Sustainable Cities and Society 26 (2016) 119–133

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

The effect of individual and social environments on the users thermal perceptions of educational urban precincts

Salman Shooshtarian[a,b,*], Ian Ridley[c]

[a] School of Property, Construction and Project Management, RMIT University, Melbourne, Australia
[b] Sustainable Building Innovation Laboratory (SBi Lab), RMIT University, Melbourne, Australia
[c] School of Energy and Environment, City University of Hong Kong, Hong Kong, China

ARTICLE INFO

Article history:
Received 19 February 2016
Received in revised form 3 June 2016
Accepted 5 June 2016
Available online 7 June 2016

Keywords:
Social environment
Individual environment
Outdoor thermal comfort
Educational urban precincts
Contextual parameters

ABSTRACT

Assessment of outdoor thermal comfort provides a valuable insight into the performance of outdoor built environments. During the last four decades the number of the thermal comfort studies focused on the impact of microclimate parameters on human health and wellbeing has increased. Meanwhile, advances in the thermal comfort studies have expanded to include non-thermal factors including the social and individual parameters indirectly interacting with thermal perceptions. These factors are believed to be contextual-based and this study aimed to understand their effects on the outdoor thermal perceptions in educational outdoor spaces. The data used in this study was collected during three rounds of the field surveys consisting of measurement and questionnaire surveys. The field surveys were conducted in three case studies which were the premises of a university campus in Melbourne, Australia, from November 2014 to May 2015. Using a Socio-ecological System Model (SESM) as the research framework, this study aimed to investigate the role of non-thermal factors that are classified under the individual environment (gender, age group, exposure to sun, level of activity and clothing insulation, skin colour) and the social environment (position, companionship and cultural background). The analytical results demonstrated the medium and low influence of individual and social environments on outdoor thermal sensation, respectively. The research outcome is specific to thermal comfort requirements in the educational precincts but also can apply to similar climate and contextual conditions. The results may be used to inform decisions made in the phase of design and planning for development of educational outdoor spaces.

1. Introduction

Assessment of outdoor thermal comfort provides a valuable insight into the level of performance of outdoor built environments. According to the definition put forward by ASHRAE thermal comfort is "... *that condition of mind that expresses satisfaction with the thermal environment*..." (ASHRAE 55, 2010). In addition to the six thermal factors (air and mean radiant temperature, relative humidity, wind speed, level of activity and clothing insulation), that are known to have the most effect on human thermoregularty system, non-thermal factors can play a key role in determination of outdoor thermal perceptions. In the recent years these factors have been investigated in the assessment of the quality of thermal comfort achievement (Brager and de Dear, 1998; Parsons, 2002; Nikolopoulou, Baker, & Steemers, 2001; Thorsson, Honjo, Lindberg, Eliasson, & Lim, 2007; Ng & Cheng 2012). The mere fact that the outdoor spaces are built by people to be used by people highlights the need for inclusion of human and social parameters in the assessment of comfort level including thermal comfort.

Non-thermal parameters are not employed in the algorithms of models used to predict thermal comfort which are premised on the heat-balance theories (Brager and de Dear, 1998Gagge et al., 1986; Höppe, 2002). However, some recent models have given more weight to these parameters in the assessment of thermal comfort (Blażejczyk et al., 2013; Chen and Ng, 2011; Zolfaghari and Maerefat, 2011). The Universal Thermal Comfort Index (UTCI), for instance, considers the space users' weight and height in the calculation of thermal comfort through UTCI-Fiala model (Blażejczyk et al., 2013). In practice, however, the value of human parameters is often assumed as constant and a limited number of studies have included the individual's parameters in assessment of ther-

* Corresponding author at: School of Property, Construction and Project Management, RMIT University, Melbourne, Australia.
E-mail addresses: salman.shooshtarian@rmit.edu.au, s.shooshtarian@yahoo.com (S. Shooshtarian).

http://dx.doi.org/10.1016/j.scs.2016.06.005
2210-6707/

mal comfort. One possible cause of this tendency is related to their impact on the thermal perceptions being dependent on context. This is a convincing reason why the human parameters should be investigated in its own context.

Gender, age group, and the level of metabolic activity and clothing insulation are among the individual parameters that are most examined in the previous thermal comfort studies (Thorsson et al., 2007). However, there is a crucial need for investigation of other less-considered factors, including the users' physical attributes, behaviour and the socio-cultural characteristics particularly in outdoor thermal conditions (Brager and de Dear, 1998; Knez, Thorsson, Eliasson, & Lindberg, 2009; Shooshtarian, 2015). Below the moderating effects of the individual and social parameters on thermal sensation that are evaluated in this study are discussed according to the existing literature:

There exists no consistency in the findings about the role of gender in determination of thermal perceptions (Tung et al., 2014). While some have reported insignificant or no effects (Knez and Thorsson, 2006; Krüger and Rossi, 2011; Pantavou, Theoharatos, Santamouris, & Asimakopoulos, 2013), others have indicated its moderating effect on thermal perceptions (Lam, Loughnan, & Tapper, 2016; Nasir, Ahmad, & Ahmed, 2012; Oliveira and Andrade, 2007; Tung et al., 2014). A comprehensive meta-analysis on gender's role in indoor thermal comfort (Karjalainen, 2012) identified differences in the survey preferences of females and males. The effect of age on thermal perceptions in several studies, likewise, has shown contradictory results; while some have failed to prove its significant effect (Knez and Thorsson, 2006; Nasir et al., 2012) others have endorsed its effective role in moderation of thermal sensation (Farage, Kenneth, & Maibach, 2010; Knez et al., 2009; Krüger and Rossi, 2011; Pantavou et al., 2013). Many laboratory-based experiments have been conducted to understand the interaction between individual physical attributes and thermal perceptions under the given thermal conditions (Arens & Zhang, 2006; Fanger 1970; Gagge et al., 1986; Parsons, 2002). Despite the evidence found on the relationship between skin colour and thermoregulation (Arens & Zhang, 2006) through the varying absorptivity of solar radiation of different skin colours (Hoppe, 1992; Lyons, Arasteh, & Huizenga, 2000), there is not a convincing explanation of how skin colour may influence human thermal perceptions (Zhou, Zhang, Lian, & Lan, 2014). Previous outdoor thermal comfort studies including Oliveira and Andrade (2007) did not find skin colour to impact on thermal perceptions.

The level of exposure to solar radiation is also considered to be a determinant of thermal perceptions. The significant effect of the extent of exposure to sun on outdoor thermal comfort has been reported (Lin, Matzarakis, & Hwang, 2010; Pantavou et al., 2013; Watanabe, Nagano, Ishii, & Horikoshi, 2014). The human body's posture largely influences the heat exchange between the body and surrounding thermal environment (Parsons, 2003; Tikuisis and Ducharme, 1996) and may also take a form of behavioural adaptation to the microclimate conditions (Oliveira and Andrade, 2007). Kurazumi et al. (2008) conducted an experiment on the effect of body posture position on steady state heat exchange and concluded that this factor has a noticeable effect on the heat transfer of the human body.

The role of socioeconomic background of users may influence thermal perceptions (Shooshtarian, 2015). Individuals from a rigid social-background may place more restrictions on the available thermal adaptive options compared with a person with more flexible-driven lifestyle (Humphreys and Nicol, 1998). The potential relationship between socioeconomic background and thermal comfort requirements has been the focus of a few studies both in indoor and outdoor conditions (Aljawabra and Nikolopoulou, 2010; Indraganti and Rao 2010; Maras, Buttstädt, Hahmann, Hofmeister, & Schneider, 2014). For instance, while Aljawabra and Nikolopoulou (2010) contended that those with a better economic/educational status were more sensitive to the prevailing outdoor climate conditions, Maras et al. (2014) indicated that generally a better economic status reduces thermal discomfort.

Companionship is a social environment factor that can modify thermal sensation. Being unaccompanied was found to be an influencing factor on thermal discomfort in outdoor environments of the Mediterranean (Oliveira and Andrade 2007; Pantavou et al., 2013), hot and arid (Aljawabra and Nikolopoulou, 2010) and temperate climates (Maras et al., 2014). Klinenberg (2015) stated that the lack of social embeddedness, including having an isolated life style can lead to a higher death rate during heat waves.

Cultural background is another factor that has recently received a lot of attention. Several studies have tried to explore the relationship between the cultural influence and thermal perceptions in outdoor environments (Aljawabra and Nikolopoulou, 2010; Kenawy and Elkadi, 2013; Knez and Thorsson 2006). Cultural background is not only reflecting on the ethnic differences in perceptions of thermal environments (Fukazawa and Havenith, 2012), but also the role of cultural norms in adaptation to prevailing thermal conditions (Humphreys and Nicol, 1998). Knez and Thorsson (2006) stated that "*. . .perceptual assessments of a physical place may be intertwined with psychological and cultural processes, rather than fixed by general thermal indices developed in line with the physiological heat balance models*" (2006, p. 1483). In Australia, Kenawy and Elkadi (2013) found that thermal perceptions differed among the culturally diverse users of urban open spaces and Lam et al. (2016) reported that Chinese tourists' thermal perceptions and preferences differed from that of Australian residents.

The research objectives in this paper has been formulated as follows: (1) to explore the moderating role of each factor mentioned above in the perceptions of outdoor thermal conditions, (2) to further understand the relationship between the social and personal environments and thermal perceptions (3) to find the specific requirements of thermal comfort in the context of educational urban precincts, where particular users (university students and staff) with diverse cultural background visited the outdoor spaces.

2. Method used for this study

2.1. Theoretical framework used in the study

This study employed a theoretical model that is Socio-Ecological System Model (SESM) to address the research objectives. This model which is built on the "Ecological System Theory" (Bronfenbrenner 1992) has long been used to study the human attitude and behaviour in an ecosystem. The EST is a greatly adaptable framework recognising that there are distinct yet interrelated factors which affect human attitudes and behaviours. The EST multi-cluster framework assumes that people are influenced through a set of environments that together with their personal characteristics create the knowledge of the reality (Bronfenbrenner and Evans, 2000). This framework has been used in the investigation of household energy consumption, behaviour and thermal comfort (Edwards and Pocock, 2016), physical activity outdoors (Hyndman, Telford, Finch, & Benson, 2012; Mehtälä, Sääkslahti, Inkinen, & Poskiparta, 2014; Owen, Humpel, Leslie, Bauman, & Sallis, 2004; Sallis, Floyd, Rodríguez, & Saelens, 2012), public health in urban and rural environments (Kearns, Barnett, & Beaty, 2007; Williams et al., 2013) and work and life balance (Pocock, Skinner, & Williams, 2014).

Through this model the influential factors on thermal perceptions were clustered under the five environments: individual (gender, age, level of clothing insulation and activity, skin colour, level of exposure to sun), social (companionship, cultural back-