# Intended Carefulness For Voiced Warning Signal Words

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ABSTRACT

Design standards for print warnings (e.g., signs and labels) recommend the use of signal words to convey the presence and level of a hazard. However, very little research has been conducted on the use of signal words presented auditorily. In the present study, 43 voiced signal words were examined as a function of several factors: voice style (monotone, emotional, whisper), sound level (low, high), participant group (college students, community volunteers) and gender of the speaker and the participant. Results indicated that auditory presentation yielded a pattern of connoted hazard levels (ratings of intended carefulness) similar to previous research using visual presentation. Emotional voicing produced significantly higher carefulness ratings than monotone or whisper voicing (with overall sound level held constant). Female speakers produced significantly higher carefulness ratings than male speakers. Implications for the design of speech warnings are discussed.

## INTRODUCTION

Signal words in warnings are intended to convey the presence and level of a hazard. The American National Standards Institute (ANSI, 1991, 1998) recommends the terms DANGER, WARNING, and CAUTION to represent high to low hazard levels, respectively (e.g., ANSI, 1991, 1998; FMC Corporation, 1985). According to ANSI (1991, 1998) DANGER is to represent immediate hazards which *will* result in severe personal injury or death. WARNING is to represent hazards or unsafe practices which *could* result in severe personal injury or death. CAUTION is to represent hazards or unsafe practices which could result in *minor* personal injury and/or property damage. Interestingly, research has consistently shown that people generally do not perceive much difference between WARNING and CAUTION (e.g., Wogalter & Silver, 1990, 1995).

In addition to the standard three signal words, ANSI (1991, 1998) suggests the term NOTICE be used to communicate important, but non-hazard related information. Research has also examined other potential signal words (Wogalter & Silver, 1990, 1995). The term DEADLY has been examined in a number of studies. This research shows that it connotes a higher level of hazard than the term DANGER (Wogalter & Silver, 1990, 1995; Wogalter, Frederick, Herrera, & Magurno, 1997).

The signal word standards and most research on the topic have primarily concerned their use in the visual medium, such as on printed warning signs and labels. Until recently, virtually no research has investigated their use in the auditory medium such as in voiced or speech warnings. Technology has now made available digital voice chips that allow the use of voiced warnings in situations heretofore not considered possible or practical. Their use may offer advantages over print warnings in certain circumstances. One relates to the characteristic of omnidirectionality. People's attention does not need to be visually directed to a particular location to receive the message. Research also suggests that individuals are more likely to comply with a warning presented by voice than the same message presented by a printed sign (Wogalter & Young, 1991; Wogalter, Racicot, Kalsher, & Simpson, 1994).

In comparison to simple nonverbal sounds (e.g., buzzers or beeps), speech warnings take advantage of people's existing knowledge. A voice yelling "Fire" has more meaning than a simple bell or siren. Research on non-verbal auditory signals has noted that various sound parameters (e.g., loudness, rate, pitch) affect perceived urgency (e.g., Edworthy & Adams, 1996). The concept of perceived urgency has been used mainly in the auditory warning domain but it is similar to other measures used to evaluate visually-presented signal words, e.g., arousal strength and perceived hazard (e.g.,Wogalter & Silver, 1990, 1995). In research on print warnings, perceived hazard has been shown to be related to other warning-related measures such as nonfamiliarity and complexity of products, injury severity, intentions to be careful, and compliance (Laughery, Wogalter, & Young, 1994).

Recently, research has begun to investigate the effects of auditorily-presented signal words (Barzegar & Wogalter, 1998; Edworthy, Clift-Matthews, & Crowther, 1998). Two main issues have been of interest. One is whether signal

words presented auditorily have the same effects as shown in previous research presenting them visually. The other issue is whether it matters how the terms are voiced. For example, Mershon and Philbeck (1991) found results that suggested that a whisper sound produces a greater startle reaction than conversational speech. Edworthy et al. (1998) found that the style of speech (appropriate vs. inappropriate) affects perceived urgency. Barzegar and Wogalter (1998) reported that signal words voiced in an emotional tone received higher 'intended carefulness' ratings than words spoken in monotone. In addition, signal words spoken by female speakers received higher ratings than those spoken by male speakers.

The present study is an extension of the initial Barzegar & Wogalter (1998) report. In that report, only data from college students was described and the analysis was limited to a small subset of five signal words from a list of 43. In the present study, we include a broader sample of participants in addition to the college students to determine whether the same or different results would be found. In this report we present statistics for the full set of (43) signal words.

The present research examined the following factors: population group (students, community volunteers), sound level (low, high), speaker gender, participant gender, voice style (monotone, emotional, whisper), and 43 signal words. In general, we expected l louder words would produce higher ratings than less loud words. The manipulation of monotone, emotional, and whisper voicing was included to investigate whether the characteristics of the voice presentation make a difference. Another issue is whether the gender of the speaker influences perceptions of participants. Social psychology research (e.g., Baron & Byrne, 1997) suggests that people's interactions with others can be affected by the gender of the individuals involved. For this reason we also included both speaker and participant gender as factors. A list of 43 signal words compiled by Wogalter and Silver (1995) was used as stimuli.

## METHOD

### *Participants*

A total of 144 individuals participated. Seventy-two were undergraduate students at North Carolina State University who received research credit in their introductory psychology courses. They had a mean age of 19 years. The other 72 participants were volunteers from the surrounding Raleigh, North Carolina community (mean age of 34 years, $SD = 9.0$). The educational levels attained by the community volunteers were: 7% completed high school, 21% completed some college or trade school, 44% completed college, 18% completed a Master's degree, and 8% completed a Ph.D degree. Ninety percent of the community volunteers were Caucasian, 7% were African American, and 3% listed other race/ethnic categories. All community volunteers reported that English was their first language. Fourteen percent believed they had some hearing difficulty; however, only one person reported having been diagnosed with a hearing problem. In addition, none owned a hearing aid. Community volunteers were paid five dollars for participating.

### *Materials*

The 43 signal words were recorded on audio tape in 18 random orders. Three male and three female speakers were used to create the recordings. Each speaker produced a monotone, emotional, and whisper voiced tape, each with the words in a different random order. In all instances the words were spoken at 8 s intervals (onset to onset). To create the monotone voice-style recordings, speakers were instructed to read the words in a staid, even manner. To create the emotional recordings, speakers were instructed to say the words in a way that would tell a loved one about the presence of an imminent hazard so that he or she would avoid the hazard. To create the whisper recording, speakers were asked say the words in a "soft" manner. The word sounds were recorded so that they were roughly similar in amplitude across the voicing style conditions. The tapes were played back to participants at either a low (60 dBA) or high (90 dBA) sound level. All recordings were produced in a sound chamber (to eliminate background noise) and subsequently played back to participants using the following equipment: Audio Technica ATR30 vocal/instrument microphone, Marantz PMD201 professional portable cassette recorder, and Koss TD/60 enclosed-ear headphones.

### *Procedure*

Initially, each participant was asked to sign a consent form. The researcher told participants that they would be hearing a series of words and they were to rate each one on "How careful would you be after hearing each word?" based on both the meaning of the word as well as how it sounds. The ratings were made on a 9-point Likert-type scale with the following verbal anchors on the even-points of the scale: (0) not at all careful, (2) slightly careful, (4) careful, (6) very careful, and (8) extremely careful. Ratings were marked on a sheet with a set of blanks numbered from 1 to 43.

Each participant heard three tapes, a monotone, an emotional, and a whisper voiced tape according a predefined set of random orders. A given participant could hear the tapes presented at either a low or high sound level spoken by a male or female. An equal number of male and female participants were assigned to all conditions.

## RESULTS

Two analyses were preformed on the data. One analyzed all of the data. The other was restricted to a specific subset of five signal words. There were 124 missing ratings out of a total of 18756 values for the 144 participants (0.66%). In order to include data for all participants, we replaced the

**Table 1.** *Intended Carefulness Means for Voice Style, Speaker Gender, and Signal Word.*

| Voice Style: | | | Monotone | | | | Emotional | | | | Whisper | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Speaker Gender: | Overall | | Male | | Female | | Male | | Female | | Male | | Female | |
| Mean, SD: | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD |
| DEADLY | 6.62 | 1.81 | 5.78 | 2.17 | 6.86 | 1.72 | 6.28 | 1.98 | 7.42 | 1.07 | 6.46 | 1.87 | 6.94 | 1.40 |
| FATAL | 6.49 | 1.97 | 5.68 | 2.14 | 7.08 | 1.68 | 6.21 | 2.29 | 7.00 | 1.85 | 6.47 | 1.75 | 6.50 | 1.74 |
| LETHAL | 6.44 | 1.91 | 5.38 | 2.42 | 6.82 | 1.76 | 6.46 | 1.96 | 7.23 | 1.19 | 6.14 | 1.79 | 6.63 | 1.67 |
| EXPLOSIVE | 6.26 | 2.02 | 5.93 | 1.93 | 6.22 | 2.17 | 6.43 | 1.75 | 6.90 | 1.71 | 5.85 | 2.19 | 6.25 | 2.17 |
| TOXIC | 5.98 | 2.00 | 5.85 | 1.81 | 6.14 | 2.15 | 5.72 | 1.97 | 6.49 | 1.86 | 5.56 | 1.91 | 6.12 | 2.21 |
| POISON | 5.77 | 2.19 | 4.71 | 2.58 | 6.28 | 2.08 | 5.18 | 2.13 | 6.67 | 1.69 | 5.64 | 2.06 | 6.14 | 1.92 |
| DANGER | 5.28 | 1.85 | 4.78 | 1.67 | 5.38 | 1.92 | 5.18 | 1.81 | 6.10 | 1.62 | 5.03 | 1.82 | 5.21 | 2.04 |
| DANGEROUS | 5.25 | 1.81 | 4.65 | 1.91 | 5.29 | 1.86 | 5.46 | 1.83 | 5.75 | 1.61 | 5.08 | 1.73 | 5.29 | 1.80 |
| HAZARDOUS | 5.24 | 1.94 | 4.38 | 1.87 | 5.65 | 1.90 | 5.08 | 1.70 | 5.92 | 1.86 | 5.17 | 1.94 | 5.25 | 2.06 |
| SEVERE | 4.90 | 1.88 | 4.10 | 1.89 | 5.33 | 1.82 | 4.63 | 1.86 | 5.58 | 1.56 | 4.72 | 2.00 | 5.02 | 1.79 |
| CRITICAL | 4.89 | 2.01 | 4.38 | 2.11 | 5.06 | 2.08 | 4.90 | 2.12 | 5.21 | 1.82 | 4.75 | 1.88 | 5.50 | 1.97 |
| HAZARD | 4.85 | 1.86 | 4.22 | 1.66 | 4.99 | 1.94 | 4.78 | 1.81 | 5.44 | 1.69 | 4.49 | 1.81 | 5.17 | 2.01 |
| URGENT | 4.84 | 1.96 | 4.11 | 1.87 | 4.65 | 1.82 | 4.46 | 2.11 | 5.54 | 1.68 | 3.88 | 1.81 | 4.26 | 2.08 |
| HARMFUL | 4.72 | 1.80 | 4.15 | 1.67 | 5.00 | 1.85 | 4.53 | 1.82 | 5.27 | 1.55 | 4.36 | 1.66 | 5.01 | 2.00 |
| VITAL | 4.57 | 2.05 | 4.08 | 1.86 | 4.99 | 2.01 | 4.22 | 2.04 | 5.09 | 2.04 | 4.38 | 2.08 | 4.67 | 2.14 |
| CRUCIAL | 4.55 | 1.95 | 4.53 | 1.94 | 4.59 | 1.89 | 4.13 | 2.04 | 5.12 | 1.66 | 4.26 | 2.03 | 4.65 | 2.01 |
| BEWARE | 4.44 | 1.88 | 3.96 | 1.85 | 4.54 | 1.79 | 4.21 | 1.71 | 5.01 | 1.74 | 4.59 | 2.07 | 4.33 | 1.97 |
| FORBIDDEN | 4.40 | 2.02 | 3.81 | 2.04 | 4.77 | 2.01 | 3.60 | 1.86 | 5.10 | 1.78 | 4.51 | 1.93 | 4.60 | 2.14 |
| WARNING | 4.40 | 1.87 | 3.53 | 1.95 | 4.43 | 1.67 | 4.49 | 1.67 | 5.64 | 1.50 | 3.86 | 1.87 | 4.43 | 1.87 |
| UNSAFE | 4.31 | 1.89 | 3.72 | 1.66 | 4.59 | 1.97 | 3.94 | 1.90 | 4.79 | 1.81 | 4.50 | 1.91 | 4.32 | 1.91 |
| STOP | 4.26 | 2.07 | 3.74 | 1.83 | 3.97 | 2.20 | 4.74 | 1.89 | 5.10 | 1.96 | 3.72 | 2.04 | 4.28 | 2.16 |
| HOT | 4.21 | 2.05 | 3.60 | 1.97 | 4.48 | 2.00 | 4.10 | 1.94 | 5.17 | 2.10 | 3.96 | 1.94 | 3.94 | 2.01 |
| CAUTION | 4.18 | 1.69 | 3.86 | 1.49 | 4.26 | 1.80 | 3.86 | 1.62 | 4.89 | 1.66 | 4.01 | 1.61 | 4.21 | 1.80 |
| SERIOUS | 4.05 | 1.88 | 4.17 | 1.78 | 4.18 | 1.95 | 4.24 | 1.71 | 4.31 | 1.77 | 3.69 | 1.95 | 3.74 | 2.05 |
| INJURIOUS | 4.05 | 1.98 | 4.13 | 1.98 | 4.06 | 2.01 | 4.23 | 2.10 | 4.60 | 1.87 | 3.61 | 1.80 | 3.69 | 2.02 |
| ALARM | 4.01 | 2.03 | 3.31 | 2.11 | 4.02 | 1.91 | 3.76 | 1.96 | 5.18 | 1.72 | 3.79 | 1.90 | 3.99 | 2.12 |
| RISKY | 3.93 | 1.82 | 3.50 | 1.75 | 4.31 | 2.03 | 3.65 | 1.86 | 4.57 | 1.63 | 3.76 | 1.63 | 3.79 | 1.78 |
| NEVER | 3.82 | 2.11 | 3.57 | 1.99 | 3.77 | 2.09 | 3.52 | 2.02 | 4.33 | 2.21 | 3.60 | 2.17 | 4.11 | 2.09 |
| HALT | 3.80 | 1.96 | 3.75 | 1.79 | 3.82 | 1.86 | 4.28 | 1.95 | 4.17 | 2.13 | 3.55 | 1.91 | 3.25 | 1.98 |
| ALERT | 3.76 | 1.90 | 3.16 | 1.87 | 3.79 | 1.92 | 3.83 | 1.82 | 4.83 | 1.67 | 3.49 | 1.78 | 3.46 | 1.92 |
| CAREFUL | 3.74 | 1.65 | 3.26 | 1.59 | 3.72 | 1.83 | 3.78 | 1.51 | 4.46 | 1.55 | 3.53 | 1.50 | 3.67 | 1.70 |
| PROHIBIT | 3.66 | 2.04 | 3.03 | 1.96 | 4.10 | 2.08 | 3.06 | 2.06 | 4.35 | 1.89 | 3.54 | 1.86 | 3.92 | 2.09 |
| DON'T | 3.54 | 2.05 | 3.24 | 1.98 | 3.17 | 1.92 | 4.19 | 2.05 | 4.17 | 2.06 | 3.27 | 2.06 | 3.19 | 1.99 |
| IMPORTANT | 3.49 | 1.92 | 3.12 | 1.87 | 3.52 | 2.01 | 3.33 | 1.70 | 4.19 | 1.87 | 3.40 | 1.88 | 3.36 | 2.08 |
| NO | 3.31 | 2.18 | 2.50 | 1.95 | 2.90 | 2.05 | 3.81 | 2.02 | 4.54 | 2.39 | 3.07 | 1.89 | 3.01 | 2.14 |
| PREVENT | 3.28 | 1.92 | 3.15 | 1.76 | 3.37 | 1.94 | 3.07 | 1.83 | 3.90 | 1.99 | 3.00 | 1.88 | 3.19 | 2.02 |
| ATTENTION | 3.23 | 1.84 | 3.13 | 1.74 | 3.24 | 1.87 | 3.18 | 1.86 | 4.06 | 1.80 | 2.65 | 1.63 | 3.11 | 1.88 |
| REQUIRED | 3.07 | 2.02 | 2.69 | 1.85 | 3.21 | 1.93 | 3.07 | 2.00 | 3.77 | 2.04 | 2.71 | 1.92 | 2.94 | 2.21 |
| NECESSARY | 2.85 | 1.90 | 2.26 | 1.67 | 3.25 | 2.01 | 2.69 | 1.79 | 3.38 | 1.91 | 2.72 | 1.94 | 2.81 | 1.91 |
| NEEDED | 2.54 | 1.89 | 2.24 | 1.71 | 2.50 | 1.98 | 2.78 | 1.97 | 3.08 | 1.93 | 2.21 | 1.77 | 2.44 | 1.90 |
| NOTICE | 2.53 | 1.91 | 2.22 | 1.72 | 2.33 | 1.81 | 2.83 | 2.12 | 3.18 | 1.99 | 2.31 | 1.83 | 2.28 | 1.85 |
| NOTE | 2.08 | 2.04 | 2.08 | 2.26 | 2.03 | 2.04 | 2.53 | 1.97 | 2.58 | 2.10 | 1.36 | 1.50 | 1.92 | 2.13 |
| REMINDER | 2.04 | 1.88 | 1.61 | 1.58 | 2.11 | 2.05 | 1.71 | 1.58 | 2.72 | 2.00 | 1.93 | 1.86 | 2.14 | 2.02 |

missing values with a mean for that particular word within its respective condition.

## *Full List Analysis*

The data set was a six-factor experimental design that was analyzed using a 2 (Population: students, community volunteers) X 2 (Sound level: low, high) X 2 (Speaker gender: male, female) X 2 (Participant gender: male, female) X 3 (Voice style: monotone, emotional, whisper) X 43 (Signal words) mixed-model analysis of variance (ANOVA) with the last two factors manipulated as repeated measures.

The ANOVA for the full list of signal words showed a significant main effect for speaker gender, $F(1, 128) = 8.83$, $p < .01$. Words voiced by female speakers ($M = 4.53$) produced significantly higher carefulness ratings than words voiced by male speakers ($M = 4.00$). The ANOVA also showed a significant main effect for voice style, $F(2, 256) = 18.51$, $p < .0001$. Tukey's Honestly Significant Difference (HSD) test showed that the emotional ($M = 4.57$) voice produced significantly higher carefulness ratings than the whisper ($M = 4.13$) and the monotone ($M = 4.09$) voices ($ps < .01$). The latter two conditions were not significantly different. The ANOVA also showed a significant main effect for signal words, $F(42, 17388) = 262.88$, $MSe = 2.107$, $p < .0001$. The overall means and standard deviations are shown in the left side of Table 1. Comparisons among these main effect means can be made using the Tukey's HSD minimum significant difference of 0.39 ($p = .05$). None of the other factors in the full analysis produced significant main effects.

The ANOVA also showed several significant interactions. Only one did not involve signal words — a speaker gender X voice style interaction, $F(2, 256) = 4.90$, $p < .01$. These means are displayed in Table 2. Female speakers produced significantly higher carefulness ratings than male speakers for

**Table 2.** *Intended Carefulness Means as Function of Speaker Gender and Voice Style.*

| | Voice Style | | | |
|---|---|---|---|---|
| *Speaker gender* | Monotone | Emotional | Whisper | *mean* |
| Male | 3.79 | 4.19 | 4.01 | 4.00 |
| Female | 4.39 | 4.95 | 4.24 | 4.52 |
| mean | 4.09 | 4.57 | 4.13 | |

both the emotional and monotone voice styles (*ps* < .01), but the speaker-gender difference for the whisper voice style was not significant. All of the remaining interactions in the ANOVA involved signal words. This finding was expected given that this factor was comprised of 43 levels and any interaction with signal word would concern conditions that are multiples of that number. The huge number of conditions makes it likely that a deviant number in one or more of these conditions could produce a significant signal word interaction. The significant interactions involving signal word are summarized as follows: In the two-factor interactions, signal word interacted with (a) population group, (b) sound level, (c) speaker gender, (d) participant gender, and (e) voice style. In the three-factor interactions, signal word interacted with (a) speaker gender X population group, (b) speaker gender X sound level, and (c) population group X participant gender. There were also two four-factor interactions involving signal word: (a) population group X sound level X speaker gender, and (b) population group X sound level X participant gender. Because of the enormous complexity of these interactions, the associated patterns of means will not be described in this report. A complete set of means is available from the authors. Table 1 shows the means and standard deviations as a function of the 43 signal words in combination with two factors that produced significant effects (individually, together, and with signal word): voice style and speaker gender.

*Five Word Analysis*

A second analysis of the data was was limited to the five signal words: DEADLY, DANGER, WARNING, CAUTION and NOTICE. A 2 (Population: students, community volunteers) X 2 (Sound level: low, high) X 2 (Speaker gender: male, female) X 2 (Participant gender: male, female) X 3 (Voice style: monotone, emotional, whisper) X 5 (Signal words) mixed-model ANOVA, with the last two factors repeated measures, was performed.

The ANOVA showed a significant main effect for speaker gender $F(1, 128) = 11.73$, $p < .001$. Words voiced by female speakers ($M = 4.90$) produced significantly higher ratings than words voiced by male speakers ($M = 4.30$). The ANOVA also showed a significant main effect for voice style, $F(2, 256) = 22.78$, $p < .0001$. Tukey's HSD test showed that words spoken in the emotional voice ($M = 4.99$) were rated significantly higher than those spoken in the monotone ($M = 4.34$) or whisper ($M = 4.47$) voice styles (*ps* < .01). There was no difference between the latter two conditions. The ANOVA showed a significant main effect for the five signal words, $F(4, 512) = 366.02$, $p < .0001$. Tukey's HSD test showed that all comparisons among the terms were significant (DEADLY, $M = 6.62$; DANGER, $M = 5.28$; WARNING, $M = 4.40$; CAUTION, $M = 4.18$; and NOTICE, $M = 2.53$) except between WARNING and CAUTION.

The ANOVA also yielded several significant interactions (*ps* < .01). There was a two-factor interaction for population group X signal word, $F(4, 512) = 6.90$, $p < .001$. These data are shown in Table 3. Simple effects analysis showed that community volunteers rated DEADLY ($M = 6.91$) significantly higher than the students ($M = 6.33$), and students rated NOTICE ($M = 2.81$) significantly higher than the community volunteers ($M = 2.24$). There were no significant differences between the population groups for the terms DANGER, WARNING, and CAUTION. There was also a significant two-factor interaction for speaker gender and signal word, $F(4, 512) = 3.83$, $p < .01$. Table 3 contains the associated means. Simple effects analysis showed that female speakers produced significantly higher ratings than male speakers for all of the words, except NOTICE.

**Table 3.** *Carefulness Means as Function of Signal Word, Speaker Gender and Population Group.*

| | Population Group | | |
|---|---|---|---|
| | Students | Community Volunteers | *mean* |
| DEADLY | | | |
| Male | 5.67 | 6.68 | 6.18 |
| Female | 7.00 | 7.15 | 7.07 |
| DANGER | | | |
| Male | 4.73 | 5.26 | 5.00 |
| Female | 5.68 | 5.44 | 5.56 |
| WARNING | | | |
| Male | 3.75 | 4.17 | 3.96 |
| Female | 5.01 | 4.66 | 4.84 |
| CAUTION | | | |
| Male | 3.87 | 3.95 | 3.91 |
| Female | 4.56 | 4.35 | 4.46 |
| NOTICE | | | |
| Male | 2.87 | 2.04 | 2.46 |
| Female | 2.75 | 2.44 | 2.60 |

In addition, there was a significant three-factor interaction for population X speaker gender X signal word, $F(4, 512) = 3.39$, $p < .01$. These means are shown in Table 3. Simple effects analyses were employed to examine the speaker gender X signal word interaction separately for each population group. The analysis showed that these two factors significantly interacted using the student data but not with the community volunteer data. In general, carefulness ratings were higher with female speakers than with male speakers for both population groups except there was no speaker-gender difference (and a small reversal) for the term NOTICE by the students.

## DISCUSSION

The results generally showed that voice presentation of signal words produces ratings of intended carefulness that are similar to those found in research assessing the words presented visually (Wogalter & Silver, 1990, 1995). DEADLY is rated higher than DANGER which is in turn rated higher than WARNING and CAUTION (which did not differ), and all are higher than NOTICE.

The results also showed that the effects of voiced signal words are influenced by the way they are presented. Words voiced emotionally and by female speakers generally raised carefulness ratings relative to the words voiced in a monotone or a whisper or by male speakers. The null effect of the whisper voice fails to support the Mershon and Philbeck (1991) finding of a difference between whisper and conversational speech, but we did note that for some signal words the whisper voice had higher ratings than the emotional voice (see Table 1). Sound level, participant group, and participant gender failed to produce main effects, although these and the other variables entered into various complex interactions in the ANOVAs.

Research has shown that non-speech auditory signals presented at faster rates and at higher frequencies increases the sounds' perceived urgency (e.g., Edworthy & Adams, 1996). Words presented by emotional voice might be characterized in this same way: speech expressed at a higher rate of speed and at higher frequencies. Note, too, that female voice are generally higher in frequency than males. In emergency situations, people generally speak at a faster rate and at a higher pitch. This effect may be similar to mothers alerting their children to a potential hazard. Our possible attunement to these voice characteristics to form urgency perceptions may have survival value. Furthermore, the present research suggests that these variables (frequency and rate) are more important for hazard perception than loudness.

The present research is one of the few existing studies examining factors related to voiced warnings. Clearly more investigations on this topic are needed given that research indicates that auditory warnings are capable of substantial levels of compliance (e.g. Wogalter et al., 1993; Wogalter & Young, 1991). With the availability of digital voice chips together with various kinds of detection systems, auditory warnings can now be practically employed in situations not previously considered. Of course, auditory warnings can not be used in every situation. Research is needed to determine the kinds of situations where auditory warnings are appropriate and where they are not.

Although the present research had a complex number of factors and conditions, there are many other parameters of voice warnings that could influence their effectiveness in eliciting careful behavior. Such research is needed for specific warning-design recommendations. Optimal effectiveness of voice warnings may also depend on the environmental and situational characteristics.

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