

Contemporary Ergonomics, 1998.

In M. A. Hanson (Ed.). Ergonomics Society (UK). London: Taylor & Francis

EFFECTS OF AUDITORILY-PRESENTED WARNING SIGNAL WORDS ON INTENDED CAREFULNESS

Rana S. Barzegar and Michael S. Wogalter

*Ergonomics Program, Department of Psychology
North Carolina State University
Raleigh, North Carolina 27695-7801 USA*

This study investigates whether signal words such as DANGER, WARNING, and CAUTION, presented under different vocal conditions, influence intended compliance. Male and female participants listened to cassette tapes of signal words presented by a male or female speaker in monotone, emotional, and whisper voice styles at either a low or high sound level. The results showed that female speakers produced significantly higher ratings of intended carefulness. Of the five signal words examined, DEADLY received the highest ratings, followed by DANGER; and NOTICE received the lowest carefulness ratings. WARNING and CAUTION did not differ. The safety implications of these results are discussed.

Introduction

Current warning design standards and guidelines recommend the use of signal words to alert individuals to the presence and level of potential hazards. Standards and guidelines in the US generally recommend DANGER, WARNING, and CAUTION to indicate high to low levels of hazard, respectively (e.g., ANSI, 1991; FMC Corporation, 1985). According to ANSI (1991) these terms have been assigned the following definitions. DANGER should be used to indicate immediate hazards that will result in severe personal injury or death. WARNING is recommended for use with hazards or unsafe practices that could result in severe personal injury or death. Finally, CAUTION is recommended for hazards or unsafe practices that could result in minor personal injury and/or product or property damage. Research has consistently shown that people do, in fact, perceive DANGER to connote a significantly greater hazard than both WARNING and CAUTION, but people do not differentiate between the two latter terms (e.g., Wogalter and Silver, 1990; 1995). Other research has investigated whether alternate terms, such as DEADLY and LETHAL, are useful in conveying different hazard levels (Wogalter and Silver, 1990; 1995).

All previous research on signal words has evaluated their effectiveness as presented visually in the print medium. Although there is research on *nonverbal* auditory warning signals (e.g., see Edworthy and Adams, 1996 for a review), there has been no research on the effects of auditory/voiced/verbal signal words. The present research is an initial attempt to examine the effects of voiced signal words on

connoted hazard (intended carefulness ratings). Previous studies suggest that voiced warnings have potential for effective warning communication. Wogalter and Young (1991) and Wogalter *et al.* (1994) showed that voiced warnings produced greater compliance than the same message in print. One benefit is that the receivers of the information do not need to be looking in a particular direction, as would be needed with visually presented information (Wogalter and Young, 1991; Wogalter *et al.*, 1994). Another benefit of voiced warnings is their potential utility for informing those who have difficulty reading the English language, including children and individuals with vision problems. With recent advancements in digital speech technology, voiced warnings could be used to communicate hazards of various types under various conditions.

The present study examines the effects of signal words presented in monotone, emotional, and whisper voices on intended compliance. Sound levels (dBA) were manipulated (low vs. high) with the amplitude levels equated among the three voicing methods. Mershon and Philbeck (1991) found that a whisper presented at the level of normal speech is significantly more salient and arousing than normal speech. In addition, gender was examined with respect to both the speaker (i.e., presenter or source) and the participant (i.e., listener or receiver). Although 43 words were used as stimuli in this research, the present article describes the results of the five terms that have been investigated most extensively in previous research (DEADLY, DANGER, WARNING, CAUTION, and NOTICE). Three of these terms, DANGER, WARNING, and CAUTION, are recommended by ANSI (1991) to indicate high to low levels of hazard, respectively. Previous research by Wogalter and Silver (1995) and Wogalter *et al.* (1997) has shown that DEADLY connotes a substantially greater hazard than DANGER. NOTICE is a *nonhazard* related term recognized by ANSI (1991) to call attention to important information (*Westinghouse Product Safety Label Handbook*, 1981).

Method

Participants

Seventy-two undergraduate students taking an introductory psychology course at North Carolina State University participated. They were compensated with credit towards the course. An equal number of males and females participated.

Stimulus materials

The signal words were taken from a list of 43 words investigated by Wogalter and Silver (1995). They are shown below in alphabetical order:

ALARM	DON'T	LETHAL	REQUIRED
ALERT	EXPLOSIVE	NECESSARY	RISKY
ATTENTION	FATAL	NEEDED	SERIOUS
BEWARE	FORBIDDEN	NEVER	SEVERE
CAREFUL	HALT	NO	STOP
CAUTION	HARMFUL	NOTE	TOXIC
CRITICAL	HAZARD	NOTICE	UNSAFE
CRUCIAL	HAZARDOUS	POISON	URGENT
DANGER	HOT	PREVENT	VITAL
DANGEROUS	IMPORTANT	PROHIBIT	WARNING
DEADLY	INJURIOUS	REMINDER	

The above words were arranged in 18 random orders, each recorded on a separate audio cassette tape. The recordings were produced in a sound chamber using a Marantz PMD201 professional portable cassette recorder, Audio-Technica ATR30 vocal/instrument microphone, microphone stand, TDK DS-X90 audio tapes and Koss TD/60 enclosed ear headphones.

Each speaker produced three recordings, one in each voicing method (monotone, emotional, and whisper) with a different random order word list for each. Each recording consisted of signal words presented at a rate of 8 s intervals (onset to onset) with a quiet period between each word. Three male and three female speakers were used to make the recordings.

Procedure

Participants were informed that they would hear a series of words presented on three cassette tapes. The instructions were to listen to each word and rate "How careful would you be after hearing each word?" based both on its meaning and on how it is presented. Ratings were made on a 9-point Likert-type scale with the following verbal anchors placed at the even-numbered points: 0 - not at all careful, 2 - slightly careful, 4 - careful, 6 - very careful, and 8 - extremely careful.

Each participant heard three tapes, monotone, emotional, and whisper, in different random orders. Sound level (low: 60 dBA vs. high: 90 dBA) and speaker gender (male vs. female) were manipulated between participant genders. All tapes heard by a given participant were presented either at the low or high sound level and by a male or female speaker. Participants were randomly assigned to conditions based on a schedule such that an equal number of males and females participated in the sound level and word order conditions an equal number of times.

Results

The data were examined using a 2 (Sound level: low vs. high) X 2 (Speaker gender: male vs. female) X 2 (Participant gender: male vs. female) X 3 (Voicing method: monotone vs. emotional vs. whisper) X 5 (Signal Words: DEADLY vs. DANGER vs. WARNING vs. NOTICE vs. CAUTION) mixed-model design analysis of variance (ANOVA). The last two variables, voicing method and signal words, were repeated measures factors; all others were between-subjects factors.

The ANOVA showed a significant main effect of speaker gender, $F(1, 60) = 13.95$, $p < .001$. Female speakers ($M = 5.10$) produced higher carefulness ratings than male speakers ($M = 4.18$). Although participant gender failed to reach the conventional p level generally considered necessary for significance, $F(1, 60) = 3.82$, $p = .055$, the means showed the tendency for male participants ($M = 4.9$) to give higher ratings for intended carefulness than female participants ($M = 4.4$).

The ANOVA showed a significant main effect of voicing method $F(2, 120) = 6.86$, $p < .01$. Comparisons among the means, using Tukey's Honestly Significant Difference (HSD) test, showed that the emotional voicing method ($M = 4.93$) produced significantly higher carefulness ratings ($p < .05$) than the monotone ($M = 4.30$). The whisper voice style ($M = 4.68$) was intermediate and was not significantly different from the other two conditions.

In addition, a significant main effect was found for signal words $F(4, 240) = 137.80$, $p < .001$. Tukey's HSD test showed that all paired comparisons were significant (DEADLY, $M = 6.35$; DANGER, $M = 5.28$; WARNING, $M = 4.44$; CAUTION, $M = 4.25$; and NOTICE, $M = 2.87$), except between WARNING and CAUTION.

Table 1. Means as a function of voicing method and signal word

Voicing method	Signal words					mean
	NOTICE	CAUTION	WARNING	DANGER	DEADLY	
Monotone	2.5	4.1	4.0	5.0	6.0	4.3
Whisper	2.6	4.3	4.4	5.4	6.7	4.7
Emotional	3.5	4.4	5.0	5.4	6.4	4.9
mean	2.9	4.3	4.4	5.3	6.3	

The ANOVA also indicated the presence of three significant interaction effects. Table 1 presents the means for the interaction between voicing method and signal words, $F(8, 480) = 2.56, p < .01$. The emotional voicing method produced significantly higher ratings than the monotone for both WARNING and NOTICE. In addition, NOTICE voiced emotionally was rated higher than NOTICE whispered. DEADLY whispered was rated higher than DEADLY voiced in monotone. There were no significant voicing-method differences for CAUTION and DANGER.

Table 2. Means as a function of speaker gender and signal word

Speaker gender	Signal words					mean
	NOTICE	CAUTION	WARNING	DANGER	DEADLY	
Male	2.9	3.9	3.8	4.7	5.7	4.2
Female	2.9	4.6	5.1	5.8	7.0	5.1

Speaker gender and signal word interacted, $F(4, 240) = 6.82, p < .001$. The means in Table 2 show that female speakers consistently produced higher carefulness ratings than male speakers for all signal words, except NOTICE. These 2 factors interacted with sound level in a three-factor interaction of sound level, speaker gender, and signal words, $F(4, 240) = 3.37, p < .05$. The means for this interaction, displayed in Table 3, depict a similar pattern to the speaker gender by signal word interaction described above, with two relatively minor magnitude changes as a function of sound level. The speaker gender difference is larger for DEADLY in the low sound level condition and for WARNING in the high sound level condition. Note that the greatest intended carefulness was produced with DEADLY spoken in a low level female voice.

Table 3. Means as a function of sound level, speaker gender, and signal word

	Signal words					mean
	NOTICE	CAUTION	WARNING	DANGER	DEADLY	
<i>Low sound level</i>						
Male speaker	3.2	4.0	4.0	4.8	5.4	4.3
Female speaker	2.8	4.6	4.8	6.0	7.3	5.1
<i>High sound level</i>						
Male speaker	2.5	3.7	3.5	4.6	5.8	4.1
Female speaker	2.9	4.7	5.4	5.7	6.7	5.1

Discussion

Various parameters of auditorily-presented signal words can affect receivers' intended carefulness. For the most part, emotionally toned voices produced the highest carefulness ratings, particularly compared to the monotone voices. Perhaps the higher ratings for the emotional tone is a reflection of the way people would naturally vocalize a hazard. In emergency-type communications, people become excited and emotional speaking at a higher pitch and at a faster rate. Therefore, the emotional tone may cue listeners to the urgency of the situation. Research has shown that *nonverbal* auditory signals presented at a faster rate and at higher frequencies increase perceived urgency (Edworthy and Adams, 1996). Related to this is the higher carefulness ratings when the signal words were presented by female speakers. This concurs with previous findings showing that higher physical

frequencies (i.e., the female voice) produce greater perceived urgency (Edworthy and Adams, 1996).

The perceived hazard levels associated with the signal words were ordered high to low as follows: DEADLY, DANGER, WARNING, CAUTION, and NOTICE. This order is consistent with previous research of visually presented signal words (Wogalter and Silver, 1995). Several other results were also consistent with previous research of visually presented signal words. First, there was no significant difference between WARNING and CAUTION on perceived hazard (i.e., intended carefulness) (Wogalter and Silver, 1990). Second, DEADLY was consistently rated higher than DANGER (Wogalter & Silver, 1995; Wogalter *et al.*, 1997). Third, the low ratings for NOTICE for both male and female participants reflects the fact that this term has no specific hazard-related implications. Several complex interactions were noted in the analysis. We will withhold elaborate explanations until there is additional evidence and replication.

Clearly these results have implications for safety. Modern technology has provided voice recordable transistor chips (found in greeting cards, answering machines), which when combined with one or more detection systems (e.g., motion, infrared, sound) can potentially communicate effective, timely warnings. Only a few of the many sound parameters were investigated in the present study. Other parameters of voice warnings still need to be examined.

References

- ANSI. 1991, *American national standard on product safety signs: Z535.1-5*, (American National Standards Institute, New York)
- Edworthy, J., and Adams, A. 1996, *Warning Design: A Research Perspective*, 129-178
- FMC Corporation. 1985, *Product safety sign and label system*, (Santa Clara, CA: Author)
- Mershon, D.H., and Philbeck, J.W. 1991, Auditory perceived distance of familiar speech sounds, Paper presented at the Annual Meeting of the Psychonomic Society, (San Francisco, CA)
- Westinghouse Printing Division. 1981, *Westinghouse product safety label handbook*, (Trafford, PA: Author)
- Wogalter, M.S., Frederick, L.J., Herrera, O.L., and Magurno, A.B. 1997, Connoted hazard of Spanish and English warning signal words, colors, and symbols by native Spanish language users. *Proceedings of the 13th Triennial Congress of the International Ergonomics Association, IEA '97*, 3, 353-355
- Wogalter, M.S., Racicot, B.M., Kalsher, M.J., and Simpson, S.N. 1994, The role of perceived relevance in behavioral compliance in personalized warning signs. *International Journal of Industrial Ergonomics*, 14, 233-242
- Wogalter, M.S., and Silver, N.C. 1990, Arousal strength of signal words. *Forensic Reports*, 3, 407-420
- Wogalter, M.S. and Silver, N.C. 1995, Warning signal words: connoted strength and understandability by children, elders, and non-native English speakers, *Ergonomics*, 38, 2188-2206
- Wogalter, M.S., and Young, S.L. 1991, Behavioural compliance to voice and print warnings. *Ergonomics*, 34, 79-89