Indirect Warnings and Instructions Produce Behavioral Compliance

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Abstract

Most research on warnings assumes a direct flow of information from the source *directly* to receivers. Reading a manufacturer's product label or manual are examples of directly received warnings. Some communications, however, involve one or more intervening entities (e.g., another person or organization) that serve to convey warning information to the ultimate receiver. With indirect warnings the information does not come directly from the source manufacturer but comes from another entity. The present research examined whether indirectly received warnings benefit compliance in the absence of directly relayed warnings. Participants performed a computer-memory installation task, in which compliance to three (subtask) behaviors given in the complete instructions/warnings was measured. The effectiveness of indirect warnings was evident. Indirect warning compliance was nearly as high as (but not significantly different from) the direct warning. Implications for the design of hazard communication systems and for warnings in forensic investigations are discussed. © 2010 Wiley Periodicals, Inc.

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1. INTRODUCTION

Some of the most important goals of warnings are 1) to communicate information to help users make high-quality decisions; 2) to remind and cue people of their existing safety knowledge; 3) to influence or persuade people to perform safe behaviors; and, ultimately, 4) to reduce accidents, injuries, and damage and to benefit health and safety (e.g., Kalsher & Williams, 2006; Laughery, 2006; Wogalter, 2006a; Wogalter, DeJoy, & Laughery, 1999). Most warning research has sought to measure aspects of effectiveness associated with these goals. The most investigated area concerns warning design in terms of internal features. Numerous investigations have examined aspects of size, color, symbols, explicit text, and so forth (see Wogalter, 2006b). There are, however, other kinds of influential warning factors that are not internal design features. They are external to the warning. One of these factors is cost of compliance. Research shows that increased effort, time, and money produce reduced warning effectiveness (e.g., Hunn & Dingus, 1992; Wogalter et al., 1987). Other external factors are 1) social influence (Wogalter, Allison, & McKenna, 1989) in which other people's compliance benefits compliance, and 2) environmental context, such as clutter making attention switch and maintenance difficult (Vredenburgh & Helmick-Rich, 2006; Wogalter et al., 1999; Wogalter, Kalsher, & Racicot, 1993).

Warnings research has focused entirely on directly conveyed communications. These are communications

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in which information directly flows from a source to receivers. The information received by a user comes directly from the primary source of the information. A person reading a warning label on a product or looking up information in an owner's/operator's manual are examples. A person who sees a flammability warning on an aerosol product and then decides not to light a match is illustrating the effect of a directly received warning provided by a manufacturer. In each of these cases, manufacturers are communicating information directly to potential users of their product. Of course, the source does not always have to be a manufacturer; it could a government entity or a parent admonishing his or her child about some hazard.

Warning information may also be transmitted *indirectly*—imparted by an entity different from the original source. The receiver gets the information second hand. An example is a person who receives a warning from someone else who had read the information in a product manual. One person receives the manufacturer's warning first hand, then transmits that information to another person. In the simplest case, that second person is the ultimate receiver of that information. In more complicated cases there could be several intervening persons. The ultimate receiver did not see the original warning from the source manufacturer but instead received the warning information through an intermediary (i.e., indirectly). A person who decides not to light a match—not because he or she read the flammability warning on the aerosol product label, but rather because an intervening person told him or her not to (because he or she had read the warning on an aerosol product label)—is an example of an effective indirect warning. In this example, the intervening person gets information directly from the source manufacturer, but the ultimate receiver does not. Had that intervening person not been in the situation, the person about to light a match might not be prevented from doing so.

Indirect warnings' utility is in spreading or dispersing safety information that might not otherwise be received directly from the original source. There are other potential ways to convey indirect warnings. Other indirect warnings include 1) a person telling a friend who had not seen a "no diving" sign not to dive, 2) a nurse who reads a patient's medication label and communicates the information to a patient who had not been provided the label, 3) a classroom safety lecture summarizing a set of safety rules collected from various sources, and 4) a consumer reporter telling the television audience about a product recall. Receivers of indirect warnings could convey the information to others, furthering the indirect spread of the warnings, yielding even greater indirect effectiveness. For example, this would be the case if the people in the television audience (example 4 earlier in this paragraph) tell others about the recall to further disperse the message.

Thus direct versus indirect warnings are defined with respect to the movement of information from the manufacturer to an ultimate potential receiver. With direct warnings, the receiver gets the information directly from the source. With indirect warnings, the recipient receives the information from an entity that received the warning either directly from the original source or indirectly from another source. There could be many interveners between the source and the ultimate receivers.

Indirect warnings may work nearly as well as direct warnings, particularly if the information transmitted second hand is similar to the information communicated by the original source. Indeed, indirect warnings might sometimes be better than direct warnings. One reason for the benefit is that indirect warnings are sometimes communicated through a different modality, auditorily, compared to most manufacturers' direct warnings, which are usually visually presented. Research on voice warnings (e.g., Noyes, Hellier, & Edworthy, 2006) shows that speech warnings can sometimes be more effective than visual (printed) warnings. In addition, aural communications can be beneficial 1) in high-visual-workload conditions, 2) when the print warning is not visible or legible at the time the message is needed, or 3) when there are literacy or language-usage barriers. Furthermore, an indirect warning may be better than a direct warning when an intervener holds greater personal influence over the receiver than the original source does. A caretaker is better at warning a young child than is a product manufacturer (through an owner's manual). People are influenced by trusted personal sources.

Thus, a main benefit of indirect warnings is that they could disperse safety information that otherwise would *not* reach relevant individuals in a direct manner. Potentially, indirect warnings could be as good as, or better than, a direct warning.

Nevertheless, it is possible that research could show a different pattern—that indirect warnings could produce no effect or even detrimental effects. In the children's "gossip" or whisper game, information is transmitted through several intervening people. A common

finding is that the information at the end is different from that at the beginning. Thus, the information relayed to a receiver via one or more interveners could be degraded due to intervening entities changing or distorting the message or by adding "noise," causing reduced effectiveness of indirect warnings.

There has been little or no past research that has examined indirect warnings. This circumstance prompted the present study. Effectiveness was measured by behavioral compliance methodology. Specifically, the method used was Freeman's (2003) procedure, which was, in itself, an adaptation of a previously published task (Wogalter, Barlow, & Murphy, 1995; and also used in Conzola & Wogalter, 1999), which measured warning compliance in a computer hardware installation task. Participants carried out a set of tasks in which compliance was measured for three behaviors directed in three specific instructions pertaining to avoidance of product damage.

Manipulated were three experimental conditions: 1) direct warning, 2) indirect warning, and 3) two-participant (no warning) control. The direct warning condition had a single individual carry out the installation task given the warnings/instructions. The indirect warning condition had two individuals participating. One was given the complete warnings/instructions (but did not carry out the installation), whereas the other carried out the installation but never read the warnings/instructions. The reader of the material has an opportunity to communicate with the installer partner (who did not read the material). The two-participant (no warning) control condition was procedurally the same as the indirect warning condition, but it lacked warnings/instructions.

2. METHOD

2.1. Participants

There were 147 participants: 102 were males (69.4%) and 45 were females (30.6%). Mean age was 19 years (standard deviation [*SD*] = 1.3). All were North Carolina State University undergraduates majoring in different subject areas. Two conditions (indirect warning, and two-participant [no warning] control) had groups of two persons (30 and 27 pairs, respectively); a third condition (direct warning) had a single individual (33 individuals). Participants enrolled in the study using an Internet-based appointment system that assigned people into separate or paired appointment times. The appointment slots, and the participants in them, were allocated so that there was random assignment to conditions.

2.2. Research Design

The three conditions are described below and in Table 1.

(1) *Direct Warning*: Individual participants were given a complete set of warnings/instructions and then performed the installation task.

(2) *Indirect Warning*: This condition has two participants. One, the viewer of the instructions/warnings, was given the complete set to read, but did not carry out the task. The installer performed the actual task, but never got an opportunity to read the instructions/warnings. The viewer could talk to the installer.

TABLE 1. Description of Conditions

Condition	Individual/Pair	Participant	Task
(1) Direct Warning	Individual	–	Read complete set of warnings & instructions & performed the install task
(2) Indirect Warning	Pair	A	Read complete warnings/ instructions but did *not* perform the install task but could talk to Participant B
		B	Did not read any warnings/ instructions, but performed the install task and could talk to Participant A
(3) Two Person (No-Pair Warning) Control		A	Read *minimal* (no) warnings/ instructions and did *not* perform the install task but could talk to Participant B
		B	Did not read any warnings/ instructions but performed the install task and could talk to Participant A

(3) *Two-Participant (No Warning) Control*: This condition was identical to the indirect warning condition, except that the viewer of the instructions/warnings was given *minimal* warnings/instructions instead of the complete set.

Behavioral compliance was measured according to the performance of three tasks in the installation procedure. These tasks were to 1) unplug the computer from the power cord, 2) engage a support foot to the computer case, and 3) don an available tether strap onto the arm/wrist and to the computer.

2.3. Materials

The task carried out by participants was to install random access memory (RAM) into a rectangular boxlike desktop computer (PowerMac 6100; Apple Computer, Inc., Cupertino, CA). Instructions and warnings were based on part of the contents of the original product manual included with the computer when purchased new. The complete memory installation instructions (used in the direct and indirect warning conditions) were printed on three pages of white 21.6 × 27.9 cm (8.5 × 11 inch) paper, with black print and contained

TABLE 2. Warning and Instructions for Installing a Memory Card

WARNING: Follow the instructions carefully to avoid permanent damage to the computer.
(1) Remove power cord before removing the cover.
(2) IMPORTANT: Power cord must be unplugged or the cover will not open properly.
(3) Open the cover by pressing the release button under the front panel and slide the cover toward you and lift up.
(4) Flip out the support foot until it snaps into its locked position.
(5) Wrap tether around your wrist or hand.
(6) Clip it to a metal component inside the machine.
(7) The tether discharges static electricity.
(8) Move the release switches toward inside the computer to unlock the top chassis.
(9) Lift open the top chassis to install memory card.
(10) Insert memory card.
(11) IMPORTANT: Handle memory card only by the edges.
(12) Close top chassis. Swing support foot back inside chassis.
(13) Replace the cover by lowering the cover all the way down onto the case and pushing it back until it snaps into place.

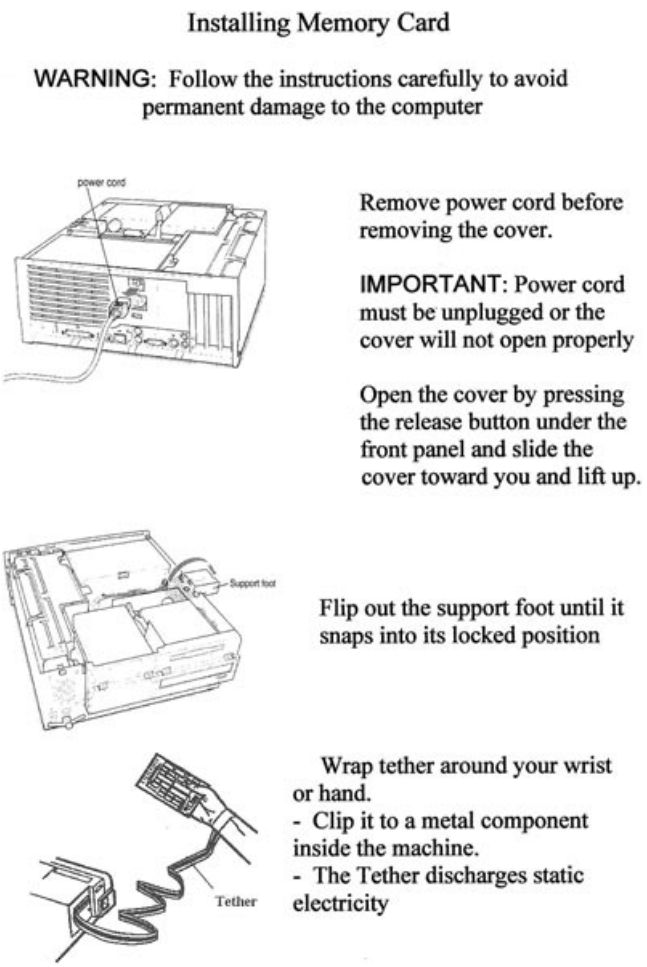

Figure 1 The complete warnings/instructions used in the direct and indirect warning condition. Only the material concerning the subtasks in which compliance was measured is shown with other material omitted.

10 steps of instruction, 4 warnings and clarifications, and 10 instructional images. The text (without the images) is shown in Table 2. A portion of the complete warnings/instructions is shown in Figure 1. This portion is only approximatey one-third of the complete warnings/instructions, but it serves to illustrate some of what was viewed.

Participants in the two-participant (no warning) control condition followed the same procedure as those in the indirect warning condition except the warnings/instructions were absent. The material consisted of one page with no text except for its title. It had two black-and-white drawings. One was an overall image of the computer box (with a closed cover), and the other was an image of a computer with the cover open and a zoomed-in image of a memory card. The instructions in this control condition are shown in Figure 2.

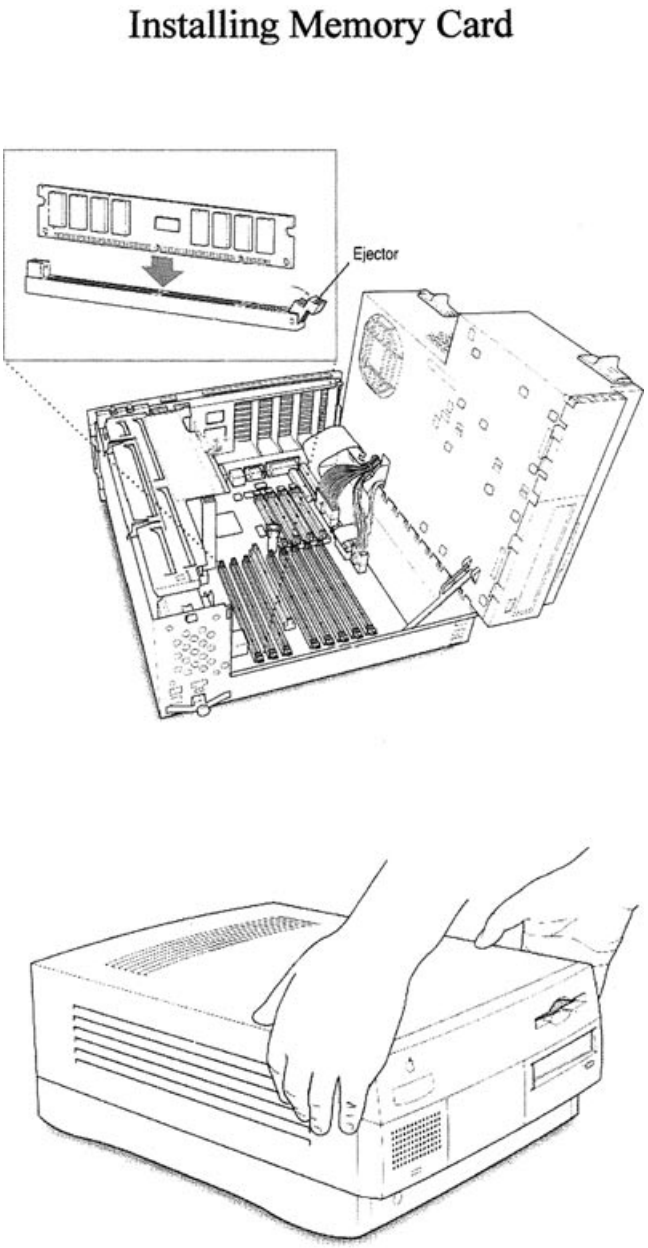

Figure 2 The minimal/incomplete instructions given in the two-participant (no warning) control condition.

Equipment included the above-named computer, a RAM card, and a static-reduction tether strap. The memory card and tether were placed to the right of the computer and the memory card to the left. One end of the power cord was plugged into the computer. The other end of the power cord was routed behind a row of heavy desks against a wall and was hidden from view. It appeared as if it was probably plugged into a power outlet, even though it was not (due to safety concerns). The cover of the computer was altered so that with not much effort the cover could be removed without having to use the release switch (located on the computer's front panel). Static-reduction tether straps were reused from session to session but were replaced with a new tether if they began to lose stickiness.

2.4. Procedure

Participants were recruited using the North Carolina State University Psychology Department's electronic appointment system for participants to sign up for research projects. Paired participants in the indirect warning and the two-participant control conditions were asked to sit across from each other at a large boardroom-type rectangular table. The experimenter sat between them and read specific instructions to them. The participant who sat on the experimenter's right side was labeled Participant A. That person was handed a set of instructions and warnings concerning the installation task. In the indirect warning condition, complete warnings and instructions were used, and in the two-participant (no warning) control condition the material read was incomplete/minimal. The individual seated on the experimenter's left side was labeled Participant B; this individual installed the memory card. Participant B was never given any written warnings and instructions but always performed the installation task. Assignments to conditions were randomized. In a few cases, when a preassigned partner did not arrive for a two-person slot, the person who showed up was released. To maintain fairness in the prearranged random assignments, the direct warning condition always used individual signup slots in the appointment system.

All participants were given a consent form to read and sign. Afterward, for the two-person conditions, the following instructions were read to participants:

> *Your task today is to install a memory card into a computer.*
>
> *[Speaking to Participant B] You will be installing the memory card with some assistance of your partner. Please do not talk to your partner at all from this point on UNTIL you start the task.*
>
> *[Speaking to Participant A] You will be given a set of instructions to read for 2 minutes. Be sure to read it carefully because you will not have the instructions during the task. You will assist your partner verbally but you*

ARE NOT ALLOWED to touch the computer at all during the task. You are to stand behind a shelf at all times until the task is complete.

Participants were asked if they had any questions; if so, brief clarifications were given. In the indirect warning and control conditions, the designated Participant A was handed either complete or incomplete warnings/instructions, respectively. After 2 minutes, warnings/instructions materials were taken away from Participant A. All participants were told that that the computer memory installation task was being timed so they should try to complete the steps as quickly and as accurately as possible. They were told to do the best they could, but they could not ask the experimenter any questions after they started the task. Any pretask questions that participants had were answered, and then both Participants A and B were brought to a large desk area where a computer and other materials were located. Participant A was positioned behind a 152 cm (5 feet) high bookshelf located along the side of the computer desk. Participant B was tasked with properly installing a memory board into the computer. Participant A was instructed not to touch the computer but was allowed to point or gesture to it. Both participants were able to talk to each other during the installation procedure. As initially positioned, Participant A could not see the inside of the computer, but Participant B could rotate or pull the computer toward Participant A so that he or she could see it clearly from all angles. In some instances, when Participant A was of shorter stature, such that he or she could not see the computer well from behind the bookshelf, a stool was provided to raise the person to aid visibility.

In the direct warning condition, there were only individual participants. They were treated similarly to the persons in the other two conditions except for the following: they were given the complete set of warnings/instructions to read for 2 minutes (like Participant A in the indirect warning condition), and they later installed the memory card themselves (like Participant B in the indirect warning condition). They did alone what pairs of participants did in the indirect warning condition. The instructions given to the direct warning participants were similar to those given to the indirect warning condition except they were adapted to fit a single individual instead of two separate individuals.

During the installation task, the experimenter was located in an unobtrusive position behind the installer and recorded the following:

(1) whether the power cord was unplugged before the installer attempted to remove the computer cover;
(2) whether the support foot was flipped over; and
(3) whether the available tether strap was attached to the arm or wrist and to the computer.

A check mark was given for each of the three tasks if completed. For data analysis, compliance was recorded as a "1" and noncompliance as a "0" for each of the three subtasks that the participant completed. The subtasks had to be completed in the same sequence as given in the warnings/instructions (i.e., before other behaviors/subtasks were attempted) to be scored as compliance. The total compliance score was a measure of the sum of the scores for the three subtasks. In addition, task completion time was measured.

Note that, prior to participating, none of the participants were told that the study's main concern was whether they performed the three above-mentioned compliance behaviors. Note that the procedure involved an "incidental exposure" methodology, which is common in high-quality behavioral compliance research. Although participants knew that the task they were conducting was to install a memory card, they were not preinformed that specific interest was in performance in three subtask steps. Participants were told the true purpose of the study at the end during debriefing.

After completing the memory installation task, participants were given a questionnaire requesting demographic information (such as age and gender) and technical/computer experience. In the latter, participants checked blanks next to items of a list of various named computer software and hardware tasks that they had performed previously. Afterward, participants were debriefed, thanked for their participation, and then released.

3. RESULTS

A one-way, three-level (independent groups) between-subjects analysis of variance (ANOVA) was used to analyze the data. The data in the analysis were calculated by summing the three scores according to whether participants unplugged the power cord, flipped over the support foot, and correctly used the tether strap. The minimum possible total score was 0 (having not complied with any) and the maximum was 3 (having complied with all). The ANOVA showed a significant

TABLE 3. Installers' Behavioral Compliance as a Function of Condition

Condition	Compliance Score	*SD*	*n*
(1) Direct Warning: (Individual Participant) Complete Warnings/ Instructions	2.27[a]	.84	33 (33 singles)
(2) Indirect Warning: (Paired Participants) Complete Warnings/ Instructions	2.10[a]	.80	60 (30 pairs)
(3) Control (Paired Participants) No Warnings/Incomplete Instructions	0.63[b]	.49	54 (27 pairs)

Note: Different superscript letters indicate significant differences ($p < 0.05$).

effect among the three conditions, $F(2, 89) = 42.56$, $p < 0.001$.

Mean compliance scores and *SD* values for conditions are shown in Table 3. Tukey's Honestly Significant Difference (HSD) test was used to compare the means. Although the direct warning condition produced the highest numerical compliance rate, it did not differ from the indirect warning. Both of these conditions were significantly higher than the two-participant (no warning) control condition, however.

Proportion compliance for each of the three subtasks as a function of condition is shown in Table 4. For the first task of disconnecting the power cord from the computer, chi-square analysis indicated an overall effect of condition ($p < 0.0001$). In the first task of unplugging the power cord, paired comparisons showed that participants in the two conditions with complete warnings (direct and indirect) did not differ ($p > 0.05$), but both of these groups unplugged the computer's power cord significantly more often than did participants in the control condition with no warning ($p < 0.05$). In the second subtask of flipping out the support foot, there were no statistically significant differences among conditions ($p > 0.05$). In the third task involving the use of the static discharge tether, there was an overall effect of conditions ($p < 0.05$). Paired comparisons showed that tether use was significantly higher in the direct warning condition than in the indirect warning condition, which in turn was significantly higher than in the control condition ($ps < 0.05$).

In the last column of Table 4 is the mean time to complete the entire installation task. The ANOVA showed a significant effect of conditions, $F(2, 73) = 3.74$, $p < 0.05$. Comparisons among the means indicated that participants in the direct warning condition had a significantly faster completion time than did those in the control condition. Times in the indirect warning condition were intermediate but not significantly different from those in the other two conditions ($ps > 0.05$). Note that the completion time analysis involves only those participants who completed the task. It does not include data from participants who failed to complete the task (and so there were no completion times for these participants). Further analyses with criterion limit times substituted for missing values did not show any significant completion time effects ($ps > 0.05$).

Another analysis of the data showed that more (18%) individuals in the direct warning condition failed to

TABLE 4. Proportion Compliance of Subtasks and Mean Task Completion Duration as a Function of Condition

Condition	Three Subtasks Power Cord	Support Foot	Static Strap	Completion Time (s)
(1) Direct Warning: (Individual Participant) Complete Warnings/Instructions	.85[a]	.73	.70[a]	104.2[a]
(2) Indirect Warning: (Paired Participants) Complete Warnings/Instructions	.83[a]	.80	.47[b]	124.0[ab]
(3) Control (Paired Participants) No Warnings/Incomplete Instructions	.04[b]	.59	.00[c]	154.3[b]

Note: Different superscript letters indicate significant differences ($p < 0.05$).

complete the entire installation task (i.e., finishing all of the steps listed in Table 1) than did individuals in the other two conditions (0% in the indirect warning and 4% in the control conditions, respectively).

Other analyses examined whether past computer/technical experience had any relationship with compliance performance. All of the prior technical activities that participants reported were summed, then the totals were used to divide participants into two levels-of-expertise groups based on a median split. The only significant finding with respect to this variable involved the completion time data. A 2 (low technical experience vs. high technical experience) × 3 (warning condition) ANOVA on memory card installation time showed a significant main effect for technical experience, $F(1, 77) = 6.72$, $p < 0.05$, but no significant interaction with warning condition ($p > 0.05$). Participants in the high-technical-experience group completed the memory card installation task faster than did participants in the low-technical-experience group.

4. DISCUSSION

The results provided evidence for the effectiveness of indirectly conveyed warnings, which are warnings that are conveyed by an intermediary to a receiver who has not been exposed to the original warning given by a source. Performance tended to be highest in the direct warning condition, but in some cases the results of the indirect warning condition were almost as high as, and not significantly different than, those of the direct warning condition.

Participants in the direct warning condition produced high compliance scores probably because they had the opportunity to directly read the manufacturer's warnings/instructions for the memory board installation task followed by doing the task themselves a short time later. Installers in the direct warning condition received complete warnings/instructions. The installers in the indirect warning condition also produced relatively high compliance scores, but the installers in the indirect warning condition did not directly read the warnings and instructions, so their behavioral compliance in them was due to interactions and communications with another intervening person who earlier received and directly read the complete warnings/instructions. That person then assisted his or her partner in installing the memory card. The installer had not read the instructions/warnings in the indirect warning condition, so to reach approximately the same level of performance as the participant in the direct warning condition meant that relevant instructions were conveyed indirectly by an intermediary. The total compliance scores show a measure of success for the indirect warning.

The lowest compliance was found in the control condition. This condition was similar to the indirect warning condition except that no warnings/instructions were provided, which reduced behavioral compliance. Thus, the benefit in compliance behavior in the indirect warning condition over the control condition was the information warnings/instructions given by the first person reading them and relaying them to the installer. Simply having a partner (an extra brain) to help is insufficient by itself as shown by performance in the control condition. At least one person needs to be given adequate warnings/instructions. Another important implication for the control condition is that it represents the provision of poor/inadequate warning. In comparison with the indirect warning condition, which had better warning, low behavioral compliance in the control condition was probably due to inadequate information and consequently less informative communication between the persons in the pair. Better warning produces greater indirect effects than does no (or inadequate) warning.

The three individual subtasks showed a somewhat similar pattern as the total compliance scores, but there were some apparent differences. A few additional comments about how participants performed the subtasks are worth noting. The first of the three tasks was to unplug the power cord before the cover was removed. Although unplugging the power cord might seem to be a well-known step when working inside an electrically powered product such as a computer, few participants in the no warning (control) condition made an initial attempt to remove the power cord before trying to remove the computer's cover. Most participants who received the complete warning and instructions (both direct and indirect warning conditions) unplugged the power cord as one of the initial steps. The computer design includes an interlock. The computer lid will not open if the power cord is plugged into the machine. Progress was hindered when the power cord was not pulled out early on, which frequently occurred in the control condition.

The instructions for the step involving the support foot were relatively clear and easy to complete. The computer cover opens even if the installer does not overtly manipulate the support foot. Performance in

this step was partly influenced by (a) it not being necessary to accomplish the ultimate goal of installing the memory card, (b) some of the instances of compliance were inadvertent, and (c) the name "support foot" being relatively unfamiliar. Thus, interpretation of the data for this step was not entirely straightforward.

The least frequently performed of the three tasks involved the tether strap. The intended reason for the tether is to safely discharge static electricity so that it does not damage the memory card or other computer components. Most of the participants appeared unfamiliar with the strap, with several persons making various comments indicating that they did not know how to use it. Some of the participants who used it only either tied it to their wrist or attached it to the machine, but did not do both. These instances were scored as failure to comply as the specific material said to "clip" it onto the machine. The supplied tether did not have a "clip" but rather was sticky (like tape) at the end that was to be attached to the computer. The difference in wording appeared to confuse some participants and thus might have affected compliance with this step. None of the participants in the control condition used the tether strap, probably because they did not know its use and because they were not instructed to use it.

Completion time data showed a pattern similar to the behavioral compliance results, with direct warning condition producing faster times than the control condition but the indirect warning condition's results intermediate between those of the two other conditions.

Additionally, participants who reported having had more computer/technical experience were faster than those reporting less experience. This finding is not surprising, but it also supports the notion that the task scenario used was externally valid because performance was benefited by prior germane experience.

One interesting, somewhat unexpected, finding was that the individual participants in the direct warning condition more often failed to complete *all* tasks involved in the entire memory card installation procedure than did participant pairs in the other two conditions. The numbers were small, so future research is necessary to determine whether this finding is real or spurious. If real, the higher levels of task completion found for conditions with participant pairs could be due to social influence. The pairing of persons working together served to urge task continuance until the last step, whereas the individual participants did not have this extra encouragement and tended to stop before the end. Social influence on performance in the context of warnings has been demonstrated in previous research (Wogalter et al., 1989).

These findings are relevant to the practice of human factors professionals serving as expert witnesses in U.S. legal cases pertaining to warnings (see Laughery & Wogalter, 2006). For example, testimony in a case may indicate that the injured party (plaintiff) or another relevant party had *not* read warnings on the product or in the product manual. Not being given or exposed to relevant safety information is a fairly frequent occurrence that can arise in numerous ways. Examples include illegible warning labels that have degraded over time or an inaccessible owner's manual for products purchased second hand, among others. The lack of reading warnings could be interpreted incorrectly by representatives of the Court with respect to their potential relevance in a case. Thus, it may be incorrect to say that the quality of the warnings is irrelevant simply because the plaintiff had not been directly exposed to the manufacturer's warning. Quality of the warnings could matter because intervening persons could have communicated the information in an indirect manner. Poor-quality warnings may not influence intervening persons to convey the warnings to others, whereas high-quality warnings may attract and prompt people to intervene and convey the message to other people. Therefore, even in cases in which the plaintiff did not have the opportunity to see a warning, expert witness opinions on the quality of the warnings may be appropriate testimony for the triers of fact (judges and juries) to hear because of the nonobvious ways that information could be transmitted to persons at risk. The quality of the materials that the plaintiff did not see is relevant testimony because direct warnings can affect the kinds of indirect warnings that develop subsequently. Well-designed warnings in a product manual are more likely to be attended to and read, which in turn enhances the likelihood that an indirect warning will be produced. Poorly designed warnings are less likely to be attended to and read in the first place, and they are less likely to develop into indirect warnings. Therefore, even if the plaintiff did not read the source material, high-quality warnings are more likely to be remembered and motivate others to convey the warning via indirect communications. Thus a plaintiff could be potentially alerted by a manufacturer's warning that he or she did not view personally. In short, high-quality direct warnings are more likely to produce better indirect warnings.

Conversely, poorly designed direct warnings are less likely to be read and remembered or to be dispersed by others.

Warnings can be communicated through multiple channels. Presentation methods could be live persons, videos, trade magazines, and so forth. Research is needed to determine which kinds of indirect warnings work better and when. Additional investigations could focus on the influence of delay time before indirect warnings are given (relative to their direct presentation by source manufacturers). Indirect warning could help to spread the word to relevant users and to supplement the effects of direct warnings.

The present research has a few limitations with respect to the task situation in which participants were placed. It was not fully realistic or at least not reflective of many situations in which indirect warnings may work. It could be described as a "best case" situation for a number of reasons. There was only one intervening entity when, in some cases, there may have been multiple interveners. Also, there was no delay between the intervener learning the material and then communicating the information to the installer. With long delays, memory may be an issue. Also, there was no intermediate level of instructions/warnings in which the warning information supplemented the instructions instead of having a complete absence of instructions/warnings in the control condition. Moreover, it would have been useful to have an independent record of what the viewer of the instructions/warnings communicated to the installer. Compliance is not a good indicator by itself because conveyed information is not necessarily complied with. Part of a warning's effectiveness is determined by whether it is communicated in the first place.

Our results indicate that indirect warnings benefit warning compliance. The indirect warning was as effective in eliciting compliance as was the direct warning. Note, however, that the results did not show that indirect warnings are better than direct warnings. Future research could examine how indirect warnings could reach a larger audience of receivers. Also, systematic research is needed on when and how indirect warnings might in some cases be better than direct warnings. The present results suggest that designers of communication campaigns consider ways to take advantage of the potential benefit of indirectly conveyed warnings to enhance safety and health.

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References

Conzola, C. V., & Wogalter, M. S. (1999). Using voice and print directives and warnings to supplement product manual instructions. International Journal of Industrial Ergonomics, 23, 549–556.

Freeman, K. (2003). The influence of consumer product manual warnings and on-product warnings on information retrieval and behavioral compliance. Masters Thesis, North Carolina State University, Raleigh.

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

Kalsher, M. J., & Williams, K. J. (2006). Behavioral compliance: Theory, methodology, and results. In M. S. Wogalter (Ed.), *Handbook of warnings (*Chapter 21, pp. 313–332). Mahwah, NJ: Erlbaum (Boca Raton, FL: CRC Press).

Laughery, K. R. (2006). Safety communications: Warnings. *Applied Ergonomics*, 37, 467–478.

Laughery, K. R., & Wogalter, M. S. (2006). The expert witness. In M. S. Wogalter (Ed.), *Handbook of warnings (*Chapter 48, pp. 605–615). Mahwah, NJ: Erlbaum (Boca Raton, FL: CRC Press).

Noyes, J. M., Hellier, E., & Edworthy, J. (2006). Speech warnings: A review. *Theoretical Issues in Ergonomics Science*, 7, 551–571.

Vredenburgh, A. G., & Helmick-Rich, J. (2006). Extrinsic nonwarning factors. In M. S. Wogalter (Ed.), Handbook of warnings (Chapter 28, pp. 373–382). Mahwah, NJ: Erlbaum (Boca Raton, FL: CRC Press).

Wogalter. M. S. (2006a). Purposes and scope of warnings. In M. S. Wogalter (Ed.), Handbook of warnings (Chapter 1, pp. 3–9). Mahwah, NJ: Erlbaum (Boca Raton, FL: CRC Press).

Wogalter. M. S. (2006b). Handbook of warnings. Mahwah, NJ: Erlbaum (Boca Raton, FL: CRC Press).

Wogalter, M. S., Allison, S. T., & McKenna, N. A. (1989). The effects of cost and social influence on warning compliance. Human Factors, 31, 133–140.

Wogalter, M. S., Barlow, T., & Murphy, S. (1995). Compliance to owner's manual warnings: Influence

of familiarity and the task-relevant placement of a supplemental directive. Ergonomics, 38, 1081–1091.

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

Wogalter, M. S., & Feng, E. (2008). Indirectly conveyed warnings: A behavioral compliance evaluation. In W. Karwowski & G. Salvendy (Eds.), Proceedings of the 2nd International Conference on Applied Human Factors and Ergonomics. ISBN 978–1-606430712.

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

Wogalter, M. S., Kalsher, M. J., & Racicot, B. M. (1993). Behavioral compliance with warnings: Effects of voice, context, and location. Safety Science, 16, 637–654.