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Towards Supporting Individuals with Situational Impairments in Inhospitable Environments

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ABSTRACT
In this paper, we describe an approach to develop alerts for individuals experiencing situationally-induced impairments and disabilities (SIIDs) in inhospitable environments, with a view to support situational awareness and decision making. Our research focuses on the needs of firefighters whose visual and auditory channels may be restricted while performing tasks, resulting in cues sometimes being missed. Through a series of contextual interviews, scenarios have been developed focusing on areas where alerts are required. A participatory-approach has been adopted with the aim of developing perceivable, meaningful and respected alerts, designed to better resist the impacts of SIIDs.

CCS Concepts
CCS → Human-centered computing → Accessibility → Empirical studies in accessibility.

Keywords
Situationally-induced impairments and disabilities;

1. INTRODUCTION
Situationally-induced impairments and disabilities (SIIDs) are faced by individuals regardless of ability when the situation itself places demands on the user's attention, sensory and motor ability [4,5]. Researchers have traditionally focused on identifying SIIDs faced by mobile device users while ambulatory (e.g. [1]). However, other groups also experience SIIDs in settings which are inhospitable. Examples include the issues faced by firefighters. Presence of thick smoke can restrict the ability to identify other firefighters and gestural cues, and even the reading of gauges located on their turnout gear. Orienting position and wayfinding within a burning structure can also pose challenges when vision is impaired, resorting to firefighters relying on the use of tactile cues (e.g. manually following a hose line to identify the exit to the structure). Noise from sirens, ventilation fans, pneumatic tools, and combustion of the structure may impact the ability to identify auditory alerts presented via communication devices or via voice. The cognitive and physical demands imposed by the inhospitable and rapidly-changing settings, can result in difficulties establishing situational awareness (SA).

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Our research aims to examine ways in which alerts to firefighters can be designed which better resist the impact of SIIDs. By presenting alerts which can be discerned when facing situational, contextual and environmental challenges, we aim to heighten levels of SA and to better inform decision making to remain safe in hazardous environments. In this paper, we describe an approach to identify and design alerts to better support firefighters when performing duties in the field.

2. RELATED WORK
Researchers have proposed a range of wearable solutions to support firefighters in action, where alerts are presented using one or multiple channels. Alerts vary from communicating the presence of dangerous gas concentrations and temperatures [6,7] to the relative distance of obstacles which may be encountered [2]. While care has been taken in the design of these alerts, the design process may have considered the impact of the SIIDs experienced by firefighters, which would affect perception. Further work is needed to develop cues which better support firefighters facing inhospitable conditions when performing duties.

3. CONTEXTUAL INTERVIEWS
Open-ended interviews were conducted with a total of six safety officers and senior fire service personnel from two districts (one urban, one suburban), and a range of firefighters from stations within these locales. Participants were asked to describe the ways in which SA can be gained in inhospitable and rapidly changing environments, the types of alerts currently present and their efficacy, along with the description of other situations where alerts would be beneficial.

Findings suggested that *temperature-related alerts were not specifically presented to firefighters when working at the scene of a fire*, meaning that they should rely on combination of their assessment of the environment, and communication with others (e.g. notifications from other firefighters, incident commanders based outside the structure) to identify whether temperatures have surpassed unsafe levels. Other areas included the need for *communicating the presence of hazards* to other firefighters (i.e. holes in the floor), alongside the *confusion caused by multiple alerts* presented via the same sensory domains (e.g. auditory alerts via radio and from body worn equipment (e.g. SCBA) within a short period of time, especially if these were impacted by situational, contextual or environmental factors.

The points raised were transformed into sets of scenarios relating to firefighters using location-independent wearable devices to receive alerts, similar to an approach adopted by [3]. These were then illustrated for successive participatory design workshops. In order to determine the validity of the resulting scenarios, checks were made by the original interviewees (domain experts).

Example of a scenario (abridged): A hazard has been detected by one firefighter in smoke-filled warehouse. The firefighter near the

hazard (hole) attempts to communicate its position to other firefighters but cannot yell loudly enough above sounds of the burning structure. He is unsure if his radio message informing the Incident Commander about its presence has been received.

4. PARTICIPATORY-BASED APPROACH

A set of design workshops were conducted, where groups of 4-8 firefighters, staff with incident commanding experience, and interface designers could work as a team, to design alerts to better meet the needs of firefighters facing inhospitable environments. Participants' experience varied considerably (3-35 years service).

Scenarios developed (described in Section 3) were presented in sequence to the teams, along with illustrations of the steps taken by firefighters in each rich story. Participants were asked to consider the conditions faced by the *actors* in the scenarios, and describe whether alerts would be useful to support SA and decision making, and if so, how these could be designed using graphical, auditory and/or tactile feedback. Design suggestions could be made verbally or illustrated. These suggestions would be developed into cues by the researchers for presentation in successive design workshops, presented via a PC (e.g. visual and auditory cues) or tactile motors. Participants were asked to reflect upon each others' ideas. The same scenarios were presented to new groups of participants. Facilitation by the interface designers was aimed to strengthen alerts which had been designed or triggering new design ideas. It was envisaged that after a number of sessions, consensus on design would be reached.

5. PRELIMINARY RESULTS

Participants from all three workshops conducted, were generally able to provide detailed feedback on the scenarios presented, and relate these to their own personal experiences or times when alerts had been missed. All participants from the first workshop agreed that cues would need to be quick to interpret, as time could not be wasted attempting to discern different forms of feedback. Mappings would need to be simple and intuitive, due to the cognitive demands faced while firefighting. If many cues were presented at one time, it could lead to confusion resolving each of these cues, leading to discussion about either improving salience or if presented via multiple devices, temporarily halting cues from one device in order to attend to alerts from another device.

Tactile feedback was found to be of interest in all workshops, as vibrational output is rarely used to support firefighters, thereby gaining the user's attention. However, a wearable device would need to be positioned close to the skin, otherwise if affixed to the outside of turnout garments (which are thick in nature), signals would be attenuated. The hand was not thought to be a practical site for presentation, as it may be encumbered with equipment, or may be moving around which may make a sensation difficult to perceive. Suggestions were made to present tactile cues within the facemask itself, to provide users with the best chance of perceiving and responding to the alerts, without needing to spend time donning additional equipment.

In terms of auditory and tactile mappings, the second team suggested associating the pitch and amplitude respectively, to the severity of the situation (i.e. unsafe temperatures, presence of a hazard). This design suggestion was then strengthened by third group, that different levels of threat should be presented via these channels, rather than a continual increase in intensity which may be ignored after a period of time. While technologies worn by firefighters contain visual alerting devices (e.g. LEDs), these were thought to be difficult to identify when smoke is present, unless presented within the facemask heads-up display. Participants from the later workshops highlighted the need to convey information through multiple means using redundant information, to heighten the likelihood of noticing the cues. Suggestions were also made to customize mappings depending on the situation or context. A set of workshops have been planned to discuss these ideas in more detail. Resulting cues will then be evaluated in both simulated and real-world environments.

6. REVIEW OF APPROACH

The participatory-based approach has enabled participants from different levels of the fire service to come together to design cues to ensure that different perspectives are considered in the design process. While firefighting staff have been able to provide key domain knowledge within the workshops, interface designers were able to offer suggestions from their experiences developing salient cues. Observations revealed that both groups have been able to work together to formulate design suggestions, and to learn from one another to better support the design process.

7. ACKNOWLEDGMENTS

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