

Perceived Effectiveness of Warning Messages for Use as Vocal Warnings in Residential Fire Alarms

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Approximately half of all deaths associated with residential fires occur while individuals are sleeping. Voice technology added to fire alarms may provide better warnings than traditional, nonverbal alarms. This study examined several verbal messages presented to participants in written form. Forty-four university students and 12 firefighters rated the appropriateness, attention-getting qualities, and content of 6 prototype messages. Data indicate similarities and differences between the two participant groups. Firefighters provided recommendations on improving the messages with respect to safe egress for children during residential fires. Areas for further research are discussed.

INTRODUCTION

During 2004 in the United States, a person died from fire every 143 minutes and was injured in a fire every 29 minutes. In that year, fires in the home caused 3,030 deaths (Karter, 2006). Preventing residential fires and reducing injury and death are important safety goals. The National Fire Protection Association (NFPA) has developed a Fire Safety Concepts Tree to assist fire analyses (Watts, 1997). Williamson (2006) places fire science into a human factors framework, noting that timely egress requires signaling and that providing instructions for that egress are essential purposes of fire warnings.

Most fire alarms are active fire protection devices that have sensors to detect the presence of smoke (and sometimes heat). The sensors trigger the presentation of a loud auditory signal or alarm. Fire alarms must be capable of not only signaling awake and alert persons, but also awakening sleeping individuals (see Bruck, 2001, for a review). This capability is important because about half of the deaths associated with residential fires occur at night while victims are sleeping (Karter, 1986; Runyan, Bangdiwala, Linzer, Sacks, & Butts, 1992). Also, deaths occur during daytime hours while victims are asleep (Brennan, 1998). Some research indicates some alarms effective for awakening adults may not be effective for awakening children, even at greater sound levels (Bruck, 1999; Nober, Peirce, & Well, 1981; Runyan et al., 1992). In one study, almost 70% of children slept through conventional alarms (Bruck, 1999).

Recent technology may be able to improve effectiveness of fire alarms (Wogalter & Mayhorn, 2006). Traditionally, smoke alarms have used simple (e.g., a tone) or complex, nonverbal (e.g., a series of tones) messages (Haas & Edworthy, 2006). However, voice technology has become available in recent years for use in fire alarm systems. Some currently-available alarms have prerecorded speech messages and some allow consumers to record their own voice messages. Voice messages can convey more speech content than more simple alarms.

One important issue in the use of voice messages is the content of the message. Measures that might be valuable in determining effective messages for use in this application include the dimensions of appropriateness, attention-gettingness, and content. These characteristics might provide valuable insights about what kinds of messages might be used. In the present research, potential (prototype) vocal warning statements were evaluated in printed form by lay consumers and firefighters.

METHOD

Participants. A total of 56 individuals participated. One group was composed of 44 university student participants recruited from a participant pool composed of students from the introductory psychology courses at North Carolina State University. This group included 32 males and 12 females ($M = 19.3$ years, $SD = 1.75$) majoring in a wide variety of disciplines. The other group was 12 professional firefighters (all males, $M = 34.3$ years, $SD = 7.85$) with an average of 11.8 years of experience ($SD = 8.32$) from the Raleigh, North Carolina area.

Materials and Procedure. Participants completed a multi-page survey that included questions related to content of voice alarm messages and judgments about voice alarms in general. Material was presented visually (i.e., on paper) to eliminate issues related to differences in perceived urgency between certain speakers/spoken words, and due to the fact that this is an early study in this research area.

An initial set of six alarm messages were created based upon discussions with individuals familiar with children (e.g., teachers, daycare providers) and the "What to Record in the KidSmart™ Vocal Smoke Detector" section in the material enclosed with the KidSmart Vocal Smoke Detector (Model No.10012VSD; <http://www.kidsmartcorp.com/>). Messages were rated on a 1 (low) to 5 (high) scale on the following questions:

- (a) How *appropriate* (for example, considering its length/applicability) is the message for use in a voice alarm intended for use with a young child?

- (b) How well would the message *attract* a young child’s attention during a fire emergency?
- (c) How well would a young child understand the *content* of the message in a fire emergency?

Participants were also asked the following:

- (a) How effective do you think voice alarms would be at *waking sleeping individuals* compared to usual fire alarms when played at the same sound level?
- (b) How effective do you think voice alarms would be at *keeping individuals calm* compared to usual fire alarms when played at the same sound level?

In responding to these two questions, participants chose from the following three alternatives: (a) more effective, (b) equally effective, or (c) less effective.

The 12 firefighters were also asked several semi-structured interview questions in small groups of 2 to 4 persons to gather addition information about their beliefs and design recommendations. Discussions lasted between 20 and 40 minutes. The main questions were the following:

- (a) How do you feel about using alarms with recorded messages in home? How about when children are in the home?
- (b) What are some advantages/disadvantages to using voice alarms in homes? How about when children are in the home?
- (c) What are some improvements that can be made to residential fire alarms?

RESULTS

Ratings of printed messages. A 2 (participant group: student vs. firefighter) x 3 (question dimension) x 6 (message statement) mixed model analysis of variance (ANOVA) was used to examine the data. Simple effects analysis and Tukey’s HSD tests were used to examine means of significant effects ($p < .05$).

There was no significant main effect for participant group, $F(1, 53) = 2.89$, $MSe = 4.30$, $p > .05$; however, there

was a significant main effect of message statement, $F(5, 265) = 18.18$, $MSe = 1.99$, $p < .0001$. These means are in the right-most column of Table 1. Tukey’s HSD test indicated that statement 6 was rated significantly higher than all of the other statements. Also statements 1 and 3 were rated significantly higher than statements 4 and 5. There was no significant difference among statements 2, 4, and 5.

There was also a significant main effect for question dimension, $F(2,106) = 38.42$, $MSe = 1.49$, $p < .0001$. Tukey’s HSD indicated that the attention-attraction ($M = 3.82$) ratings were significantly higher than the appropriateness ($M = 2.96$) and content ($M = 2.89$) ratings.

The participant group X message statement interaction was significant, $F(5, 265) = 4.73$, $MSe = 1.99$, $p < .0001$. These means are shown in Table 1. Simple effects analysis showed that students gave higher ratings than firefighters for message statements 1, 2, 3, 4, and 5; however, the only significant difference was for message 3. Firefighters gave significantly higher ratings than students for message statement 6.

As mentioned above, there was also a two factor interaction between question dimension and message statement, $F(10, 530) = 27.06$, $MSe = 0.53$, $p < .0001$, as well as significant three factor interaction, $F(10, 530) = 8.49$, $MSe = 0.53$, $p < .0001$. Table 2 shows the means involved in these interactions.

With respect to the question dimension X message statement interaction, the ratings for appropriateness and content were similar, but attention ratings were significantly higher than appropriateness and content for all messages except messages 1 and 6. The only other exception was that for message statement 3, attention ratings were higher for content but not for appropriateness. Finally, with respect to the three-factor interaction, the pattern of means in Table 2 appears to show that firefighters tended to have lower attention ratings for message statements 4 and 5 relative to the students.

Table 1. Mean Ratings as a Function of Message Statement and Participant Group.

Message Statement	Student	Firefighter	mean
(1) “Don’t panic but go outside if you can. Call 911 for help if you can’t get out of your room. Everything will be fine.”	3.55	3.00	3.28
(2) “[child’s name], call 911 for help. Call out the window if you see anyone. Everything will be okay soon.”	3.32	2.88	3.10
(3) “[child’s name], there’s a fire in the house. Stay calm and you’ll be all right. Call 911. Call out the window.”	3.73	3.03	3.38
(4) “DANGER! DANGER! There is a fire in the house. You MUST get up and check it out, there is a fire.”	2.97	2.39	2.68
(5) “DANGER! There’s a fire! DANGER! There’s a fire! Get up and investigate!”	2.80	2.49	2.64
(6) “There’s a fire. Stay calm. Follow the safety plan.”	3.79	4.70	4.24

Perceptions of Relative Effectiveness for Conventional and Voice Alarms. Chi-square tests of goodness-of-fit evaluated perceptions of relative effectiveness (Table 3). Although 57% of student respondents indicated conventional alarms would be more effective at awakening people, these percentages were not significant, $X^2(2, N = 44) = 3.59, p = .17$. Student perceptions of effectiveness at keeping individuals calm during a fire emergency were not equally distributed; 73% of individuals believed voice alarms would be more effective, $X^2(2, N = 44) = 27.63, p < .001$.

Semi-structured interviews with firefighters. The overwhelming theme that the professional firefighters discussed was preparedness; that is, every family should not

only discuss the appropriate course of action in different situations, but also practice procedures to ensure preparedness. Two of the four groups also recommended an interlinked system of detectors that could deliver different messages based upon the location of the fire to properly identify the best method of egress.

The preferred alarm described was a looped message that identified the speaker (e.g., “This is dad”), the situation (e.g., “There might be a fire.”), and a reference to a rehearsed egress procedure (e.g., “I need you to get out of the house like we talked about.”). Each group of firefighters communicated that repetition, succinctness, realistic reassurance, personalization, and communication of an authentic emergency are important.

Table 2. Mean Ratings as a Function of Question Dimension, Message Statement, and Participant Group.

Message Statement	Appropriateness		Attention		Content	
	Student	Firefighter	Student	Firefighter	Student	Firefighter
(1) “Don’t panic but go outside if you can. Call 911 for help if you can’t get out of your room. Everything will be fine.”	3.9	3.1	3.0	3.4	3.8	2.5
(2) “(child’s name), call 911 for help. Call out the window if you see anyone. Everything will be okay soon.”	3.2	2.6	3.8	3.6	3.0	2.5
(3) “(child’s name), there’s a fire in the house. Stay calm and you’ll be all right. Call 911, call out the window.”	3.6	2.9	4.2	3.4	3.3	2.8
(4) “DANGER! DANGER! There is a fire in the house. You MUST get up and check it out, there is a fire.”	2.0	1.7	4.8	3.3	2.1	2.2
(5) “DANGER! There’s a fire! DANGER! There’s a fire! Get up and investigate!”	1.8	1.8	4.8	3.6	1.8	2.1
(6) “There’s a fire. Stay calm. Follow the safety plan.”	4.2	4.6	3.3	4.8	3.9	4.6

Table 3. Frequency Counts (and Percentages) of Perceptions of Relative Effectiveness - Conventional Versus Voice Alarms

	Awakening Individuals		Keeping Individuals Calm	
	Student	Firefighter	Student	Firefighter
Voice alarm more effective	9 (20%)	8 (75%)	32 (73%)	9 (75%)
Equally effective	16 (36%)	2 (13%)	8 (18%)	3 (25%)
Conventional alarm more effective	19 (43%)	2 (13%)	4 (9%)	0 (0%)

Note: n = 44 for students, n = 12 for firefighters

DISCUSSION

Fire alarms are an inexpensive technology intended to reduce fire deaths and injuries by alerting individuals and enabling safe egress. This recent voice technology will likely replace traditional alarm sounds with recorded voice messages, and may be beneficial with respect to the aspects of awakening, calming, and instructing children. This study sought to examine some aspects that may be useful in producing effective messages in this application.

Both groups of participants, consumers and firefighters, rated that the message "There's a fire. Stay calm. Follow the safety plan" (message statement 6) as the best of the messages evaluated in this study. Apparently, participants valued notification of the situation, a soothing component, and a reference to a pre-established course of action. However, for this message to be actually effective, a fire safety plan must have been developed and possibly rehearsed by users. This prior planning is an assumption that might not be realized in practice. According to a phone survey of 1,104 adults conducted on behalf of the National Fire Protection Association, creation and rehearsal of a plan occurs in few households (Harris Interactive, 2004).

There are potential advantages in recording one's own messages as opposed to using a pre-recorded voice message. High levels of stress associated with dangerous situations such as a fire in the home could reduce the quality of decision-making. The presence of a caregiver can provide a calming effect to children during stressful situation, according to well-known child development research (Ainsworth, Blehar, Waters, & Wall, 1978). People are more likely to respond to meaningful sounds (e.g., one's name) than less meaningful sounds (Oswald, Taylor, & Treisman, 1960; Zung & Wilson, 1961). A familiar voice transmitted by a voice alarm could potentially produce better decision-making and fewer casualties during fire emergencies.

Of course, the "right" messages need to be used by the person recording the statements. In addition, the messages must be aimed at potential persons of the household. For example, different messages would be appropriate for young children compared to older children. Another benefit of consumer recorded messages is that they can be changed when necessary (e.g., as safety plans change or as children get older).

However, for the spoken warning to be both heard and properly understood, consideration should be given to other potential sounds that may be present, hearing impairments of persons in the residence, intelligibility of the message, and perceived urgency of the warning, among other factors (see Haas & Edworthy, 2006; Edworthy & Hellier, 2006).

Due to the preliminary nature of this study and to the limited number of conditions involved, messages were not systematically manipulated. Consider the finding that firefighters gave ratings to the two messages including "DANGER!" (statements 4 and 5) compared to other messages. It is unclear whether the effects seen were due to the signal word or to the portion of the statement that says to

investigate or check out the fire. In future research, the appropriateness and effectiveness of recommended signal words (e.g., Deadly, Danger, Warning) for various applications could be systematically evaluated.

In addition, results suggest that participants did not have an appreciation for the attention-getting qualities of one's name (Oswald, Taylor, & Treisman, 1960). Nevertheless, the lack of systematic manipulation of the messages does not allow attribution of differences to a particular word or set of words within the message. Furthermore, it is also important to note again that the messages evaluated were in printed form. It is possible that these same messages would receive somewhat different ratings if they had actually been presented in auditory form. Again, the present study is an early investigation in the topic where the interest was in potential content of message statements.

Recommendations from professional firefighters. In addition to discussing potential alarm messages, the firefighters emphasized preparedness and practice. Firefighters also emphasized the importance of indicating that an authentic emergency exists and making the right decision quickly. This recommendation is well-supported; only 8% of individuals in an NFPA survey indicated that their first thought upon hearing a smoke alarm is "fire" or "get out" (Harris Interactive, 2004).

The preferred type of voice alarm mention by every group of firefighters tested was a looped message that identified the speaker (e.g., "This is Dad"), a realistic assessment of the situation (e.g., "There might be a fire"), and a reference to a rehearsed action appropriate for the situation (e.g., "I need you to get out of the house like we talked about."). This corroborates with their ratings, as the highest ratings were given to "There's a fire. Stay calm. Follow the safety plan."

Future Research. This preliminary research was intended as a first step to determine what types of messages should be used in future research involving recorded messages, children, and caregivers.

Future research could also involve listening to systematically varied alarm messages and examining the differences between voice alarms and conventional alarms for awakening, facilitating egress, etc. Despite the inherent difficulties of conducting an experiment with a special population such as sleeping children, there has been recently-reported research comparing personalized parent voice smoke alarms with conventional residential alarms for the purpose of awakening children (Smith, Splaingard, Hayes, & Xiang, 2006). In the Smith et al. (2006) study, the child's mother recorded a voice alarm message, "(First name)! (First name)! Wake up! Get out of bed! Leave the room!" The message median times to awaken were 20 seconds with a voice alarm and 3 minutes with the conventional tone alarm; the median time for egress (i.e., leave the room) was 38 seconds for the voice alarm and the maximum 5 minutes for the conventional tone alarm.

In future investigations, caregivers could be asked to compose their own messages using currently available instructions; these messages could be evaluated against established guidelines (Edworthy & Hellier, 2006) and to messages suggested in previous research (e.g., Bruck, Reid, Kouzma, & Ball, 2004; Smith et al., 2006). Furthermore, messages could be evaluated for characteristics such as sound pressure level at the child's pillow and effectiveness as a reminder for proper actions and pre-existing plans.

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