THERMAL COMFORT ADAPTATION IN OUTDOOR PLACES

Inji Kenawy[1] and Hisham Elkadi[2]

[1] Deakin University, Australia, ikenawy@deakin.edu.au
[2] Deakin University, Australia, hisham.elkadi@deakin.edu.au

ABSTRACT

The level of international migration has been growing in the last decades creating a plurality of cultures and inspiring a multicultural nature in global cities (O'Byrne, 1997; Short and Kim, 1999; Hawkins, 2006). This created new challenges in urban planning or the management of the coexistence of different people that are having different characteristics shaping their unique identity and needs in shared places. Being the urban stages where the social interactions happen, public places are considered important parts of cities (Thompson, 2002; Varna, 2009). These places can contribute to enhance the quality of life within cities, or contrarily increase isolation and social exclusion (Lo et al., 2003).

As agreed by researchers the users' state of comfort gives a good indication for how successful is the public outdoor places (Rosheidat et al., 2008; Kwong et al., 2009; Aljawabra and Nikolopoulou, 2010). In order to create a successful open space usable by all members of a community, urban designers need to satisfy their thermal comfort needs in its wider meaning according to a variety of users (Knez and Thorsson, 2006; Thorsson et al., 2007). While assessing the thermal comfort, in addition to the strong influence of the microclimatic parameters, the term thermal adaptation seems to becoming increasingly important. The thermal comfort adaption is then a considerable issue in design guidelines of outdoor environments (Nikolopoulou and Steemers, 2003).

The main aim of the research is to examine the influence of thermal adaptation and environmental attitude on participants' thermal requirements in outdoor public places. It focuses on understanding the effect of adaptation on the thermal comfort perception of immigrants. The research methodology of the research is provided through quantitative analysis of a case study. The findings of thermal comfort investigations could be applied into improving the quality of urban areas in order to increase the outdoor activities of citizens and use of outdoor places.

Keywords: Thermal comfort, Outdoor places, Thermal adaptation, Cultural diversity.

INTRODUCTION

The public realm is believed to have a critical role in creating the intercultural city as the built environment both influences the development of cultural life and is in turn influenced by the culture of the inhabitants, builders and decision makers. The public places where greatest amount of human contact and interaction takes place, are seen as the focal point for communities. They provide potential social, ecological, health and quality of life benefits (Thompson, 2002). Especially in the multicultural cities, researchers recognized that those public places need to be inclusive, inviting and accessible so that everyone come in, understand and experience the space as theirs (Bloomfield & Bianchini, 2005; Janssens et al., 2009). The success of an urban open space is influenced by many factors. The myriad components of the physical (i.e. environmental comfort, urban morphology, etc.), social environment, and the location of the space within the structure of the city all play primary roles (Herrington & Vittum, 1977). Users' state of comfort gives a good indication for how successful are the public outdoor places and influence the attendance and the behavior their users (Aljawabra & Nikolopoulou, 2010). Understanding the richness of environmental conditions in outdoor urban places and the comfort implications for the users open up new possibilities for the development and improvement of urban spaces (Panagopoulos, 2008).

Nikolopoulou and Steemers (2003) argued that although microclimatic parameters strongly influence thermal sensation, they cannot fully account for the wide variation between objective and subjective comfort evaluation, whereas, users' adaptation seems to become increasingly important. The term adaptation can generally be defined as the gradual decrease of the organism's response to repeated exposure to a stimulus, involving all the actions that make them better suited to survive in such an environment (de-Dear & Brager, 1998 a; Nikolopoulou, 2004). In the context of thermal comfort, this may involve all the processes that people go through to improve the fit between the environment and their requirements. The adaptive hypothesis states that one's satisfaction with an indoor climate is achieved by matching the actual thermal environmental conditions prevailing at that point in time and space with one's thermal expectations of what the surrounding climate should be like. Within such a framework, adaptive opportunity can be separated into three different categories: physical, physiological and psychological (Nikolopoulou et al., 1999). This means that the satisfaction with the thermal environment of the space doesn't only depend on the space, but also on personal variables people bring to the area with them. An awareness of these issues would be valuable to architects, planners and urban designers, not by the way of limiting possible solutions, rather by enriching the design possibilities.

In this study, we are concerned with the concept of physiological adaptation. This kind of adaptation implies changes in the physiological responses resulting from repeated exposure to a stimulus, leading to a gradually decreased strain from such exposure. Any physiological responses of the human body in a given thermal environment can be viewed as being within the comprehensive definition of physiological adaptation (de-Dear & Brager, 1998 b). There are two sub-categories included in physiological adaptation in the context of thermal environment; genetic adaptation (from generation to generation) and acclimatization (within one generation). Perspiration is a common form of physiological adaptation, which can play a significant role in the maintenance of the core temperature of the human body at a reasonable level (Wyndham, 1970).

METHODS

Two different ways are used to estimate the human thermal comfort. The objective way to estimate the thermal comfort conditions is through calculating the human thermal comfort indices from the meteorological data measured on the site. Social survey with questionnaires is the subjective way to enlarge the knowledge about the complicated relationships between the thermal environment and the evolved subjective human reactions. This survey will be performed using both objective and subjective assessments, where thermal comfort related parameters will be measured using electronic sensors and the outcomes will be analyzed concurrently with results from questionnaire.

Study area:

To meet the objectives of the study, the selected site had to be in a global multicultural city. Australia is a place having a long history of migration. As a result of the long-term immigration 24% of Australia’s population was born overseas. The study area is an outdoor place located in Geelong City in Australia (144 22’ E, 38 10’ S, at an altitude of 23 m), during a cultural festival on a typical summer day. In this festival, the activity level of people is typically walking, standing or sitting.

Physical measurements:

The major weather parameters (air temperature, relative humidity, wind speed and solar radiation) are measured using a portable weather station that contains meteorological sensors. The weather station is set to record the measurements at a 15 minutes interval during four hours (typically from 10:00 am to 02:00 pm local time) at a height of 1.6m above ground.

Table 1: The Range Of Weather Measurements from 10:00 am to 02:00 pm

Parameters	minimum	maximum
Air Temperature	22. 7 C	29. 7 C
Relative Humidity	40%	62%
Mean Radiant Temperature	48.8 C	59.6 C

Questionnaire:

In order to assess the thermal comfort, the questionnaire ask the people to report their thermal sensation, preference for better conditions, and satisfaction with the actual thermal comfort conditions, perceptions, and attitude. In this study, the questionnaire collected demographic information (e.g., age, gender and cultural background), the numbers years spent in Australia; investigated the people's perception of the overall thermal comfort and their perception of individual weather parameters (air temperature, humidity, wind speed and solar intensity). Thermal comfort was rated on ASHRAE 7-point thermal sensation vote scale (-3, cold; -2, cool; -1, slightly cool; 0, neutral; 1, slightly warm; 2, warm; and 3, hot), adding to it (-4 very cold, +4 very hot). Four different groups were targeted in the questionnaire in order to assess the influence of physiological adaptation on the thermal sensation of outdoor places' users.

Table 2: The four different groups of people according to the years spent in Australia.

Group 1	Group 2	Group 3	Group 4
Less than 1 year	More than 1 year to 5 years	More than 5 years to 20 years	More than 20 years

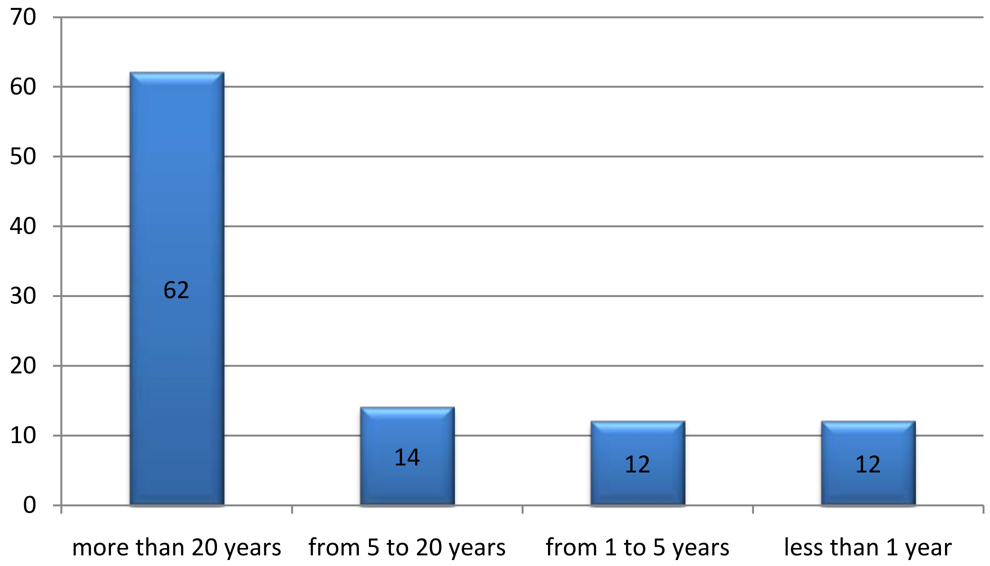

Figure 1: Percentage of participation for each group according to the years spent in Australia.

Thermal comfort indices:

Current human bio-meteorological methods used in assessing outdoor thermal comfort rely on rational indices determined by solving the human energy equation. Although there remain problems in the assessment of outdoor comfort indices, SET*, PMV and PET have proven to be suitable for application at the current state of the art (Honjo, 2009). In this study the PMV index will be used in assessing the thermal comfort. The mean radiant temperature and the PMV were calculated as using Rayman program.

Table 3: The PMV calculated by Rayman from 10:00 am to 02:00 pm

Time	10:00 am	11:00 am	12:00 pm	01:00 pm	02:00 pm
PMV value	1.1	1.6	2.4	2.9	2.6

The comparison between overall comfort votes against calculated PMV is shown in figure 2. Although there is a great dispersion in the graph, correlation (R = 0.53) is significant.

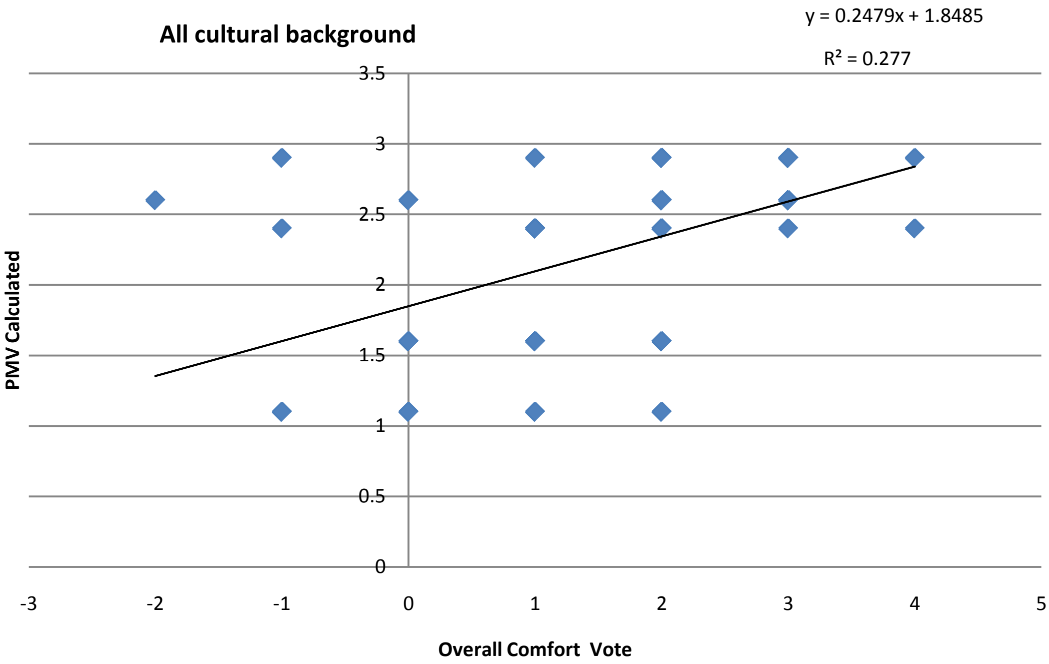

Figure 2: Overall Comfort Vote versus calculated PMV values.

Results:

The distribution of surveys responses to the overall comfort for each group is shown in figure 3. It is noted from the figures that among a total of 100 questionnaire, 37% of the responses rated the overall weather as warm (+2), 23% of the responses rated it as slightly warm, 21% of the responses rated it as hot and only 11% of the responses rated it as neutral.

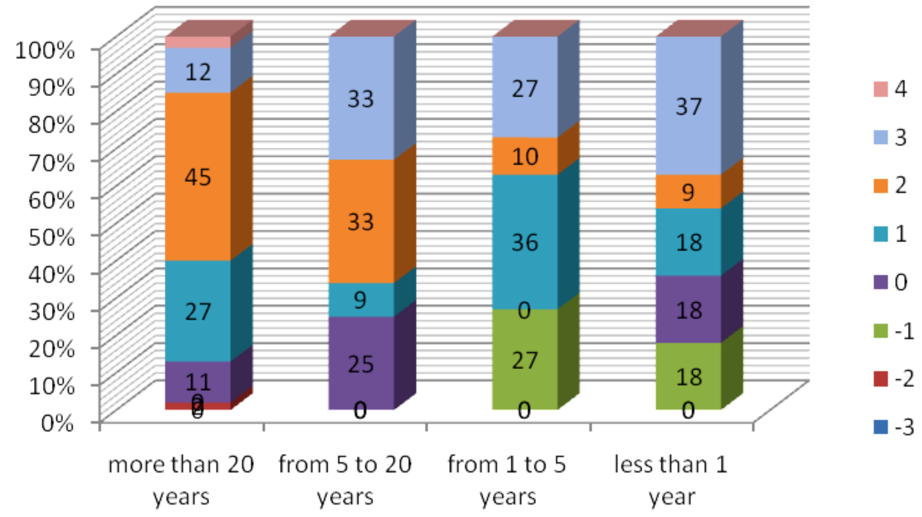

Figure 3: Overall Comfort Vote versus calculated PMV values.

From this figure we can see the different voted overall comfort for each group. It is noted that 45% of the users who have been in Australia for more than 20 years were feeling warm. On the other side 18% of the users who have been in Australia for less than one year are feeling slightly cool. The relation between the percentages of overall comfort vote for each group is shown in figure 4.

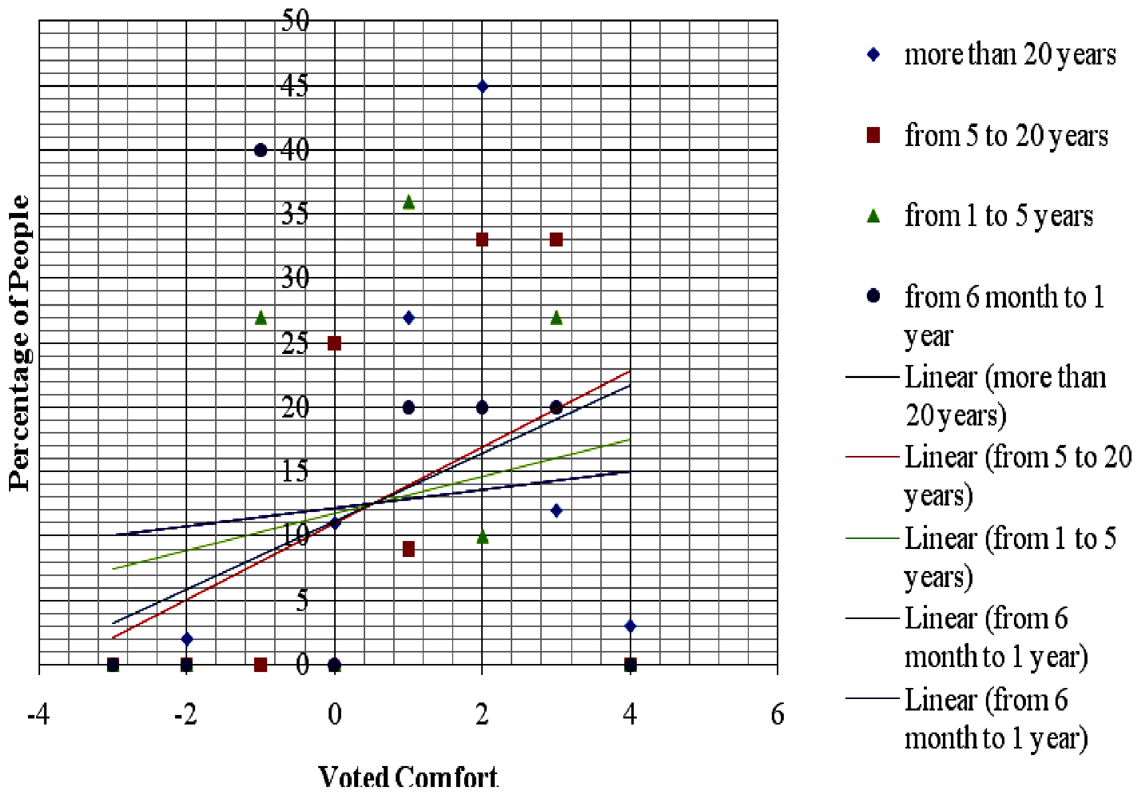

Figure 4: Overall Comfort Vote for each group

The graph shows that the groups (from 5 to 20 years) and (more than 20 years) can be fitted by two very close lines. For the other groups, we can notice that the less the group is thermally adapted, the more the line with the best fit is far from the first group (more than 20 years).

The cross correlation coefficients between the voted comfort for each group and the group who spent more than 20 years in Australia are calculated in table 4.

Table 4: The cross correlation coefficients between different groups and group of people who spent more than 20 years in Australia

Less than 6 month	From 6 month to 1 year	From 1 year to 5 years	From 5 years to 20 years
0.07948	0.25873	0.29338	0.67335

As demonstrated by the highest cross correlation coefficient, we can notice that among the four different groups, the more the people spend time in Australia the more they have closer votes to the group spending more than 20 years in Australia. These results prove the existence of the thermal comfort adaptation.

SUMMARY

This work has shed light on the complexity of issues involved in thermal comfort in outdoor urban spaces. The study presents some of the initial findings on thermal comfort in multicultural cities, working towards understanding the influence of the thermal adaptation on users' thermal perception. Preliminary analyses were obtained of the sample of subjective and objective data over one day in a festival on a summer day in Geelong city, Australia. The findings indicate that the time spent in a place is influencing the perception of thermal comfort and support that a purely physiological approach is not enough in assessing the human thermal comfort in outdoor places. The physical environment is important in assessing the outdoor thermal comfort; however, psychological adaptation is also an important factor influencing thermal perception. The findings are also in accordance with other previous studies (Nikolopoulou and Steemers, 1999; 2003; Lin, 2009). It is important that the urban planner takes into consideration the two complementary parameters of physical environment and psychological adaptation in order to create comfortable urban places. The consideration of this duality can increase the use of these open places, and thus strengthen the social interaction between citizens.

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