Introduction

Speech alarms have been used extensively in aviation and included in International Building Codes (IBC) and National Fire Protection Association's (NFPA) Life Safety Code. However, they have not been implemented on space vehicles. Previous studies conducted at NASA JSC showed that speech alarms lead to faster identification and higher accuracy.

This research evaluated updated speech and tone alerts in a laboratory environment and in the Human Exploration Research Analog (HERA) in a realistic setup.

Lab Study

This study measured alarm identification time and errors for 4 alerts: two emergency, a warning, and a caution alert presented as both speech and tone.

Subjects

- N = 24
- Normal hearing
- Recruited through the Test Subject Facility

Method

Stimuli

- Tone alerts as currently defined by the HSIR (see Alert Definition section).
- Speech alerts using word repetitions specific to the alert type, e.g., “Fire! Fire!”.

Conditions

- Alerts without background noise
- Alerts with communication loop noise
- Alerts with fan noise

Task

Participants listened to an alarm and were asked to identify it as quickly and accurately as possible by clicking the corresponding icon, see Figure 1.

Results

The incorrect trials were removed from the data set. Response times larger than 5000 ms (12 trials out of 6636 correct trials) were excluded as outliers.

A repeated measures ANOVA was conducted on response time. There was a significant main effect of noise condition, $F(2,22) = 3.76, p = 0.039$.

There was also a significant main effect of alarm type, $F(1,23) = 20.15, p < 0.001$. That is, speech alarms were identified faster than tone alarms (mean diff 203 ms). The interaction was not significant, $F(2,22) = 0.86, p = 0.43$.

Alarms with voice or fan background noise were identified slower than alarms without background noise, mean RT difference of 38 ms, $t(23) = 2.2, p = 0.02$ and mean RT difference of 37 ms, $t(23) = 2.1, p = 0.04$, respectively. There was no difference in RT to alarms with communication loop and fan background noise, $t(23) = 0.03, p = 0.97$.

Overall, participants were more accurate identifying speech alerts than tone alerts, $t(22), p = 0.004$, mean difference of 3 errors.

Alert Definitions from Human System Integration Requirements

- **Emergency:** Specifically identified life threatening warning event that requires immediate action.
- **Warning:** Event that requires immediate action because it is or has the potential to become a life/mission threat.
- **Caution:** Event that needs attention, but not immediate action.

HERA Evaluation

The purpose of this evaluation was to test the alerts in an analog environment during a realistic task of completing a procedure.

Subjects

- N = 6
- Normal hearing
- Recruited through the Test Subject Facility

Method

Stimuli

- Tone alerts as currently defined by the HSIR.
- Speech alerts using word repetitions specific to the alert type.

Task

- Participants completed a realistic task while alerts played in the background at predetermined intervals not disclosed to the participants.
- When an alert occurred, participants indicated the type of alarm (caution, warning, fire, depressurization) using the Alarm Response survey.
- After identifying the type of alarm, participants responded to the alert by following the instructions provided in the alert. This involved retrieving a code located in various locations around the HERA habitat.

Recommendations

Speech alerts have been used in aviation and are required in building codes as fire alerts in addition to the use of tones. They are recommended for use in space habitats and space flight due to the higher accuracy and faster identification than tone alerts, either on their own or in combination with tone alerts.