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THE PRINCE OF WALES AWARD

MILLENNIUM PRODUCTS

Sound versus Sight for Emergency Egress

Dr. Peter Rutherford and Dr. Deborah J. Withington present recent research findings on the role of sound in safe evacuation and suggest how auditory egress beacons can improve emergency egress.

1 THE EMERGENCY SITUATION

One of the most frightening experiences that we ever face is to be lost and disorientated. Under such circumstances, our ability to process and store environmental information deserts us, and ultimately our very survival may be threatened. For example, imagine your worst nightmare; you are trapped on the fourth storey of a large, burning department store in the centre of London. Alarms are sounding all around you, your vision is obscured by dense, black, irritating smoke. The fear of being burned to death or suffocated by the rush of hot smoke and gases, coupled with the sight of spreading flames begins to alter the pattern of logical human behaviour around you….people are beginning to panic! You frantically scan for any clue as to where the exits are, looking for the emergency exit signs that you noticed, in passing, 5 minutes ago. Like everything else in the building, they are now completely obscured by the blanket of smoke that hangs from the ceiling.

Of course, for anyone visually impaired, this situation can arise even without the presence of smoke. At present there are precious little aids which enable anyone with a visual disability to identify an emergency exit. Many organizations are keen to encourage access to buildings for the visually disadvantaged but generally make little or no provision for enabling them to egress quickly and safely.

The question that arises is how do you get out and it is a problem that applies equally to both sighted and blind occupants of any building. How can you communicate to a sighted, never mind visually impaired person, the spatial layout of an unfamiliar, complex building so that he, or she, can evacuate with ease?

2 TRADITIONAL EGRESS METHODS

It seems obvious that efficient emergency egress is of paramount importance to both visually impaired and sighted individuals, whether it be from aeroplanes, hotels, department stores, industrial complexes or ferries. Given that we have approximately one million people in the UK who are registered visually impaired (with a further estimated 750,000 unregistered), it is surprising to find that the locations of emergency exits and escape routes within buildings are indicated solely by visual means. Of course, some buildings are better provided for through the implementation of tactile wayfinding aids on handrails, but these methods assume primarily that they are cool enough to touch and accessible to all occupants, irrespective of age, height or disability. Unless the victim of a fire situation *knows* where the exits are, he or she will waste precious seconds searching by touch alone and given the rapid rate with which fires can develop, time becomes a critical factor in emergency egress. The purpose of any wayfinding aid, therefore, is to eliminate any errors and reduce hesitation at major decision making points within a building, such as would be experienced in large open spaces, at corridor intersections, and staircases. For this purpose, it is imperative that an alternative sensory modality is activated, and the use of sound is the obvious solution.

Figure 1: At the onset of fire, the emergency exit sign is fully visible.

Figure 2: After a few seconds, the room begins to fill with smoke, the eyes become irritated and the exit sign gets partially covered.

Figure 3: After a few minutes, the room is now completely smoke filled. You can hardly see your hand in front of your face or locate the exit sign.

3 THE ROLE OF SOUND IN EVACUATION

Generally, all uses of sound in emergency evacuation are provided in the guise of an "alarm" which merely alerts people to the presence of imminent danger. Irrespective of whether this information is provided by conventional tones or speech based alert mechanisms, alarms give absolutely no information concerning the direction to, or location of, the nearest exits. Even if such alarms were placed over exit doors as *beacons*, they would still be impossible to locate. Why is that? To understand why these devices would not suffice as an exit locator, it is necessary to describe how we manage to locate sounds in space, including the type of signal necessary for accurate localization.

4 THE SCIENCE BEHIND SOUND LOCALIZATION

Although it is one of the most difficult processes undertaken by the human brain, we have the potential to be very accurate at sound localization. For example, we can localize sound with an accuracy of 5 degrees; as long as the sound contains a mixture of many frequencies. This is called 'broadband' noise and can be most easily described as the sound of a rushing river or waterfall. For accurate localization, our brains have to decode a wide variety of sound cues, which in isolation convey only limited amounts of spatially ambiguous information. Fundamentally, these cues include the timing and intensity differences between the sound at both ears, and the effect of which the external ear has on the spectral transformation of sound.

There are problems however. Because the cues of timing and intensity differences are virtually identical for sounds emanating either directly in front of or behind the head, front / back confusions are one of the most common difficulties associated with sound localization. Each type of sound localization cue operates over a different and relatively narrow frequency range but to provide complete localization knowledge, information from all cues must be combined. In other words, you *need* broadband noise. This is why the conventional fire alarm and speech are ineffective. They operate over a very narrow band of frequencies and hence do not provide enough information to have their location determined. In effect, they are *unlocalizable* and not appropriate for emergency egress use.

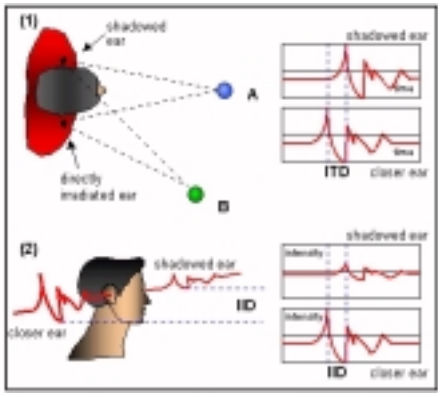

Figure 4: The sound localization cues of Interaural Time and Intensity Differences. The source off to one side (B) arrives sooner and much louder at the closer ear.

5 TESTING THE EGRESS BEACON

To validate the effectiveness of the egress beacon, tests were conducted in a smoke filled environment here at Leeds University, filmed by a thermal imaging camera. It was found that an individual would take 3 mins. 50 secs. to find a conventional emergency exit sign relying primarily on their memory of the immediate environment. In contrast, however, when appropriate rapid bursts of broadband noise were played through the egress beacon immediately adjacent to the exit, the same individual took 15 secs. to find their way out. It is obvious that the beacon proved to be a crucial aid under such visually impaired conditions. By providing directional information, it removes the need for having prior experience with the environment, reducing hesitancy and eliminating wayfinding errors. Ultimately, overall evacuation time is substantially reduced.

Additionally, the egress beacon has the advantage of alerting visually impaired people to exits that would otherwise have been missed, helping to reduce the obvious problem of overcrowding at main entrances and stairwells. Furthermore, the implementation of *melodic* complexes can provide "go up" or "go down" information and could be placed at strategic stairwells in an exit route. For example, the fire victim would go down a staircase when the tone rapidly descends in frequency and vice versa.

Figure 5: A typical egress beacon, a compact integrated sounding unit.

6 CURRENT INSTALLATIONS

In order to be both accessible and safe, it is imperative that buildings communicate to both visually impaired and sighted users information necessary to aid emergency egress. From this perspective, the egress beacons that have been developed certainly fulfill their role as a guide. It should be noted however that these egress beacons are by no means a replacement for current alert mechanisms. They are

envisioned as a complementary system to conventional fire alert mechanisms, providing the additional benefit of locating exits.

At present, two installations of these beacons are due to be completed by the end of March 1998, complementing existing fire safety provisions. The first, a large, 2 storey residential home for the visually impaired, run by the RNIB in Burnham-on-Sea, Somerset will comprise of 15 beacons and 1 control panel. Placed at strategic points within the building, these beacons consist of down sounds at stair heads and rapid broadband pulses at final exits. The second installation, a 3 storey resource centre run by LOOK in Whitehaven, Cumbria comprises 5 egress beacons and 1 control panel in a configuration similar to the Somerset installation.