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Increased effectiveness of an interactive warning in a realistic incidental product-use situation

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Abstract

Information about hazards and safe use of products is often provided in warning labels. In recent years, researchers have been exploring factors that influence warning effectiveness. One promising design factor is an interactive label that requires manipulation by users before or during use of a product. In the present research, the effectiveness of two interactive warning labels (with and without a color component) were compared to a standard label in the context of a realistic product-use task. The task involved the setup of video equipment in which participants connected the electrical cords to power outlets – during which they were incidentally exposed to one of three warnings attached to extension cords. Another factor manipulated in the experiment was task load, low versus higher, in which the higher load condition had an extra task that had to be performed within the same time frame. The results showed that the interactive labels were noticed, recalled and complied to more often than a standard on-product label. Increasing task load and adding color to the interactive label showed no significant influence. The results suggest that the interactive label facilitates the capturing of attention, thus increasing the potential for further processing of the message.

Relevance to industry

One reason that consumers and employees fail to comply with warnings is that the warnings frequently lack salient features that would increase the likelihood of the labels or signs being noticed in the first place. This study shows that an interactive label, requiring physical manipulation before or during use of a product, can be an effective safety strategy that reduces the failure-to-notice bottleneck. Manufacturers should take advantage of attention-getting features in designing warnings to avoid personal injury and property damage.

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

1. Introduction

Technological advances have made it increasingly important to inform consumers of product-related hazards. Manufacturers frequently place warnings on products to convey information concerning the safe use of products and equipment. A majority of these warnings have not been tested for their effectiveness in communicating hazard information or in reducing product-related injuries.

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Over the last decade, Human Factors researchers have been systematically examining the factors that may influence warning effectiveness. Most warnings research has focused on the physical design of warnings. These design factors have included the attributes of the warning itself (e.g., increasing the size of the warning, adding color and pictorials) and extra-warning characteristics (e.g., proximal location and lack of contextual clutter). However, it is not always the case that changes in intra- and extra-warning characteristics result in increased effectiveness (e.g., DeJoy, 1989).

In order to increase the likelihood that a user will read and ultimately comply with a warning, it must first be noticed. One design factor that has shown promise in increasing noticeability is interactivity, initially examined by Gill et al. (1987). An interactive warning requires manipulation prior to (or while) using a product. Research has shown that the interactive label is more noticeable than a conventional on-product label (Frantz and Rhoades, 1993; Gill et al., 1987; Hunn and Dingus, 1992; Wogalter et al., 1994).

One explanation for the ability of the interactive label to draw attention (as compared to a non-interactive label) may be related to cognitive theories of mental models (Johnson-Laird, 1983), schemas (Brewer and Treyens, 1981), and scripts (Schank and Abelson, 1977). For example, script theory suggests that after experience in a particular domain, people tend to use behaviors based on that experience in future encounters. With repeated experience, these sets of behavioral sequences become well-learned and become connected into larger sequences of behavior, and are theorized to occur automatically without much conscious thought. Therefore, if a person is familiar with a product, most behaviors associated with that product will be driven by scripted sequences of actions. In order to "break" these script-driven processes, some sort of non-scripted component needs to be introduced into the situation. Because the physical manipulation of an interactive label is a novel behavior, it may serve to break into or interrupt the individual's script, making it more likely that the individual will notice the warning. This attention-getting event then sets the stage for further processing such as reading and complying with the warning.

Although research has shown that interactive warnings can be effective in drawing attention to warning information, research on its potential to influence subsequent processing, particularly behavioral compliance, is less clear-cut. For example, both Gill et al. (1987) and Hunn and Dingus (1992) found no advantage for an interactive warning in promoting compliance, whereas two recent studies (e.g., Frantz and Rhoades, 1993; Wogalter et al., 1994) have shown interactive labels to facilitate levels of compliance. Closer inspection of these studies, however, shows that variations in experimental procedures may, at least in part, account for the observed differences in behavioral compliance. The procedures differed with respect to whether the task mirrored realistic product-use conditions and the degree of familiarity with the products and tasks. Additionally, numerous other variables differed between experiments, and therefore, it is difficult to disentangle the specific reasons for the discrepant results. Nevertheless, it is important to re-test the concept of label interactivity because it holds potential promise for increasing warning effectiveness.

The most appropriate follow-up test would include: (a) the use of an interactive warning label in conjunction with a familiar consumer product in a realistic product-use situation, and (b) the use of an incidental exposure situation that does not draw explicit attention to the warning. Both components were adopted in the present study. Thus, one purpose of this research was to examine the effectiveness of two kinds of warnings (conventional Tag vs. Interactive) on a familiar product (an electrical extension cord) under incidental exposure conditions within a set of tasks that consumers might perform in the home or at work (i.e., realistic product-use conditions).

A second purpose of the study was to examine the effects of task load on warning noticeability and compliance. Task load refers to the number of tasks an individual is carrying out at any given time. Several theories of human information processing posit that an increased level of task load can negatively impact performance (Wickens, 1989). A similar decrement might be expected for warning-related behaviors. Specifically, if an individual is carrying out several tasks at once (e.g., reading instructions, assembling parts, or talking on the phone), increased task load may result in a failure to notice, read, and comply with a warning.

Before the present study was performed, a pilot study was used to make an initial examination of the potential effects of task load on noticing, reading, and complying with a warning. Participants were asked to plug the electrical cord of various products such as a TV and videocassette recorder (VCR) into outlets using a set of extension cords. The cords contained safety information about their proper use. In the increased task load condition, participants had to perform additional tasks that included: inserting a videotape into a VCR, rewinding the tape, and then cueing the tape to a specified starting position. It had been expected that participants in the increased task load condition would be thinking about the secondary task (i.e., cueing the tape) while they were plugging in the products (i.e., primary task). This increased load might serve to absorb some quantity of cognitive resources such that participants may fail to see, read, and comply with the warning. Nevertheless, the task load manipulation failed to show any effect. One potential explanation for this null finding is that the two tasks occurred in serial order, and not simultaneously. Thus, thinking of performing an extra task might have no effect during the time participants were using the extension cords. In the present study, another task load manipulation was developed in which the additional (secondary) task was expected to be performed simultaneously with the primary task.

Additionally, a third purpose of the study was to examine the possible influence of color in a warning. Similar to the expected effect of interactivity, the presence of color might enhance the noticeability of a warning. Most studies concerned with color in the warning literature have measured subjective reports on the levels of connoted hazard of various colors (e.g., Kline et al., 1993), but surprisingly, color has received very little systematic investigation in behavioral compliance research. One study by Wogalter et al. (1987) showed that a water fountain sign containing color components (that warned of contaminants) was more effective in dissuading drinking than a sign without color. However, color was only one of several enhancements made to the color-present sign; it was also enhanced by the addition of a pictorial and physical enlargement of the warning. Therefore, it is difficult to determine from the Wogalter et al. (1987) study whether and how much influence color had in facilitating compliance. Thus, the present study examined the potential effect of color by comparing an interactive warning label with color (bright safety orange background) to an otherwise identical label except color (white background).

In summary, three independent variables were manipulated in the present experiment: Label Type, Task Load and Color. Their influence was assessed using three dependent measures of warning effectiveness: (1) noticing, (2) reading, and (3) complying. It was hypothesized that an interactive colored warning label under lower task load conditions would be most effective.

2. Method

2.1. Participants

One hundred twenty undergraduates at Rensselaer Polytechnic Institute participated in the study. They received credit toward an introductory psychology course in which they were enrolled. Participants were randomly assigned, in equal proportions, to one of eight experimental conditions.

2.2. Design

A 2 Task Load (Low, Increased) × 4 Label Type (No Label Control, Tag, Interactive with Color-Absent, Interactive with Color-Present) between-subjects factorial design was used. Three dependent variables were examined: noticing the warning label, recall of the warning content (as an indicant of reading), and behavioral compliance. Noticing and recall were assessed by items on a post-task questionnaire. Compliance was assessed by observing whether the participants' performed the safety behaviors directed by the warning.

2.3. Materials

Four sets of white extension cords were used to present the warning information. Each white 2.74 m cord had a removable outlet cover which was permanently attached near its female (receptacle) end. The cover was designed to fit into the cord's receptacle to prevent shock when the receptable was not in use. The original manufacturer's warning was located on the plastic outlet cover, molded in raised white text on a white background. Due to its low visibility and legibility, the warning was removed by shaving off a layer of plastic leaving a smooth surface.

The four pairs of extension cords differed only in terms of the presence, location, and color of the warning. In the No-Label (Control) condition, there was no warning information on the cords. In the Tag condition, the warning label was permanently attached to the extension cord 5 cm above the female receptacle. In the two interactive conditions, the warning label was affixed to the outlet cover on the female receptacle. The two interactive labels were identical except for the presence or absence of color.

The redesigned label warned of the potential for fire and electrical shock if too many products are plugged into the extension cords. Fig. 1 shows the label used in the three warning-present conditions.

The text on all of the warning labels occupied

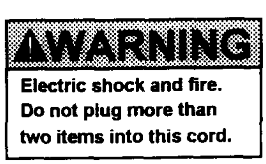

Fig. 1. Warning label used in the warning-present conditions. The gray shading represents orange color used in the color-present condition. In the color-absent condition, the background of the upper panel was white.

a space of 3.8 cm × 2.2 cm. The signal word and warning instructions were printed respectively in 18-point and 8-point sans serif proportional font. The signal word (WARNING) was printed in black text on a white background (Color-Absent condition) and in black text on a bright, highly saturated safety orange background (Tag and Color-Present conditions). In addition, a signal icon (i.e., exclamation point surrounded by a triangle) was located to the left of the signal word.

2.4. Procedure

Participants were initially told they would be evaluating instructional media. This provided a scenario in which attention would not be explicitly drawn to the warning information. Each participant was led into a room in which a television, video-cassette recorder, and videotape rewinder were set up on a small table. The lights in the room were turned off and the equipment was intentionally left unplugged to make the room appear as if it was not properly set up for the experiment. Upon entering the room, the experimenter turned on the lights and gave the participant a research consent form to complete. While the participant completed the form, the experimenter left the room for a few seconds and returned with a pair of extension cords (all conditions) and a small battery operated tape player (Increased Task Load condition only). The experimenter casually placed the extension cords on a chair about 1 m from the video equipment and placed the tape player on a table in front of the participant. The experimenter then collected the research consent form.

While preparing the equipment, the experimenter remarked that he had left the videotape in another room and would have to retrieve it. The experimenter then explained to the participant the tasks that they would be asked to do. Participants in the Low Task Load condition were told that they would be watching a job training videotape and then would complete two questionnaires. Participants in the Increased Task Load group were told that they would listen to a portion of an audiotape lecture on industrial control rooms (the added task load component), then would watch a job training videotape, and would later complete two questionnaires.

In the Increased Task Load condition, the experimenter started the audiotape and told the participant that he would return shortly with the videotape. The Low Task Load condition lacked the audio tape and all procedures associated with it. Before exiting the room, the experimenter asked every participant (regardless of condition) if he or she would mind "helping out" by plugging in the television, video cassette recorder, and videotape rewinder. For those participants in the Increased Task Load condition, this task was to be carried out while they listened to the audiotape. The experimenter then left the room, and after approximately four minutes had elapsed, the experimenter returned to the room with the videotape. Participants were shown the brief four-minute videotape in order to avoid drawing explicit attention to the tasks they had just performed (i.e., plugging in the products) and to help disguise the true purpose of the study.

Finally, participants were taken into another room to complete two post-task questionnaires. The first questionnaire requested various demographic data (e.g., age, gender) and ratings of 18 consumer products including electrical extension cords. The rating questions evaluated three dimensions: perceived hazard, severity of injury, and product familiarity. Responses were based on 9-point Likert-type scales anchored with "0" denoting absence of quantity to "8" indicating maximum quantity. The specific questions and numerical and verbal anchors were:

(a) "How hazardous is the product?" with the anchors: (0) not at all hazardous, (2) slightly hazardous, (4) hazardous, (6) very hazardous, and (8) extremely hazardous.
(b) "How severely might you be injured with this product?" with the anchors: (0) not at all severe, (2) slightly severe, (4) severe, (6) very severe, and (8) extremely severe.
(c) "How familiar is the product?" with the anchors: (0) not at all familiar, (2) slightly familiar, (4) familiar, (6) very familiar, and (8) extremely familiar.

For each of the above questions, the products were arranged into three different random orders.

The second questionnaire asked participants whether they saw a warning label, and if so, specifically what the warning said and where it was located. Participants in the Increased Task Load condition were also asked to recall the content of the audiotaped lecture.

After completing the questionnaires, participants were debriefed, thanked for their participation, and dismissed. The experimenter then examined the two extension cords to determine if one or both had been used by the participant. Correct performance (compliance) was operationally defined as plugging in two of the three products into one extension cord and one product into the other extension cord.

3. Results

Two raters independently scored the open-ended items on the questionnaires. Inter-rater agreement was computed using the formula: agreements/(agreements + disagreements) × 100. Inter-rater agreement for each item ranged from 96% to 100% with a mean of 97% across all items.

A 2 Task Load (Low, Increased) × 4 Label Type (No-Label Control, Tag, Interactive with Color Absent, Interactive with Color Present) between-subjects Multivariate Analysis of Variance (MANOVA) was performed on three dependent variables: noticing, recall, and compliance. Multivariate tests of significance using Hotelling's criterion showed a significant main effect of Label Type, $F\ (9, 326) = 17.48$, $p < 0.001$, but there was no significant main effect of Task Load, $F\ (3, 110) < 1.0$, nor was there a significant interaction, $F\ (9, 326) < 1.0$.

Separate univariate one-way analyses of variance (ANOVAs) were performed on each of the dependent variables for the significant main effect of Label type that was shown in the MANOVA. Post-hoc tests (i.e., Newman-Keuls Multiple Range Test at an α of 0.05) were used to compare conditions. The following three sections describe the results of these analyses.

3.1. Noticeability

There was a significant effect of Label Type on noticing the warning label, F (3, 116) = 49.67, $p < 0.001$. Participants reported seeing both interactive labels ($M = 76.7\%$ and $M = 86.7\%$ for the Color Absent and Present conditions, respectively) significantly more often than the Tag label ($M = 16.7\%$) and when the no-label control was present ($M = 0.0\%$). There was no significant difference between the Interactive Color-Absent and Interactive Color-Present conditions, nor was there a difference between the Tag condition and the No-Label Control conditions.

3.2. Recall of content

There was also a significant effect of Label Type on recall of the warning content, F (3, 116) = 29.00, $p < 0.001$. Participants recalled the content of both interactive labels ($M = 53.3\%$ and $M = 73.3\%$ for the Color Absent and Present conditions, respectively) significantly more often than the Tag label ($M = 10.0\%$) and when the no-label control was present ($M = 0.0\%$). There was no significant difference between the Interactive Color-Absent and Interactive Color-Present conditions, nor was there a difference between the Tag and the No-Label Control conditions.

3.3. Compliance

There was a significant effect of Label Type on behavioral compliance, F (3, 116) = 14.57, $p < 0.001$. Participants complied with both interactive labels ($M = 53.3\%$ and $M = 43.3\%$ for the Color Absent and Present conditions, respectively) significantly more often than the Tag label ($M = 6.7\%$) and when the no-label control was present ($M = 0.0\%$). There was no significant difference between the Interactive Color-Absent and Interactive Color-Present conditions, nor was there a difference between the Tag and the No-Label Control conditions.

3.4. Rating analyses

The results confirmed that participants were highly familiar with the extension cord product. Electrical extension cords were assigned a mean familiarity rating of 6.79 (just below the midpoint between the verbal anchors of "very familiar" (a rating of 6) and "extremely familiar" (a rating of 8) on the scale). Extension cords were assigned a mean hazard rating of 3.05 which is located midway between the verbal anchors of "slightly hazardous" (a rating of 2) and "hazardous" (a rating of 4) on the scale, and a mean severity of injury rating of 3.08 which was positioned between the verbal anchors of "slightly severe" (a rating of 2) and "severe" (a rating of 4) on the scale. None of the experimental conditions differed with respect to familiarity, perceived hazard, or severity of injury ($ps > 0.05$).

3.5. Compliance contingencies

Of the 54 participants who reported seeing the warning, 43 (80%) were able to accurately recall its contents (phi coefficient: $\Phi = 0.62$, $p < 0.0001$) and 31 (57%) complied with it ($\Phi = 0.59$, $p < 0.0001$). Of the participants who recalled the warning, 72% complied with it ($\Phi = 0.76$, $p < 0.0001$). All (100%) of the participants who complied with the warning reported seeing it and could correctly recall its content.

4. Discussion

The results of this study showed that the interactive label was noticed, read (as measured by recall), and complied with more often than a conventional on-product (tag) label. These findings are consistent with those of Frantz and Rhoades (1993) and Wogalter et al. (1994), who also showed a positive effect of interactive warnings. However, this study only partially confirmed the results of Gill et al. (1987) and Hunn and Dingus (1992). Their finding of increased noticeability of an interactive warning was confirmed, but not their finding of no effect of an interactive warning on compliance.

It should be noted that in the present study, participants were considered to be in compliance with the warning only if they met all four of the following requirements: They (a) stated that they saw the label, (b) recalled the content of the label, (c) indicated the correct location, and (d) properly connected the equipment. This definition of compliance was used to reduce the effects of chance, by eliminating those behaviors that may have been attributed to chance (i.e., correctly connecting the equipment but stating they did not see the warning).

While positive effects were found for the interactive label, none were found for the tag relative to the no-label control. Research by Wogalter and Young (1993) has shown that a tag label (attached to a small bottle container) can produce higher levels of compliance than a no-label control condition. However, the tag in that study was very different than the tag in the present study. Wogalter and Young's (1993) tag label required more interaction by the user while using the product than the non-interactive version in the present study.

This study failed to demonstrate an influence of task load on warning compliance. Possibly, the high task load condition (i.e., attending to the audiotape while plugging in the products) did not actually produce an increase in cognitive effort at the point in time expected. Post-task questioning indicated that 78% of the participants in this condition reported hearing the contents of the audiotape, but it is not clear whether they were listening to the tape at the precise moment they were plugging in the electrical equipment. As task load has been found to influence performance in a variety of other tasks, additional research on its effect on warning compliance is needed. Some other potential task load manipulations might include having participants simultaneously attend to an important telephone conversation concurrent with the warning-related task or constructing a situation where performance speed is emphasized. If task load is found to have an impact on warning effectiveness under certain conditions, steps should be taken to design warnings that will attract a user's undivided attention and persuade them that compliance is a most important primary task.

The presence of color did not significantly enhance the interactive warning's effectiveness. However, there was a (non-significant) trend favoring color for noticeability and recall, but not for compliance. One possible explanation for this is that the strong effect of the interactive label might have mitigated any additional effect of color. As was noted earlier, research on the effects of color on compliance has been limited. Additional research is needed to determine not only the effect of color (its presence versus absence), but also the effects of different hues, and varying levels of brightness and saturation on measures of warning effectiveness.

This and other research indicates that interactive warnings are useful in conveying safety information. However, an important question that remains is whether employees and consumers would be willing to accept and purchase products with interactive warning labels. By its very nature, the interactive design is intrusive; it purposely interrupts task performance. According to script theory, this interruption is necessary to break into people's highly familiar sequence of actions. Thus, a balance probably needs to be maintained between too much intrusiveness, which could cause annoyance (possibly leading to its removal) and not enough intrusiveness that might fail to elicit people's attention. How such a balance could be implemented is an important topic of future research.

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References

Brewer, W.G. and Treyens, J.C., 1981. Role of schemata in memory for places. Cognitive Psychology, 13: 207–230.

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

Duffy, R.R., Kalsher, M.J. and Wogalter, M.S., 1993. The effectiveness of an interactive warning under varying task load. In: Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting. Human Factors and Ergonomics Society, Santa Monica, CA, pp. 935–939.

Frantz, J.P. and Rhoades, T.P., 1993. A task analytic approach to the temporal placement of product warnings. Human Factors, 35: 719–730.

Gill, R.T., Barbera, C. and Precht, T., 1987. A comparative evaluation of warning label designs. In: Proceedings of the Human Factors Society 31st Annual Meeting. Human Factors Society, Santa Monica, CA, pp. 476–478.

Hunn, B.P. and Dingus, T.A., 1992. Interactivity, information and compliance cost in a consumer product warning scenario. Accident Analysis and Prevention, 24: 497–505.

Johnson-Laird, P.N., 1983. Mental Models. Cambridge University Press, Cambridge, UK.

Kline, P.B., Braun, C.C., Peterson, N. and Silver, N.C., 1993. The impact of color on warnings research. In: Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting. Human Factors and Ergonomics Society, Santa Monica, CA, pp. 940–944.

Laughery, K.R., Young, S.L., Vaubel, K.P. and Brelsford, J.W., 1993. The noticeability of warnings on alcoholic beverage. Journal of Public Policy and Marketing, 12: 38–56.

Schank, R.C. and Abelson, R., 1977. Scripts, Plans, Goals, and Understanding. Erlbaum, Hillsdale, NJ.

Wickens, C.D., 1989. Attention and skilled performance. In: D. Holding (Ed.): Human Skills (2nd Edition). Wiley, New York, pp. 71–105.

Wogalter, M.S., Barlow, T. and Murphy, S., 1994. Compliance to owner's manual warnings: Influence of familiarity and the task-relevant placement of a supplemental directive. Ergonomics, in press.

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. and Young, S.L., 1993. Enhancing warning compliance through alternative product label designs. Applied Ergonomics, 34: 79–89.

Young, S.L., 1991. Increasing the noticeability of warnings: Effects of pictorial, color, signal icon and border. In: Proceedings of the Human Factors Society 35th Annual Meeting. Human Factors Society, Santa Monica, CA, pp. 580–584.