

Behavioural compliance to voice and print warnings

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The present research examined the effect of warning modality on compliance behaviour in two laboratory experiments and a field experiment. In the laboratory experiments, subjects followed a set of printed instructions to perform a chemistry demonstration task that involved the measuring and mixing of disguised chemicals. In the first experiment, subjects were directed to wear mask and gloves by a warning presented in one of three ways: printed on the top of the instruction sheet (print-only); given aurally by the experimenter (voice-only); or given both in the printed instructions and by the experimenter (print and voice). The results showed that compliance was significantly higher when the warning was presented in both modalities compared to the print-only condition. The voice-only condition produced intermediate compliance that was not reliably different from the other two conditions. To reduce possible experimenter influence in the voice warning conditions of the first experiment, the warning was presented by audiotape in the second experiment. The results again showed greater compliance to a warning presented in both modalities compared to a print warning alone. To check the external validity of these results, a field experiment was performed which simulated a slippery-floor hazard in a shopping mall. The results confirmed the findings of the two laboratory experiments. This research demonstrates that voice warnings enhance behavioural compliance, probably due to their inherent attention-getting and information transmission properties. Practical applications of voice warnings are discussed.

1. Introduction

As consumer products become more technologically complex, the hazards associated with their use may not be obvious to people unfamiliar with the products. Such hidden hazards can be responsible for accidents and injury. The prevention of these consequences can be handled in several ways. First and foremost, the manufacturer should foresee possible uses and misuses of the product and try to remove the hazards at the design stage. If this cannot be accomplished, then barriers or guards should be used to prevent the consumer from encountering the hazard. Additionally, consumers could be trained on how to use the products safely through educational programmes and instruction. However, these means of protection are not always possible or practical. In such cases, warnings should be used.

The utility of warnings has been debated hotly in the legal arena and in the research literature. McCarthy *et al.* (1984) concluded from a literature review of 400 papers on warnings that research has failed to demonstrate their effectiveness. However, at the time this article was published, very few papers

dealt with behavioural compliance to warnings. The probable explanation for this condition is that behavioural compliance research is difficult to carry out. There are three reasons for this. First, observing behaviour that is the direct result of warnings is labour intensive because the critical events are generally infrequent and sporadic. Second, laboratory studies which permit control of extraneous variables in order to draw inferences about causal relations may lack external validity: We may not be able to generalize results to real-world settings. And third, creating hazardous situations that are ethically acceptable and at the same time believable is challenging. It is unethical to manipulate warnings when real dangers are present except in special circumstances. Because of these difficulties, most of the research on warnings has employed rating and self-report measures. However, these measures might have limited validity in actual compliance situations.

Since the appearance of the McCarthy *et al.* (1984) review, new methodologies have been developed to measure actual behavioural compliance to warnings. Recent research using these methodologies have begun to examine the factors that affect compliance behaviour. This research shows that warning placement (Wogalter *et al.* 1987), embedding the warning in other text (Strawbridge 1986), social influence (Wogalter *et al.* 1989) and cost (Wogalter *et al.* 1989) directly influence behavioural compliance to warnings.

One promising variable which has yet to be investigated is the modality or channel of verbal warnings. The present research addresses this by comparing the effect of voice and print warnings on compliance.

Although there is no research comparing these two verbal modalities directly, other literature suggests auditorily-presented warnings would be more effective than visually-presented warnings. Numerous ergonomic and human factors texts and handbooks (e.g., Eastman Kodak Company 1983, Sanders and McCormick 1987, Sorkin 1987) recommend the use of simple auditory warnings (i.e., beeps or alerting tones) when immediate attention must be secured (e.g., when the receiver might be occupied by other tasks or when the receiver might not be focusing directly on a visually-presented warning). However, simple auditory warnings are often used solely as a means of alerting the user. More complex auditory warnings have the potential not only to alert but also to inform the user of the kind of hazard present. Complex auditory warnings of the non-verbal type have been used in situations where several different messages need to be communicated under conditions of high visual demand (e.g., in aircraft cockpits). Different messages are coded by various temporal, frequency and amplitude sound patterns. Though research has shown that large sets of complex non-verbal signals can be learned, such learning may require considerable training time and regular retraining (Patterson and Milroy 1980). Operators frequently have trouble appropriately identifying, assigning priorities and responding to complex non-verbal auditory displays (Banks and Boone 1981, Cooper 1977).

Another type of complex auditory warning is voice warnings. Voice warnings also have the potential to alert and inform, but in addition they can take advantage of prior learning and knowledge of the receivers. With voice warnings, the receiver generally does not need to learn or be trained to understand the meaning of the sounds.

Research comparing voice and non-verbal auditory warnings has been rather limited. Speech warnings have been found to produce better pilot performance

than non-verbal auditory warnings in aircraft simulation tasks (e.g., Brown *et al.* 1968, Simpson and Williams 1980, Voorhees *et al.* 1983). This research suggests that voice warnings are useful compared to non-verbal auditory signals, but they do not address whether voice warnings are better than print warnings which contain the same verbal message. This latter issue is examined in the present research.

A large body of human memory research has demonstrated that verbal materials presented auditorily tend to be better remembered than the same materials presented visually. In a literature review, Penney (1975) found that virtually every short-term memory study comparing the two modalities shows that auditory presentation of verbal materials produces superior retention, particularly for recently presented words. This research suggests that a voice warning might be more effective than the same warning presented in print form.

However, other research suggests a different hypothesis. Results supporting the visual sense's superiority or dominance over other modalities (Pezdek and Stevens 1984, Posner *et al.* 1976) would predict greater influence by a message presented in the visual modality than in the auditory modality. From this basis, the prediction can be made that a print warning should be more effective than a voice warning.

Also examined was whether the combination of both print and voice warnings would produce greater behavioural compliance than either presentation mode alone. Research (Baggett and Ehrenfeucht 1981) and theory (Garner 1974) suggest that presentation of materials in more than one modality leads to better retention. In a practical sense, redundant presentation of a warning should facilitate reception, particularly when the message in one modality is missed. Moreover, the redundant presentation might help to reinforce the message when both modes are received. Thus, it was expected that a warning presented in both print and speech form would be more effective than warnings presented in only one form.

The effects of warning modality on behavioural compliance were addressed in two laboratory experiments and in a field experiment.

2. Laboratory Experiment 1

In the first laboratory experiment, three warning conditions were examined: voice-only, print-only, and voice-print combined. The procedure involved a chemistry demonstration paradigm employed by Wogalter *et al.* (1987, 1989) in which subjects followed instructions to mix chemicals under varied conditions. The procedure was similar to the high-cost condition of Wogalter *et al.* (1989).

2.1. Method

2.1.1. *Subjects:* Eighty-one undergraduates from the University of Richmond participated for credit in an introductory psychology course.

2.1.2. *Materials:* A variety of chemistry equipment was provided. The equipment used to perform the task included a triple-beam balance, flasks, beakers, glass rods and graduated cylinders. Latex gloves and moulded paper masks were also provided. Three substances and two solutions were prepared and labelled: Substance A (white flour); Substance B (red-dyed granulated sugar); Substance C (yellow corn meal); Solution A (blue-dyed water); and Solution B

(green-dyed water). The solutions and substances were disguised to help create the illusion that the subjects were mixing potentially hazardous chemicals.

A printed instruction sheet was prepared that described the specific procedures of the chemistry demonstration task. It contained a short introduction to the task, followed by a six-step procedure for measuring and mixing the substances and solutions. In the two conditions with print warnings, a warning was placed after a short introductory paragraph and before the specific mixing instructions: 'WARNING: Wear gloves and mask while performing the task to avoid irritating fumes and possible irritation of skin'. In the voice-only condition, the warning was absent from the instruction sheet.

The task instructions led the subject through a series of steps in which they were to measure and mix certain quantities of the solutions and substances in a predetermined order. A post-experiment questionnaire was used to assess subjects' awareness and memory of the quantities of substances and solutions used, the presence of various chemistry equipment, the presence of the warning and the verbal content of the warning.

2.1.3. *Procedure*: Subjects participated individually. Initially they were seated at a table in a small room. A large number of latex gloves and paper masks were placed conspicuously on this same table. After signing the consent form in this room, subjects were taken to an adjoining room where they were asked if they were familiar with a triple-beam balance. If they were not, they were shown how to use it. Subjects were then given a brief overview of the task they were to perform. The overview informed subjects (1) that they should complete the laboratory task as quickly and as accurately as possible, (2) that they had a limited amount of time to complete the task, and (3) that the final product would be evaluated for accuracy. In the two conditions with a voice warning, the preliminary instructions were followed by an aural warning from the experimenter: 'Please wear mask and gloves while performing the task to avoid possible irritating fumes or irritation of the skin'. Subjects were then given the instruction sheet and were told that no further conversation could take place. The experimenter stood in the doorway and observed the subject's performance. In order to comply with the warning, subjects had to walk out of the demonstration room and back into the room where they had signed the consent form to retrieve mask and gloves before starting the task. After 7 min if subjects had not already completed the task, they were stopped and were given a questionnaire. Subjects were later debriefed as to the purpose of the study and the manipulations that were employed.

2.2. Results

The method of warning presentation was the independent variable and warning compliance (i.e., use of gloves and mask) was the dependent variable. The highest rate of compliance was seen in the voice-print condition (20 of 27, i.e., 74%), followed by voice-only (16 of 27, i.e., 59%) and print-only (11 of 27, i.e., 41%). A Chi-square analysis of compliance showed that the modality of presentation was significant, $\chi^2(2) = 6.18$, $p < 0.05$. The voice-print condition produced significantly greater compliance than the print-only condition, $\chi^2(1) = 6.14$, $p < 0.02$. No other difference was significant.

Items on the questionnaire were also examined. Of the 34 subjects who did

not comply, 24 (71%) saw the masks and gloves. Of the 23 subjects exposed to the print warning and who did not comply, 17 (74%) reported that they saw the warning and were able to recall its content.

2.3. Discussion

The voice plus print warning condition produced significantly greater compliance than the condition with a print warning alone. This enhanced compliance appears to be due to the addition of the voice mode. Although not significant, the compliance rate of the voice-only condition tended to be higher than that of the print-only condition. Non-compliance was apparently not due to a failure to see the mask and gloves, or to see the warning or to comprehend it. Many subjects saw the warning, understood it, and were aware of the necessary apparatus, but still did not make the necessary effort to comply. The failure to persuade some participants to comply though they were aware of the warning is a fairly common finding in the behavioural compliance literature (e.g., Friedmann 1988, Otsubo 1988, Strawbridge 1986). Apparently the combination of both voice and print was more persuasive in motivating people to obey the warning than the print version alone.

3. Laboratory Experiment 2

Enhanced compliance in the voice plus print warning condition may have been due to the experimenter's personal presentation of the warning. That is, the increased compliance rates of the two condition with voice warnings may have been created or enhanced by social influence (i.e., direction from a live authority figure) and not the auditory presentation of the message *per se* (Zeece and Crase 1982, Wogalter *et al.* 1989). To reduce experimenter influence, the voice warning in Experiment 2 was presented using a tape player. Two warnings conditions were examined: audiotape plus print, and print-only.

3.1. Method

3.1.1. *Subjects*: Twenty-two undergraduates from the University of Richmond participated for credit in an introductory psychology course.

3.1.2. *Materials*: The chemistry equipment, instructions and print warning were identical to those used in Experiment 1. The auditory warning was a tape-recording of a female saying the same voice warning as used in Experiment 1.

3.1.3. *Procedure*: The procedure for Experiment 2 was similar to that of Experiment 1. After signing the consent form in the room where the masks and gloves were located, subjects were taken to the adjacent room where the chemistry demonstration took place.

In the audiotape plus print warning condition, the experimenter started the tape recorder and instructed the subject to stop the tape after the message had finished and to turn over the instruction sheet and begin. The experimenter then left the room and viewed the subject through a doorway. The warning was presented only once and was the same warning given vocally in Experiment 1. The print-only condition was similar except the procedure concerning the audiotape was absent.

3.2. Results

The method of presentation of the warning (print-only or print-audiotape) was the independent variable and compliance was the dependent variable. Greater compliance was observed in the print-audiotape condition (8 of 10, i.e., 80%) than the print-only condition (2 of 12, i.e., 16.7%). A Chi-square analysis of compliance showed that the presentation modality was significant, $\chi^2(1) = 8.82$, $p < 0.01$.

3.3. Discussion

The results again show that a voice warning combined with a print warning, produces greater compliance than a print warning alone. With the social influence source removed, the results suggest that the facilitated compliance of the voice warning in Experiment 1 can be attributed to the modality of the verbal presentation and not to the experimenter's personal presentation of the message. The results suggest that the source of the voice message (presented by a person or tape player) is not as important as the modality of presentation (voice versus print).

While the compliance rate of the print-voice condition in Experiment 1 (74%) was similar to that of the print-audiotape condition in Experiment 2 (80%), there was a disparity in compliance rates between the print-only conditions in the two experiments (41% vs. 16.7%). The compliance rate found by Wogalter *et al.* (1989) in a similar condition was identical to the rate found in Experiment 2 (16.7%). We have not been able to generate a reason for the aberrant compliance rate in Experiment 1.

4. Field experiment

Compliance behaviour for a print warning was enhanced by adding a voice warning in the laboratory. A field experiment was conducted to determine whether a voice warning has a meaningful effect in a real world setting.

4.1. Method

At a major shopping centre in Richmond, VA, a slippery-floor hazard was simulated. An orange traffic cone was placed at the entrance to the shopping centre and a second orange cone was placed 6.10 m farther into the centre. A tape player was placed in an empty bucket about 1.5 m from the lead cone and was hidden by a mop. A total of 531 people entering the shopping centre encountered one of four warning conditions: (1) no warning (cones, bucket and mop); (2) voice-only; (3) print-only; and (4) voice-print combined. In the print-only condition, a sign (60.9 cm \times 76.2 cm) was attached to the lead cone which stated: 'WARNING! WET FLOOR. MAY BE SLIPPERY'. In the voice-only condition, the warning was presented aurally every 10 s by the tape player. The sign and tape-recorded message were combined in the voice-print condition. The experimenter observed from about 5 m away. Each condition was repeated 3 times in a predetermined random order. Compliance for each of the conditions was measured for a total of 45 min (3 sessions of 15 min). Compliance was defined as not entering the area between the cones or not entering the area within 1.5 m² of the cones as delimited by large floor tiles.

4.2. Results

Of the 531 people observed during the experiment, a total of 123 were excluded from the analysis because they either entered the area accompanied by a group of people ($n = 108$) or they were too young ($n = 15$). Greatest compliance was shown for the print-voice condition (76%), followed by the voice-only (64%), print-only (42%) and no-warning (20%) conditions. A 2 (voice present vs. absent) $\times 2$ (print present vs. absent) analysis of variance (ANOVA) was used to analyse these data. Although a Chi-square test is usually used to analyse binomial data, an ANOVA was considered appropriate here because (1) the experimental design conformed to a 2×2 factorial layout which allowed investigation of a possible voice by print interaction, and (2) in previous research which has directly examined the adequacy of ANOVA relative to chi-square. Cochran (1950) concluded that ANOVA is a valid, reasonably robust test of binomial data.

Both modalities produced reliable main effects. Significantly greater compliance was observed with voice warnings present (71%) than absent (31%), $F(1, 404) = 78.06$, $p < 0.001$. Similarly, greater compliance was observed in conditions with print warnings present (60%) than absent (42%), $F(1, 404) = 15.73$, $p < 0.001$. No significant interaction was found. Pairwise comparisons using Newman-Keuls test indicated that all four conditions differed significantly from each other (all p 's < 0.05).

4.3. Discussion

These results confirmed the findings of the two laboratory studies. A warning presented in two modalities produced greater compliance than a warning presented in only one modality. In addition, the field experiment also showed that a voice warning alone produced greater compliance than a print warning alone, which confirmed the trend in Experiment 1.

Besides supporting the effects found in the two laboratory experiments, the field experiment provided additional information that was not obtained earlier. First, compliance differences were found in a real world setting suggesting that voice and print presentation have meaningful effects. Second, the design provided an opportunity to examine whether the presentation modalities combine additively or interact. The results showed that each modality produced separate additive effects. Third, the field experiment provided a situation in which the experimenter was remotely located and it was not overtly apparent that the experimenter was recording behavioural measures as was the case in the two laboratory experiments. And fourth, the participants' attention was not unduly directed to the source as it might have been in Experiments 1 and 2.

5. General discussion

Past research has demonstrated the alerting benefits of voice warnings over simple auditory warnings (e.g., Brown *et al.* 1968, Simpson and Williams 1980, Voorhees *et al.* 1983). The present research demonstrates the benefits of voice warnings over print warnings. The field experiment showed that the single modality voice warning produces greater compliance than the single modality print warning, confirming the non-significant tendency found in the first laboratory experiment. The present research also demonstrates that warnings

presented in two modalities, both print and voice, produces greater compliance than the single modality print warning.

Comparison across the two laboratory experiments suggests that the presence of the source of the voice message is not as important as the modality of presentation itself. Both experiments showed that the addition of a voice warning, whether received directly from the experimenter or via audiotape, produced significantly greater compliance behaviour than the print-only condition.

Results from Experiment 1's post-task questionnaire suggest that subjects who failed to comply were aware of the warning and aware of the means to comply. Apparently, these subjects were not persuaded by the warning to take efforts to obey it. Greatest persuasion was evident in the voice plus print warning condition and least in the print-only condition. These results support the findings of Chaiken and Eagly (1976) who found that for easily comprehended messages, persuasion is greater for audiotape than for print presentations.

The results also support the literature showing that verbal materials presented auditorily are memorially more effective than the same materials presented visually (e.g., Penney 1975), but fail to support a prediction provided by the visual superiority or dominance effect (Pezdek and Stevens 1984, Posner *et al.* 1976) that visual information has greater impact on human processors than information received by other modalities (in this case, auditory). However, closer examination of the literature supporting this effect reveals that it is found only in situations when information is simultaneously presented in two modalities and when the messages they convey are conflicting. This was not the case in the present study. When the warning was presented in both modalities, the messages were not given simultaneously and they were redundant.

A critical factor for differences in compliance might be due to presentation frequency. In the voice plus print condition, the warning was presented once in each modality and was therefore presented twice. However, in the single modality conditions the warning was presented only once. One method of controlling for frequency would be to print the warning twice and/or to have the experimenter say the warning twice. Because audition and vision have different characteristics, exposure is difficult to equate. In the field experiment, consider that a slow walking shopper might hear the warning more than once, and thus might attend to the voice warning for a longer duration than they might have looked at the printed warning. However, it is also conceivable that this same person might have stared at the printed warning for a greater duration than the total time given to a repeated voice stimulus. The point is that repetition does not necessarily imply greater processing time or attention. Empirical work estimating the parameters of repetition would be useful for determining the compliance limits and effects of within-modality presentation. However, as a control for amount of attention given to the warning message, the difficulty of matching processing time becomes a concern. That the voice-plus-print warning involves two message presentations is a natural consequence of combining modalities. Perhaps the most useful information that can be drawn from these experiments is that the two modalities together have a powerful influence on compliance.

The benefits of voice warnings over printed warnings are numerous. Voice

warnings are attention-getting and omnidirectional. This is an important consideration when the target person's visual attention may be distracted by other people, objects, or tasks, and when the hazards are temporary and unexpected (e.g., wet floor). In some situations, voice warnings might be less disruptive than print warnings because registration of auditory information does not necessarily require reorientation of visual attention to a warning in the visual modality. This is an important consideration for persons involved in tasks whose visual channels are in constant use or are focused on other sources of information. Voice warnings can also benefit certain population groups who have difficulty with printed language such as the blind and the illiterate.

Simple non-verbal auditory warnings are commonly used in real-world situations for the purpose of attracting attention to changes in the environment. Automobile drivers signal to careless persons on the road by blowing the horn, and passengers in commercial airlines are signalled with a tone when there is a change in the non-smoking/seat-belt status of an aircraft. But simple auditory warnings are often used only as a means of signalling a change. The person must then visually search to ascertain what the change is. In complex systems, such as a cockpit or a nuclear reactor control room, simple auditory signals may be inadequate. Voice warnings have the potential to convey information more directly on the kind of hazard present. Although more complex non-verbal auditory warnings have the potential to inform as well, they may require extensive learning and maintenance retraining (Patterson and Milroy, 1980). Voice warnings do not require training to recognize their meaning because they take advantage of people's verbal capabilities and their extensive pre-existing knowledge. The variety of messages that voice warnings can convey is unlimited.

However, consideration should also be given to some of the problems inherent in the use of voice warnings. Voice warnings take time to be transmitted, and simultaneous presentations of several voice warnings could create confusion. These disadvantages can be overcome, for example, by making the different messages discriminable or by prioritizing the order of the messages. In addition, it is necessary to consider the environment involved in the warning system (e.g., the maximum number of warnings that might be encountered, and the characteristics of the potential targets). As an implication of the present research, it should probably be recommended that, when practical, warnings should be presented both auditorily and visually.

There may be certain circumstances when a very large amount of complex information must be communicated. Chaiken and Eagly (1976) found that with difficult messages, presentation in the print mode produced greater persuasion than the voice mode. Similarly, complex warning messages might be better presented in the print mode. When a complex warning message is necessary, the combination of a concise voice warning and a more complex printed warning might be used. For example, a brief voice warning might be used to capture attention, present the most important information concisely, and cue the user to orient to a more detailed printed warning. Clearly research is needed to examine the best ways to present complex warning information. For example, how should information be best allocated to the different modalities?

The proliferation of new and improved voice recognition and synthesis technology in recent years has made voice warnings more feasible through the development of voice generation chips and digitized sound processors. Given

the cuing benefits of voice warnings over print warnings, and the information transmission benefits of voice warnings over non-verbal auditory warnings, the present study suggests that the many possible uses of voice warnings have not been realized.

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