display compared to a static display. A sign composed of programmable light-emitting diodes (LEDs) presented the warning message using special effects (apparent motion) or it was displayed continuously. A third purpose was to examine whether various sign placements in a cluttered laboratory environment influences compliance. The wearing of protective equipment by participants as directed by the warning was the measure of behavioral compliance in a chemistry laboratory task. More participants wore the protective equipment when a warning was present than when it was absent. The personalized sign increased compliance compared to the impersonal sign. No effect of dynamic presentation was found, and the only effect among sign placements was found for perceived accuracy. The effect of personalization is explained in terms of the special alerting feature of one's own name and increased perceived relevance that results when the message is directed to them. Implications for flexible control of personalized warning messages using available technology are discussed.

## INTRODUCTION

Workplace accidents and injuries are a major concern of employers. These incidents 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 for the higher injury rates seen 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. As a rule, OSHA has held employers responsible for workplace safety even if accidents result from employees' failure to follow company policy with regard to safety procedures. For example, if an employee refuses to wear OSHA-required safety gear, the company may be held responsible. In 1986, OSHA initiated a standard called the "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 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 researchers to address the problems of communicating hazards and persuading people to comply with safety messages.

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, Godfrey, Fontenelle, Desaulniers, Rothstein, and Laughery, 1987) facilitate measures of warning effectiveness such as seeing and remembering the warning, and most importantly, behavioral compliance. Enhancing the conspicuousness increases the probability that the warning will be noticed, thereby increasing the likelihood that it will be read and complied with.

While some warnings' research has focused on increasing the salience of the message, 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 product-label and task-instruction warnings, research on compliance to posted warning signs has been relatively limited except for studies on transportation-related warnings (e.g., traffic signs). Recently, Wogalter, Kalsher and Racicot (1992, in press) showed that a highly visible posted warning sign produced significantly lower compliance than the same (but smaller) warning embedded as part of set of task instructions. Moreover, 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 enhancements. Wogalter et al. (1992, in press) speculated that the sign's lowered compliance was possibly due to participant's belief that the sign was not directed to them or relevant to the tasks that they were performing. One purpose of the present study was to examine whether relevance is a factor that could influence

people's willingness to comply to posted signs.

However, even if an effect of personalization is found, there is still a need to address the applicability of such research for real-world work environments. That is, how practical or even feasible is it to have personalized warning signs in the workplace? Clearly, personalization is not easily accomplished with conventional signs. However, recent technological advancements have assisted in making personalization possible. In the present study, a newly developed sign apparatus is used that allows multiple messages to be shown 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 showing apparent motion created by on-off sequences of the LED array (i.e., special effects). A dynamic display might make the sign more salient which could be useful in capturing people's attention to the message compared to a more static display of the information. However, the possible advantage of this kind of dynamic information display has not yet been tested 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 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, in press) found that visual noise in the surrounding area of a sign reduced compliance. The present experiment examined a somewhat different question than the earlier research: Given that an environment is highly cluttered, are there better 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 behavioral compliance to a warning was examined. Compliance was measured by observing whether or not participants wore the required safety equipment (mask and gloves) 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.

## METHOD

### *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) x 3 Placement (A, B, C) x 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.

### *Materials and Apparatus*

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

CAUTION! IRRITANT
Use Mask & 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 to participate in research projects. The names was 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 & Gloves

A programmable sign (Adaptive Micro Systems Inc., Alpha ES-440A EZ Key II) 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 39.4 in (100.1 cm) x 8.0 in (20.3 cm) x 4.0 in (10.2 cm) in length, height, and depth, respectively.

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 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 14.7 ft. (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 18 ft (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 then the other two placements. In Position C, the sign was approximately 8.1 ft (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 but the apparatus was turned off so that no message was shown.

*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.

At first, individual participants entered a room adjacent to the laboratory room described above. They were seated and given a consent form to read and sign. 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 min 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 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 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 the completing the questionnaire, participants were given a debriefing on the actual purpose of the study and thanked for participating.

## RESULTS

*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, $F(12, 143) = 2.25$, $p < .05$. A contrast between the No Warning (Control) condition and a composite of the 12 warning-present conditions was significant, $F(1, 154) = 5.13$, $p < .05$. Participants exposed to a warning were more likely to wear protective equipment ($M = .80$, $n = 144$) than participants not exposed to a warning ($M = .17$, $n = 12$).

The 12 warning conditions were analyzed using a 2 Personalization (Impersonal, Personal) x 3 Placement (A, B, C) x 2 Display motion (Static, Dynamic) between-subjects factorial ANOVA. The ANOVA showed a main effect of Personalization, $F(1, 132) = 7.88$ $p < .01$. Participants exposed to the personalized sign ($M = 1.01$) showed significantly greater compliance than participants exposed to the impersonal sign ($M = .58$).

The ANOVA also showed a small main effect of Placement, $F(2, 132) = 3.45$, $p < .05$. Although Placement A ($M = 1.08$) appeared to produce higher compliance than Placements B ($M = .65$) and C ($M = .67$), the Newman-Keuls multiple-range test showed none of the paired comparisons were significant ($ps > .05$). Furthermore, the ANOVA showed no main effect of Display Motion, or any significant interactions.

*Post-Task Questionnaire*

Analysis of the questionnaire data showed 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, $\chi^2(12, N=156) = 25.18$, $p < .05$). The only reliable contrast among the experimental conditions was the expected finding that more participants reported seeing a warning when it was present ($M = .61$) than when it was absent ($M = .00$), $\chi^2(1, N=156) = 16.82$, $p < .001$.

Second, the recall scores showed a significant effect among conditions, $\chi^2(12, N=156) = 22.82$, $p < .05$. As expected, participants exposed to a warning ($M = .52$) more often recalled its content than participants not exposed to a warning ($M = .00$), $\chi^2(1, N=156) = 11.88$, $p < .001$. Also, the recall scores showed a significant effect of Personalization. A contrast between the personal and impersonal sign conditions, $\chi^2(1, N=144) = 10.03$, $p < .01$, showed that participants exposed to the personalized sign

($M$ = .61) more often recalled the warning than participants exposed to the impersonal (signal word) sign ($M$ = .36).

Third, a one-way ANOVA (with all 13 conditions) on the accuracy ratings yielded a significant effect, $F(12, 143) = 2.59$, $p < .01$. 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 ($M$ = 5.12), $F(1, 154) = 8.58$, $p < .01$. A 2 x 3 x 2 ANOVA (including only the 12 warning-present conditions) on the accuracy ratings showed two significant main effects. One was Personalization, $F(12, 132) = 10.74$, $p < .01$. 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, $F(12, 132) = 3.12$, $p < .05$. 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%), $\chi^2(1, N=156) = 33.19$, $p < .0001$.

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 ($ps > .05$).

## DISCUSSION

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 they were performing. This result supports the suggestion by Wogalter et al. (1992, in press) 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 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.

Further support for the notion of perceived relevance is provided by Racicot and Wogalter (1992). In this study, the use of videotaped models was effective in improving compliance compared to a posted sign. Since the model was in the same situation as the research participant, the warning was probably perceived as more relevant than a static (and impersonal) sign condition.

There is also another explanation for the personalization finding. Research in the auditory information processing literature (Moray, 1959) indicates that one's own name is a particularly good way to capture people's attention in the auditory modality. If the current results are viewed as similar, then the name effect appears to be generalizable to the visual modality as well and potentially useful for alerting individuals to visual displays. Indeed, the results suggest that an individual's own name has greater alerting value than the signal word (whose intended purpose is, in part, to alert people that a hazard/warning is present). However, one potential benefit of signal words that is not provided by an individual's name is that these terms can also provide an indication of the level of hazard involved (Westinghouse, 1981; Wogalter and Silver, 1989). Nevertheless, the questionnaire data did not provide any support for this latter function of signal words as there were no differences between conditions for perceived hazard or carefulness.

The present research also supports another conclusion by Wogalter et al. (1992, in press). In their study, they showed that increasing the physical salience of certain features of the sign did not increase compliance. 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 do not always translate into increased compliance. Multiple methods of enhancement may be necessary before seeing substantial compliance gains.

In addition, sign placement in the cluttered room was also expected to show differences in compliance. While an ANOVA showed a small significant effect, none of the subsequent paired comparisons were significant (as sometimes happens). Warning location has been shown in several previous studies (e.g., Wogalter et al., 1987) to produce significant effects on compliance behavior. In this 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 particular environment did not allow 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 clear cut, particularly when no other dependent variable showed this effect, and no previous warning study has reported an accuracy effect. Further research is necessary to determine whether the effect is reliable and whether reports of accuracy reflect actual task accuracy.

Although the insertion of individuals' names into warning messages may seem difficult to implement, 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 eliminate certain problems that have been cited at various times in the warnings literature. One of these problems is habituation. The use of electronic detectors embedded into encoded name tags could be used to detect individual employees and visitors entering safety-sensitive areas within a workplace. The detector could also be programmed to present a warning to particular individuals below some criterion level of experience each time they enter a safety sensitive area (e.g., new employees or visitors to a workplace) and to present a warning less frequently to others above some criterion level of experience/exposure to the warning. A procedure could also 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.

## REFERENCES


Ansberry, C. (1989, June 16). Workplace injuries proliferate as concerns push people to produce. *The Wall Street Journal*, pg. 1.

Barlow, T., and Wogalter, M.S. (1993). Alcoholic beverage warnings in magazine and television advertisements. *Journal of Consumer Research.*

DeJoy, D. M. (1989). Consumer product warnings: Review and analysis of effectiveness research. In *Proceedings of the Human Factors Society 33rd Annual Meeting* (pp. 936-940). Santa Monica, CA: Human Factors Society.

Jaynes, L. S., and Boles D. B. (1990). The effects of symbols on warning compliance. In *Proceedings of the Human Factors Society 34th Annual Meeting* (pp. 984-987). Santa Monica, CA: Human Factors Society.

Kalsher, M. J., Clarke, S. W., and Wogalter, M. S. (1993). Evaluation of a warning placard for communicating alcohol facts and hazards. *Journal of Public Policy and Marketing, 12*, 78-90.

Milkovich, G. T., and Boudreau, J. W. (1991). *Human resource management*. Boston, MA: Irwin.

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology, 11*, 56-60.

Racicot, B. M., and Wogalter, M. S. (1992). Warning compliance: Effects of a video warning sign and modeling on behavior. In *Proceedings of the Human Factors Society 36th Annual Meeting* (pp. 608-610). Santa Monica, CA: Human Factors Society.

Westinghouse (1981). *Westinghouse product safety label handbook.* Trafford, PA: Westinghouse Printing Division.

Wogalter, M. S., Godfrey, S. S., Fontenelle, G. A., Desaulniers, D. R., Rothstein, P. R., and Laughery, K. R. (1987). Effectiveness of warnings. *Human Factors, 29*, 599-612.

Wogalter, M. S., Kalsher, M. J., and Racicot, B. M. (1992). The influence of location and pictorials on behavioral compliance to warnings. In *Proceedings of the Human Factors Society 36th Annual Meeting* (pp. 1029-1033). Santa Monica, CA: Human Factors Society.

Wogalter, M. S., Kalsher, M. J., and Racicot, B. M. (in press). Behavioral compliance to warnings: Effects of voice, context, and location. *Safety Science.*

Wogalter, M.S., and Silver, N.C. (1990). Arousal strength of signal words. *Forensic Reports, 3*, 407-420.

Wogalter, M. S., and Young, S. L. (1991). Behavioural compliance to voice and print warnings. *Ergonomics, 34*, 78-89.

Young, S. L., and Wogalter, M. S. (1990). Comprehension and memory of instruction manual warnings: Conspicuous print and pictorial icons. *Human Factors, 32*, 637-649.