DEVELOPMENT OF A CROWD STRESS INDEX (CSI) FOR USE IN RISK ASSESSMENT

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A Crowd Stress Index for use in risk assessment was developed in four parts: a literature review to identify relevant factors and understand the terms 'crowd' and 'crowding'; a study on an underground train; personal interviews; and a climatic chamber experiment in which physiological and subjective measures were taken from people in a crowd. Eight components were identified: physical, social, personal, crowd characteristics, crowd dynamics, crowd behaviour, location and psychological. Ninety-two questions in a risk assessment questionnaire provide the data for scores on 42 themes, leading to scores on the eight components in terms of contribution to crowd stress and finally a single index value ranging from 'no crowd stress' to 'extremely high crowd stress'. The index appears sufficiently well developed for validation in practical applications.

Introduction

A person in a crowd can be exposed to stress due to the proximity of other people. This stress can cause both physiological and psychological strain that can range from discomfort and dissatisfaction to concern, panic and death. There may be positive reactions to being in a crowd. A feeling of purpose, belonging, excitement or simply warmth. This paper presents the development of a Crowd Stress Index. It identifies factors that can contribute to crowd stress and proposes a method that integrates them into a single number that relates to the magnitude of that stress, and hence likely strain, on people in the crowd. A detailed description is provided in Mahudin (2003).

Method

An appropriate structure for the Crowd Stress Index and factors that can contribute to it were not obvious at the outset and hence information was collected in four parts:

1. *A literature review* to determine the nature of a stress index of this type, identify how terms such as 'crowd' and 'crowding' have been used and to review studies of peoples' reaction to stress caused by crowds.

2. *A study on an underground train* to determine the physiological and subjective response of one person in context and in a range of 'crowd' levels.
3. *Personal interviews* with a range of people to identify their perceptions of crowds and their responses to being in a crowd.
4. *A climatic chamber experiment* to identify physiological and subjective responses of people while being exposed to a 'crowd' under controlled conditions.

Part 1 : Literature Review

Le Bon (1895) prophesied that we were entering the era of crowds. They represent a primary datum of social existence. A crowd is more than a mass of people, each crowd is unique and has a life of its own. Dickie (1995) stated that ebullient crowds with inadequate management have within them their own seeds of disaster. Berlonghi (1995) emphasised that those involved in crowd management must foresee the nature of the crowd that will be in attendance, be able to observe the behaviour of a crowd whilst an event is taking place and make timely decisions for effective action.

Mahudin (2003) identified four areas of research: animal research; experimental research on people; conceptual research; and human behaviour research. She considered definitions of 'crowd' and 'crowding' from different perspectives (demographic, phenomenological, social) and crowd stress as 'the feeling of having insufficient space due to the proximity of other people'.

A Crowd Stress Index will therefore predict the extent to which a person in a crowd will feel that they have insufficient space due to the proximity of other people. A high Crowd Stress Index (CSI) value will therefore predict high levels of strain with consequences such as panic, injury and death. A low CSI value will predict low levels of strain and no unacceptable consequences. A particular aspect of crowd stress is strain caused by heat. Griffitt and Veitch (1971) found that people were less friendly to each other on hot days and that even moderate temperature combined with crowding led to aggressive behaviour. Parsons (2003) suggested that examples of aggressive behaviour (e.g. security 'forces' providing a confrontational social context) may encourage aggressive behaviour. Braun and Parsons (1991) conducted a laboratory study into crowding and found that the inability to disperse metabolic heat, including restrictive evaporative loss due to sweating, can cause significant strain even in moderate temperatures and low density crowds.

Part 2 : Crowd stress on an underground train

To obtain information about strain caused by crowding in a practical context, skin temperatures, heart rate and subjective responses were measured on a standing passenger while travelling on an underground train. In addition, information on crowd characteristics was gathered by an observer who was seated nearby. The male passenger was a 24 year old undergraduate of Asian origin. The experiment was conducted from 16.15 hrs to 18.30 hrs in summer with outside (above ground) temperature of 28°C and relative humidity of 47%. Conditions inside the carriage increased over the recording period from 26.6°C and 44%rh minimum to 30.1°C and 52%rh maximum. Mean skin temperature (Ramanathan, 1964) rose from 31°C to 33°C over the session and heart rate increased slightly from 61bpm to around 80 bpm. Heart rate measurement was however unreliable as the recording instrument appeared to receive interference from train operation. Results showed that in general the subject was under little strain. He generally reported his experience in the crowds as pleasant and not tense, not irritable, tolerant, not sticky and had little difficulty in moving around. Crowd density was however generally light. In more dense crowds higher skin temperatures were recorded and the subject perceived the situation as 'very crowded', squashed, warm and slightly

uncomfortable.

Part 3 : Personal interviews

The results of the literature review and preliminary study on an underground train indicated that more detailed personal interviews were required to identify a fuller breadth of factors that would influence crowd stress. Individual interviews were therefore carried out with a selected range of ten male and ten female subjects (aged 20 to 45 years). They included students, university staff and the general public. One male subject was a person in a wheelchair. The interview was semi-structured and in six sections. A. Definitions of crowd and crowded; B. General experience in crowds; C. Discussion of scenarios (trapped in a lift, going in and out of a stadium and standing close in a cash dispenser queue); D. Describe feeling if in a crowd presented in photographs (swimming pool, football match, concert); E. Discussion of similarities and differences between pictures of crowds; F. Final comments. Interviews were private, recorded and lasted 30-40 minutes. The results provided seven components and a total of 48 factors within the components (see Figure 1).

Part 4 : Climatic chamber experiment

To complement the studies presented in Parts 1, 2 and 3, a laboratory experiment under controlled conditions was conducted to determine detailed responses of people while in a crowd. One male subject (23 years, 1.70m, 63kg) had subjective and physiological (skin temperature and heart rate) responses recorded while surrounded by nine male subjects in a climatic chamber set to 30°C and 50%rh and 0.15ms^{-1} air velocity. All ten participants and a thermal manikin stood in a space 1.0m x 1.5m representing a tightly packed crowd. Subjects were of Asian origin and did not appear to be disturbed by the crowd. Over the one hour session mean skin temperature rose from 33.5°C to 34.7°C and heart rate from 71 bpm to 93 bpm. The subject initially felt very crowded, uncomfortable, slightly irritable and slightly intolerant. As he knew the others in the crowd well he did not feel that he had to avoid interaction. The 'crowd' around the subject generally felt very crowded, squashed and uncomfortable. All agreed that they needed more space. Behavioural measures indicated that there was a tendency for individuals to reduce crowd density by subtle movements away from those around them. Interviews with crowd members suggested that factors such as density level, space satisfaction, heat, air, lighting, adaptation, room volume, duration of exposure, focus of attention, relationships and social atmosphere all affect crowd stress levels. In particular, the expectation about the crowd, especially knowledge of when they could leave the crowd, influenced strain experienced.

A Crowd Stress index

Figure 1 shows the structure of the Crowd Stress Index that was developed from Parts 1, 2, 3 and 4. Forty-two factors contributed to eight components that lead to a final Crowd Stress Index for use in risk assessment.

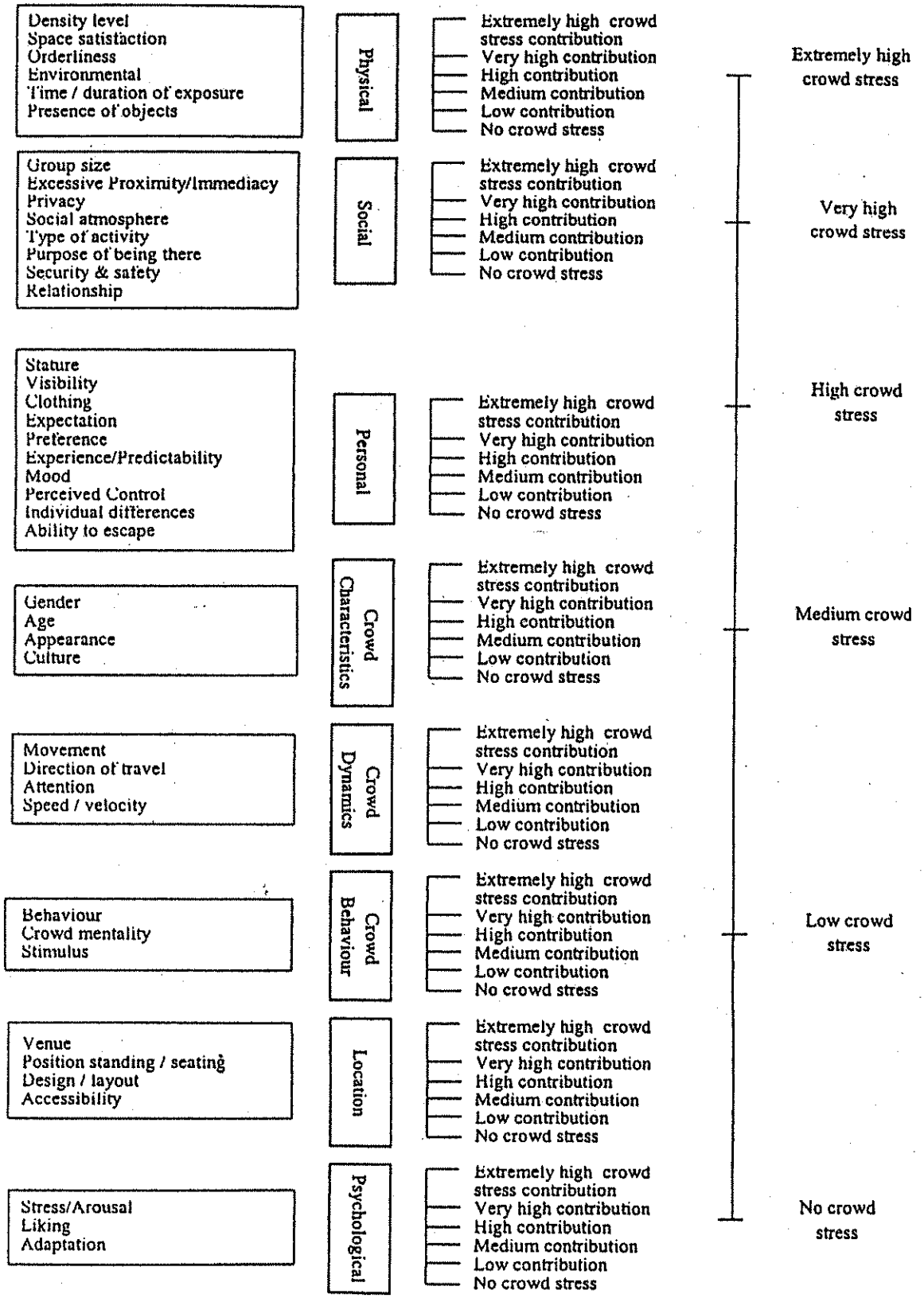

Figure 1. Model of a crowd stress index

Conclusions

A four-part method investigating crowd stress from different perspectives has allowed the development of a Crowd Stress Index. The index is a simple tool that could be used for risk assessment as well as in the management of crowd control. It is sufficiently well developed to allow validation over a range of practical applications.

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