Relative Order and Space Allocation of Message Components in Hazard Warning Signs

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Standards, guidelines, and research findings suggest that safety signs should generally contain four components: signal word, hazard, consequence and instruction statements. The purpose of this research is to determine the relative importance of different safety sign components. Two experiments examined this issue by having subjects construct a set of warning signs from component sections. In Experiment 1, participants manipulated component sections and assembled them onto a metal plate (of limited size). In Experiment 2, subjects worked with a technician to produce the signs on a computer. The relative importance of the individual components was determined by examining (1) use vs. omission rates, (2) size, and (3) order. The results show that few subjects used all the components in their warnings. Participants enlarged certain statements (Experiment 1) or added pictorials (Experiment 2) which necessitated the omission of other, presumably less-important, elements. The order of sign components was consistent only for signal words, which were placed generally at the top. The results suggest that, for certain hazards, the overall quality of information conveyed by a sign might be improved by eliminating or making smaller less important information, while simultaneously increasing the size of more relevant verbal information (or adding pictorials).

Introduction

Standards (ANSI, 1991), guidelines (e.g., FMC, 1985; Westinghouse, 1981), and research findings (e.g., Wogalter et al., 1987) suggest that warnings should, in general, contain the following four message components: (1) signal word, (2) hazard statement, (3) consequence statement, and (4) instructions. However, Wogalter et al. (1987) reported some instances where certain statements were not needed because they were redundant with people's prior knowledge (e.g., a consequence statement which stated that fire could cause burns). This study raised the question of *relative* importance of the four sign components.

Relative importance of individual sign elements is an issue because of limitations on the overall size of signs. Signs are often constrained by the location where they are to be posted, the size of the board or container packaging itself, and/or monetary limitations. One possible solution to this problem is to make the sign's most important text larger than the less-important text (or possibly deleting the less-necessary text entirely). Currently, there is no published research on the relative size that should be allocated to components of warnings. Moreover, standards and guidelines (e.g., ANSI, 1991; FMC, 1985; Westinghouse, 1981) provide no direction in this area.

Related to the size issue is order. Since people read text from top to bottom, one possible way to convey relative importance among message components is to place the most critical information at or near the upper portions of the sign. However, Galluscio and Fjelde (1993) examined component order and found that switching the consequence and instruction statements in a four-component warning did not influence the speed or accuracy of interpretation. They did not examine order with respect to relative importance. Standards and guidelines provide little guidance on statement order except for the signal word panel—it should be placed in the upper-most section of the sign.

The purpose of the present research is to examine the relative importance of different safety sign components. Two experiments examined this issue by having subjects construct a set of three warning signs. The first experiment had subjects assemble different-sized components onto a fixed-size metal plate. In the second experiment, subjects worked with a technician to produce the signs on a computer. The relative importance of the individual components was determined by examining (1) use vs. omission rates, (2) size, and (3) order.

Experiment 1

Method

One-hundred thirty-six participants (68 North Carolina residents tested at a local flea market, 52 North Carolina State University undergraduates, and 16 Rice University undergraduates) were asked to assume that they were hired to create the best warning sign (one which would be effective for them as well as other people) for each of three hazard situations: Electric Shock, Confined Space, and Slippery Floor. The participants were provided with a flat metal plate (with height and width dimensions of 17.8 x 25.4 cm or 7 x 10 in), onto which they would place the message components shown in Table 1. Each message component was available on magnetized strips which came in three sizes (or heights, since all widths were

25.4 cm): small (3.18 cm.; 1.25 in), medium (4.45 cm; 1.75 in), and/or large (5.72 cm; 2.25 in). The print size corresponded proportionately with the size of the strip, and the strips were magnetized so they would adhere to the plate.

Participants constructed all three warning signs (in one of six random orders). They were told that they could assemble the statements in any order with whatever size panels they thought best, but that they could not exceed the plate size. Participants were encouraged to try out different message orders and size combinations until they constructed the best possible sign. There were no time limits.

Before constructing each sign, participants were provided with context which consisted of a large glossy color photograph of some aspect of the hazard situation. In addition, the experimenter read a scenario description aloud. For example, the photograph associated with electric shock showed a metal electrical switch cabinet. The scenario description associated wit this statement was:

> *There is a high voltage switch inside this cabinet. Many people go by it every day. It is safe unless you open it up and touch the switches inside, in which case you could be electrocuted and killed.*

After being provided with this context, subjects were given a set of 12 magnetic panel strips (3 sizes x 4 components) associated with a given sign. The metal plate could be filled completely by using the following combinations: 4 medium, 2 large and 2 small, or 1 large, 2 medium and 1 small (3 large strips would leave 1/4 inch). Subjects were not required to fill the entire space, so they could use other combinations.

Results and Discussion

Of all the signs constructed (n = 408), only 30.4% contained all four message components. Most had 3 statements (55.9%), while almost all of the others consisted of two statements (13.0%). A Chi-square test demonstrated that the number of components used depended on the type of hazard described, χ^2 ($df = 6$) = 16.2, $p < .05$. Post-hoc cell analysis showed that the Electric Shock hazard had significantly more 3-component warnings and significantly fewer 2-component warnings than did the other hazard types ($ps < .05$). The Slippery Floor hazard had significantly more 2-component warnings than did the other hazards ($ps < .05$). There was no difference in the number of 4-component warnings constructed for the three hazards ($p > .05$).

Since a substantial number of signs lacked one or more of the message components, an analysis was conducted to determine what elements were omitted. Table 2 demonstrates that the signal word and hazard statement were the two most important elements for both the 2- and 3-component warnings. In only one instance (Confined Space warning with only 2 components) was the signal word not used a majority of the time (33%). The consequence statement was used frequently in

Table 1. Components of the warnings for Experiments 1 and 2

Component	Electric Shock	Confined Space	Slippery Floor
Signal Word	DANGER	DEADLY	CAUTION
Hazard	High Voltage Inside	Hazardous Atmosphere	Slippery When Wet
Consequence	Equipment Can Shock or Burn You	Confined Space Can Cause Death	You Can Fall and Injure Yourself
Instructions	Do Not Enter	Keep Out!	Watch Your Step

Table 2. Percentage of time each component was used as part of a 2- or 3- component warning[a]

	2-Component Warnings			3-Component Warnings			Total %
Component	Electric Shock (n=10)	Confined Space (n=15)	Slippery Floor (n=28)	Electric Shock (n=86)	Confined Space (n=71)	Slippery Floor (n=71)	(n = 281)
Signal Word	**90**	33	**100**	**99**	**78**	**100**	90.0
Hazard	**70**	**67**	**68**	**90**	**87**	**68**	79.4
Consequence	20	13	7	**77**	49	49	50.5
Instruction	20	**87**	25	35	**86**	**83**	51.6

a. Note: If a component was used in every warning, it would have a value of 100%. Thus, each column will add up to 200 for the 2-component warnings or 300 for the 3-component warnings. Percentages in bold-underline are the most-often used components for each hazard.

only one sign (Electric Shock with 3 components—77%). The instruction statement was used frequently with the Confined Space hazard regardless of the total number of components used.

One of the reasons sign components were omitted was to make the other elements larger. The bottom half of Table 3 shows that with four components in a sign, the signal word was generally large, the hazard statement was predominantly medium-sized, and the consequence statement was usually small. The size of the instruction statement was variable, depending on the type of hazard. However, when one of the four components was omitted (see top half of Table 3), the three remaining elements were generally increased in size.

Analysis was then conducted on the order of the individual components using only the signs with all four components (thus eliminating bias due to missing components). The results showed that 77% of the time (over all three hazards), the signal word was placed first. The hazard statement was generally placed second (34%) or third (45%), and the consequence statement was usually placed third (38%) or fourth (50%). Placement of the instruction statement depended on the hazard. For the Electric Shock and Slippery Floor signs, subjects generally placed the instruction in the second position (52% and 54%, respectively). For the Confined Space, the instruction statement ("Keep Out") was frequently placed in the first position (45%).

Experiment 2

Because of the nature of the stimulus materials, subjects in Experiment 1 were limited to three sizes of the warning components. In Experiment 2, virtually all limitations (except overall size) were removed and subjects were allowed to create a sign to their own liking. This was accomplished by constructing the warnings on a computer. In addition to the components used in Experiment 1, the use pictorials was examined.

Method

Three files (one for each warning to be constructed) were created using a Macintosh paint/draw program. Each file consisted of four pages with height and width dimensions of 21.6 x 27.9 cm (8.5 x 11 in). The view on the computer was reduced 33% so subjects could see all four pages on the screen at once. Thus, subjects saw one large white space on the screen divided into four quadrants by page-break lines. In the upper-left quadrant were 24 pictorials (the same set for all three hazards). In the upper-right quadrant were the three warning statements: hazard, consequence, and instruction. All these statements were identical to the ones used in Experiment 1 and they were presented in 48-point, lowercase, bold Helvetica. In the bottom-left quadrant were four signal words (WARNING, DANGER, CAUTION, and NOTE) in 48-point, uppercase, bold Helvetica (in both black-on-white and white-on-black print). The lower-right quadrant was where the warning was to be constructed.

Eleven Rice University undergraduates were tested individually while seated next to a technician in front of a computer, which had a 15 in. diagonal (38.1 cm) monitor. Subjects were told that they would have to construct three warning signs for three different hazards (the same three as in Experiment 1). The scenario descriptions and glossy photographs employed in Experiment 1 were used to give context. There were only two constraints: (1) subjects could not make their warning sign any larger than the space in the lower-right quadrant, and (2) they could not change the wording of any of the warning

Table 3. Percentage each component was used by hazard and number of components[a]

		Electric Shock			Confined Space			Slippery Floor		
	Component	Small	Med.	Large	Small	Med.	Large	Small	Med.	Large
3 Components	Signal Word	2	3	**96**	0	7	**93**	1	8	**92**
	Hazard	6	30	**64**	8	18	**74**	15	31	**54**
	Consequence	23	33	**44**	23	6	**71**	11	23	**66**
	Instruction	0	23	**77**	3	13	**84**	5	32	**63**
4 Components	Signal Word	10	13	**78**	6	39	**55**	9	14	**77**
	Hazard	38	**50**	13	**47**	**47**	6	43	**46**	11
	Consequence	**60**	28	13	**67**	31	2	**54**	37	9
	Instruction	38	**50**	13	12	33	**55**	**40**	37	23

a. Note: Percentages in bold-underline are the most-often used size for each component (for each hazard).

statements. Otherwise, subjects were told that they could alter the size, shape, color, case, background, order, etc. of any of the components. Subjects were instructed that they did not have to use any of the pictorials, statements, or signal words that they did not want to use. The subjects told the technician what they wanted to appear on the screen and the technician (the same individual for all subjects) followed their instructions, doing only what was requested and nothing more. No movement or alteration of any item was made unless specifically requested, and there was no prompting on the part of the technician. Each subject received a random order of the three hazards.

Results and Discussion

While there was considerable variation in the design of the warnings, there were some interesting consistencies. First, regardless of hazard, virtually all of the subjects (97%) used only one (39%) or two (58%) of the four verbal statements. Most of the signs contained the signal word (85% over all three hazards) and hazard statement (73%), while fewer included consequence (48%) and instruction (58%) statements. There were no discernible consistencies in the ordering of the verbal statements. This was probably due to the freedom subjects had in constructing the warnings.

One reason that the use of verbal statements was limited was likely due to the availability of pictorials—they were used prominently in almost all of the warnings constructed. Figure 1 shows the pictorials used for each of the three hazards. Below each pictorial is the number of times it was used in all the signs (out of 11 possible). The number of pictorials used does not add up to 11 because some subjects used more than one per sign (as many as 3 per sign). As shown in Figure 1, the majority of the pictorials used were specific (or content-related) to the hazard. Additional pictorials were generic icons (e.g., exclamation point inside a triangle). There were no differences in the size of the pictorial (relative to the entire sign) as a function of the hazard ($p > .05$).

While signal words were usually included in signs (85%), there was variability in the use of different signal words. Most warning standards indicate that signal words connote varying degrees of hazard: DANGER, WARNING, CAUTION, and NOTE (in order, from high to low hazard). For example, given the nature of the Slippery Floor hazard, use of the terms WARNING (38%) and CAUTION (62%) was appropriate. The other two hazards (Electric Shock and Confined Space) involve the risk of death, and therefore the term DANGER is required by the standards. However, subjects used DANGER (55%) and WARNING (45%) almost equally for Electric Shock. One subject used NOTE for the Confined Space hazard. In terms of total warning area, signal words for Confined Space (18%) consumed significantly more area than they did for Electric Shock (9%) and Slippery Floor (9%), $p < .05$.

General Discussion

These two studies shed light on the importance of the content, size and order of components in warning/safety signs. Because of the limited space available to construct the signs, it is clear that subjects made trade-offs regarding the size and type of information included. These experiments also demonstrated the importance of considering the nature of the hazard in assigning relative importance to the individual components.

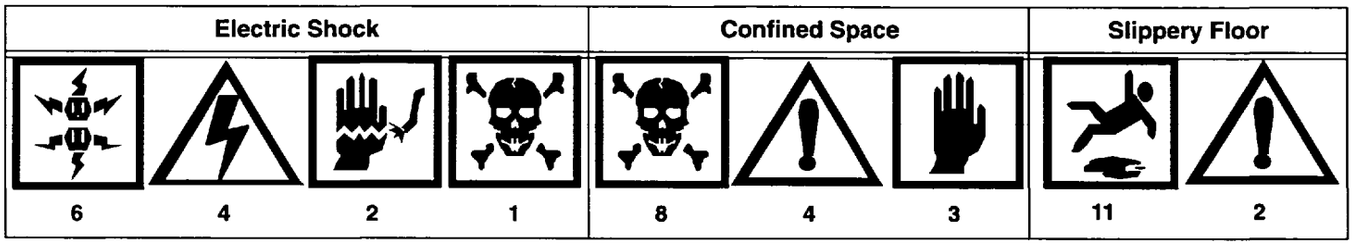
Experiment 1 demonstrated that the signal word was, by the three criteria listed at the outset of this article, the most important sign component. It was almost never excluded, it was almost always large, and it was almost always placed first (at the top of the sign). By the same criteria, the hazard and consequence statements appeared to be second and third in importance, respectively. The instruction statement was very important in some instances (e.g., Confined Space), but relatively unimportant in others (e.g., Slippery Floor). The relevance of the instruction statement was very much dependent on the hazard and/or the wording of the other statements included in the sign.

Experiment 2 confirmed the results of Experiment 1 by demonstrating (1) that the signal word and hazard statement were important warning components, and (2) that the use of the instruction statement depended on the hazard. The major difference between the two experiments was the inclusion of pictorials in Experiment 2. When pictorials were not an option (Experiment 1) subjects used 3 or 4 verbal components 86% of the time (across the three hazards). When pictorials were available (Experiment 2), subjects used 3 or 4 verbal components only 3% of the time. This was likely due to the fact that the pictorials provided information which was redundant with the omitted verbal statements (two of the three hazards had at least one hazard-specific pictorial available from the set of 24

Table 4. Percent of subjects using particular components by hazard scenario (Experiment 2)

Scenario	Signal Word	Hazard	Conseq.	Instruction	% Using All 4	% Using Only 3	% Using Only 2	% Using Only 1
Electric Shock	100	82	27	55	0	0	64	36
Confined Space	82	64	45	64	9	0	64	27
Slippery Floor	82	73	36	27	0	0	45	55

Figure 1. The pictorials used for each hazard and the number of times each was used



choices). In an unpublished follow-up study, we have demonstrated that pictorials are less frequently included when the pictorial does not convey information directly related to the verbal statements (e.g., the biohazard symbol). Thus, it appears that the benefit of pictorials, like other components of the warning, depends on the hazard.

In all, these two experiments suggest that the overall quality of information conveyed by a sign might be improved by eliminating or making smaller less important information, while simultaneously increasing the size of more relevant verbal statements (or adding pictorials). However, there are two important issues related to this recommendation. First, it only applies to the potential *quality* of information conveyed (e.g., the information that people really need in order to avoid the hazard) and not to behavioral compliance. The present experiments did not gather data regarding the behavioral effects of these sign manipulations. Thus, while a manipulated sign might convey more relevant information in a more productive manner, it still may not affect behavior. Second, information should only be eliminated from a sign if it is known or can be deduced from other information which remains on the sign. For example, very few people included the consequence statement in the sign for the Electric Shock hazard. It is likely that people already know that shocks or burns can result from contact with high voltage. In any event, the deletion of safety sign components should be done only as a result of testing to ensure that the most relevant information is properly emphasized and that all necessary information is included.

Three criteria were suggested for determining the importance of individual components. Two issues related to these criteria deserve attention. First, the relative importance of the elements (except for the signal word) generally depended on the type of hazard. In both studies, the signal word and hazard statement were commonly used. However, the consequence and instruction statements were used consistently only for some hazards, suggesting that they may have been redundant with people's knowledge and were therefore less necessary. Since the three hazards used here are generally well known and concrete, making generalizations about the relative importance of sign components for all hazards is difficult. One must take into account how well known or understood the hazard is in the general population, which requires testing.

Second, there were three indices of relative importance used in this research: (1) use vs. omission rates, (2) size, and (3) order. It is not easy to tell, from these data, to what extent each criterion conveys relative importance. It is likely that the best indicator of the relative importance is whether the element is used or omitted. Omission indicates that the information is less important or not needed at all. Size appears to be the next-best indicator, since increasing the size of one component necessitates that other information be made smaller or eliminated entirely. Order is one indication of importance, but is probably not a very good one for two reasons: (1) there may be a logical ordering to the components which follows grammatical or other rules (e.g., Hazard "could cause" Consequence. "Therefore," Instruction) instead of an importance hierarchy, and (2) signing conventions (or people's limited knowledge about them) may determine order apart from importance (e.g., people may be used to seeing a signal word at the top of signs).

The results presented here suggest that, with careful consideration and forethought, signs can be made more accessible and potentially more effective by examining the relative importance of individual components. Additional work might take the computer approach further by examining the ordering and use of verbal statements when hazards are more abstract and less conducive to the use of pictorials. In addition, research might examine the effects of these manipulations on behavioral compliance.

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