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Discrimination among Sign and Label Warning Signal Words

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ABSTRACT

Signal words are commonly used in warnings to quickly communicate potential hazards. Current standards and guidelines define the terms DANGER, WARNING, CAUTION, and NOTICE as denoting decreasing hazard levels, respectively. This study examined whether definitions assigned to these words coincide with people's understanding of them. Seventy-two participants attempted to match published definitions to the terms. Additionally, they rated the terms on various dimensions (e.g., hazardousness, understandability). The results showed that people differentiate DANGER and NOTICE but less clearly discriminate between WARNING and CAUTION. The term DEADLY, a proposed higher level signal word, was perceived as connoting the greatest hazard. Implications for warning design are discussed. © 1998 John Wiley & Sons, Inc.

1. INTRODUCTION

People are sometimes unaware of the existence of hazards associated with products, equipment, or environments. In such situations it is important to be able to quickly and effectively communicate information regarding the nature of the hazard. Warning signs and labels provide a method for presenting such information. Signal words are used in warnings to draw attention to the sign or label and to quickly communicate the level of the hazard (Leonard et al., 1988). Warnings also include a second component, the message panel, that can include verbal text and/or a pictorial that identifies the nature of the hazard, describes the consequences of noncompliance, and outlines what actions should be performed to avoid the hazard.

Specific signal words have been assigned based on the level of hazard associated with a particular situation. For example, the American National Standards Institute (ANSI, 1998) in the Z535.2 (environmental signs) and Z535.4 (consumer product labels) standards has designated DANGER, WARNING, CAUTION, and NOTICE based on a respective decreasing degree of hazard. Other organizations, including the FMC Corporation (1985) and Westinghouse Corporation (1981), have published guidelines for signal word usage similar to those adopted by ANSI (1998).

Research has confirmed some of the signal word specifications. One of the most consistent findings is that DANGER is perceived to have a greater connoted hazard than

Requests for reprints should be sent to Michael S. Wogalter. Portions of this research were presented as a poster at the 40th Annual Meeting of the Human Factors and Ergonomics Society, Philadelphia, PA (Drake et al., 1996).

either WARNING or CAUTION, but differentiation between WARNING and CAUTION is much less clear and most research finds no difference (Chapanis, 1994; Kalsher et al., 1995; Wogalter et al., 1995; Wogalter and Silver, 1990, 1995). Two recent studies by Kalsher et al. (1995) and Wogalter et al. (1995) also included the term DEADLY and found that this word connoted a greater degree of hazard than DANGER, confirming earlier results obtained by Wogalter and Silver (1990). Other reports have noted similar results (Braun et al., 1994; Braun and Silver, 1995; Edworthy and Adams, 1996; Taveira et al., 1995).

Virtually all previous research involving signal words has had participants rate the terms on perceived hazard level and other dimensions such as understandability, injury likelihood, and injury severity. Although signal words have been the focus of many studies, there is little research examining people's ability to associate a meaningful and distinguishable definition with each signal word. In fact only one other study has dealt with signal word definitions rather than using a rating methodology. Chapanis (1994) asked participants to describe the terms DANGER, WARNING, and CAUTION in their own words while considering the level of hazard, likelihood of injury, and severity of injury, thereby revealing subjective definitions. Analysis of the descriptions revealed that participants consistently defined the term DANGER as the most severe, hazardous, and potentially life threatening of the three. However, descriptions of WARNING and CAUTION were much closer in subjective meaning and were not readily distinguishable.

Previous signal word research has examined the ordering of the terms' mean ratings with respect to other terms. That research has one important shortcoming. In real-life situations individuals encounter warnings one at a time and rarely need to interpret the hazard level relative to other terms, meaning that people make judgments on an absolute, rather than a relative, basis. Having appropriate signal word definitions could aid in deciding which term to use and how it will be interpreted in a given environment, situation, or product.

The present study had three major goals. The primary goal was to determine whether the signal word definitions published in standards and guidelines relate to people's understanding of the terms. Laughery and Wogalter (1997) noted that the transmission of warning information from a sender, in this case published standards and guidelines, to a receiver (warning recipient) can be viewed in terms of a communications model. For successful communication to occur, the warning message (including the signal word) must provide information that allows the recipient to understand the level of hazard present in a particular situation. If the receiver's perception of the term's meaning does not match the sender's intended meaning, then miscommunication could result and might produce confusion. In the present study, a test of whether the intended meaning of signal words concurs with the perceived meaning was accomplished by having people match definitions to the signal words. This is the first signal word study to employ such a definition matching methodology.

The second goal of this study was to measure individuals' judgments of the signal words on seven dimensions: degree of hazard, likelihood of injury, carefulness, understandability, severity of injury, intention to comply, and immediacy of consequences. The first five dimensions were chosen because they have been used in previous research involving signal word rating (Chapanis, 1994; Wogalter and Silver, 1990, 1995). Intention to comply was included because it has been used in several warning and risk perception studies but has been used in only one signal word study and that study failed to show a difference between signal words (Leonard et al., 1986). Immediacy of consequences was

added because many of the signal word definitions found in standards and guidelines suggest a temporal relationship between the type of hazard and its consequence if not avoided. The present study sought to confirm the results of earlier research (Kalsher et al.,1995; Wogalter et al.,1995; Wogalter and Silver, 1990, 1995) that has consistently found that DANGER connotes a greater degree of overall hazard than either WARNING or CAUTION, and these latter two terms fail to be consistently differentiated.

The third goal of the study was to determine if the inclusion of the signal word DEADLY influences people's definition assignments and perceptions. DEADLY was included because prior research found that it is rated significantly higher in perceived hazard than DANGER (Kalsher et al., 1995; Wogalter et al., 1995; Wogalter and Silver, 1990, 1995) and it has been proposed for use in conveying an extreme level of hazard beyond the level connoted by DANGER. Use of the term DEADLY may also be advantageous in situations where the term DANGER has become habituated from repeated exposures. In the present study one-half of the participants made definition matches and ratings with the term DEADLY present, while the other half of the participants were not exposed to this term.

2. METHOD

2.1. Participants

A total of 72 individuals participated. Thirty-six were undergraduate students (17 females and 19 males with a mean age, *M*, of 19.7 years and a standard deviation, *SD*, of 5.0) enrolled in introductory psychology courses at North Carolina State University. They received course credit for their participation. Thirty-six were community volunteers (17 females and 19 males, age $M = 36.8$ years, $SD = 13.9$) attending a flea market in the Raleigh–Durham, North Carolina area. As an incentive for making careful, accurate judgments, all participants were informed that a monetary prize of $20.00 would be given to the participant with the highest number of correct responses for the definition matching task. The prize was subsequently awarded to one of the participants.

2.2. Materials

The materials in the definition matching task included 25 white paper cards and five white cardboard boxes. The cards (29.2×5.2 cm) were covered with a clear plastic laminate. One signal word definition was printed in black in a 26-point san serif font on each card. The definitions were taken from ANSI (1998) Z535.2 and Z535.4 standards, FMC Corporation (1985), the International Organization of Standardization (ISO, 1990), Westinghouse Corporation (1981), *Webster's New World Dictionary* (Guralink, 1982), and a white paper report on safety sign components (Brewster, 1995). A complete list of the definitions is shown in Table 1. Because the term DEADLY is a proposed signal word and has not yet been defined in any standard or guideline, the only definition for this item was taken from the dictionary. A different signal word (DEADLY, DANGER, WARNING, CAUTION, NOTICE) was printed on each of the five cardboard boxes ($35 \times 24 \times 5$ cm). Half of the participants were not exposed to DEADLY and received 24 definitions and four boxes. The other participants received identical materials plus the dictionary definition of DEADLY and a box labeled with this term.

For the rating task, a questionnaire containing seven items was used to elicit various judgments about the signal words. The participants received the same set of questions

and a separate answer sheet for each signal word. Each answer sheet was labeled with the corresponding signal word and seven blank lines on which the participants wrote their judgments. Nine-point Likert-type scales were used. The questions, scales, and anchors are as follows:

1. "Would you COMPLY with the warning if you saw this term?" The numerical and verbal anchors for this question were (0) definitely would not comply, (2) probably would not comply, (4) might comply, (6) probably would comply, and (8) definitely would comply.
2. "What degree of HAZARD do you associate with this term?" The numerical and verbal anchors for this question were (0) not hazardous, (2) slightly hazardous, (4) hazardous, (6) very hazardous, and (8) extremely hazardous.
3. "What is the SEVERITY of injury implied by this term?" The numerical and verbal anchors for this question were (0) not severe, (2) slightly severe, (4) severe, (6) very severe, and (8) extremely severe.
4. "What is the LIKELIHOOD of injury implied by this term?" The numerical and verbal anchors for this question were (0) never, (2) unlikely, (4) likely, (6) very likely, and (8) extremely likely.
5. "How CAREFUL would you be after seeing this term?" The numerical and verbal anchors for this question were (0) not careful, (2) slightly careful, (4) careful, (6) very careful, and (8) extremely careful.
6. "How IMMEDIATE are the consequences?" The numerical and verbal anchors for this question were (0) never, (2) within a few years, (4) within a few days, (6) within a few minutes, and (8) instantaneously.
7. "How UNDERSTANDABLE is this term?" In making your rating please consider whether the term would be understood by ALL people in the general population (including young children, visiting foreigners, etc.). The numerical and verbal anchors for this question were (0) not understandable, (2) somewhat understandable, (4) understandable, (6) very understandable, and (8) extremely understandable.

For ease of analysis and presentation of results, the numerical and verbal anchors for the immediacy question are shown in the reverse order relative to how they actually appeared on the questionnaire.

2.3. Procedure

Participants were randomly assigned to one of two groups. One group evaluated the terms DANGER, WARNING, CAUTION, and NOTICE. The other group evaluated these terms, as well as DEADLY. For the definition matching segment of the experiment, participants were given the definition cards with the order randomized for every participant. The cardboard boxes were arranged in a row in a randomized order in front of the participant. The group exposed to DEADLY was presented with 25 cards and five boxes. The other group was given 24 cards and four boxes. Participants were instructed to read the definition on each card, then place the card into the box labeled with the signal word that they believed best corresponded to the definition.

After the matching task was completed, participants completed four or five rating questionnaires, depending on whether their group assignment included or lacked the term DEADLY. Participants were informed that there was no time limit to complete the tasks.

3. RESULTS

3.1. Definition Matching

Table 1 shows the signal words, their definitions by source, and the number of times each definition was matched to each signal word as a function of DEADLY condition and participant group. Initially, the matching distributions of students and community volunteers were compared for each definition in both the with and without DEADLY conditions. Forty-nine (25 with DEADLY and 24 without DEADLY) Chi Square Tests of Independence and Fisher's Exact Tests revealed only three significant differences between the two participant groups (p values < 0.05). Because approximately this number of significant differences would be expected by chance alone, the student and community volunteer groups were combined into a single data set to simplify presentation of the analyses with these data.

3.2. Without DEADLY

DANGER and NOTICE definitions were correctly matched 64% and 68% of the time, respectively. Participants had more difficulty with the two intermediate terms WARNING and CAUTION, correctly assigning them only 31% and 43% of the time, respectively. Participants making incorrect assignments were more likely to match the definitions to signal words of greater hazard. WARNING definitions were incorrectly matched to DANGER 43% of the time. Similarly, 40% of the time CAUTION definitions were judged by participants as best corresponding to DANGER or WARNING.

If the definitions provided no information with respect to peoples' understanding of the signal words, participants would be only guessing in their assignments. Participants would tend to randomly distribute their matching assignments across the available choices by guessing. Because participants in this condition had four signal words from which to choose when assigning definitions, chance performance would produce 25% correct matches. Comparisons between the obtained matching percentages versus the value expected by chance indicated that 20 of the 24 definitions were correctly matched at percentage levels greater than chance. The four exceptions were the WARNING definitions proposed by FMC Corporation and Brewster were each correctly assigned only 14% of the time, Webster's dictionary definition of CAUTION was correctly matched by only 19% of the participants, and Brewster's was matched by only 17%. The definitions with the highest percentage of correct matches were: DANGER, ANSI (81%) and FMC (75%); WARNING, Webster's (69%); CAUTION, ANSI (61%) and Brewster (61%); and NOTICE, Brewster (81%) and Westinghouse (78%).

3.3. With DEADLY

Results for the group exposed to DEADLY were consistent with those of the group not exposed to DEADLY in that definitions for the more extreme terms were matched correctly more often than those for the intermediate terms. Overall, DEADLY was correctly assigned 84% of the time, DANGER 30%, WARNING 23%, CAUTION 34%, and NOTICE 58%. There was also a trend toward incorrectly assigning a definition to a higher level term. DANGER definitions were erroneously assigned to DEADLY 42% of the time. WARNING definitions were incorrectly matched with DEADLY (34%) and DANGER

TABLE 1. List of Definitions Used in Matching Test with Frequencies of Matches

Signal Word	Source	Definition
DEADLY	Webster's, 1982	(a) Causing or likely to cause death.
DANGER	Webster's, 1982	(a) Liability to injury, damage, loss, or pain. A thing that may cause injury, pain, etc.
	ANSI Z535.2, 1998	(b) Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal is to be limited to the most extreme situations.
	FMC, 1985	(c) Immediate hazards which will result in severe personal injury or death.
	Westinghouse, 1981	(d) To indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.
	Brewster, 1995	(e) A sign to be used in the immediate area of the hazard when there is a threat of death or serious injury.
	ISO, 1990	(f) To call attention to a high risk.
WARNING	Webster's, 1982	(a) The act of one that warns; to tell (a person) of a danger, coming evil; to caution, admonish.
	ANSI Z535.2, 1998	(b) Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
	FMC, 1985	(c) Hazards or unsafe practices which could result in severe personal injury or death.
	Westinghouse, 1981	(d) To indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.
	Brewster, 1995	(e) A sign to be used when there is a threat of death or serious injury.
	ISO, 1990	(f) To call attention to a medium risk.
CAUTION	Webster's, 1982	(a) Warning; admonition; prudence; wariness.
	ANSI Z535.2, 1998	(b) Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
	ANSI Z535.3, 1998	(c) To alert against unsafe practices.
	FMC, 1985	(d) Hazards or unsafe practices which could result in minor personal injury or product or property damage.
	Westinghouse, 1981	(e) To indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.
	Brewster, 1995	(f) A sign to be used when there is a threat of minor injury.
	Brewster, 1995	(g) To be used to alert against behavior that can lead to property damage.
	ISO, 1990	(h) To call attention to a low risk.
NOTICE	Webster's, 1982	(a) An announcement or warning; a written or printed sign giving some public information, warning, etc.
	ANSI, Z535.2, 1998	(b) Signs used to indicate a statement of company policy directly or indirectly related to the safety of personnel or protection of property.
	Westinghouse, 1981	(c) To notify people of installation, operation, or maintenance information which is important but not hazard-related.
	Brewster, 1995	(d) A sign to be used to indicate a statement of company policy or instructions for the protection of property, safe work practices, reminders of proper safety procedures, or the location of safety equipment.

Note: DS, students with DEADLY; S, students without DEADLY; DC, community volunteers with DEADLY;

Frequency Matched																	
DEADLY		DANGER				WARNING				CAUTION				NOTICE			
DS	DC	DS	S	DC	C	DS	S	DC	C	DS	S	DC	C	DS	S	DC	C
17	**14**	1	—	5	—	0	—	0	—	0	—	0	—	0	—	0	—
0	2	**7**	**9**	**4**	**8**	7	3	5	2	4	6	5	2	0	0	3	5
17	13	**1**	**16**	**5**	**13**	0	2	1	4	0	0	0	0	0	0	0	0
13	13	**5**	**14**	**5**	**13**	0	4	1	3	0	0	0	1	0	0	0	0
9	9	**5**	**9**	**4**	**12**	3	6	4	4	1	3	2	1	0	0	0	0
7	11	**7**	**13**	**7**	**12**	2	3	1	3	1	1	0	2	1	1	0	0
2	1	**8**	**10**	**8**	**6**	2	5	7	4	6	3	1	4	0	0	2	3
0	2	1	0	2	2	**11**	**15**	**11**	**10**	6	3	1	3	0	0	3	2
8	9	6	11	7	11	**3**	**5**	**2**	**4**	1	2	0	2	0	0	1	0
10	7	7	16	8	12	**0**	**2**	**4**	**3**	1	0	0	1	0	0	0	1
6	9	7	7	6	7	**2**	**6**	**1**	**6**	3	3	3	0	0	2	0	0
12	13	5	14	4	11	**1**	**2**	**2**	**3**	0	2	0	1	0	0	0	2
0	0	0	0	3	0	**6**	**6**	**6**	**4**	9	12	3	10	3	0	4	3
0	0	3	1	1	1	12	11	8	12	**1**	**4**	**7**	**3**	2	2	3	1
0	0	6	1	4	2	4	4	10	5	**7**	**12**	**4**	**10**	1	1	1	0
0	0	1	0	2	2	5	6	6	4	**9**	**6**	**9**	**7**	3	6	2	4
0	0	4	5	5	1	6	2	5	6	**7**	**10**	**6**	**10**	1	1	3	0
0	0	3	2	6	5	6	8	7	6	**8**	**5**	**4**	**4**	1	3	2	2
0	1	4	1	4	1	7	4	1	2	**6**	**10**	**10**	**12**	1	3	3	2
0	0	0	0	0	1	7	7	10	7	**6**	**5**	**3**	**1**	5	6	6	8
0	0	0	0	0	0	4	2	2	2	**5**	**11**	**9**	**9**	9	5	8	6
0	0	0	0	0	0	9	8	11	9	5	2	3	2	**4**	**8**	**5**	**6**
0	1	0	0	0	0	2	3	3	2	4	3	3	3	**12**	**12**	**12**	**12**
0	1	0	0	0	0	0	0	3	2	3	1	4	4	**15**	**17**	**11**	**11**
0	0	0	0	0	0	1	1	2	0	2	1	5	4	**15**	**16**	**12**	**13**

C, community volunteers without DEADLY.

(25%). CAUTION definitions were matched with WARNING by 34% and with DANGER by 15% of the participants.

Analyses also examined the extent to which participants were guessing in their assignments. Because participants in this condition had five signal words from which to choose when assigning definitions, chance performance would be 20% correct matches. Comparisons between the obtained matching percentages versus the value expected by chance indicated that 18 of the 25 definitions were correctly matched at percentage levels greater than chance. The seven exceptions were the DANGER definition proposed by ANSI was correctly assigned by only 17% of the participants; WARNING definitions by ANSI, FMC, Westinghouse, and Brewster were correctly matched only 14%, 10%, 8%, and 8% of the time, respectively; and CAUTION definitions by Webster's and Brewster were matched correctly only 21% and 24% of the time, respectively. The definitions that were most frequently correctly matched were: DEADLY, Webster's (84%); DANGER, ISO (43%); WARNING, Webster's (59%); CAUTION, ANSI (49%); and NOTICE, Brewster (70%) and Westinghouse (73%).

3.4. Ratings

Correlation analyses were performed among the ratings for the seven questions. The intercorrelation matrix showed that five dimensions (compliance, hazard, severity, likelihood, and carefulness) were highly intercorrelated (r values = 0.87 to 1.0). Therefore, these dimensions were combined to form a single score herein called the overall injury potential. Correlations showed that immediacy and understandability were not as highly related with the other dimensions (r values = 0.60 to 0.97) and were analyzed separately.

Mean ratings of the signal words are displayed in Table 2 as a function of condition, question, and participant group. In the table, the overall injury potential variable is shown after the first five highly correlated dimensions from which it was formed. Although the students' and community volunteers' ratings were relatively consistent, some analyses revealed a few differences as a function of group. Because of these effects, the analyses described below include participant group as a factor in the analyses of variance (ANOVAs).

3.5. Without DEADLY

Repeated-measures ANOVAs on the overall injury potential scores showed no main effect of group, $F(1, 34) = 2.27$, $p > 0.05$, but there was a significant main effect of signal word, $F(3, 102) = 92.57$, $p < 0.0001$. DANGER ($M = 6.57$) was rated highest, followed by WARNING ($M = 4.94$), CAUTION ($M = 4.13$), and NOTICE ($M = 2.58$). Tukey's Honestly Significant Difference (HSD) showed that all four terms were significantly different (p values < 0.05). There was also a significant interaction, $F(3, 102) = 4.96$, $p < 0.01$. Simple effects analyses showed that both groups were consistent in rating the words except for the term NOTICE where community volunteers ($M = 3.29$) rated it significantly higher than the students ($M = 1.87$), $p < 0.05$.

On the dimension of understandability, repeated-measures ANOVAs showed no main effect of group, $F(1, 34) = 1.42$, $p > 0.05$, but there was a significant main effect of signal word, $F(3, 102) = 17.82$, $p < 0.0001$. DANGER ($M = 5.22$) was rated highest, followed by WARNING ($M = 4.39$), CAUTION ($M = 3.72$), and NOTICE ($M = 3.00$). Tukey's HSD showed that DANGER was rated significantly higher than the other three

TABLE 2. Mean Ratings (and Standard Deviations) of Signal Words on Dimensions as Function of Presence Vs. Absence of Term DEADLY

		Compliance		Hazard		Severity		Likelihood		Carefulness		Overall Injury Potential		Immediacy		Understandable	
	Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Without DEADLY																	
DANGER	Student	6.89	1.40	6.67	1.37	6.67	1.81	6.89	1.23	6.44	1.46	6.71	1.28	6.67	1.37	5.77	1.80
	Com. Vol.	6.89	1.41	6.22	1.52	6.22	1.52	6.78	1.40	6.00	2.28	6.42	1.20	7.45	1.50	4.67	2.17
WARNING	Student	5.89	1.60	4.33	2.09	4.22	1.93	5.33	1.68	5.05	1.96	4.97	1.70	5.78	1.80	4.89	1.96
	Com. Vol.	6.00	1.82	4.11	2.00	4.56	2.36	4.89	1.57	5.00	2.50	4.91	1.38	6.34	1.41	3.89	2.11
CAUTION	Student	5.44	1.34	3.22	1.21	3.00	1.24	3.89	1.08	3.55	1.29	3.82	0.87	5.33	1.68	4.11	1.87
	Com. Vol.	6.22	1.66	3.78	1.93	3.67	1.24	4.00	1.37	4.56	2.04	4.44	1.16	6.67	1.37	3.32	1.94
NOTICE	Student	4.00	1.68	1.00	1.02	0.67	0.97	1.67	1.02	2.00	1.37	1.87	0.85	3.45	2.55	2.77	1.21
	Com. Vol.	5.67	1.97	2.00	2.06	1.78	1.52	3.11	1.71	3.89	2.00	3.29	1.21	5.23	2.49	3.22	2.18
With DEADLY																	
DEADLY	Student	8.00	0.00	8.00	0.00	8.00	0.00	7.55	1.10	7.77	0.65	7.87	0.27	7.78	0.65	7.00	1.41
	Com. Vol.	8.00	0.00	7.78	0.65	7.78	0.65	7.33	1.94	7.67	1.03	7.71	0.55	6.67	2.66	6.56	2.45
DANGER	Student	7.33	0.97	5.55	1.29	5.67	1.02	6.11	0.83	6.77	1.55	6.29	0.95	6.83	1.20	5.72	1.53
	Com. Vol.	7.00	1.57	5.11	2.08	5.11	2.40	5.78	1.66	6.00	1.94	5.80	1.51	6.45	2.12	4.78	2.39
WARNING	Student	5.44	1.34	3.44	2.03	3.17	1.61	3.77	1.17	4.33	1.97	4.03	1.41	5.50	1.94	4.89	1.71
	Com. Vol.	5.72	2.27	3.78	1.43	3.67	1.97	4.11	1.75	4.89	1.97	4.43	1.61	6.00	2.06	3.78	1.80
CAUTION	Student	5.72	1.53	2.44	1.10	2.77	1.39	3.89	1.14	4.00	1.68	3.67	1.09	5.56	1.62	4.27	1.27
	Com. Vol.	5.44	2.36	2.89	1.57	3.00	2.20	4.22	1.52	4.33	1.71	3.98	1.42	5.78	2.05	3.89	2.11
NOTICE	Student	3.61	1.72	0.67	0.97	0.39	0.77	1.94	1.70	1.72	1.18	1.67	0.88	2.50	2.83	3.00	1.41
	Com. Vol.	3.94	2.07	1.56	1.29	1.78	2.05	3.22	2.07	3.17	1.62	2.73	1.02	5.00	3.01	2.89	1.57

Overall injury potential is the score obtained by combining the first five highly correlated dimensions.

terms, and the only other significant difference was between WARNING and NOTICE, $ps < 0.05$. There was no significant interaction, $F(3, 102) = 2.55$, $p > 0.05$.

Repeated-measures ANOVAs on the dimension of immediacy showed a significant main effect of group, $F(1, 34) = 6.66$, $p < 0.05$. In general, community volunteers judged the consequences associated with the terms to be significantly more immediate ($M = 6.42$) than the students ($M = 5.31$). In addition, there was a significant main effect of signal word, $F(3, 102) = 20.47$, $p < .0001$. DANGER ($M = 7.06$) was rated highest, followed by WARNING ($M = 6.06$), CAUTION ($M = 6.00$), and NOTICE ($M = 4.34$). Tukey's HSD showed that all four terms were significantly different (p values < 0.05) except WARNING and CAUTION. The interaction was not significant, $F(3, 102) = 1.22$, $p > 0.05$.

3.6. With DEADLY

Repeated-measures ANOVAs for the overall injury potential scores revealed no main effect of group, $F(1, 34) = 0.79$, $p > 0.05$; however, there was a significant main effect of signal word, $F(4, 136) = 182.12$, $p < 0.0001$. DEADLY ($M = 7.79$) was rated highest, followed by DANGER ($M = 6.04$), WARNING ($M = 4.23$), CAUTION ($M = 3.82$), and NOTICE ($M = 2.20$). Tukey's HSD showed that all terms were significantly different (p values < 0.05) except for WARNING and CAUTION. However, there was also a significant interaction, $F(4, 136) = 3.44$, $p < 0.05$. Simple effect analyses showed that both groups were consistent in rating all terms except NOTICE; the community volunteers ($M = 2.73$) rated it significantly higher than students ($M = 1.67$).

For the dimension of understandability, repeated-measures ANOVAs showed no main effect of group, $F(1, 34) = 1.61$, $p > 0.05$; but again there was a significant main effect of signal word, $F(4, 136) = 42.59$, $p < 0.0001$. DEADLY ($M = 7.00$) was rated highest, followed by DANGER ($M = 5.25$), WARNING ($M = 4.33$), CAUTION ($M = 4.08$), and NOTICE ($M = 2.94$). Tukey's HSD showed that all terms were significantly different (p values < 0.05) except for WARNING and CAUTION. There was no significant interaction, $F(4, 136) = 1.14$, $p > 0.05$.

Repeated-measures ANOVAs on the dimension of immediacy showed no effect of group, $F(1, 34) = 0.78$, $p < 0.05$; however, there was a significant main effect of signal word, $F(4, 136) = 26.14$, $p < 0.0001$. DEADLY ($M = 7.44$) was rated highest, followed by DANGER ($M = 6.64$), WARNING ($M = 5.75$), CAUTION ($M = 5.67$), and NOTICE ($M = 3.75$). Tukey's HSD showed no difference between the term DANGER and the terms DEADLY, WARNING, and CAUTION, or between WARNING and CAUTION. In addition, there was also a significant interaction, $F(4, 136) = 5.32$, $p < 0.001$. Simple effects analyses showed that the groups had consistent ratings except for the term NOTICE; community volunteers ($M = 5.00$) rated it significantly higher than the students ($M = 2.50$).

4. DISCUSSION

This experiment examined signal words and definitions through matching and rating procedures. The present study had three major objectives. One was to determine whether people's understanding of the words agrees with the signal word definitions published in standards and guidelines. The evaluation was accomplished by having people match definitions to the signal words. The low scores on the definition matching task indicate that

some terms (e.g., WARNING) do not correspond with their intended meanings. The definition matching results show that people are better able to assign definitions for the terms at the extremes of the hazard spectrum (DEADLY, DANGER, and NOTICE). When mismatched, the definitions of the intermediate terms (WARNING and CAUTION) tended to be assigned to higher level signal words, suggesting that people tend to underestimate the degree of hazard that the words are intended to convey relative to their assigned definitions—the published definitions imply more hazard than the words that they are supposed to characterize or, conversely, the words imply less hazard than their corresponding definitions. For example, the definitions for the term WARNING were frequently matched with the term DANGER because the definitions for WARNING are apparently viewed to be stronger than the term itself conveys.

The second goal of this study was to measure individuals' judgments of the signal words along seven dimensions: degree of hazard, likelihood of injury, carefulness, severity of injury, intention to comply, immediacy of consequences, and understandability. The first five dimensions were chosen because they were used in previous research involving signal word ratings (Chapanis, 1994; Wogalter and Silver, 1990, 1995). Because correlational analyses showed substantial interrelationships among these five variables, they were combined to form a single score called overall injury potential. The general trend in participants' ratings showed DEADLY, if available, was rated the highest, followed by DANGER, WARNING, CAUTION, and NOTICE. Independent of the presence of DEADLY, significant differences were found between all terms except WARNING and CAUTION. These findings confirm the results of earlier studies that also found DANGER to be judged as more hazardous than WARNING or CAUTION and failed to show significant differences between these latter two terms.

The lack of consistency with which definitions were matched to signal words and the nonsignificant differences between ratings of some of the conventional terms suggests a need for the standards organizations to revise their guidelines. For example, these results indicate that people do not readily distinguish between WARNING and CAUTION. Unfortunately, government, manufacturers, employers, and standards bodies may assume people can discriminate between these two terms with respect to the hazard level that they convey when this and other research says that they do not. Even with the definitions in hand people have difficulties relating them to the words.

The final goal of the study was to determine if the inclusion of the signal word DEADLY influenced people's definition assignments and perceptions. DEADLY was included because prior research has found that it is rated significantly higher in perceived hazard than DANGER (Kalsher et al., 1995; Wogalter et al., 1995; Wogalter and Silver, 1990) and its use has been proposed as a higher level hazard term to distinguish between extreme hazards and very high hazards. The results confirm that DEADLY, when available, was consistently rated the highest and rarely confused with other terms in the definition matching task. This and other research (Wogalter et al., 1995; Wogalter and Silver, 1990) found that the term DEADLY successfully conveys the intended degree of hazard with very little ambiguity. These results support its usage as a word to signify extreme hazard.

An additional noteworthy point is that generally the students and the community volunteers produced similar patterns of results. The mean differences between participant groups in the tables were generally not statistically significant. However, the analyses did indicate that NOTICE was rated significantly higher by the community volunteers than the students. We do not have a conclusive explanation for this finding. One possibility is that students are more accustomed to participating in studies that require Likert-type rat-

ings and are less likely to be influenced by the study's context and materials. The community volunteers, who have less experience making such ratings, may have been influenced by the context of the study, which led to more varied and inflated rating scores.

Because the signal words were shown to connote less hazard than the definitions assigned to them, a possible consequence is that it could lead to people underestimating the hazard involved in a particular situation, product, or environment. If people underestimate the hazard implied by a signal word, they may not use appropriate caution in real-life situations. This and other research (e.g., Kalsher et al., 1995; Wogalter and Silver, 1990, 1995) indicates that people's perceptions of the signal words at the extremes of the hazard dimension (DEADLY, DANGER, and NOTICE) are congruent with prevailing standards and are readily understood. Therefore, on this count alone, changing the definitions assigned to them would not be indicated. DEADLY is "an extreme hazard in which failure to comply will result in death or serious injury." DANGER is "an extreme hazard in which failure to comply could result in death or serious injury." NOTICE "conveys information about a product, situation, or environment that is not directly hazard related." However, definitions for the intermediate terms (WARNING and CAUTION) still require further research and testing to determine whether the definition(s) that safety experts and warning designers use are congruent with peoples' existing understanding of the terms. The point is that the intended and perceived meanings should be similar. Because people do not readily differentiate between the terms, it suggests that WARNING and CAUTION should have the same definition and be used interchangeably in practice.

Further research is needed to determine whether alternative signal words, such as DEADLY, can be used successfully used to unambiguously convey the appropriate degree of hazard for a particular situation. In particular, the effects of habituation need further investigation. The use of alternative signal words may be advantageous in situations where the commonly used term no longer adequately performs the signaling function due to extensive repeated exposure. At this point, we do not know the relative importance of habituation in relation to other factors such as experience, context, extent and content of training, supervision, etc. If English speaking persons are the targets, the terms SERIOUS or HAZARD may be an appropriate substitutes for the term WARNING. However, if the target population includes low-literate or non-English speaking persons, then the effects of habituation may be of less concern relative to other factors. Consistent use is important in this case. Indeed, individuals less familiar with written English might be trained on a limited set of standard terms, but they will be less likely to know less frequently used synonymous terms. We believe that additional investigations can profitably explore alternative and understandable signal word definitions to enhance the fit between the hazard levels intended to be conveyed and peoples' interpretations.

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